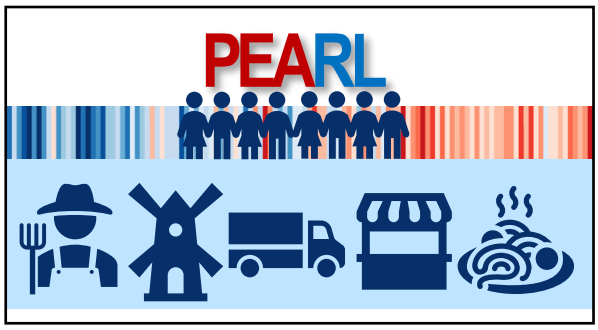


Annex 2
Master Feasibility Study

Collated Findings and Recommendations of Independent Baseline and Feasibility Studies for Developing A GCF-funded Project:

Public-Social-Private Partnerships for Ecologically-Sound Agriculture and Resilient Livelihood in Northern Tonle Sap Basin (PEARL), Cambodia

April 2022
Team of FAO Experts and Consultants
Phnom Penh, Cambodia

TABLE OF CONTENTS

ABBREVIATIONS AND ACRONYMS 8

1. INTRODUCTION 12

2. BASELINE CONDITIONS 14
- 2.1. Agriculture as Cambodia's Key Economic Sector 14
- 2.2. Agriculture in the NTSB and its Underlying Socioeconomic Vulnerabilities 15
- 2.3. Market Entry Challenges for Smallholder Farmers and Other Local Value Chain Actors 22
- 2.4. Prevalent Socioeconomic Vulnerability 24

3. CLIMATE CHANGE IN NTSB 28
- 3.1. Climate Baseline 28
- 3.2. Climate Impacts: Historical Climate Trends 30
- 3.3. Future projected climate 36

4. RATIONALE FOR INTERVENTION AND BARRIERS 46
- 4.1. Opportunities for transitioning to climate resilience and sustainable agriculture in the NTSB 46
- 4.2. Narrative of transformation 49
- 4.3. Complementarity and coordination with other adaptation approaches 49
- 4.4. Barriers to promoting climate change adaptation through higher-value agriculture in NTSB 52

5. PROJECT OBJECTIVE AND EXPECTED RESULTS 56
- 5.1. PEARL Project Objective 56
- 5.2. Expected Outcomes (Project Outcomes) 57
- 5.3. Leveraging Private Sector Support for Outcome Delivery 59

6. RELEVANT POLICY AND INSTITUTIONAL CONTEXTS 61
- 6.1. Climate Change and Agriculture 61
- 6.2. Environmental Conservation and Agriculture 64
- 6.3. Agricultural Production and Socioeconomic Development 64

7. OUTCOME ONE: FARMERS' CAPACITIES ARE ENHANCED TO MANAGE CLIMATE IMPACTS AND RELATED DISASTER RISKS 66
- 7.1. Baseline Conditions – Agrometeorological Services 66
- 7.2. Suggested Output and Actions under Outcome 1 76

8. OUTCOME TWO: ADAPTIVE CAPACITIES INCREASED 79
- 8.1. Increased Premium Market Access Through Agricultural Certifications (Output 2.1) 79
- 8.2. Suggested Actions under Output 2.1 94
- 8.3. Access to Technologies and Finance for Smallholder Farmers, ACs, FAs, and SMEs (Output 2.2) 96
- 8.4. Suggested Actions under Output 2.2 117
- 8.5. Climate-resilient and High-value Techniques and Technologies Adopted (Output 2.3) 123
- 8.6. Suggest Actions under Output 2.3 190
- 8.7. Upper-Watershed Areas Restored And Protected To Increase Agroecological Functions (Output 2.4) 192
- 8.8. Suggested Actions under Output 2.4 202

9. OUTCOME THREE: ENABLING CONDITIONS FOR CLIMATE-RESILIENT AGRICULTURE ARE ENSURED 203

9.1. Regulatory and institutional arrangements and capacity relevant to developing certification-based value chains strengthened to provide enabling conditions for adopting climate-resilient, high-value and sustainable agriculture and food security (Output 3.1)_____ 203
9.2. Suggested Actions under Output 3.1. 205
9.3. Gender-responsive landscape-level agroecology monitoring system (LAMS) developed to crowd in public and private investments in climate-resilient, high-value and sustainable agriculture (Output 3.2) 206
9.4. Suggested Action under Output 3.2. 207

10. PROJECT COSTS AND FINANCING_____ 209

11. IMPLEMENTATION ARRANGEMENTS _____ 211

12. ECONOMIC AND FINANCIAL ANALYSIS _____ 218
13.1. Macro-finance Analysis 218
13.2. Economic and Financial Analysis 227
Annex I: Baseline Investments 233
Annex II: AquaCrop Analysis 245
Annex III: Target Beneficiaries 269
Annex III: TSSD's Revolving Fund Experience _____ 271
Annex IV: Examples of Technologies and Infrastructure Assets under FARM_____ 273

TABLE OF FIGURES, TABLES AND ANNEXES

Figure 1: Landcover map of Cambodia and location of NTSB.....15
Figure 2: Changes in Planted Areas between 2013 and 2019 16
Figure 3: Agricultural Chemical Use and Irrigation Status (2018-2019) 17
Figure 4: Sources and mediums of extension support 24
Figure 5: Change in Number of Female-headed Agricultural Households (NIS 2019).....26
Figure 6: Vulnerability to Different Shock Types 27
Figure 7 Total average precipitation (cumulative mm) over the rainy season May-October (left) and from January-April (right) averaged over the period 1989-2016 from the reanalysis dataset W5E5 (FAO analysis).....28
Figure 8 Average temperature maximum (left) and temperature minimum (right) during the rainy season May-October over the period 1987-2016 from the reanalysis dataset W5E5 (FAO analysis).....28
Figure 9: Percentage of dry-season rice cultivated areas (from UNDP, 2019, National Drought Study) 29
Figure 10: Agricultural growth in percentage over the period 2008-2017.....30
Figure 11 Historical mean temperature change over the period 1960-2000 by season December-February (top left), March-May (top left), July through August (bottom left) and September-November (bottom right).....30
Figure 12 Trend in the annual average temperature maximum (left) and temperature minimum (right) over the historical period 1980 to 2016 from reanalysis dataset WE5E. Statistical significance is indicated by a black point over relevant pixel. (FAO analysis).....31
Figure 13 Trend in the number of days with temperature maximum >33C during the rainy season May to October over the period 1980-2016 using the WE5E reanalysis dataset (FAO analysis) 31
Figure 14 Historical mean precipitation change over the period 1960-2000 by season December-February (top left), March-May (top left), July through August (bottom left) and September-November (bottom right).....32
Figure 15 Precipitation trend over the period 1980-2016 in the months (a) March-May, (b) June-August and (c) September-November. Statistical significance of 0.05 is indicated with a black dot (FAO analysis) 32
Figure 16 Trend in the number of days with precipitation >30mm during the rainy season May to October over the period 1980-2016 using the reanalysis dataset WE5E. Statistical significance of 0.05 indicated with a black dot (FAO analysis) 33
Figure 17: The average length of rainy season defined by daily rainfall timing and amount (1980-2016). Rainy season typically runs from May Oct for about 180 days on average, with spatial and interannual variations (FAO, 2020).....33

Figure 18: Drought vulnerability index in 2014 34
Figure 19: Three months SPEI for Kampong Thom weather station (computed by ClimPACT2) 34
Figure 20: Flood and drought prone areas in the Greater Mekong Sub-region (food security atlas). 35
Figure 21: Percentage of rice cultivated areas affected (A) and damaged (B) by drought and flood. Data shown represent 20-years' average values. 35
Figure 22 Temperature maximum deviation from historical baseline period (1980-2005) under RCP 4.5 (top row) for the period 2011-2040 (left), 2040-2070 (middle) and 2070-2100 (right) and RCP8.5 (bottom row) for the same time periods. The deviation highlights the projected change into the future in degrees celcius based on projections from bias corrected regional CORDEX data (FAO analysis). 37
Figure 23 Temperature minimum deviation from historical baseline period (1980-2005) under RCP 4.5 (top row) for the period 2011-2040 (left), 2040-2070 (middle) and 2070-2100 (right) and RCP8.5 (bottom row) for the same time periods. The deviation highlights the projected change into the future in degrees Celsius based on projections from bias corrected regional CORDEX data (FAO analysis). 38
Figure 24 Number of days with temperature >33 degrees Celsius shown as the deviation (in days) from historical baseline period (1980-2005) under RCP 4.5 (top row) for the period 2011-2040 (left), 2040-2070 (middle) and 2070-2100 (right) and RCP8.5 (bottom row) for the same time periods. The deviation highlights the projected change into the future in days based on projections from bias corrected regional CORDEX data (FAO analysis)....38
Figure 25 Cumulative precipitation per year deviation from historical baseline period (1980-2005) under RCP 4.5 (top row) for the period 2011-2040 (left), 2040-2070 (middle) and 2070-2100 (right) and RCP8.5 (bottom row) for the same time periods. The deviation highlights the projected change into the future in millimeters/year based on projections from bias corrected regional CORDEX data (FAO analysis). 40
Figure 26 Cumulative precipitation (mm) over the rainy season (May-October) per year under RCP 4.5 (top row) for the period 2011-2040 (left), 2040-2070 (middle) and 2070-2100 (right) and RCP8.5 (bottom row) for the same time periods (FAO analysis). 41
Figure 27 Deviation in cumulative precipitation in rainy season (May-October) from historical baseline period (1980-2005) under RCP 4.5 (top row) for the period 2011-2040 (left), 2040-2070 (middle) and 2070-2100 (right) and RCP8.5 (bottom row) for the same time periods. The deviation highlights the projected change into the future in millimeters based on projections from bias corrected regional CORDEX data (FAO analysis). 41
Figure 28 Deviation in number of days with heavy precipitation (50 mm) from historical baseline period (1980-2005) under RCP 4.5 (top row) for the period 2011-2040 (left), 2040-2070 (middle) and 2070-2100 (right) and RCP8.5 (bottom row) for the same time periods. The deviation highlights the projected change into the future in days based on projections from bias corrected regional CORDEX data (FAO analysis)....42
Figure 29: Length of rainy season in the historical period (1981-2000) in left panel, and for the future SSP5-8.5 scenario (2071-2100) from CMIP6 simulations in right panel (FAO). 43
Figure 30: Northern Sections of NTSB (AOI) 48
Figure 31 Value chain for an effective provision of climate services 67
Figure 32: Structure of DoM and main offices. 68
Figure 33: MoWRAM observational network of stations including provincial centers 69
Figure 34 *Flow of meteorological products to public, ministries, media andothers (MoWRAM presentation)* 71
Figure 35 Survey results from Cambodia's MoWRAM on deliverymechanisms and agrometeorological advisory products prepared by the institution . Source: FAO, 2021 71
Figure 36 Crop and pest/disease monitoring capacities of key agricultural institutions. Source: FAO, 2021b 72
Figure 37: Evolution of volume of organic rice committed and delivered under Contract Farming agreements in Preah Vihear, from 2014 to 2018 81
Figure 38 market destinations of rice produced in Preah Vihear 82
Figure 39: Life cycle of mango tree 87
Figure 40 Process to raise awareness, capacities and support SMEs on food safety and quality standards and certification 91
Figure 41: FARM extensive model 97
Figure 42: FARM intensive model 98
Figure 43: Selected points used for downscaling climate information and running the AquaCrop model along the Northern Tonle Sap basin 124
Figure 44 Major climate impacts to input supply 126

Figure 45 Practices implemented during input supply to adapt to climate hazards 126
Figure 46 Major climate impacts to rice harvest. 127
Figure 47 Practices implemented during rice harvest to adapt to climate hazards 127
Figure 48 Major climate impacts to rice storage 129
Figure 49 Practices implemented during storage to adapt to climate hazards 129
Figure 50 Major climate impacts to rice processing/milling. 130
Figure 51 Practices implemented during rice processing to adapt to climate hazards. 130
Figure 52 Major climate impacts to rice transportation. 131
Figure 53 Practices implemented during rice transportation and interest in implementing further practices. 132
Figure 54 Major climate impacts to rice markets 132
Figure 55 Practices implemented within markets to adapt to climate hazards. 133
Figure 56 Restoration opportunities for intervention of cashew plantation (option 9) and bamboo (option 10) according to the IUCN, 2018. 139
Figure 57 Challenges and opportunities for the cashew value chain in the NTSB. 140
Figure 58 Major climate impacts to input supply 141
Figure 59 Practices implemented and interest in implementing further practices during input supply to adapt to climate hazards. 142
Figure 60 Major climate impacts to cashew harvest 143
Figure 61 Practices implemented and interest in implementing further practices during cashew harvest to adapt to climate hazards 143
Figure 62 Major climate impacts to cashew storage 145
Figure 63 Practices implemented during cashew storage to adapt to climate hazards 146
Figure 64 Major climate impacts to cashew processing 147
Figure 65 Practices implemented and interest in implementing further practices during cashew processing to adapt to climate hazards. 148
Figure 66 Trade of cashew nuts and producers/buyers (Swiss Church Aid) 149
Figure 67 Major climate impacts to cashew markets. 150
Figure 68 Practices implemented within cashew markets to adapt to climate hazards 151
Figure 69 Major challenges to the mango value chain. 157
Figure 70 Major challenges to food safety across the mango value chain 158
Figure 71 Climate risks to the mango value chain 159
Figure 72 Major climate impacts to mango harvesting. 161
Figure 73 Major climate impacts to mango transportation. 162
Figure 74 Major climate impacts to mango markets. 163
Figure 75 Practices implemented within markets to adapt to climate hazards. 164
Figure 76 Major challenges to the vegetables value chain 169
Figure 77 Major challenges to food safety in the vegetables value chain 170
Figure 78 Climate risks to the vegetables value chain 170
Figure 79 schematic representation of the current vegetables value chain in Cambodia 172
Figure 80 Major climate impacts to input supply 173
Figure 81 Practices implemented, and requested to be implemented further, during input supply to adapt to climate hazards. 173
Figure 82 Major climate impacts to vegetables harvest. 174
Figure 83 Practices implemented, and requested to be implemented further, during vegetables harvest to adapt to climate hazards. 174
Figure 84 Major climate impacts to vegetables storage. 176
Figure 85 Practices implemented and requested to be implemented further during vegetables storage to adapt to climate hazards. 176
Figure 86 Major climate impacts to vegetables transportation. 177
Figure 87 Major climate impacts to vegetables markets 178
Figure 88 Practices implemented and requested to be implemented further within vegetables markets to adapt to climate hazards. 179
Figure 89 Map of 20 selected CPAs and CFs in PEARL Targeted Areas 201

Figure 90: Project Implementation Arrangements 213
Figure 91: Backward and forward multipliers for Cambodia 219
Figure 92: Economic impact of spending in agriculture (dollars) 220
Figure 93: Emissions (fig. a), natural resources usage (fig. b) and environmental themes (fig. c) linked to increase in spending 221
Figure 94: Cumulative economic impact on households' income (mil. USD) 224
Figure 95: Present value of incremental income by household quintiles (USD Mil.) 225
Figure 96: Cumulative economic impact on agriculture sub-sectors (present value - USD million) 226
Figure 97: Cumulative impact on main economic sectors (present value - USD million) 226

Table 1: Overview of Key Crops in NTSB ____ 23
Table 2: Agricultural Households ____ 25
Table 3: Demographics in Northern Sections of NTSB ____ 25
Table 4: Key Crops and Their Climate Exposure and Impacts in the NTSB ____ 43
Table 5: Relevant Projects under the Programmatic Coordination ____ 50
Table 6: Agro-meteorological Forecasting, Warning and Advisory Service Capacity Gaps ____ 57
Table 7: List of Potential Private Sector Partners ____ 59
Table 8: Automatic weather stations in project area, province and funding source. ____ 68
Table 9: Summary table of meteorological capacities for forecasting, observation and agricultural meteorology. Source: FAO, 2021b. ____ 69
Table 10 Agrometeorological bulletin services and sustainability in Cambodia. Source: FAO, 2021b ____ 74
Table 11: Major challenges and recommendations to overcome last mile barrier to climate services in Cambodia 75
Table 12: Analytical framework of agricultural certifications study ____ 80
Table 13 Estimation of organic rice expansion potential in Preah Vihear ____ 83
Table 14 Price of RCN in Kampong Thom and Preah Vihear province in 2017 ____ 85
Table 15: Summaries of Trends, Concerns and Climate-resilient Agriculture Potential with Target Crops ____ 89
Table 16: Key agricultural certification programs in Cambodia ____ 93
Table 17: FARM Design Options under the first approach ____ 99
Table 18 FARM Design Options under the second approach ____ 105
Table 19 Trust fund fees ____ 110
Table 20:FARM scenario one ____ 116
Table 21: FARM scenario two ____ 117
Table 22 Climate resilient practices requested by survey respondents at production and post-harvest stages __ 134
Table 23: Recommended climate-resilient measures for rice based on the observed and projected climate impacts along the food value chain ____ 135
Table 24 Climate resilient practices requested by survey respondents at production and post-harvest stages. __ 152
Table 25 Recommended climate-resilient measures for cashew based on the observed and projected climate impacts along the food value chain ____ 152
Table 26 Climate resilient practices requested by survey respondents at pre- and post-harvest stages. ____ 164
Table 27 Recommended climate-resilient measures for mangoes based on the observed and projected climate impacts along the food value chain. ____ 165
Table 28 Climate resilient practices requested by online survey respondents at pre- and post-harvest stages. __ 180
Table 29 Recommended climate-resilient measures for vegetables based on the observed and projected climate impacts along the food value chain. ____ 181
Table 30 Summaries of 20 Selected CPAs and CFs for the PEARL project ____ 196
Table 31: Project Costs and Financing ____ 209
Table 32: Assignment of EEs (see Annex 4 for sub-activity level assignments) ____ 211
Table 33: Key Positions ____ 214
Table 34: Project cost by component (USD) ____ 221
Table 35: PEARL GCF investment matrix - Annual expenditure (USD) ____ 223
Table 36: Summary table on PEARL direct and indirect economic impact (USD million) ____ 226
Table 37. Computation of the Standard Conversion factor (SCF) for the economic analysis ____ 227
Table 38. Import parity price for key importable inputs ____ 228

Table 39. Export parity price for exported output 228
Table 40. Cambodia: GDP growth rate 229
Table 41. Number of HHs adopters 229
Table 42: Results of the economic and sensitivity analysis 230
Table 43: Risk Analysis 231
Table 44: Key Baseline Investments in relation to the barriers and interventions 234

ABBREVIATIONS AND ACRONYMS

AC	Agricultural Cooperative
ACIAR	Australian Centre for International Agricultural Research
ACL	Agricultural Cooperative Loan
ACTAE	Towards Agroecology Transition in the Mekong Region Project
ADB	Asian Development Bank
AE	Accredited Entity
AEC	ASEAN Economic Community
AFD	*Agence Française de Développement* / French Agency for Development
AFTA	ASEAN Free Trade Agreement
Agromet	Agrometeorological
AIMS	Accelerating Inclusive Markets for Smallholders Project (IFAD project)
ALiSEA	Agroecology Learning Alliance in South East Asia
AMA	Accreditation Master Agreement
AMK	Angkor Microhenranhvatho Kampuchea
ARDB	Agricultural and Rural Development Bank of Cambodia
ASEAN	Association of South-East Asian Nations
ASPIRE	Agriculture Services Program for Innovation, Resilience and Extension (IFAD project)
AusAID	Australian Agency for International Development
AVSF	*Agronomes et Vétérinaires Sans Frontières*
AWD	Alternate Wetting and Drying
AWS	Automated weather stations
BRC	British Retail Consortium
BRICo	Battambang Rice Investment Company
CARD	Council for Agricultural and Rural Development
CARDI	Cambodian Agricultural Research and Development Institute
CASP	Core Agriculture Support Program (Greater Mekong Subregion)
CAVAC	Cambodia Agriculture Value Chain Program (AusAID)
CB	Certification Body
CBC	Credit Bureau of Cambodia
CBI	Centre for the Promotion of Imports from developing countries
CamGAP	Cambodia Good Agricultural Practices
CC	Climate Change
CCA	Climate Change Adaptation
CCR	Climate Change Risk
CDRI	Cambodia Development Resource Institute
CEO	Chief Executive Officer
CF	Community Forest
CIRAD	*Centre International de Recherche Agronomique pour le Développement*
CNSL	Cashew Nut Shell Liquid
CO	Certificate of Origin
CoP	Code of Practices
COrAA	Cambodian Organic Agriculture Association
CPA	Community Protected Area
CSR	Corporate Social Responsibility
DAA	Direct Access Applicant
DACP	Department of Agricultural Cooperatives Promotion
DAE	Direct Access Entity
DAE	Department of Agricultural Extension
DAI	Department of Agro-industry
DIC	Department of Industrial Crops
Dis.	District
DMC	Direct-seeding Mulch-based Cropping system
DoM	Department of Meteorology

DP	Development Partner
DPPSP	Department of Plant Protection Sanitary and Phytosanitary
DRC	Department of Rice Crops
DRR	Disaster Risk Reduction
EC	European Commission
EE	Executing Entity
EIRR	Economic Internal Rate of Return
ELC	Economic Land Concession
ESMF	Environmental and Social Management Framework
ESR	Equitable, Solidaire, Responsable (Fairness, Solidarity, Responsibility) – Ecocert owned standard
EU	European Union
FA	Farmers Association
FAO	Food and Agriculture Organization of the United Nations
FARM	Farmer-led Agricultural Resilience Mechanism
FASMEC	Federation of Association for Small and Medium Enterprises of Cambodia
FFS	Farmer Field School
FGD	Focus Group Discussion
FIRR	Financial Internal Rate of Return
FI	Financial Institution
FO	Farmer Organizations
FSMS	Food Safety Management System
GAP	Good Agricultural Practices
GCF	Green Climate Fund
GCM	Global Climate Model
GDA	General Directorate of Agriculture
GEF	Global Environment Facilities
GHG	Greenhouse Gas
GI	Geographical Indication
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GMP	Good Manufacturing Practice
GMS	Greater Mekong Subregion
GRET	Groupe de Recherches et d'Echanges Technologiques
HACCP	Hazard Analysis and Critical Control Points
HH	Household
HR	Human Resources
ICEM	International Centre for Environmental Management
ICM	Integrated Crop Management
ICS	Internal Control System
ICT	Information and Communication Technology
IFAD	International Fund for Agricultural Development
IFC	International Finance Corporation
IFEA	Integrated Finance and Economic Analysis
IFOAM	International Federation of Organic Agriculture Movements
IIED	International Institute for Environment and Development
IP	Intellectual Property
IPC	Integrated Pest Control
IPD	Intellectual Property Department of the Ministry of Commerce
IPM	Integrated Pest Management
IPPPM	Integrated Production, Pest and Pollution Management
IRAM	*Institut de Recherche et d'Application des Méthodes de Développement*
IRRI	International Rice Research Institute
ISC	Institute of Standards of Cambodia
IT	Information Technologies
ITC	International Trade Center

IUCN	International Union for the Conservation of Nature
IVY	International Volunteers of Yamagata
IWM	Integrated Watershed Management
JICA	Japanese International Cooperation Agency
KHR	Khmer Riel
KII	Key informant interview
KT	Kampong Thom
LAMS	Landscape-level Agroecology Monitoring System
M&E	Monitoring and Evaluation
MAFF	Ministry of Agriculture, Forestry, and Fisheries
MD	Man Day
MEF	Ministry of Economy and Finance
MFI	Micro-Finance Institution
MIH	Ministry of Industry and Handicraft
MLVT	Ministry of Commerce
MoC	Ministry of Commerce
MoE	Ministry of Environment
MoL	Ministry of Labour and Vocational Training
MoU	Memorandum of Understanding
MoWA	Ministry of Women Affairs
MoWRAM	Ministry of Water Resources and Meteorology
MPWT	Ministry of Public Works and Transport
MT	Metric Tonnes
MWS	Manual weather stations
NDA	National Designated Authority
NDC	Nationally Determined Contribution
NFMS	National Forest Monitoring System
NGHGI	National Greenhouse Gas Inventory
NGO	Non-Governmental Organization
NMHS	National Hydro-Meteorological Services
NOP	National Organic Program (USA organic standards)
NVP	Net Present Value
NSC	National Standard Council
NSDP	National Strategic Development Plan
NTSB	Northern Tonle Sap Basin
OA	Organic Agriculture
OACP	Office of Agricultural Cooperatives Promotion
OECD	Organization for Economic Co-operation and Development
OM	Oddar Meanchey
PDAFF	Provincial Department of Agriculture, Forestry and Fisheries
PDoC	Provincial Department of Commerce
PDoE	Provincial Department of Environment
PEARL	Partnerships for Ecologically-Sound Agriculture and Resilient Livelihood in Northern Tonle Sap Basin
PG	Producer Group
PGS	Participatory Guarantee System
PICSA	Participatory Integrated Climate Services for Agriculture
PMUAC	Preah Vihear Meanchey Union of Agricultural Cooperatives
PoA	Plan of Action
PPCR	Pilot Program for Climate Resilience
PSPP	Public, Social and Private Partnership
PV	Phreah Vihear
PWG	Project Working Group
QMS	Quality Management System
RCN	Raw Cashew Nuts
RDB	Rural Development Bank

REDD+	Reducing Emissions from Deforestation and Forest Degradation
RGC	Royal Government of Cambodia
RIMES	Regional Integrated Multi-hazard early Warning System for Africa and Asia
RUA-CD	Royal University of Agriculture – Chamcar Daung
SCCRP	Support to the Commercialization of Cambodian Rice Project
SCM	Supply Chain Management
SCP	Specialized Cambodian Products
SEA	South East Asia
SETFO	Secured Transactions Filing Office
SIAL	*Salon International de l'Agroalimentaire* (Paris)
SIFAV	Sustainability Initiative Fruit and Vegetables
SMAE	Small and Medium-sized Agricultural Enterprise
SME	Small and Medium Enterprise
SNEC	Supreme National Economic Council
SoA	Signatures of Asia
SOP	Standard Operating Procedure
SPA	Sales and Purchase Agreement
SPS	Sanitary and Phyto-Sanitary
SRP	Sustainable Rice Platform
SWOT	Strengths, weaknesses, opportunities, and threats analysis
TA	Technical Assistance
ToR	Terms of Reference
ToT	Training of Trainers
TPD	Trade Promotion Department of the MOC
TWGAW	Technical Working Group on Agriculture and Water
UK	United Kingdom
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Program
UNEP	United Nation Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
USA	United States of America
USAID	United States Agency for International Development
USD/US$	United States Dollar
USP	Unique Selling Proposition
V&A	Vulnerability and Adaptation
VAT	Value-added Tax
VC	Value Chain
VHT	Vapor Heat Treatment
VINACAS	Vietnam Cashew Association
VSO	Volunteer Services Overseas
WB	World Bank
WCR	Working Capital Requirement
WCS	Wildlife Conservation Society
WOP	Without Project
WP	With Project
WIPO	World Intellectual Property Organization
WREI	Water Resources & Environment Institute
WTO	World Trade Organization

1. INTRODUCTION

1. This master feasibility study report describes the project, “Public-Social-Private Partnerships for Ecologically-Sound Agriculture and Resilient Livelihood in Northern Tonle Sap Basin (PEARL)”, proposed for funding under the Green Climate Fund (GCF) by drawing on findings and recommendations from baseline and feasibility studies, which were carried out during the project identification and preparation phases. These individual study reports are appended to this report for reference.

2. The document begins by providing an overview of the baseline situation with respect to the role of agriculture in the Cambodian economy, historical and future climate trends and their impacts on agriculture, and prevailing socio-ecological vulnerabilities of the Northern Tonle Sap Basin (NTSB) that make this agriculturally important region a priority for urgent climate action in Cambodia. Against this backdrop, the project's rationale and design are presented from several feasibility perspectives to identify specific sets of actions under each outcome to address critical barriers to the NTSB's climate change adaptation.

3. The project comprises three distinct but interdependent outcomes that focus on 1) strengthening information and awareness to manage climate risks, 2) alternative value chain development, and 3) establishing an enabling policy, regulatory and institutional environment. The design of the project, together with technical feasibility considerations, is presented by outcome. This is followed by the project budget and financing, a description of the institutional and implementation arrangements, and an overview of the project monitoring and evaluation framework. These critical elements of the project are then evaluated through a detailed economic and financial analysis and environmental and social assessment.

4. The development of the PEARL project began in the second half of 2017 when the Royal Government of Cambodia (RGC) appointed FAO to prepare a GCF funding proposal to address anticipated impacts of climate change on agriculture and rural livelihoods, particularly in the northwestern part of the country to complement another GCF project, “Climate-Friendly Agribusiness Value Chains Sector (FP 076)”, by the Asian Development Bank (ADB), which aims at addressing agricultural emissions and adaptation needs along the Mekong River and in the Mekong Delta in the southeastern part of the country.

5. Under the direct guidance and leadership of Cambodia’s National Designated Authority (NDA), FAO had since undertaken a series of stakeholder consultations and baseline and feasibilities studies to develop a project Concept Note (CN) for the PEARL project, which was first submitted to the GCF Secretariat in December 2019. After several technical consultations between the GCF and FAO and successive revisions of the CN, the Climate Investment Committee 2 (CIC2) of the GCF has endorsed the CN in July 2021 and granted financial support through its Project Preparation Facility (PPF) to complete the Funding Proposal package.

6. During the preparation of the CN and project funding proposal, several baseline and feasibility studies were conducted to inform the project design and provide both the context and justification for the project’s investments. During project preparation, approximately 1,102 individual stakeholders, representing over 600 private and public entities and institutions, have been consulted (143 women and 966 men). Subsequently, the Funding Proposal, together with this report and other required supporting documents, were submitted to the NDA for review and clearance in February, 2022. With

the NDA's No-objection Letter (NoL), the Funding Proposal package has been submitted to the GCF for its board's consideration.

2. BASELINE CONDITIONS

2.1. Agriculture as Cambodia's Key Economic Sector

7. Cambodia remains one of the few Least Developed Countries (LDCs) in Asia (UNDESA, 2018). The country has nonetheless made steady economic development progress. In 2018, Cambodia's gross national income (GNI) per capita reached US$ 1,380, which had more than tripled since 2004 (WB, 2019). Much of this growth was due to favorable macroeconomic policies and developments (i.e., increased lending, investments, and exports) in the agriculture sector, which accounts for nearly a third of the country's GDP (CIB & CSEZB, no date; WB, 2015; Cramb, Sareth and Vuthy, 2020). Among the main crops produced in Cambodia, rice is the staple and single most important crop in the country, providing nearly 70% of nutritional needs and accounts for almost 80% of Cambodia's crop production (MoE, 2015a; MAFF, 2017). Rice production accounts for nearly 15% of the country's Gross Domestic Product (GDP) and occupies nearly 75% of the total cultivated land area (IFC, 2015). The agricultural expansion, supporting the country's economic growth in the past decades, has also come at the cost of environmental degradation, mainly through deforestation to make way for crop production, particularly for cash crops like cassava.

8. Around 80% of rice production originates from local varieties that are cultivated during the rainy season. High-yielding varieties are mainly planted during the dry season, and account for the remaining 20% of the production. Around 50% the paddy produced in Cambodia is exported to neighboring countries (primarily Vietnam and Thailand) for milling and further distribution, which represents a huge lost opportunity for Cambodian rice millers.

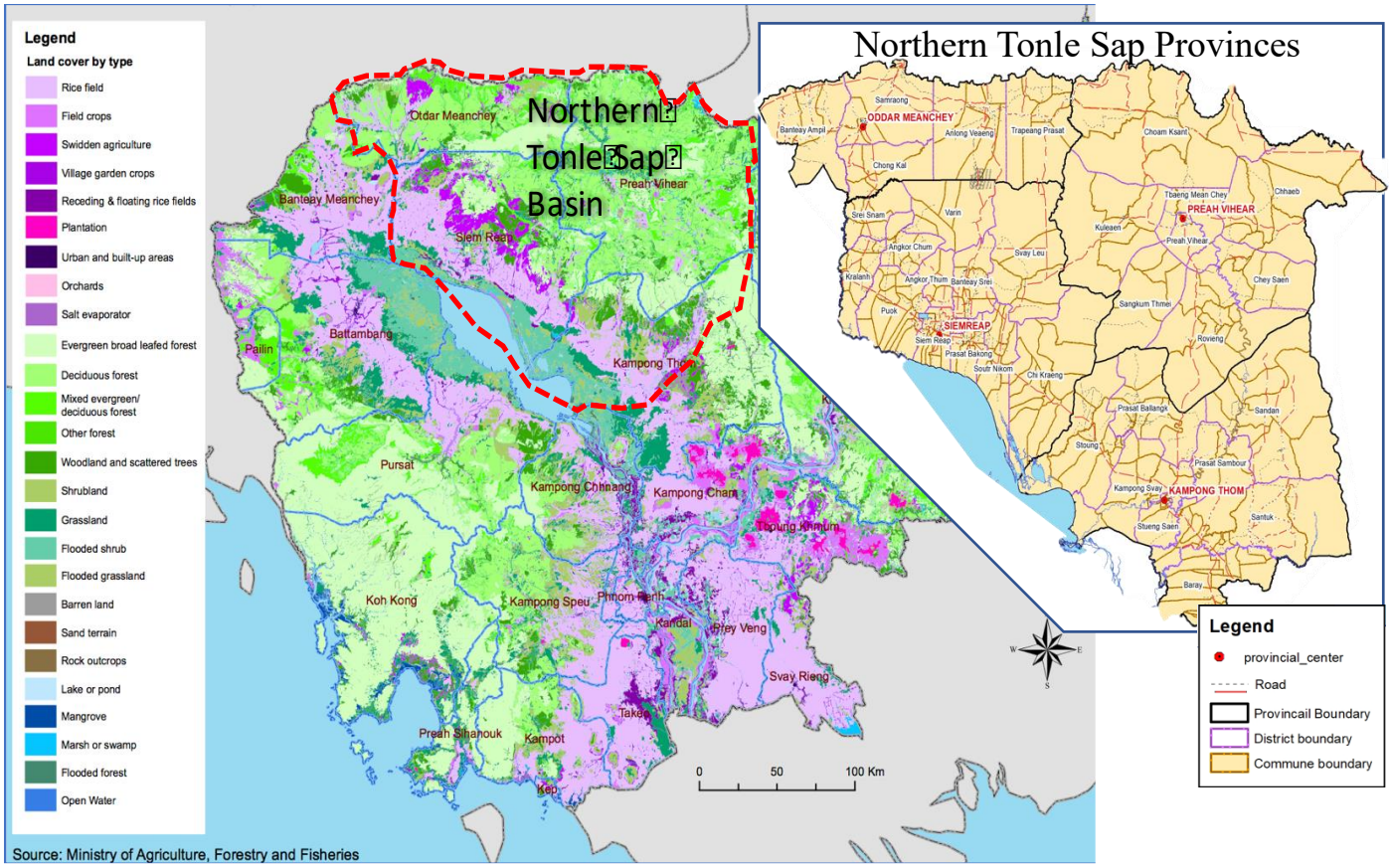
9. Despite the overall growth and expansion of the agriculture sector, smallholder farmers in rural areas have notably lagged behind this progress due to their limited capacity and access to finance, technologies, and information. Roughly 45% of the country's labor force is directly engaged in agriculture, and over 60% of which is found in rural areas where poverty rates are often higher than 20%, compared to 10% in the country's capital, Phnom Penh (RGC, 2014, 2018b). While Cambodia's rural agrarian population plays an essential role in the country's economy, persistent poverty makes many farming communities and households vulnerable to extreme weather events and natural disasters such as droughts and landslides. The environmental degradation resulting from agricultural expansion has also exacerbated the impacts of these extreme weather events.

10. Since 80% of the country's cropland (approximately 5.3 million ha.) is used mainly for rain-fed agriculture, and only the remaining 20 % is irrigated, farmers in Cambodia are highly susceptible to droughts (ADB, 2018). seasonal flooding between July and October due to high water levels in the Mekong River and Tonle Sap Lake is an integral part of local agricultural systems, providing fertile alluvial soils and water to the central plains. However, the increased unpredictability in the extent, timing and duration of seasonal flooding observed in the recent decades has made agriculture, most notably rice production, challenging for many farmers. In addition, relatively low yields, coupled with frequent natural disasters, contribute to temporary food shortages. Seven of Cambodia's 25 provinces (including Phnom Penh), are classified as severely to extremely food insecure, and an additional seven moderately insecure (NIS, 2015).

11. The vulnerability of farmers and farming households to the increased climate variability poses a significant threat to the country's sustainable development as it affects not only the country's main economic engine but also its food security and social cohesion. The COVID-19 pandemic, which has disrupted agricultural supply chains and demand due to the restrictions on the movement of people and goods, has also elucidated the

critical linkages between the market and underlying socioeconomic vulnerabilities of Cambodian farmers, particularly the poor, women and other social minorities, and their households (MAFF, CARD and FAO, 2020). The collapse of the tourism industry in Siem Reap, for instance, has significantly reduced the demand for vegetables from the tourism and hospitality industry to affect vegetable farmers, many of whom are women (ibid.). This pandemic has also underscored the need for addressing these vulnerabilities of farmers and farming households by building more resilient and sustainable relationships between farmers and agricultural

Figure 1: Landcover map of Cambodia and location of NTSB

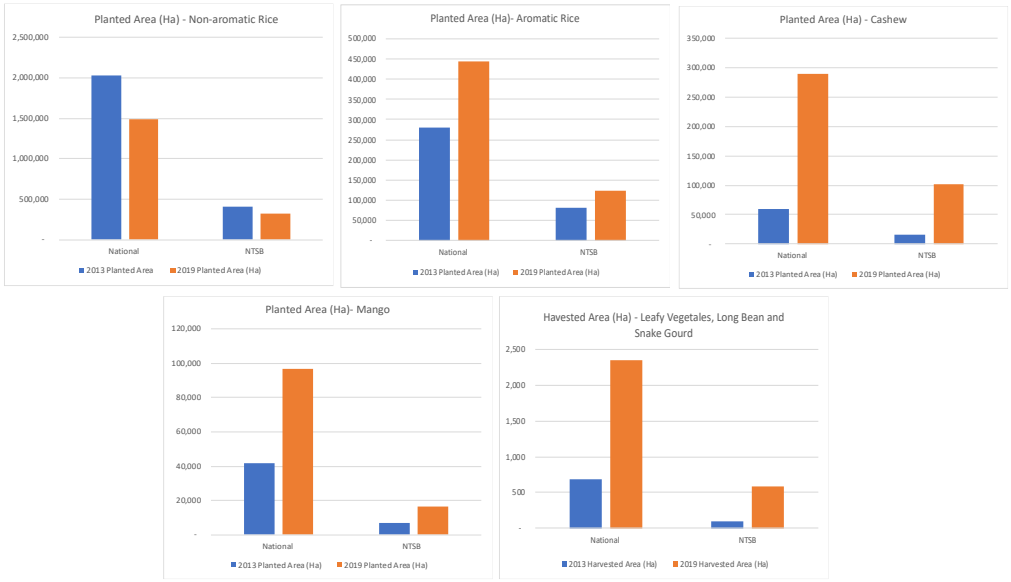


markets to cope with both economic and natural shocks.

2.2. Agriculture in the NTSB and its Underlying Socioeconomic Vulnerabilities

12. In this report, the NTSB is defined as the areas north of the Tonle Sap Lake, including Oddar Meanchey, Kampong Thom, Preah Vihear, and Siem Reap provinces. It encompasses a total land area of 2.5 million hectares with evergreen and deciduous forests, covering hilly areas in the north, vast swaths of cropland in the middle (mainly for rice production) and flooded forests and grassland areas along the Tonle Sap Lake in the south (see Figure 1). The average annual rainfall in the region varies from 1000 to 1500 mm. There are 10 main soil types and 5 main watersheds, including Stung Sen and Stung Staung that are vital sources of water for rice production and livelihoods the region (Oeurng et al., 2019). Over 20% of the country's aromatic rice production, among others such as cassava (35%) and sugarcane (27%), comes from this region (NIS, 2019).

Figure 2: Changes in Planted Areas between 2013 and 2019



13. The production of cashew, mango, organic (aromatic) rice, and vegetables has expanded in recent decades in Cambodia as demand for these crops has increased domestically and internationally (ResponsAbility Investments AG, 2015; Duong and Khin, 2016; Bunthoeun, 2019; Vannak, 2019). The NTSB was responsible for 31% and 14% of the country's total harvested volumes respectively for cashew and mango in 2018 and 2019 (NIS, 2019). Cashew yields were approximately 20 % higher than the national average in Kampong Thom and Preah Vihear, and similarly, for Oddar Meanchey, its mango yield was 30% above the national average (ibid.). In terms of planted areas (Figure 1), the production of aromatic rice, cashew, mango and vegetables had increased both nationally and in the NTSB between 2013 and 2019 while the production of non-aromatic rice had decreased during the same period. While the production areas for vegetables had decreased nationally, the NTSB had expanded the production areas for vegetables in the same period.

14. Aromatic rice, cashew, mango, and vegetables have emerged as alternative agricultural commodities and value chains in the NTSB with the potential to access premium price markets through meeting quality control and food safety standards such as organic certification, the Cambodian Good Agricultural Practices (CamGAP), Geographical Indication (GI)[1], Sustainable Rice Platform (SRP), Hazard Analysis Critical Control Point (HACCP), and ISO 22000 (Burn et al., 2018; ICEM, 2020). For instance, although the yield for aromatic rice in Preah Vihear was 20% lower than the national average in 2019, agricultural chemical input for aromatic rice production in the province was notably lower than the national average and compared to the other NTSB provinces (Figure 2). This indicates the province's prevailing trend towards organic rice production (IFC, 2015; SARAN, 2017).

2.2.1. Organic Rice

15. Organic rice production is a rapidly expanding segment in Cambodia, reflecting the rising global demand for organic food, which has seen at least a fivefold increase in the past two decades (Burn, 2018). There are roughly 5,000 farmers in Preah Vihear producing over 30,000 tons of organic paddy a year in 2018, accounting

[1] An intellectual property tool, protecting products with a specific geographical origin and possess qualities or a reputation that are due to that origin (https://www.wipo.int/geo_indications/en/).

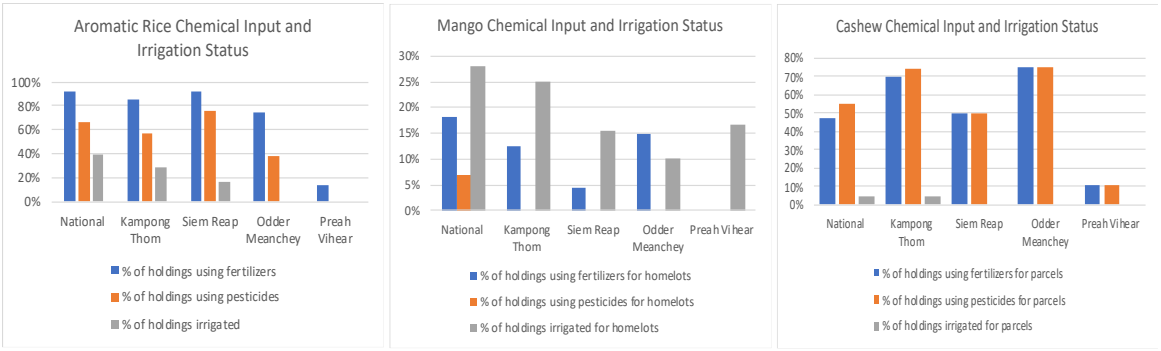
for 12 % of the total annual harvest in the province (ODC, no date; Burn *et al.*, 2018). The majority of these organic rice farmers grow medium and long-duration rice varieties under rainfed conditions (Burn *et al.*, 2018). These farmers predominantly produce organic rice certified by Ecocert[2] for the EU and USA National Organic Program (NOP) standards. Under contract farming with rice millers and exporters, namely AMRU Rice, Golden Rice and Signature of Asia (SoA), nearly 50% of the rice grown in these areas is organic fragrant rice (mostly Phka Rumduol), and the rest is organic white rice (ibid.). Organic fragrant rice is mainly sold to high-end international markets at higher prices than organic white rice. There is, however, a wider market based for organic white rice domestically and internationally for general consumption and processing.

16. The price premium for organic rice is up to 30%, compared to conventional rice (Kennvidy, 2011). Organic rice production requires almost half the cost of conventional rice production for every tonneof paddy while conventional rice production requires costly synthetic fertilizers (ibid., Burn *et al.*, 2018). Although the production capacity of organic rice farmers tends to be smaller, the average net revenue for organic rice farmers can be higher in some instances.

17. However, several enabling conditions are required to make organic rice farming viable (Rada, Nanseki and Chomei, 2017, ibid.). Such conditions include access to information and organic fertilizers, labor availability and soil suitability. While soil suitability is most critical, the farmers' ability to obtain appropriate farming knowledge and awareness of benefits and risks is also crucial. Access to organic fertilizers is another critical factor as it can be in short supply. Organic rice production is more labor-intensive than conventional rice farming, which makes large-scale production unfeasible. This also makes it challenging for farmers with off-farm jobs or multiple farming activities and female-headed households with labor shortages.

18. Primary considerations for converting to organic rice production include its price premium, lower production input cost, and soil improvement, health and environmental benefits (Rada, Nanseki and Chomei, 2017). At the same time, the reduction in yield during organic conversion and increased pest and diseases can act as main deterrents to organic conversion (ibid.). These deterrents underscore the need for improved access to agrometeorological advisory services, including pest and disease forecasts, extension services to promote integrated pest management (IPM) and financial support for farmers interested in organic conversion.

Figure 3: Agricultural Chemical Use and Irrigation Status (2018-2019)



[2] Ecocert (https://www.ecocert.com/en/home) is one of the largest organic certification bodies in the world, which provides certifications for international markets, including markets in the EU, USA and Japan.

Macro Market Trends: Rice (Mana Impact, 2022)

Nearly 80 % of conventional white non-fragrant rice produced is consumed domestically particularly within the rural markets, while urban markets have seen increased demand for higher quality fragrant varieties.

Cambodia is a major exporter of rice. The country officially exported more than 3.6 million tons of milled rice and paddy worth over US$ 1.26 billion according to the MAFF. Among the outbound rice shipments, milled rice accounted for nearly 20% of the total exported volume, worth nearly US$ 539 million (42.8% of the total value). Among the 60 international markets, China is the largest buyer at 42% of the total exports, followed by the European Union (EU) at 30% share, and six ASEAN countries with 13%. The unofficial export of paddy, however, represents the largest portion of export from Cambodia. In 2020, shipments of an estimated 2.9 million tons (mainly white non-fragrant conventional rice), with a combined value of more than US$ 723 million, were shipped to neighboring countries, primarily Vietnam. Millers and traders in Vietnam and Thailand constantly look for sources of procurement in Cambodia to partially compensate for the limited growth in rice production in their respective countries.

Despite fierce competition from exporters in Vietnam and Thailand, Cambodia's rice export market has continued to grow, especially since 2010. Partially, the growth is supported by favorable policies in the EU (a top destination market for high-end rice) under the special Everything But Arms (EBA) arrangement of the EU-Generalized System of Preferences (GSP) where rice is exempt from import duties.

Cambodia has gained significant recognition internationally for its unique and high-quality rice such as Phka Romdoul, a World's Best Rice Award winner jasmine variety, as well as IBIS rice, which includes a few different varieties, but all high-quality premium and organic rice with an ethical and sustainable focus to protect national parkland in Preah Vihear. Thus, instead of exporting cheap and low-end white rice, Cambodia's milled rice for exports is predominantly premium and fragrant rice (74% share of total milled rice).

2.2.2. Cashew and Mango

19. The economic importance of cashew and mango production for the sector has rapidly increased in Cambodia (Bunna, 2019). Crops like cashew and mango are relatively drought-tolerant with limited irrigation needs (Dendena and Corsi, 2014; Maniania, Ekesi and Dolinski, 2016). Figure 2 shows the prevalent use of chemical fertilizers and pesticides in cashew production. Also, for mango, the use of agricultural chemicals was relatively limited to fertilizers, but the application of chemical fertilizers and pesticides has been on the rise due to increased pest and diseases. There is also a limited use of irrigation during critical periods for flowering. Meanwhile, the perennial nature of these crops also provides additional benefits for increasing sustainable fuelwood supply, and forest conservation and climate change mitigation efforts (Bernacki *et al.*, 2018).

20. Kampong Thom is responsible for 75% of cashew production (NIS, 2019). Nearly 80% of cashew farmers in the province grow a variety called M23. Compared to the local variety, M23 gives higher yield and quality (i.e., larger kernells), thereby having higher market value. There is growing demand from regional buyers from countries like China, Japan and Viet Nam for cashew kernels from Kampong Thom in recognition of their quality products. The local variety, on the other hand, is considered more drought, pest and disease tolerant than M23, thus requiring less labor and inputs like fertilizers and pesticides (Burn *et al.*, 2018).

21. Many favorable conditions for cashew production are found in Kampong Thom and some areas of Preah Vihear (Burn et al., 2018). The production of cashew nuts requires an annual rainfall of 1,000 -2,000 mm in the optimum temperature range between 24 and 30 °C, with the optimal seed-germination temperature of around 35 °C (Dendena and Corsi, 2014). Having a dry period of four months or more is also crucial for

flowering (ibid.). Kampong Thom harvests 550,000 tons of raw cashew nuts (RCNs) annually, according to the Provincial Department of Agriculture, Forestry and Fisheries (PDAFF). However, the observed drier conditions and increased frequency of intense and short rainfall events have posed some challenges in recent years (Rai et al., 2015; ADB, 2016). Reduced rainfall prior to the flowering season, low humidity levels, and heavy off-season rainfall during flowering have affected the yield due to increased pest and diseases during fruit development (Burn et al., 2018). This has also led to the increased use of agricultural chemicals.

22. More than 50% of mango production in the NTSB comes from Oddar Meanchey (NIS, 2019). Most mango farmers in the province grow a variety called 'Keo Romeat', and this variety is highly regarded in Cambodia and Southeast Asia for their flavor and taste (Burn *et al.*, 2018; Bunna, 2019). Fresh Keo Romeat mangoes from Cambodia are both consumed domestically and sold internationally mainly to Viet Nam and Thailand and increasingly to China, while small quantities of processed mangoes enter markets in Australia, South Korea and United Kingdom (Vanny, 2017; Burn *et al.*, 2018). Although the variety is not unique to Oddar Meanchey (it is gown throughout Cambodia and Thailand), the unique topography and relatively dry climate of Oddar Meanchey are highly suited for this variety of mango and are considered to give the mangoes a distinct flavor and fragrance.

23. Mango fruits are highly vulnerable to insect pests (e.g., fruit flies and mango seed weevil). These pest insects can damage 40-80 % of fruits when poorly managed (Maniania, Ekesi and Dolinski, 2016). The observed climate variability including drier conditions, higher temperatures and erratic rainfall patterns in recent years has resulted in more favorable conditions for these pest insects, resulting in increased need for pesticide application. Most farmers grow mangoes through two harvest cycles (March–May and October–December), and the off-season (i.e., March-May) cycle is done through hormone-induced flowering (Kono and Chey, 2017). The prevalent and increased use of agricultural chemicals undoubtedly affect their potential for accessing higher-value market segments.

24. There is notable value addition potential for cashew nuts and mangoes from these provinces. There are several farmers associations and small and medium-sized enterprises (SMEs) (e.g., Sombo Cashew Association and Kosal Farm for cashew and SeasonFresh for mango) that are putting such potential into practice. They have been able to develop premium market outlets with domestic health food retailers and foreign buyers (mainly from Japan) by producing cashew in near organic conditions and processing and packaging cashew kernels themselves to generate a price premium of 150-250% compared to the average whole sale price (Kono and Chey, 2017). SeasonFresh promotes the systematic application of the CamGAP practices[3] through contract farming in some parts of the country in partnership with the Ministry of Agriculture, Forestry and Fisheries (MAFF), and considering expanding its operations to Oddar Meanchey.

25. Among both cashew and mango farmers, there is a fair amount of interest in adopting higher-value practices by shifting to organic or near-organic production, and developing further value addition capacities and direct market access. However, there are several barriers to this comprising a combination of individual and systemic

Box 1: Lost Opportunity
The interviewed representatives of the Oddar Meanchey Provincial Department of Commerce (PDC) and Keo Romeat Mango Association indicated that the absence of mango processing and packaging capacities in the province had created a significant lost opportunity for mango producers as the majority of fresh mangoes had been brought to processing facilities in adjacent Thailand and processed and sold as Thai products. The lack of a systemic approach across the value chain to meet international standards

[3] CamGAP was established in 2010 through MAFF's Ministerial Proclamation and is based on the ASEAN GAP standards on food safety, product quality, workers' health, safety and welfare and good environmental management. By complying with the standards, a certification is issued by the General Directorate of Agriculture (GDA).

capacity limitations (ibid.). At the individual level, most farmers lack access to information and support services to make the transition, pointing to the lack of extension services on organic and near-organic production. Also, at the systemic level, an enabling environment in which farmers and SMEs have access to finance and appropriate technologies to meet the postharvest storage, processing and packaging standards of premium market segments is largely absent (Vanny, 2017; Bunna, 2019; Bunthoeun, 2019). Greater institutional efforts are needed to support research and development to identify viable practice and technological options for organic or near-organic practices for farmers. Such support would reduce the cost of transition to organic production, thereby making the transition easier for farmers. Market differentiation efforts to increase consumer awareness of organic or near-organic cashew would also be timely and strategic against the backdrop of the recently introduced legislation on food safety (Burn *et al.*, 2018; Ngon, 2019). Another challenge stems from the lack of contract farming opportunities for cashew and mango farmers. Such opportunities could promote and standardize higher-value practices, reduce farmers' risks significantly and provide access to the necessary finance and technologies (Sreymom and Pirom, 2015).

Macro Market Trends: Mango and Cashew:

Mango (Mana Impact, 2022)

Retail outlets are usually markets, small shops and street vendors. In addition to the fruit, the leaves are also used in Khmer cuisine and mangoes are an important part of various soup and sources. Retailers usually purchase products to supply markets via processors.

The export market is an important aspect of the Cambodian mango business, with nearly 950,000 tons of mangoes exported in 2020 according to MAFF. However, most of these mangoes are sold without Sanitary and Phytosanitary (SPS) certification, which is a requirement for some key markets such as South Korea. In recent years, Cambodia has signed SPS protocol agreements with South Korea and China which could help further spur export demand. Similar positive developments in the export market in recent years include the recent joint venture between Korean conglomerate, Hyundai, and Mao Legacy, a local mango producer, which is a sign that further market development in mango exports is possible and can attract international investments.

Most mangoes in Cambodia are sold informally, as mentioned above, mainly to Thailand and Vietnam. This is a "leakage" that highlights the potential for the market to take better advantage of the business potential of mangoes, as adding a separate link (such as a reseller in Thailand) will not benefit the Cambodian mango farmers.

Cashew (Burn *et al.*, 2018)

About 80% of the global production is harvested between February and May in the northern hemisphere, and Cambodia is in a good position because its harvest season usually starts slightly earlier than other countries to meet the early season demand. In 2017, Cambodia produced 104,268 tons of raw cashew, and more than 95 % of the cashew nuts produced in Cambodia were exported to Vietnam, according to MAFF.

Prices of kernels depend on three factors – size, color, and condition. With adequate harvesting time, post-harvest treatment, and processing, cashew nuts from Cambodia have an excellent quality potential to access premium price markets. Over the last ten years, there has been an upward trend in global production capacity, mainly driven by Africa. However, this growth has not been accompanied by a sufficient increase in processing capacity. For processing, Vietnam has a significant market share. In 2008, 41% of the global processes cashew came from Vietnam. In 2016, this figure increased to 76%. The most notable international markets include North America, Europe, and India, but some new markets are emerging in China, Russia, South Asia, the Middle East, North Africa, Australia, and Brazil. Consumers of these nuts in these markets are individuals and households with higher income, thus suggesting its considerable potential for premium price market development through branding and quality differentiation. In Europe and North America, there is a growing market for cashew as a healthy snack, as they are low in saturated fat and perceived as "natural" products. As such, there is a growing focus on traceability, food safety, and corporate social responsibility (CSR) for companies involved in the cashew sector. As with mangoes, Cambodia cashew farmers have a significant market potential to address this leakage by targeting premium price market segments in Europe, North America, and emerging markets across Asia.

26.

27. Without these efforts, cashew and mango farmers in the NTSB will continue to produce low quality and low value products. These baseline conditions call for improvements in several areas, including agrometeorological advisory services to provide farmers with specific pest insect and disease early warning, extension services to improve farmers knowledge of IPM and higher value production and processing options, and public and private partnership development to increase market opportunities for farmers and other local value chain actors to increase investment and standardize higher-value agriculture.

2.2.3. Leafy Vegetables

28. Vegetable farming is another crucial segment of agriculture in the NTSB as it is an important source of income and nutrition. Vegetables are considered the third most important food group, after rice and fish, in the Cambodian diet (ICEM, 2020). According to the Census of Agriculture (NIS, 2015), cucumber, watermelon, chilli and pumpkin are the most commonly produced vegetables in Cambodia, followed by eggplant, winter melon and leafy green vegetables. With the growing middle-class and urban consumers, there is an increasing demand for vegetables. Reflecting this trend, retailers, restaurants and hotels in urban areas and tourist centers are also increasing the volumes and variety of vegetable purchases as more people afford to eat out. This trend has been helped by a steady influx of foreign tourists into the country although international tourism has largely been suspended due to COVID-19 since 2020 (MoT, 2019; MAFF, CARD and FAO, 2020).

29. Nearly 15% of the country's leafy vegetables, long bean and gourd production comes from the NTSB (NIS, 2019). The increased public awareness of healthy eating and food safety, particularly among middle-class consumers and international tourists, the demand for vegetables, produced with fewer pesticides or organically has increased significantly (Ngon, 2019; ICEM, 2020). However, accessing safe vegetables is a major challenge in Cambodia as a significant proportion of domestic and imported produce, mainly from Viet Nam (38%), Thailand (34%) and China (14%), has been reported to contain high levels of pesticide residues (Anonymous, 2017). Due to highly seasonal supply and a limited variety of vegetables grown in Cambodia, over 50% of the country's vegetable supply relies on imports (Duong and Khin, 2016). One study by Alliance 2015 (2017) found a total of 53 types of pesticide residues, including chlorothalonil, cypermethrin, metamorphos and permethrin in 25% of randomly sampled vegetables in Cambodia. Many of these pesticides are toxic to humans and kill important natural pollinators like bees. Vegetables with these substances are not permitted to enter the EU and US markets and banned from use in Cambodia. This raises two critical concerns – first, the food safety of the imported vegetables; and second, the poorly regulated agrochemical supply chain in Cambodia (Kula, Turner and Sar, 2015; Duong and Khin, 2016; ibid.).

30. Cambodian consumers generally prefer domestically produced vegetables as they often perceive the imports to be less safe and more expensive (Duong and Khin, 2016). This presents a tremendous opportunity for vegetable producers in the NTSB to substitute imports with their products. This opportunity also drives home the need for IPM, improved quality management through adoption of standards like CamGap, and increased supply capacity to meet the demand in terms of the variety and volume throughout the year to (Kula, Turner and Sar, 2015).

31. Such efforts must also come with increased regulatory and enforcement capacities to control agrochemicals that entre the country and ensure that labels and instructions are provided in the Khmer language (Duong and Khin, 2016). There is also a need to make quality seeds affordable and accessible and promote improved postharvest handling and storage practices and transport technologies and techniques to reduce post-harvest

loss and damage and increase market value. In addition to the regulatory and institutional support required, the role of retailers, restauranteurs and hoteliers to move towards contract farming and direct purchase agreements with vegetable farmers to lessen their risks and ensure an enabling environment for the farmers to improve their quality management practices and supply capacity.

32. The majority of vegetable farmers are women, who grow vegetables in their home gardens for home consumption. But, an increasing number of these farmers rely on vegetable productions for income generation to diversify their livelihoods. While their production practices remain small-scale and rudimentary, a variety of horticultural techniques and technologies (e.g., solar water pump, water tanks, irrigation ponds, net-houses, raised vegetable beds, intercropping, shade production) are available to improve their production capacity by addressing challenges including pest and diseases, labor shortages and flooding and drought related loss and damage. As discussed in the following section, addressing labor shortage, thus introducing time-saving practices, is critical for many female farmers who juggle multiple responsibilities at home and on farm.

33. Increased efforts in both extension and market research and development are also needed to address the current seasonal supply shortage and price fluctuation issues that in turn keep the production capacity low and the reliance of imported vegetables high. Vegetable yields are generally good during the cool months between November and February for most vegetable growers; however, prices also tend to drop during this period due to the oversupply of vegetables (Sreymom and Pirom, 2015). This poses a challenge for retailers, restauranters and hoteliers in sourcing vegetables consistently throughout the year.

Macro Market Trends: Leafy Vegetables (Mana Impact, 2022)

Wholesalers buy their vegetables from local and imported channels, with a majority of inputs from the provinces where they are based. They are also faced with competition from neighboring Vietnam, which can offer lower-priced vegetables. However, recent studies reveal that imported vegetables tend to have high concentrations of pesticide residues, some of which are highly toxic and have been banned in Europe and North America.

With the recently introduced law on food safety and increased consumer awareness and preference for safely produced food, Cambodian consumers are slowly turning to locally grown vegetables and pushing producers to reduce their application of harmful pesticides.

Retailers are more likely to sell imported vegetables than wholesalers to address the seasonality issue. Restaurants and hotels mainly purchase their vegetables from wet markets. Like end-consumers at wet markets, they are quality concerned and often willing to pay a higher price for safe and quality produce. This suggests a significant potential for Cambodian vegetable producers to invest in practices and technologies to increase their production capacity and quality control measures and address their seasonal production gaps, while exploring direct purchasing agreements to reduce their investment risk.

2.3. Market Entry Challenges for Smallholder Farmers and Other Local Value Chain Actors

34. These segments of agriculture in the NTSB present considerable sustainable expansion and diversification opportunities for smallholder farmers and other local value chain actors(Burn et al., 2018). However, they face several challenges in accessing such opportunities. Table 1 provides an overview of such opportunities and challenges associated with these emerging segments of agriculture in the NTSB. The selection of the specific geographical areas, identified in Table 1, is informed by the above analysis of the agricultural census data and feasibility studies on these value chain potential, prepared for the preparation of the PEARL project (Burn et al., 2018; ICEM, 2020).

35. A general conclusion from the assessment of these challenges points a couple of barriers – limited knowledge and resources that reinforce one another to make these opportunities inaccessible. For instance, the lack of knowledge in terms of market trends, pesticide use risks and higher quality production often leads to low quality and value production. This gives farmers with limited marketability and price negotiation power to limit their income generation and contract farming opportunities, which in turn keep these farmers away from the market opportunities. Particularly for the northern sections of the NTSB, their distances from major market centers often further reinforce these barriers to make market access even more challenging (Burn et al., 2018). The lack of an enabling regulatory and institutional environment, for instance, through law enforcement in the management of pesticide, also contributes to these circumstances, which are discussed later.

Table 1: Overview of Key Crops in NTSB

Alternative Crop/ Area Grown	Opportunities	Challenges
Cashew/ Kampong Thom and Preah Vihear Mango/ Oddar Meanchey	• Most cashew farmers grow a variety called M23 (to a lesser degree, H09, M10, and M04), which gives a higher yield and market value than traditional varieties. • Most mango farmers grow a variety called Keo Romeat, which is well regarded for its quality. • Premium price markets exist for quality-controlled products. • Growing market trends offer opportunities to access premium price markets by adopting relevant international quality and production standards. • Perennial nature provides agroforestry potential for rural livelihood diversification, increased fuelwood supply, forest conservation, mitigation, and catchment protection.	• Moderate use of pesticides with insufficient control measures. • Most smallholder farmers, agricultural cooperatives (ACs), and farmers associations (FAs) and producer groups (PGs) sell to wholesale buyers with limited value addition opportunities. • Lower profit margins give little incentive for adopting climate-resilient and sustainable practices, including integrated pest management (IPM). • Smallholder farmers, ACs, FAs, PGs and other local value chain actors lack the necessary resources (i.e., knowledge, finance, technologies) to access higher-value markets. • Weak self-governance capacity for mobilizing organized support for value chain access and development. • Lack of postharvest storage and processing capacity.
Organic Rice/ Preah Vihear	• Combination of labor shortages, increased climate variability and market trends have encouraged farmers to adopt the production of short-duration aromatic rice (key organic rice segment), shifting from longer duration non-aromatic rice. • Price gain through organic production could offset the anticipated decline in yield for farmers in these remote hilly areas. • Organic rice in Preah Vihear is certified in the US and EU markets, and further value addition opportunity through GI. • Topography keeps paddy fields small and fragmented with natural buffers to maintain rich agroecosystems.	• Lack of favorable contract farming and direct market access opportunities. • Limited mechanization. • Limited access to finance and quality supplies and extension services. • Limited capacity of ACs, PGs and FAs to provide structured and strategic support to individual farmers. • Lack of IWM to ensure water quality and availability at the landscape level. • Limited integration of agrometeorological and market advisory services to optimize production.
Leafy Vegetables/ Siem Reap and Preah Vihear	• Several champion vegetable farmers networks[4] with expanding access to local markets (retailers, hotels, and restaurants) in Siem Reap and Phnom Penh. • Growing demand for safe and sustainably produced vegetables offers higher prices.	• Lack of resources (knowledge, finance, and technologies) to increase product varieties and quality and overcome seasonality. • Lack of market access.

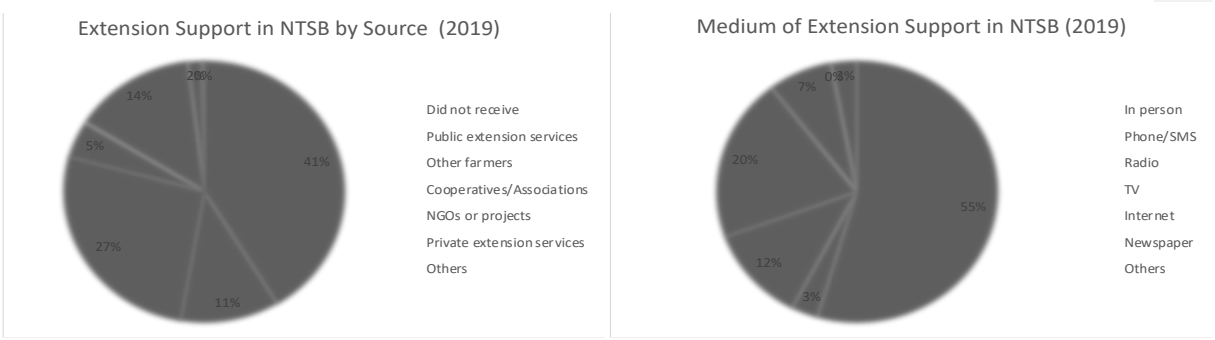
[4] Champion farmers have extensive experience in farming and mastered the knowledge and skills, and diffused them to other farmers.

	• Horticultural innovations enable climate-resilient production for income generation and household consumption.	• Limited quality control measures (e.g., postharvest storage, handling and transportation). • Lack of organized support through e.g., unions for value chain development.

2.3.1. Limited Extension Services

36. Another factor related to these challenges is the lack of consistent and reliable agricultural extension services, including agrometeorological and market related advisory services, through the public and private sources, which was evident through the most recent Agricultural Census (2019). As shown in Figure 3, over 40% of farmers in the NTSB claimed that they did not receive any extension support, while farmer-to-farmer learning was the most common source of extension support, followed by public extension services (ibid.). In addition, the feasibility study carried out by ICEM (2020) for the preparation of the PEARL project also found that more than 80% of the vegetable farmers surveyed highlighted that they had never met any agricultural extension agent or had never been to an agricultural extension centre during the last harvest season. Sometimes input

Figure 4: Sources and mediums of extension support



suppliers provide technical advice to farmers, but they also have limited understanding about the use of inputs, and as a result, they provide farmers with incorrect instructions (Kono and Chey, 2017). This very weak system of extension service provision exacerbates the lack of knowledge of farmers and input suppliers about agricultural production techniques and input use. In terms of communication mediums for extension support, in-person communications was the primary medium, followed by TV and radio.

37. These circumstances underscore both the gaps in agricultural extension capacity. Cambodia's Agricultural Extension Policy 2015 also recognizes the ineffectiveness of the current agricultural extension system, attributing to: 1.) lack of supporting institutional organization and policy framework, 2.) lack of human resources, 3.) limited technology development, 4.) lack extension materials and methodology, and 4.) lack of investment. These shortcomings may also be emphasized by the region's relative remoteness. Nevertheless, these circumstances underscore the need to strengthen the capacity of public and private extension services to increase the awareness and capacity of smallholder farmers and other local value chain actors, for instance by improving their access to agrometeorogical advisory and market-led farm management support services. Such efforts must also be coupled with other types of support for improved access to finance and technologies and increased private sector investment to unlock the alternative market opportunities.

2.4. Prevalent Socioeconomic Vulnerability

38. NTSB is home to nearly 15% of the country's population. As shown in Table 2, 16% of the country's agricultural households are found in the NTSB. A significant proportion of them are considered poor. Cambodia's GDP per capita in 2017 was US $ 1427 (ibid.). However, such a figure would have been much lower in the NTSB where primary livelihood activities are tied to farming.

39. Key drivers of poverty include limited employment and market opportunities for this region's primarily agriculture-dependent population. Factors such as a lack of access to finance, technology, and knowledge prevent smallholder farmers and other small-scale local value chain actors from moving away from low-value and low-quality production, which reinforces these drivers. Such factors are partly due to the country's limited agricultural extension capacity, lack of effective PPPs with solid representation by agricultural unions and associations, and weak regulatory conditions and enforcement capacity to de-risk such partnerships.

40. The ID Poor Programme was first established in 2006 under the Ministry of Planning to reduce duplication of effort and resources by different institutions and organizations in identifying their target groups for various poverty reduction interventions, and to ensure that assistance is provided to those households that are in most need. According to the ID Poor data collected between 2017 and 2020 (RGC, 2020), the NTSB was home to 14.5% of the country's ID Poor households (Table 2). While these proportional figures also correlate with the population size of each province, poverty rates in the NTSB were among the highest in the country during the previous decade. Oddar Meanchey had the second-highest poverty rate (28%), followed by Preah Vihear (25%), which was the 4th highest in the country (RGC, 2014).

Table 2: Agricultural Households

NTSB Province	Agricultural Households		% of National Total ID Poor Households
	Number	% of National Total	
National	2720669	100%	100%
Kampong Thom	153243	6%	17%
Siem Reap	163620	6%	13%
Odder Meanchey	43614	2%	10 %
Preah Vihear	49075	2%	18%
NTSB	409552	16%	14.5%

41. Particularly, the northern sections of the NTSB had an above average concentration of ID Poor population, compared to the average for the NTSB. As shown in Table 3, 16% of the population in the northern 24 districts of the NTSB was categorized as ID Poor, suggesting that poverty is more pronounced in the north, as these more remote communities face various socioeconomic challenges, stemming from limited market and employment opportunities.

Table 3: Demographics in Northern Sections of NTSB

Total Population of Target Areas	1,619,712(43% women)
# of districts	24
% of ID poor population	16%
# of Households	357,800 (23% headed by women)
# of people farming as primary activity	590,574 (43% women)

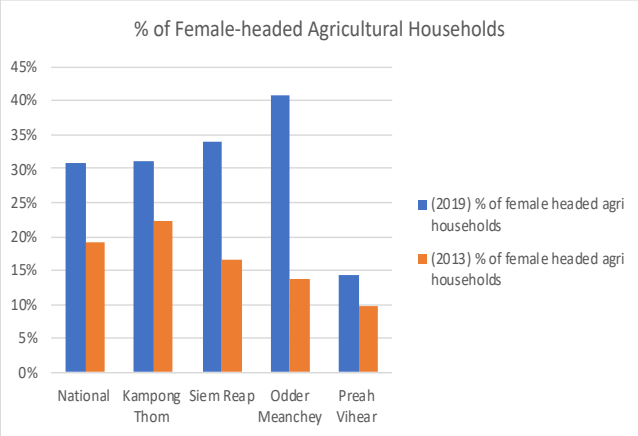
42. Labor migration by men to urban areas and abroad is particularly common and an expanding trend across the NTSB, especially in these remote northern sections. Figure 5 shows that the numbers of female-headed households in all four provinces had increased between 2013 and 2019. This trend was particularly noticeable in Oddar Meanchey where the poverty rate was among the highest in the country during this period (RGC, 2014, 2018b).

43. To cope with labor shortages caused by labor migration, many female-headed households in the region are eager to diversify their livelihoods and income sources. One of such avenues is shifting to vegetable production from rice production, which is more labor intensive and becoming more unpredictable due to increased climate variability in recent years (Rada, Nanseki and Chomei, 2017). This demographically induced trend towards vegetable production also presents an opportunity to introduce climate-resilient and higher value practices and technologies to enhance their diversification efforts with built-in sustainability measures.

Box 2: Champions in Horticulture

Eco-Farm Group in Siem Reap is a champion vegetable farmers network with expanding smallholder organic vegetable production programs to produce organic fertilizer production, provide extension services and quality seeds, support niche market development through local farmers markets and direct sales to urban retailers and adoption of small-scale climate-resilient technologies and community development activities (e.g., supporting ID poor households and education of village children). Eco-Farm Group looks to expand their membership for increased supply capacity and quality through adopting standards such as the CamGAP (Kono and Chey, 2017).

Figure 5: Change in Number of Female-headed Agricultural Households (NIS 2019)

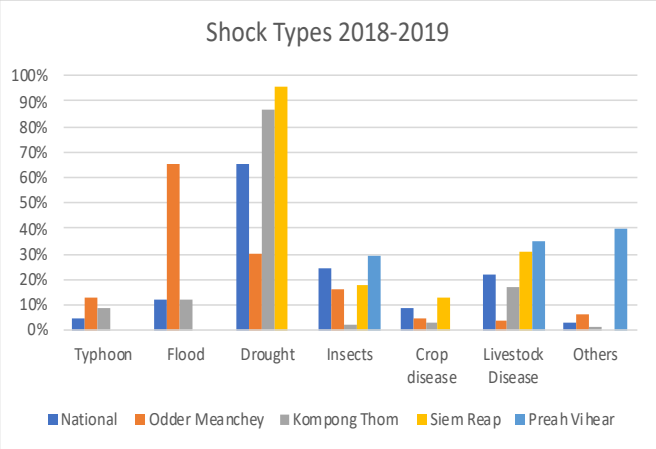


44. Promoting such climate-resilient, diversified and sustainable agricultural options is crucial across the NTSB. Agricultural households in the region are increasingly exposed to shocks, particularly through droughts (WB, 2015). Most recently, the 2019 drought brought severe water shortages to the majority of farmers in the NTSB, cultivating dry season rice. Particularly Kampong Thom and Siem Reap are major rice producers in the country and considered among the most vulnerable to floods and droughts (ADB, 2016).

45. Droughts and pest and diseases are the most common types of shocks in the NTSB (see Figure 5) (NIS, 2019). Farming households in the region face these risks, and a large proportion of the farming households (20-60%) experience moderate to severe food shortages due to crop loss and damage on an annual basis (NIS, 2015). Between 37 and 57 % of the households claimed that they often experience these shocks consecutively, thus having little time to make a full recovery from such shocks, while many of these households (30-50%) also reported increasing copying capacities as they had built some level of familiarity with dealing with such shocks almost annually (NIS, 2019).

46. Their high susceptibility to droughts stems largely from their heavy reliance on rainfed systems (NIS, 2015). Particularly in the norther sections of the NTSB (i.e., Oddar Meanchey and Preah Vihear) farming activities often take place in relatively hilly terrains, which make irrigation not an option. In Siem Reap and Kampong Thom in the lower sections of the NTSB, irrigation is more common with nearly 50% of farmers using irrigation systems (ibid.); however, with increased uncertainty in water availability due to more frequent droughts observed in recent years, such systems are also becoming less viable in some areas.

Figure 6: Vulnerability to Different Shock Types



47. Nonetheless, the most common response to such shocks were "Do not do anything," followed by "borrow money," and "sell crops, livestock animals and household assets" (ibid.). In 2013, the three most common sources of lending in the NTSB were microfinance (30%), friends and relatives (23%) and local money lenders (15%) (NIS, 2015). These sources have shifted slighted to more formal sources – banks (36%) and microfinance institutions (36%) – in 2019 (NIS, 2019), suggesting that increased outreach by formal financial institutions and ability and knowledge of agricultural households to provide collateral and security to borrow in larger sums of funds at relatively reasonable interest rates.

3. CLIMATE CHANGE IN NTSB

3.1. Climate Baseline

48. In Cambodia, the rainy season, which lasts from May to early October (Figure 7), accounts for 90% of annual precipitation in the basin. The dry season, from November to April, brings drier and cooler air from November to March, and then hotter air in April and early May. The maximum mean temperature in Cambodia is about 28°C and the minimum mean temperature is about 22°C. These trends of warmer temperatures and drier climate are primarily caused by the El Niño Southern Oscillation, whereas colder temperatures are influenced by La Niña events (GFDRR, 2011). FAO's analysis of CORDEX data over the period 1987-2016 shows the average temperature maximum and temperature minimum (Figure 8) across Cambodia.

Figure 7 Total average precipitation (cumulative mm) over the rainy season May-October (left) and from January-April (right) averaged over the period 1989-2016 from the reanalysis dataset W5E5 (FAO analysis).

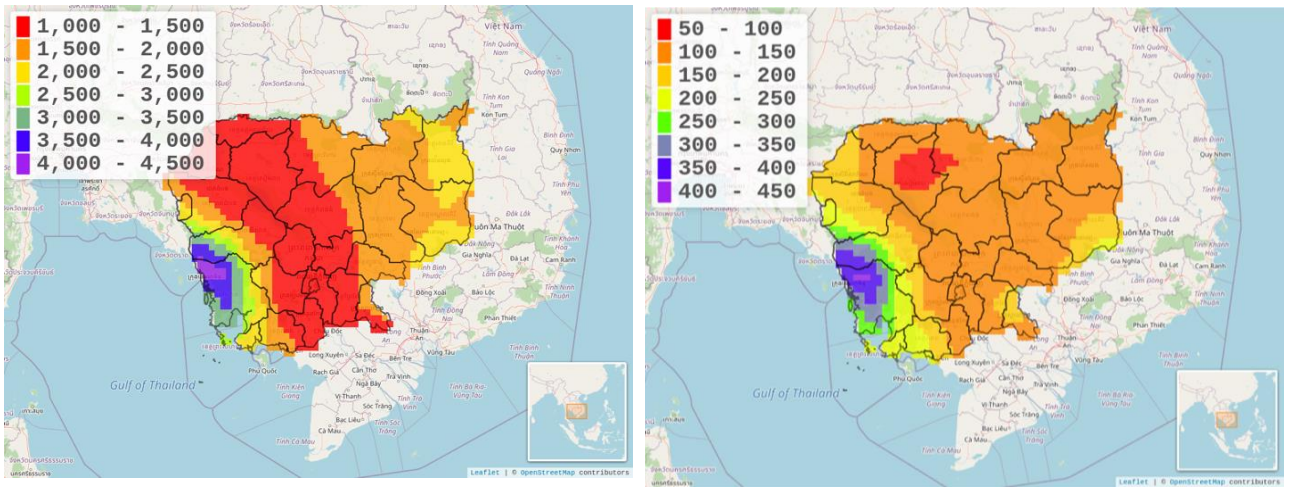
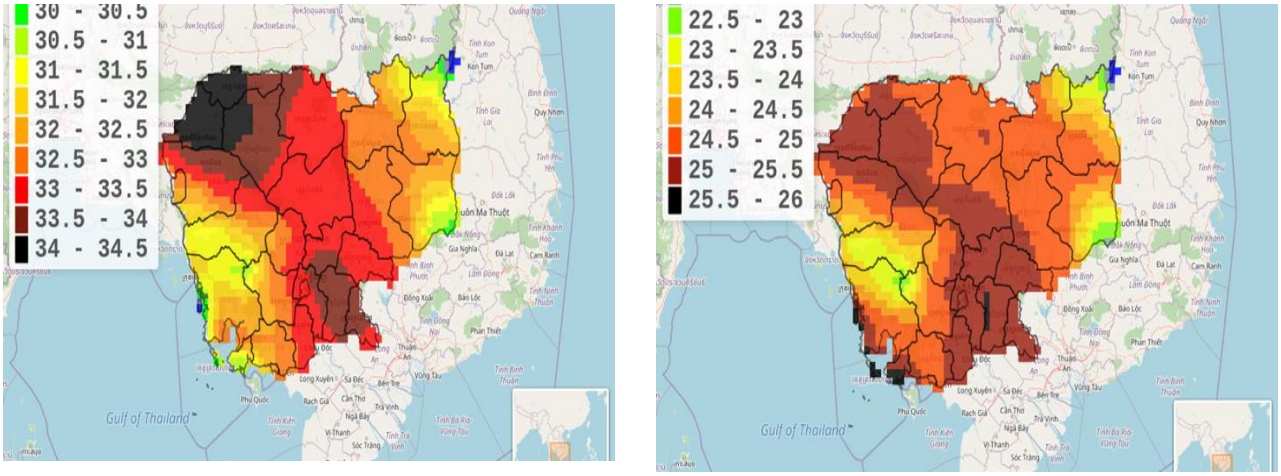


Figure 8 Average temperature maximum (left) and temperature minimum (right) during the rainy season May-October over the period 1987-2016 from the reanalysis dataset W5E5 (FAO analysis).

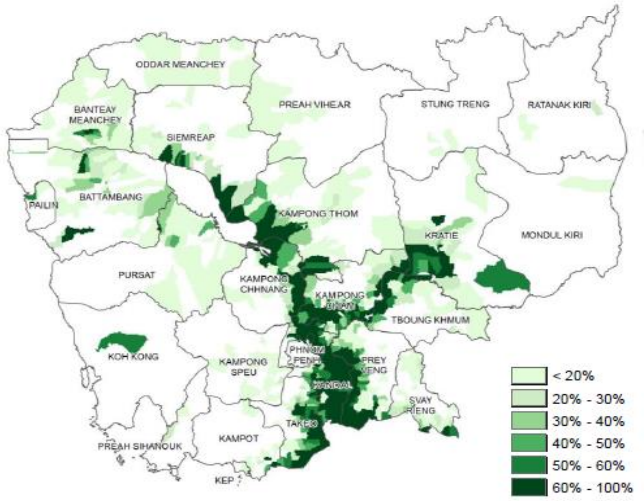


49. Historical mean annual temperature in Cambodia over the period 1901-2016 is 27°C. This average increased by 0.8°C from 1960 to 2003, particularly in the drier season. However, the rate of increase is slower in the wet season (World Bank Group, 2020). The number of hot days per year (Temperature maximum >35°C y^{-1}) has increased since 1960, reaching an average of 46 hot days by 2016. Mean annual rainfall varies depending on the region, with 1400 mm in the center and up to 4000 mm in the south-west coast and in "highland areas" (Thoeun, 2015). At a national level, significant changes in annual average precipitation rates have not been detected from 1901 to 2016, as a result of high frequency and intensity variability which obscure the overall trend (World Bank Group, 2020). However, analysis suggests that the length of the rainy season has decreased over the last century (FAO, 2022).

50. The incidence of extreme weather events such as droughts and floods vary geographically throughout the country. The central plains experience seasonal flooding, bringing fertile alluvium soils and majority of water in this region. The frequency of severe floods has increased over the historical period since 1990. Severe floods are documented in the years 1991, 1996, 2000, 2001, 2002 and 2011 (NCDM, 2011). However, floods in Cambodia are not strictly linked to high rainfall, and are often driven by high water levels in the Mekong River and Tonle Sap Lake between early July and early October.

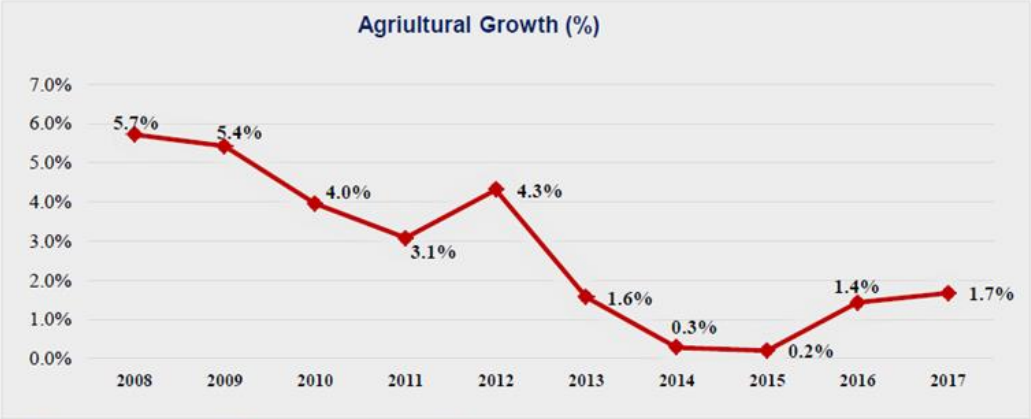
51. Based on data from the past 20 years, losses in rice production were mainly due to flooding (about 62%) and drought (about 36%). During the dry season, rice cultivation is concentrated in the areas with better water availability, in Lower Mekong River basins and around the Tonle Sap Lake (Figure 9).

Figure 9: Percentage of dry-season rice cultivated areas (from UNDP, 2019, National Drought Study)



52. Drought in Cambodia is strongly correlated with El Nino, for example, during the 2015/2016 El Nino event, one of the worst droughts for Southeast Asia in decades, 2.4 million people across 18 provinces in Cambodia were impacted. According to the joint assessment of 2400 households by WFP, FAO and UNICEF in May 2016, 37% of the households reported water shortages; 18% of agricultural households experienced crop failures; household paddy and cassava production declined by 22%; animal morbidity and mortality rates were high especially for poultry; 62% of households reported income loss. Agricultural growth experiences a large dip during the period (Figure 10).

Figure 10: Agricultural growth in percentage over the period 2008-2017.



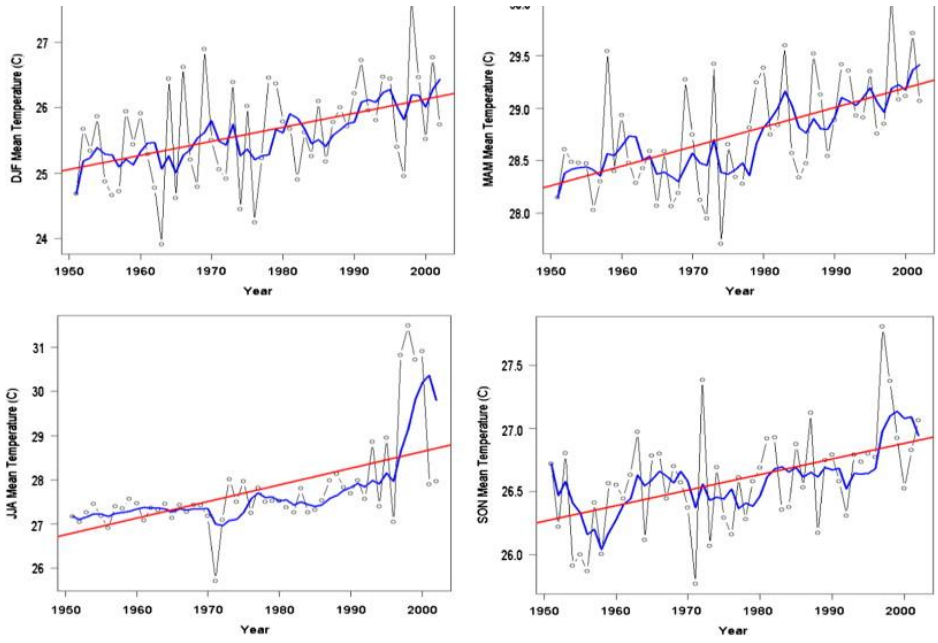
Source: Assessment by Ministry of Planning 2017

3.2. Climate Impacts: Historical Climate Trends

3.2.1. Temperature

53. Analysis of observed historical data station data shows annual mean temperature anomaly has increased by 0.8 °C since 1950 with a rate of 0.023 °C per year(Thoeun, 2015). The rate of change is most rapid in the dry season (December, January and February) and followed by the spring season (March, April and May) and slowest in the wet season (June, July and August). Figure 11 highlights the trends in temperature by season over the period 1960-2000.

Figure 11 Historical mean temperature change over the period 1960-2000 by season December-February (top left), March-May (top left), July through August (bottom left) and September-November (bottom right).



54. FAO's analysis of the bias corrected reanalysis WE5E data in Cambodia with a more recent time-frame (up to 2018) supports a continued increasing trend in both temperature maximum and temperature minimum continuing between 1990-2018 (Figure 12) and supports the findings by Thoeun et al. (2015) of a significant increasing trend in temperature throughout the year. FAO analysis further highlights the number of very hot days (defined as days with temperature maximum >33C) in the project area has increased by an average from 7-14 days over the period 1980 to 2018 (Figure 13). Increasing temperature maximum, minimum and very hot days suggests increasing evapotranspiration, higher water stress for crops during warmer months and in particular during the dry season.

Figure 12 Trend in the annual average temperature maximum (left) and temperature minimum (right) over the historical period 1980 to 2016 from reanalysis dataset WE5E. Statistical significance is indicated by a black point over relevant pixel. (FAO analysis).

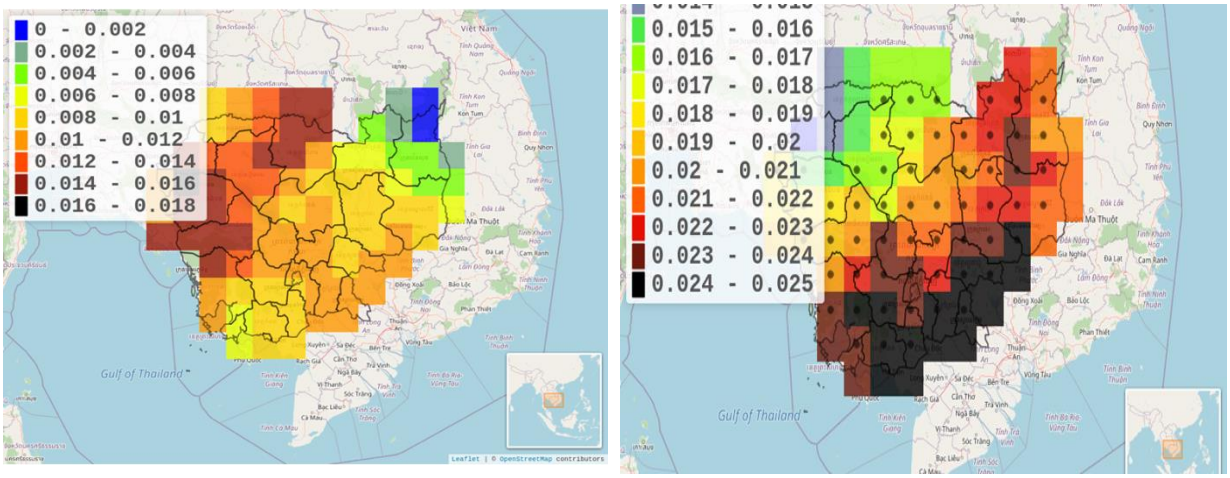
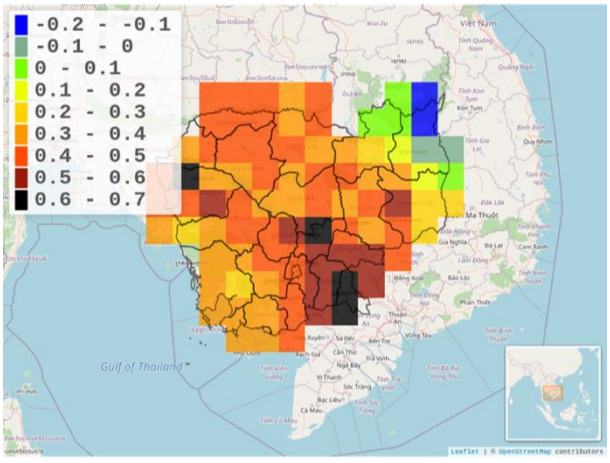


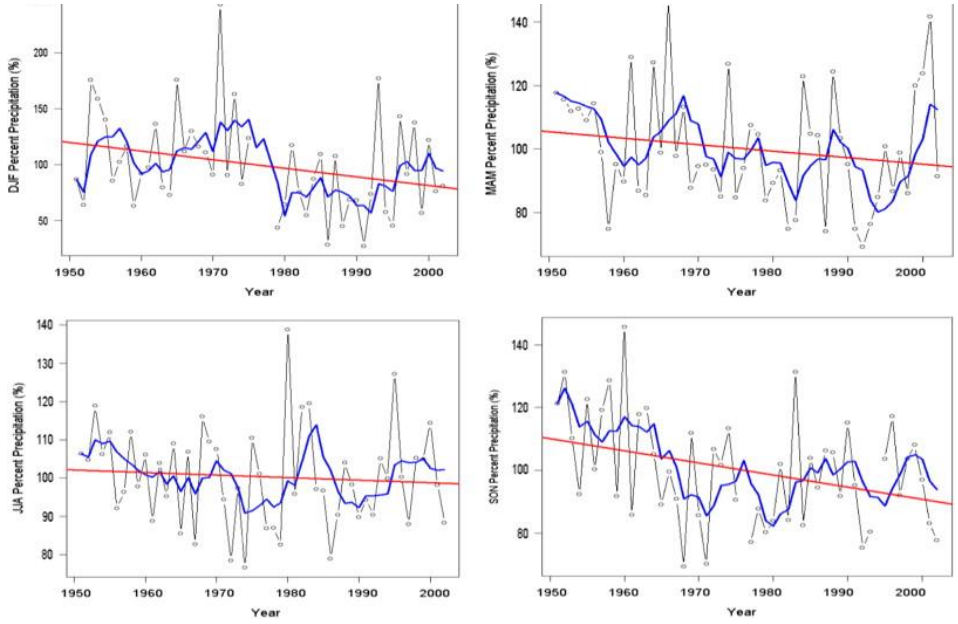
Figure 13 Trend in the number of days with temperature maximum >33C during the rainy season May to October over the period 1980-2016 using the WE5E reanalysis dataset (FAO analysis)



3.2.2. Precipitation

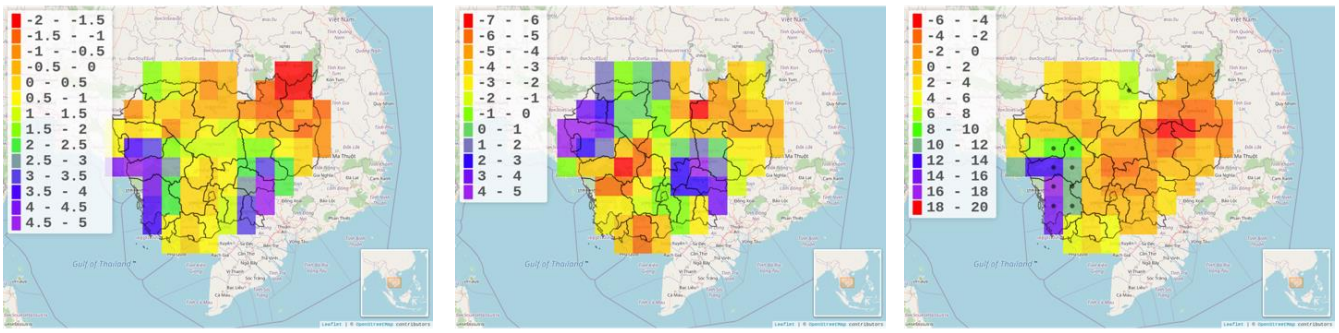
55. Analysis of historical station precipitation observations in Cambodia highlights significant interannual and intra-seasonal variability in precipitation during all seasonal periods throughout the year (Figure 14). Historical data show general decreasing trends, with large interannual variability in particular in the rainy season (Thoeun, 2015). The trend in decreasing precipitation is largest in September to November with a smaller rate of change during other periods. During the period June-August, the trend over the historical period shows little change over the period 1960-2000.

Figure 14 Historical mean precipitation change over the period 1960-2000 by season December-February (top left), March-May (top left), July through August (bottom left) and September-November (bottom right).



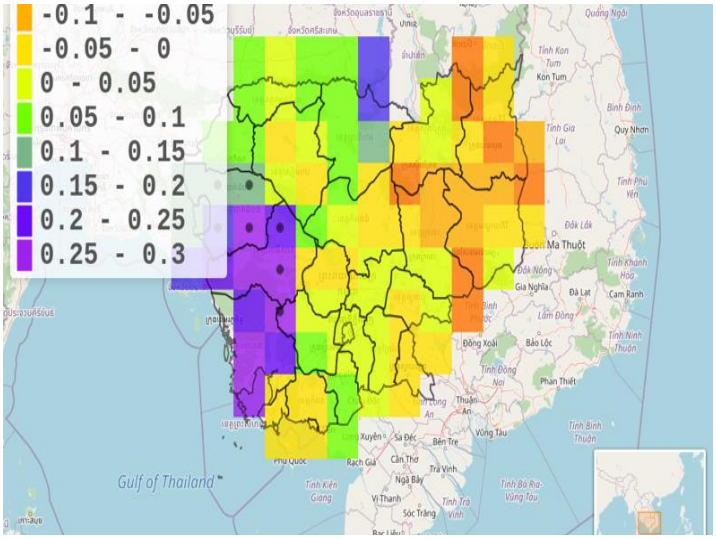
56. FAO's analysis of WE5E reanalysis historical data to the year 2018 shows a slight shift in recent years in some seasons while the trend in the wet season (June-August) shows a continued decrease, with large interannual variability (Figure 15).

Figure 15 Precipitation trend over the period 1980-2016 in the months (a) March-May, (b) June-August and (c) September-November. Statistical significance of 0.05 is indicated with a black dot (FAO analysis)



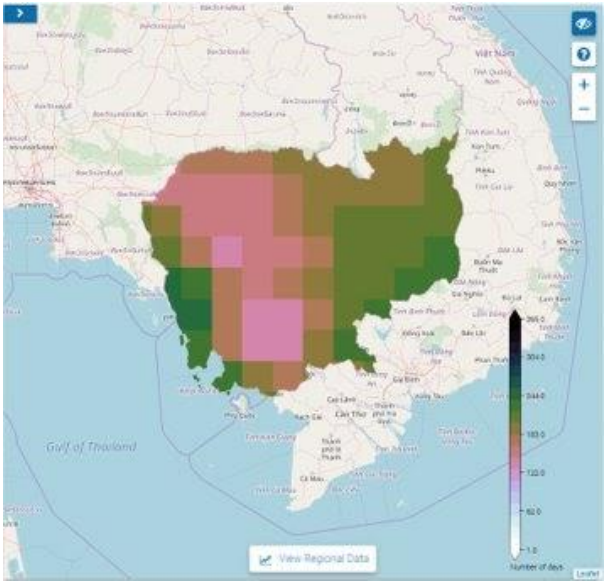
57. Analysis of extreme indicators shows that this decline is driven by the decrease in the number of rainy days in rainy season. Despite this decline, the rainfall amount on rainy days has increased (Figure 15) suggesting heavy rain over shorter periods, which often lead to reduced consistency in water availability. The evidence suggests amount and duration of rain in the rainy season has decreased over the period 1980-2018 while the dry season has been getting longer (Figure 16).

Figure 16 Trend in the number of days with precipitation >30mm during the rainy season May to October over the period 1980-2016 using the reanalysis dataset WE5E. Statistical significance of 0.05 indicated with a black dot (FAO analysis)



58. In addition, the analysis highlights that the rainy season has been getting shorter and rainfall during the rain season is decreasing over the historical period (Figure 17).

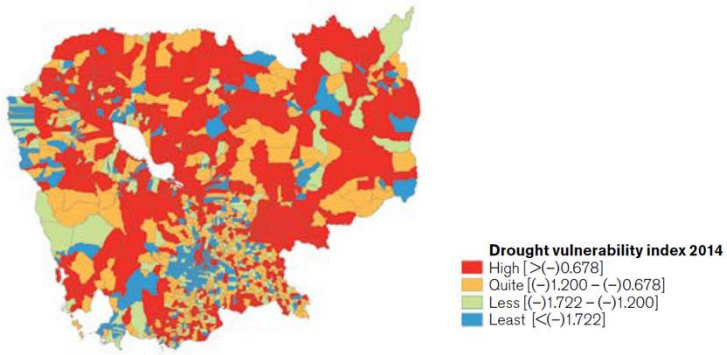
Figure 17: The average length of rainy season defined by daily rainfall timing and amount (1980-2016). Rainy season typically runs from May Oct for about 180 days on average, with spatial and interannual variations (FAO, 2020).



3.2.3. Drought, flooding and crop pest and diseases

59. Drought in Cambodia occurs regularly and is driven by extended dry periods and the level of water resources in the terrestrial water bodies. The frequency of drought varies from province to province with many parts of the NTSB significantly affected according to the drought vulnerability index (Figure 18). The same figure highlights that the NTSB is highly vulnerable to drought in many regions (Rai *et al.*, 2015).

Figure 18: Drought vulnerability index in 2014



60. The frequency of droughts varies significantly driven by climatic factors and local variability. Kampong Thom province, a key agricultural producer in the NTSB is prone to drought conditions as well as significant interannual variability. The 3-month SPEI (standardized precipitation evapotranspiration index) shows an increasing trend over the last 15 years, but very severe droughts continue to occur periodically in recent years (Figure 19). The SPEI takes into account both precipitation and potential evapotranspiration, therefore capturing the impact of increased temperatures on water demand than a simple precipitation index in its estimation of drought. During the 2019 drought, water shortage was reported for most of the provinces cultivating dry season rice.

61. x`A study from the Greater Mekong Sub-region Flood and Drought Risk Management and Mitigation Project identified flood and drought prone areas in Cambodia (ADB, 2016)(Figure 20). The study focused on floods in Cambodia for years, 1961, 1966, 1996, 2000, 2001, 2004, and 2006, and on severe droughts during the years 2001 to 2003 (www.foodsecurityatlas.org/khm/country/vulnerability/risk-analysis). The severe floods of 2000 reduced the harvested area of rice to 1.9 Mha (NIS 2002), and yields had decreased from 2.10 t/ha in 2003 to 1.98 t/ha in 2004 due to drought. The major rice growing areas of the Mekong-Tonle Sap basin are exposed to flooding every year but in recent years have often been exposed to extreme flooding. Extended periods of flooding in the Mekong River and Tonle Sap Lake have ruined many deep-water rice crops. In La-Nina years, up to one-fifth of the total cultivation area (0.5 Mha) of wet season rice has suffered from flooding. In agriculture areas where temporary flooding occurs, floods result in severe challenges for germination for some direct-seeded rice and most upland crops, including legumes.

Figure 19: Three months SPEI for Kampong Thom weather station (computed by ClimPACT2)

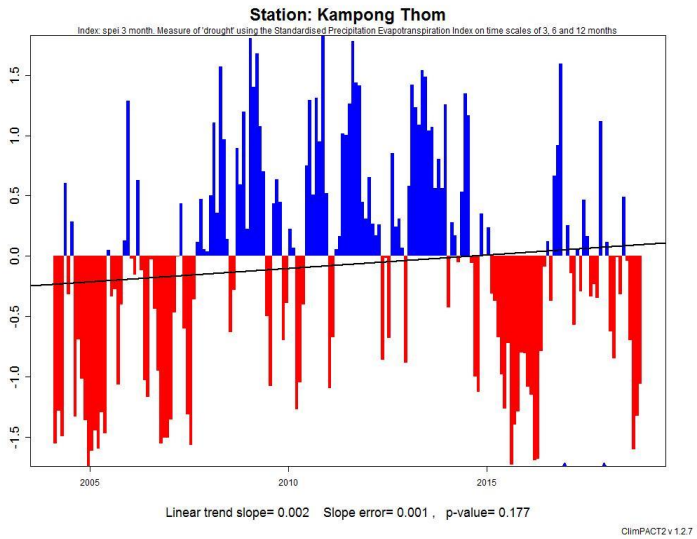
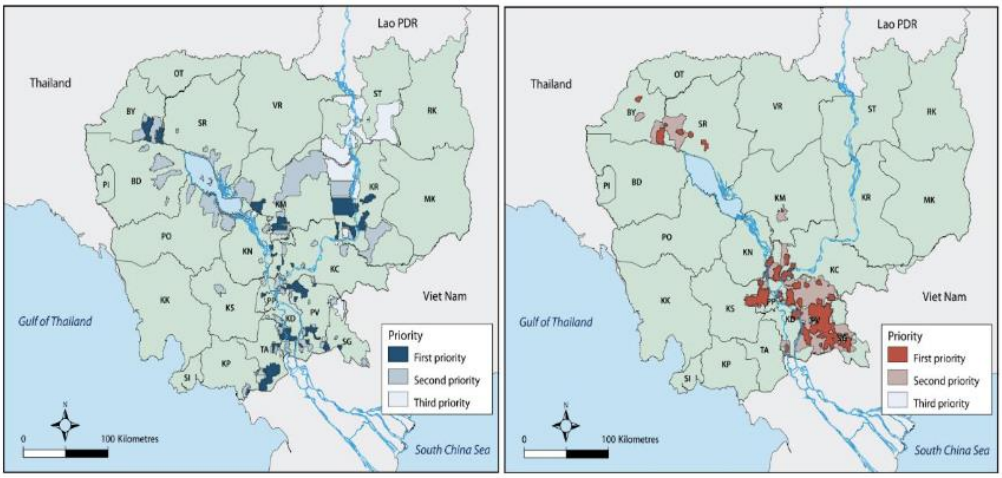
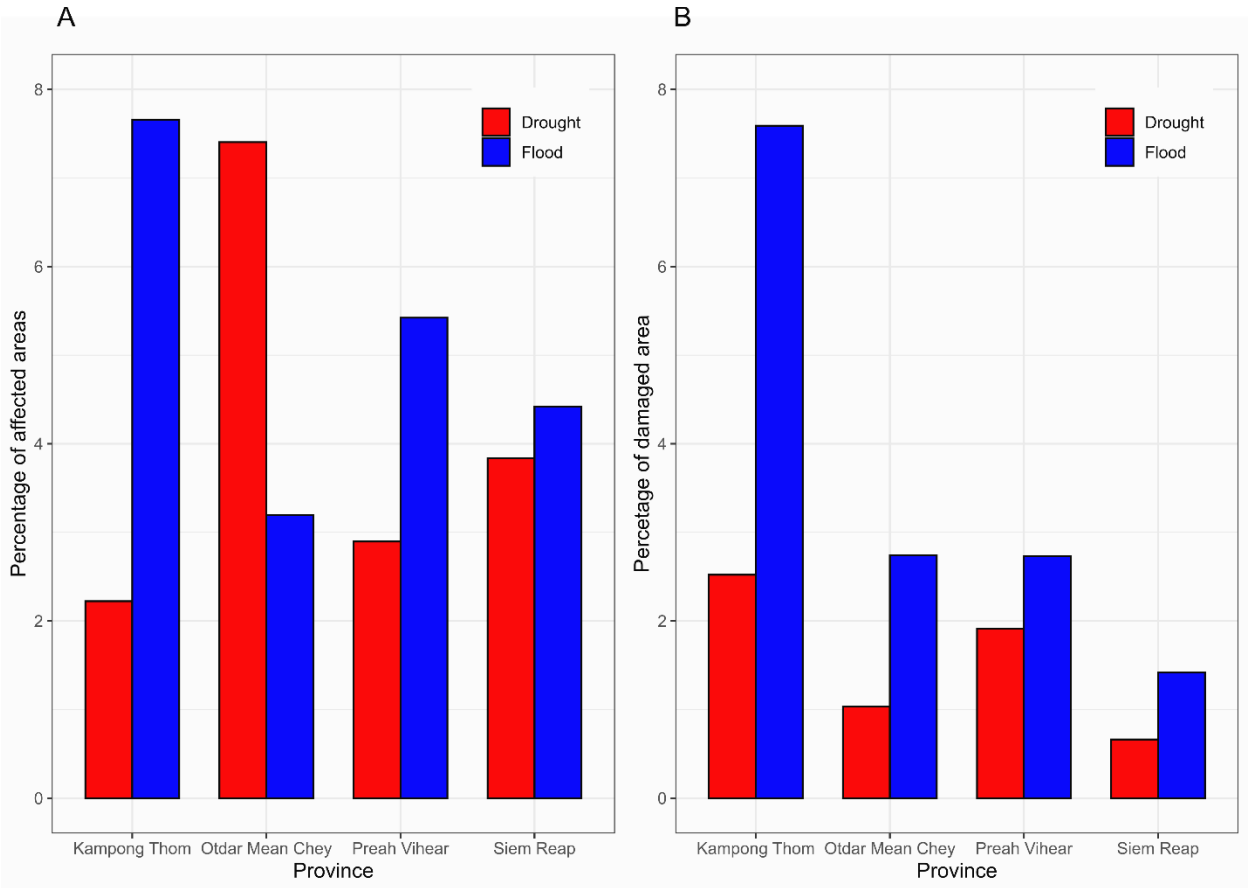


Figure 20: Flood and drought prone areas in the Greater Mekong Sub-region (food security atlas).



62. Generally, floods in Cambodia are not entirely a local climatic problem as the water level is highly affected by the hydrology in the entire Mekong River Basin. From 2000 to 2019, affected areas by drought and flood in four provinces of the NTSB (Figure 21) were on average 4.1% and 5.2% of the total rice-cultivated land

Figure 21: Percentage of rice cultivated areas affected (A) and damaged (B) by drought and flood. Data shown represent 20-years' average values.



respectively, corresponding to about 6,000 ha. On average, while Kampong Thom was the most flood-affected province, farmers in Oddar Meanchey faced yield losses due to drought stress. FAO's assessment of affected and damaged areas due to drought and flooding in the target provinces show that the percentage of damaged areas was higher for flooding compared to drought (Figure 21), indicating that flooding poses a major risk when farmers lack adaptive capacity in the face of major flooding events. This challenge is particularly relevant for rice and cashew production in Kampong Thom province, and also for vegetable production in Siem Reap.

63. One major challenge identified by agricultural producers and value chain actors through results of the survey, conducted for the preparation of this project, is the occurrence of pest and diseases and changes due to changes in climatic drivers. Flooding events and excessive water can result in increases in pest and disease infestations, which will be discussed further in the crop specific impact assessments below. Some major pests in the project area for rice include gall midge, stem borer, brown plant hopper, green leafhopper, grasshopper, leaf folder, rice bug, case worm, armyworm and rats. The populations of some of these pests are likely to increase significantly under extreme climate conditions(MoE, 2002). Mango and cashew producers also note the increasing occurrence of serve pest and disease infestations as a major challenge for production, storage and transportation.

3.3. Future projected climate

3.3.1. Methodology

64. The Coordinated Regional Climate Downscaling Experiment (CORDEX) data was downloaded from the Earth System Grid Federation (ESGF) node and post-processed with the climate data operators (CDO) to interpolate rotated coordinates to regular latitude and longitude grids. We used the Global Climate Model MPI-ESM, which is a comprehensive Earth-System Model, consisting of component models for the ocean, the atmosphere, and the land surface. The model is developed by the MPI for Meteorology (MPI-M) and based on its predecessors, the ECHAM5/MPIOM coupled model and its COSMOS versions. MPI-ESM has been used in the context of the CMIP5 process (Coupled Model Intercomparison Project-CMIP Phase 5) and is currently employed for the MPI-M contributions to CMIP6. To have reliable climate projections at regional scale, we used REMO2009 which downscales MPI-ESM by repeatedly using slightly different conditions (such as initial conditions or different physical parameterizations) and producing in that way an ensemble of outputs closely related.

65. Climatic files were combined to obtain one file per representative concentration pathway (RCPs) from CDO. Two future climate scenarios were used, namely the RCP 4.5 and the RCP 8.5, ~550 and ~1000 CO_2 ppm by 2100, respectively. The different climatic variables (temperatures and precipitation) were derived from the latter data sources and visualized in R software. The processed climatic data was read and processed again in R to visualize average changes and climate extremes overtime, with a custom-made function elaborated by the Office of Climate Change, Biodiversity and Environment (OCB) at FAO-HQ. Briefly, the function permitted to read into the R environment netCDF files (network common data form) allowing to compute 30-by-30-year averages for a specified climatic variable, time-period and country/province of interest.

3.3.2. Temperature

66. FAO's analysis of bias corrected data from the Coordinated Regional Downscaling Experiment (CORDEX), based on CMIP5 global climate projections and RCP scenarios shows temperature change under RCP4.5 and RCP8.5 in the near (2011-2040), medium (2040-2070) and far (2070-2100) future for temperature maximum (Figure 22) and minimum (Figure 23). The analysis shows the deviation into the future from the historical

baseline (1980-2005). Maximum temperature is expected to increase consistently from the historical baseline into the future, in particular in the northern regions, relevant for the PEARL project area. Maximum temperature will increase to a larger degree under RCP8.5, up to 3.6C by the far future period (Figure 22). With regards to the spatial variability, the inner Cambodia will experience a higher temperature change compared to coastal areas. While the changes overtime will be lower than 1C along the coastal areas, the inner parts of the country will experience a temperature rise of more than 2C in both RCPs.

Figure 22 Temperature maximum deviation from historical baseline period (1980-2005) under RCP 4.5 (top row) for the period 2011-2040 (left), 2040-2070 (middle) and 2070-2100 (right) and RCP8.5 (bottom row) for the same time periods. The deviation highlights the projected change into the future in degrees celcius based on projections from bias corrected regional CORDEX data (FAO analysis).

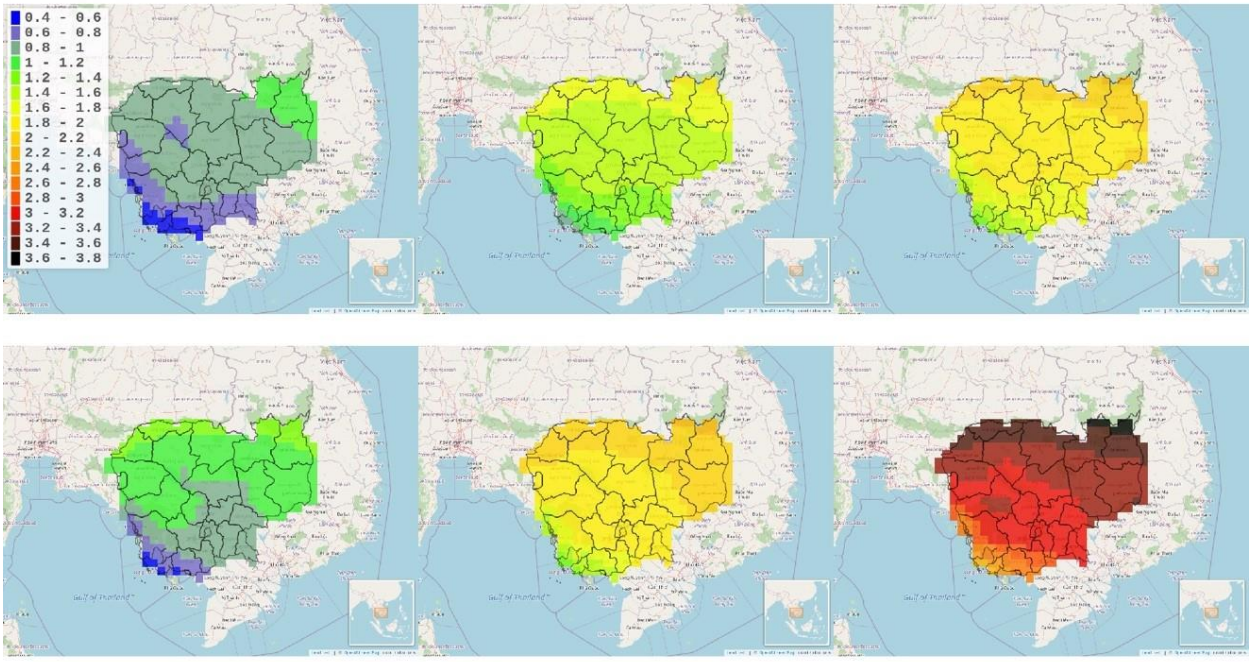
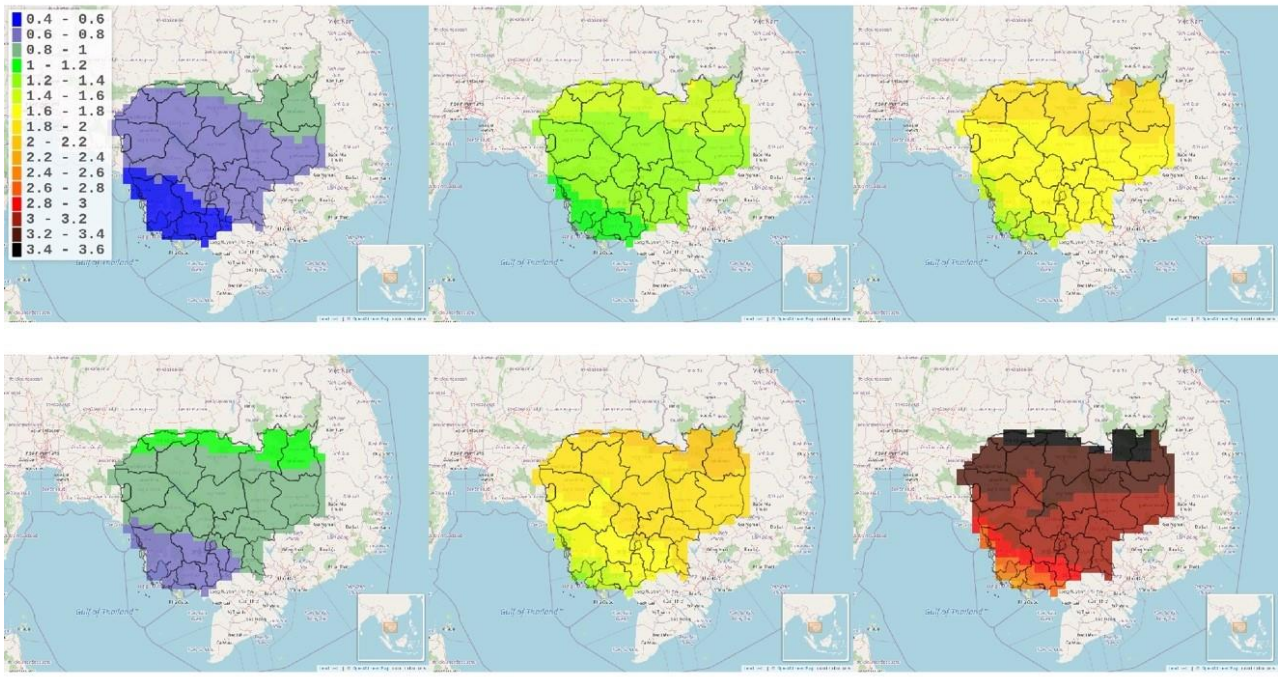


Figure 23 Temperature minimum deviation from historical baseline period (1980-2005) under RCP 4.5 (top row) for the period 2011-2040 (left), 2040-2070 (middle) and 2070-2100 (right) and RCP8.5 (bottom row) for the same time periods. The deviation highlights the projected change into the future in degrees Celsius based on projections from bias corrected regional CORDEX data (FAO analysis).

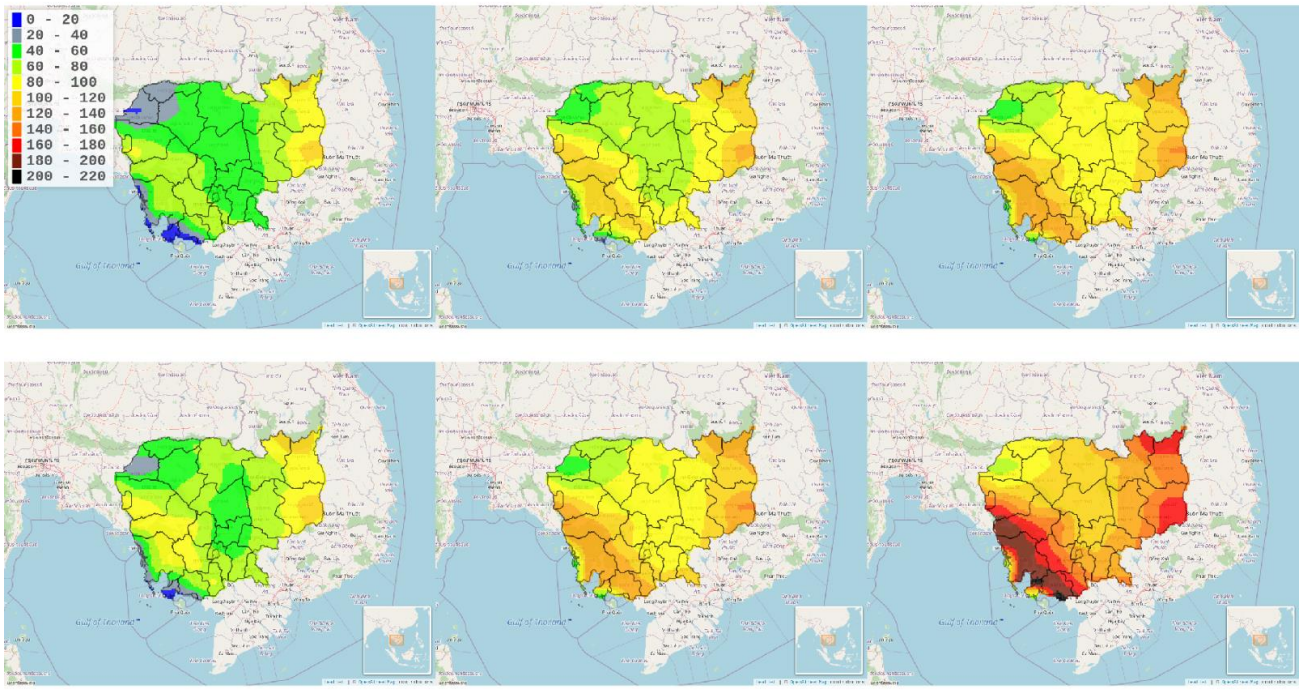


67. Temperature minimum across Cambodia shows similarities in spatial and temporal distribution to temperature maximum, increasing into the future with a larger magnitude for RCP8.5 as compared to RCP4.5 (Figure 23). Figure 23 illustrates deviation from the historical baseline period (1980-2005) into the future, with largest values in the northern regions and under RCP8.5 compared to RCP4.5. In both min and max temperature, the northernmost regions show the highest increase from baseline.

68. The number of days with temperature over >33C also increases into the medium and far future, with larger increases observed under RCP8.5 (Figure 24; bottom row). Geographically, it is observed that the number of days >33C is higher in the southwestern and northeastern regions of the country and will be exacerbated into the future (Figure 24). The increase in these two regions in the country is due to the fact that temperature maximum in the central region is on average higher and therefore the historical baseline (1980-2005) temperature exceeds the 33C threshold, while in the regions with the highest increase, this threshold will be more often exceeded into the future.

Figure 24 Number of days with temperature >33 degrees Celsius shown as the deviation (in days) from historical baseline period (1980-2005) under RCP 4.5 (top row) for the period 2011-2040 (left), 2040-2070 (middle) and 2070-2100 (right) and RCP8.5 (bottom row) for the

same time periods. The deviation highlights the projected change into the future in days based on projections from bias corrected regional CORDEX data (FAO analysis).

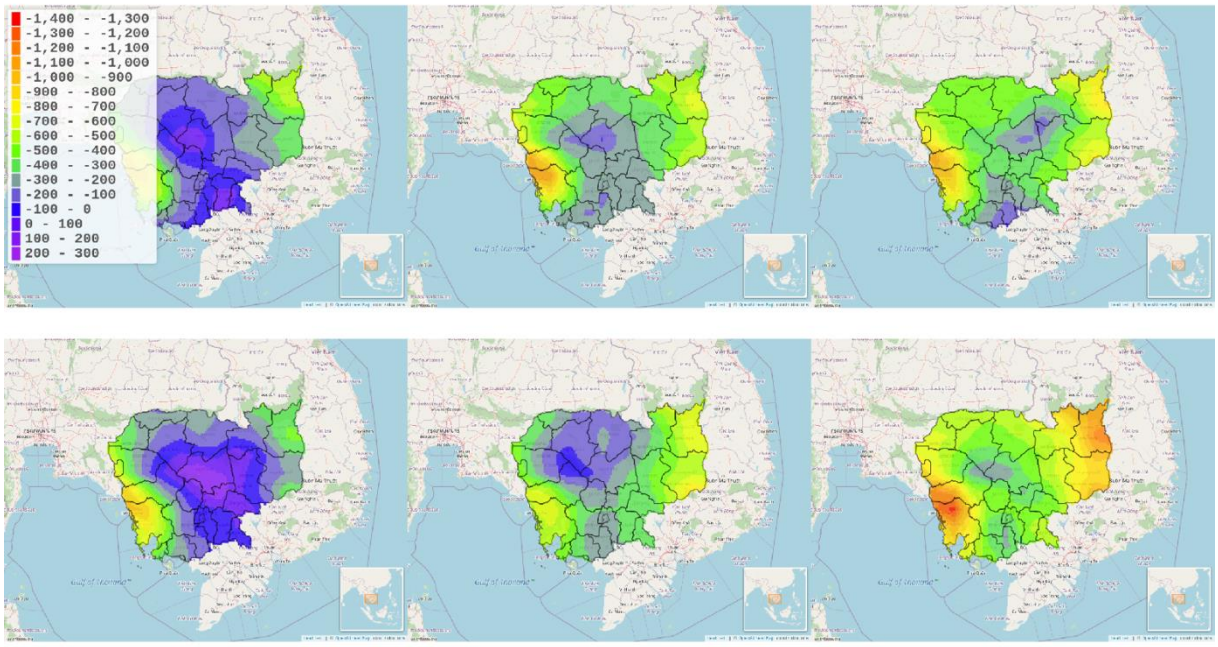


3.3.3. Precipitation

69. Although projections from the Climate Information Platform 5 based on CORDEX South Asia Ensemble Mean suggest an overall increase in annual mean precipitation in the medium to far future, FAO's downscaled analysis from the same CORDEX data indicates an overall decrease in annual cumulative precipitation into the future. There is an upward trend in rainfall between June and August in the northwest, and a downward trend in the northeast of the country (Figure 25). The projected increases in wet season rainfall will be partially offset by projected decreases in dry season rainfall. Precipitation deviation from the historical average period (1980-2005), shows a largest increase in the near future, with subsequent decreases in annual precipitation in the medium and far future, with variation geographically (Figure 25).

5 https://climateinformation.org

Figure 25 Cumulative precipitation per year deviation from historical baseline period (1980-2005) under RCP 4.5 (top row) for the period 2011-2040 (left), 2040-2070 (middle) and 2070-2100 (right) and RCP8.5 (bottom row) for the same time periods. The deviation highlights the projected change into the future in millimeters/year based on projections from bias corrected regional CORDEX data (FAO analysis).



70. As many agricultural producers rely on rainfed production in the wet season, Figures 26 and 27 show changes in cumulative precipitation in the wet season precipitation and deviation from the historical average in the wet season, respectively. This analysis suggests decreasing wet season precipitation into the future, to a higher degree under RCP 8.5 and with changes up to -500 mm/year in the regions of the PEARL project (Figure 27).

Figure 26 Cumulative precipitation (mm) over the rainy season (May-October) per year under RCP 4.5 (top row) for the period 2011-2040 (left), 2040-2070 (middle) and 2070-2100 (right) and RCP8.5 (bottom row) for the same time periods (FAO analysis).

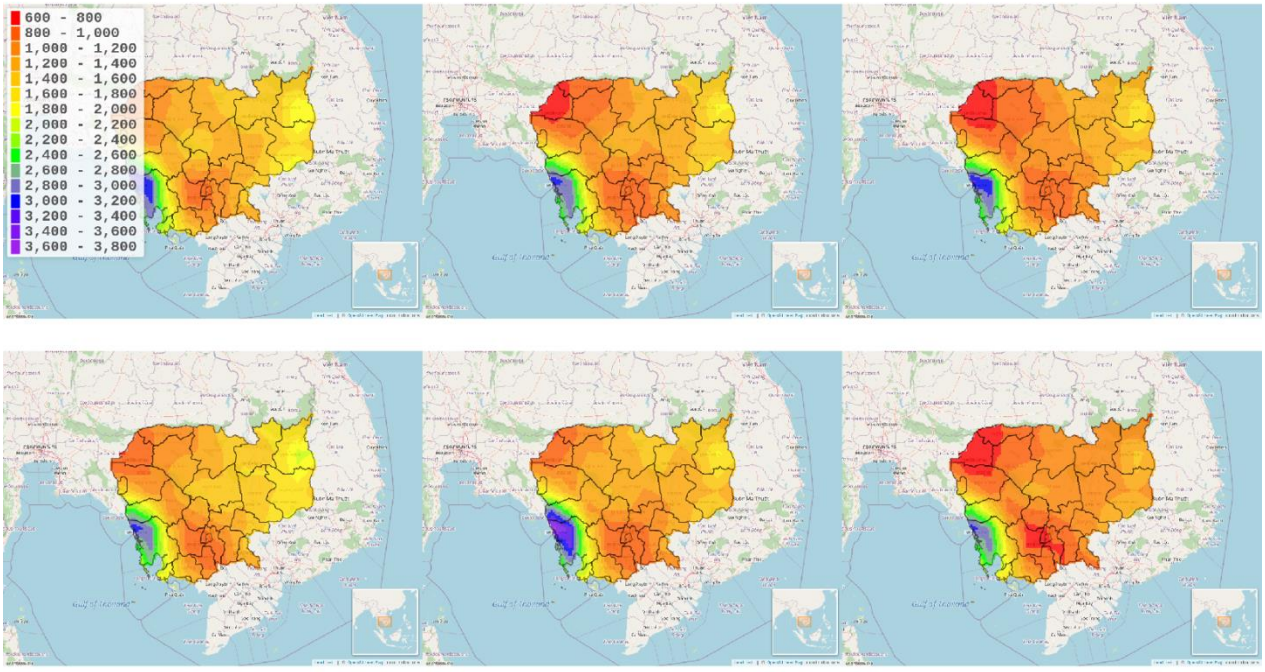
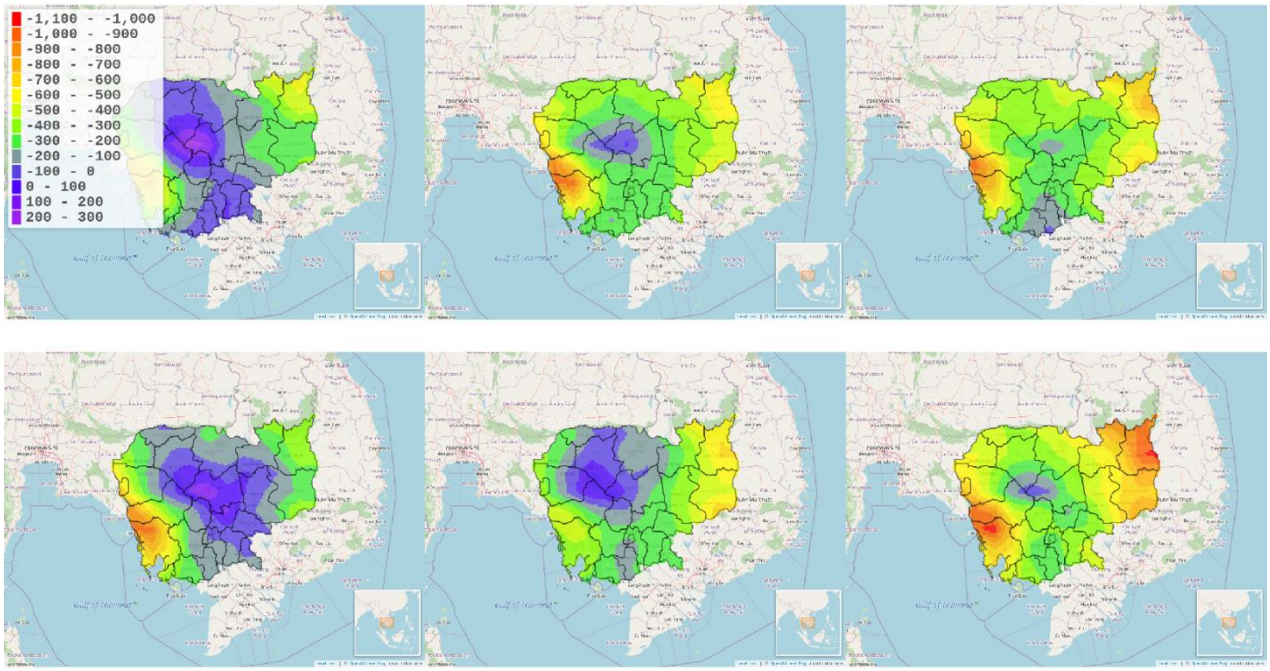
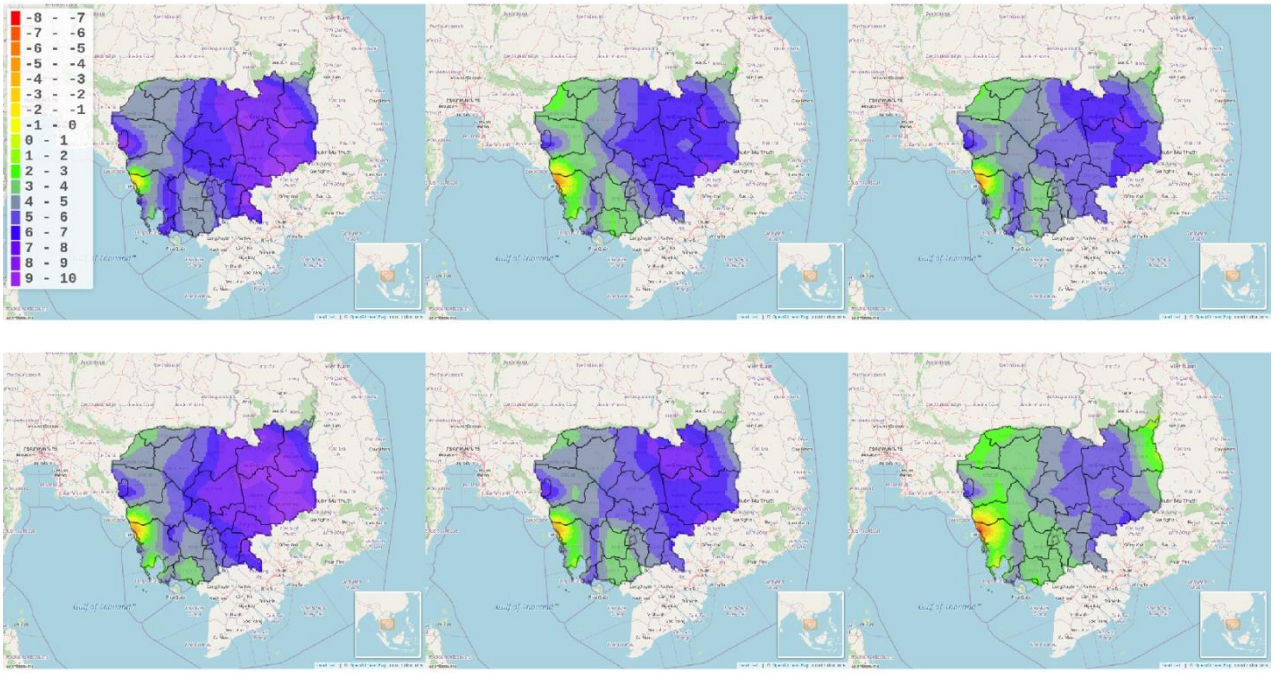


Figure 27 Deviation in cumulative precipitation in rainy season (May-October) from historical baseline period (1980-2005) under RCP 4.5 (top row) for the period 2011-2040 (left), 2040-2070 (middle) and 2070-2100 (right) and RCP8.5 (bottom row) for the same time periods. The deviation highlights the projected change into the future in millimeters based on projections from bias corrected regional CORDEX data (FAO analysis).



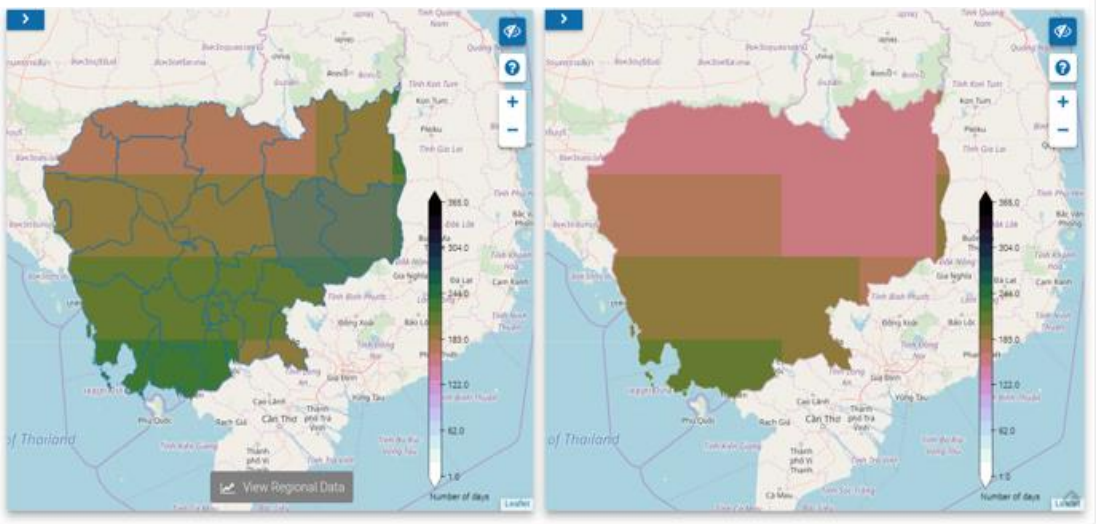
71. Changes in heavy rainfall events or days with heavy precipitation (>50 mm/day) are expected to increase in the near and medium term into the future, up to 9 days and in the longer term by fewer days (5-6 days) compared to the baseline period (Figure 28). An increase in heavy precipitation days with an overall decrease in cumulative precipitation (Figure 28) suggests that rainfall events will be more intense and infrequent into the future. Future assessment also suggests that the rainy season will become shorter into the future (Figure 29).

Figure 28 Deviation in number of days with heavy precipitation (50 mm) from historical baseline period (1980-2005) under RCP 4.5 (top row) for the period 2011-2040 (left), 2040-2070 (middle) and 2070-2100 (right) and RCP8.5 (bottom row) for the same time periods. The deviation highlights the projected change into the future in days based on projections from bias corrected regional CORDEX data (FAO analysis).



72. Results from CORDEX find that while annual precipitation are projected to increase in the near and long term futures, the rainy season is expected to shorten, potentially with larger rainfall events over short time periods (Figure 29) while the dry season is expected to become dryer with longer extended periods without rain (FAO, 2022).

Figure 29: Length of rainy season in the historical period (1981-2000) in left panel, and for the future SSP5-8.5 scenario (2071-2100) from CMIP6 simulations in right panel (FAO).



3.3.4. Anticipated Climate Impacts on Key Crops in NTSB

73. These anticipated impacts of climate change will affect the key crops and the associated opportunities and challenges (described in Table 1) differently. As shown in Table 4, changes in rainfall patterns and increased temperatures will variously affect the production and postharvest handling of cashew, mango, organic rice and vegetables in the NTSB. These crop specific impacts are analyzed further later in Sections 7 and 8 where specific baseline conditions, agrometeorological advisory and extension capacity needs and market-based adaptive options are discussed. Annex II also provides AquaCrop analysis of future climate impacts on rice and key vegetables targeted by the project.

Table 4: Key Crops and Their Climate Exposure and Impacts in the NTSB

Key Crop/ Areas Grown	Climate Exposure and Impacts
Cashew/ Kampong Thom and Preah Vihear	**Production (yield) – Food losses:** • Heat stress: occurs >34°C and cashew trees are particularly vulnerable to the delayed onset of winter and a cool dry period at flowering; • Droughts and low humidity: relatively tolerant; • Strong winds and storms: damage to trees and flowers; • Pest/Diseases: during the flowering and fruiting season; and • Heavy rain: As per impact from heavy rainfall during cashew's flowering season, there are not major problems faced by farmers as the flowering period starts from November which is at the end of the rainy season. **Affected Quality (yield):** • Developing mold due to high humidity at fruiting, spoiled nuts, kernel deterioration, bacterial attack; and

	• Heavy rains cause spread of mold and fungal diseases, pests and diseases at flowering and fruiting. **Post-harvest Losses:** • Increased mold, fungal attacks, damage and loss during transport without proper storage and processing capacity.
Mango/ Oddar Meanchey	**Production (yield):** • Shifts in seasonal patterns: early-onset of the dry season and drier and longer dry season, combined with increased temperatures, increasing pests at flowering and fruiting; • Heat stress: >46°C, at the flowering stage, beginning of fruiting; • Droughts at flowering and fruiting; • Pest and disease: increased pest and insect-related damage during the flowering seasons in October and November and April and May. Also driven by drier conditions, increased temperatures and erratic rainfall patterns, insect pests can lead to 40-80 % of fruit loss and damage when poorly managed; • Heavy rains and late-onset of the wet season: affect hormone-induced off-season flowering process; and • River Floods: not a major challenge due to higher elevation of the region. **Affected Quality (yield):** • Food spoiled, damaged by heavy rains and pests and diseases, rust/fungus attack. **Post-harvest Losses:** • Increased mold, fungal attacks, damage and loss during transport without proper storage and processing capacity.
Organic Rice/ Preah Vihear	**Production (yield) – Food losses:** • Droughts: severely affected organic rice production in Kampong Thom from 2000 to 2019 (>10,000 tons of yield losses). Higher resilience to drought conditions in upland where organic rice is produced; • Pest/Diseases fungal attacks: army worms, rice blight, rice blast. Number of days with optimal temperature for rice blast and bacterial rice blast development shows a downward trend. Significant yield losses reported in 2016 due to armyworm; • River Floods: a major threat to organic rice production. Yield losses are double compared to yield losses due to drought, particularly in lowland areas around the Tonle Sap Basin; • Heavy Rains: Yields losses due to heavy rains (e.g., consequent floods in 2017 led to 20-30% lower yields than 2016); and • Heat stress: Exposure to temperatures above the relatively high temperature threshold of 36°C can cause sterility and if daytime maximum temperatures exceed 40°C production will decline. **Post-harvest Losses:** • Losses due to humid or hot conditions in storage and limited drying and milling capacity at the farm level.
Vegetables/ Siem Reap and Preah Vihear	**Production (yield) – Food losses:** High seasonality of production (from November to January, early dry season), heavily dependent on natural resources and therefore vulnerable to climate hazards: • Droughts - combined with limited or no irrigation systems, can pose risks to crop failures; • Floods - minor problem; • Heat stress; • Pest/Diseases - e.g., flea beetle, cut worm, leaf folder, army worm, aphid, lady beetle, snail, butterfly, root rot, bacteria wilt; • Shifts in seasonal patterns; and • River flow reductions. **Affected Quality (yield):** • vegetable degradation; • variations in vegetable size at production level; • inappropriate timing for harvesting, resulting in over or under maturity; and • short-duration of vegetables storage prone to degradation. **Post-harvest Losses:**

	• short-duration storage due to lack of cold storage infrastructure, capacity of products, rapid damaging.

4. RATIONALE FOR INTERVENTION AND BARRIERS

4.1. Opportunities for transitioning to climate resilience and sustainable agriculture in the NTSB

74. The selection of the NTSB as a priority region for adapting the agriculture sector and associated livelihoods to the observed and anticipated impact of climate change is based on factors presented above and summarized below.
    - The NTSB is one of the most important agricultural regions in the country and home to 15% of the country's population.
    - The significant proportion of the NTSB's population relies on agriculture as their main livelihood. At the same time, the persistent poverty levels among smallholder farmers keep agriculture low-value and low-quality to reinforce socio-economic vulnerabilities cyclically.
    - The observed and anticipated impacts of climate change make the NTSB one of the most vulnerable regions with the increased risks of droughts, floods, and pest and disease events.
    - Premium price market opportunities for cashew, mango, organic rice, and vegetables and the production capacity of these crops have grown significantly in the NTSB; however, many smallholder farmers and other small-scale local value chain actors are unable to benefit from such opportunities due to the second factor.

75. The absence of support in the region that connects these risks and opportunities by bundling technical and financial services to utilize the presented market opportunities hampers the progress of climate change adaptation efforts in the NTSB. Such support would also de-risk public and private investment to crowd in further public and private sector investments into making the region's agriculture climate-resilient and high-value.

76. The above analysis of observed and anticipated impacts of climate change on agriculture in the NTSB elucidates the need to increase the adaptive capacity of agriculture-dependent, vulnerable households. While rice remains the predominant crop, the production of other crops such as cashew, mango, and leafy vegetables has increased in the NTSB. These trends build on the region's current suitability for producing these crops and their increased domestic and international market demand in recent years. The projected erratic rainfall patterns during the wet season, prolonged droughts during the dry season, and increased pest and diseases will undoubtedly affect the production of rice and these emerging crops. Such climate-induced impacts will disproportionately affect some crops such as rice more than the others, and the analysis of their impacts on cashew, mango, organic rice and vegetables in the NTSB are discussed in later sections where the capacity needs for improved agrometeorogical advisory services and crop-specific adaptive measures are discussed. Changes in suitability, yield and practice will more severely affect vulnerable farmers, particularly women.

77. At the same time, the increased public awareness of healthy eating and food safety in the country and the growing international tourism market drive consumer demand for higher-quality agricultural products (Ngon, 2019). Premium price markets, which have been established with organic rice and are emerging for cashew, mango, and vegetables in the NTSB, provide opportunities for these vulnerable farmers and local value chain actors who also depend on agriculture to incentivize and afford the necessary adoption of adaptive practices and technologies. Such opportunities will enable these vulnerable farmers and local value chain actors to cope with climate-induced shocks and improve their livelihoods through increased income and diversification. To achieve such outcomes will require concerted efforts to ensure these vulnerable farmers and value chain actors have access to tailored and crop-specific agrometeorological advisory services, targeted extension

services, financial and business development support, and private-sector partners. Having an enabling regulatory and institutional environment, particularly to unlock private investment in developing markets that are more inclusive, gender-responsive and climate-adapted, is also a critical factor for leveraging such multifaceted efforts.

78. One of the advantages of focusing on the premium price market opportunities for the climate change adaptation of smallholder farmers and other local value chain actors in the NTSB is that their emphasis on quality over volume matches the region's relatively small-scale production practices and remote accessibility, limited by its demographic and geographical factors. Through various certification schemes, including CamGap, GI, and organic certification, farmers and other local value chain actors can improve their production and processing quality on a case-by-case basis based on their unique strengths. This approach also gives granular attention to crop-specific climate risks and socioeconomic vulnerabilities that often compound one another to make farmers, other local value chain actors and their communities vulnerable to climate change. It is also essential to note that higher operating costs and limited economies of scale associated with this approach call for highly targeted and context specific application.

79. This approach is particularly suited for the northern sections of the NTSB with relatively well-kept agroecological conditions and predominantly small-scale agricultural practices, combined with serious underlying socioeconomic vulnerabilities driven by poverty. These northern sections, especially along national and provincial roads hold significant impact potential (see Figure 30). There are 24 districts in these shaded areas. While relatively well connected to transport networks, poverty in these areas is much more pronounced than the rest of the NTSB (RGC, 2020). Many smallholder farmers in these areas are producing cashew, mango, organic rice and vegetables (Burn et al., 2018; ICEM, 2020). Their remoteness and relatively hilly topography make large-scale commercialization, mechanization, and intensification difficult in these areas. Their growing capacity to produce cashew, mango, organic rice and leafy vegetables will, therefore, remain relatively small-scale. This raises a question: how could the current agricultural trends in the NTSB be best harnessed to increase the region's adaptive capacity? One answer is to support the inclusive development of premium market segments for these key crops in the NTSB.

80. *Figure 30: Northern Sections of NTSB (AOI)*

81. For instance, the organic rice certification process has already enabled many smallholder rice farmers in Preah Vihear with small, irregularly shaped paddy fields with limited mechanization and irrigation potential to turn such shortcomings into their strengths by focusing on improving and marketing their organic production quality and socioecological practices that ensure enabling agroecological conditions (Burn et al., 2018). However, their knowledge of climate risks and adaptive measures are currently limited to pose threat to their organic production. Therefore, providing these organic rice farmers with increased knowledge and access to resources for making climate-informed decisions would reinforce their premium market benefits in light of climate change to increase their adaptive capacity.

82. Due to the labor migration, many female-headed households are eager to diversify their livelihoods and income sources through vegetable production. The labor shortages combined with the increased climate variability observed make rice production more difficult, particularly for female-headed households. Horticultural techniques and technologies (e.g., raised-bed and net-house production and drip irrigation) coupled with certification schemes like CamGap and direct sales opportunities would offer female farmers alternative options that are time-saving, less labor intensive, climate-resilient and higher-value. Particularly, with the growing middle-class and urban consumers and the international tourism sector, there is an increased demand for vegetables by retailers, restaurants, and hotels in urban areas and tourist centers that offer opportunities for direct purchasing agreements and contract farming.

83. Mango farmers in Oddar Meanchey provide another example of how this premium market approach would benefit them. A large proportion of raw mangoes harvested in this province currently crosses the borders into Thailand to be processed and sold as Thai products. This value chain practice provide little incentive for farmers to increase their production quality and limits their income earning potential, thus ill-affording

adaptive measures to address their increased climate risks. This also limits opportunities for other local value chain actors, particularly through processing and value addition. Increasing contract farming and direct purchasing opportunities that promote climate-resilient and higher-quality production through public-private partnerships, and value-addition capacity among cooperatives, associations and local businesses through improved access to finance and technologies would put agriculture around the province's emerging mango production on a climate-resilient and sustainable pathway.

84. Having stated these opportunities, the baseline conditions, however, suggest that smallholder farmers and other local value-chain actors currently do not have access to these premium market opportunities due to their lack of knowledge and access to resources, such as crop-specific agrometeorological advisory and market information, climate-resilient and higher-value production practices, and post-harvest storage and value-added processing facilities. As a result, smallholder farmers often resort to the use of pesticides without proper knowledge of effective application methods and take the first price offer by collectors in fear of not being able to sell all of their harvests. These practices keep their agricultural production low quality and low value. Consequently, these farmers often have limited means to improve their product quality and afford long-term adaptation measures. Please see Annex III for details of target beneficiaries.

4.2. Narrative of transformation

85. Based on these market opportunities, observed and anticipated impacts of climate change on agriculture, particularly these key crops grown in the NTSB, and underlying socioeconomic vulnerabilities, the value chain approach targeting premium price markets around cashew, mango, organic rice and vegetables illuminates a viable pathway towards climate-resilient, higher-value, inclusive and sustainable agriculture.

86. If smallholder farmers and other local value chain actors in these areas of the NTSB have improved access to finance, technologies, and knowledge to adopt climate-resilient and higher-value practices to access the premium market segments for cashew, mango, organic rice, and vegetables, then their adaptive capacity to cope with the observed and expected impacts of climate change will increase significantly. It is because their advanced knowledge and market access will afford them the necessary means to address their climate risks and underlying socioeconomic vulnerabilities, and permanently shift towards climate-resilient and diversified agricultural livelihoods.

4.3. Complementarity and coordination with other adaptation approaches

87. Having indicated this logical transformation narrative, however, commercialization, mechanization, intensification and infrastructural improvement efforts are also crucial especially in the lowland areas of the NTSB around the Tonle Sap Lake where such interventions would be highly effective and appropriate. Therefore, an array of agricultural enhancement and climate change adaptation options need to be demonstrated and made available to farmers and their communities across the NTSB in a highly complementary manner.

88. This value chain approach, targeting premium price markets to increase the adaptive capacity of smallholder farmers and other local value chain actors, particularly in the northern sections of the NTSB, must coordinate with other initiatives supporting the adaptation of agriculture and farming communities to climate change in the region. Table 5 shows three recently launched initiatives that are supporting agricultural enhancement and adaptation to climate change with some geographical and strategic linkages in the NTSB and other regions of Cambodia. These initiatives are highly complementary with the premium-market based approach.

Table 5: Relevant Projects under the Programmatic Coordination

Relevant Project	Investment Size (~million USD)	Type of Synergy	Complementarity with the premium market-based approach
FAO-led project, "Enhancing sustainability of the Transboundary Cambodia - Mekong River Delta Aquifer", under the under the Global Environment Facility (GEF) at inception.	15	Scaling up the impact at the landscape level with the GEF	The project will strengthen environmental sustainability and water security in the Lower Mekong Basin by focusing on improved governance and sustainable utilization of the Cambodia-Mekong River Delta Transboundary Aquifer. The project will support transboundary consensus-building by assessing the current state of groundwater resources, recharge, extraction dynamics, and groundwater-related dependencies of related ecosystems and developing standard measurement methodology and indicators. The project will also demonstrate innovative groundwater management and utilization approaches. The PEARL project will consider and integrate the methodology, indicators, and groundwater management approaches into its IWM and groundwater budgeting and management efforts, particularly in selecting and promoting specific climate-resilient and high-value techniques and technologies that impact groundwater.
FAO-led project, "Promoting Climate-Resilient Livelihoods in Rice-Based Communities in the Tonle Sap Region," with funding from the Least Developed Countries Fund (LDCF), under the GCF, under implementation.	9	Scaling up the impact at the landscape level with the GEF	The project aims to support traditional rice farmers and communities in building their resilience to climate change through an ecosystem-based, market-driven approach in the lower sections of the NTSB and other areas along the Tonle Sap Lake. The project is highly complementary with the premium market-based approach as it offers a range of adaptation support to rice farmers, while the premium market-based approach focuses narrowly on adaptation options through niche market tools and opportunities. Also, given the downstream location of this project along the Tonle Sap Lake, there is significant potential for establishing a landscape-level approach by focusing on upstream-downstream relationships and effects. Activities such as catchment restoration, erosion control, and IPM can be pursued through integrated watershed management (IWM). Also, their shared geographical focus suggests the potential for collaboration on the development of agrometeorological advisory services and dissemination.
ADB-led GCF project, "Climate-Friendly Agribusiness Value Chains Sector (CAVS)", under implementation.	141	Replicating the experience and lessons of another GCF project and scaling up the impact at systemic and institutional levels.	The project aims to improve climate resilience and reduce the carbon footprint of commercial rice, maize, cassava, and mango value chains by investing in climate-resilient agricultural production and post-harvest infrastructure. The project will support production intensification and commercialization and promote low-carbon technologies in Kampong Cham and Tbong Khmum provinces along the Mekong River and Kampot and Takeo provinces in the Mekong Delta, another priority agricultural region for climate action. Despite its geographical and production expansion focuses, there is strong complementarity with the premium market-based approach in the NTSB as it also employs a value chain approach, targeting a similar range of crops and promoting the broader adoption of CamGAP. From this perspective, effective knowledge sharing and harmonization of systemic and institutional capacity development

			support will ensure their additionality and lower the incremental cost of climate change adaptation of agriculture in the country.
IFAD-led project, "Sustainable Assets for Agriculture Markets Business and Trade (SAAMBAT)", under implementation.	142	Building on the parallel co-financing for complementary investment results.	Building on its existing projects, "Accelerating Inclusive Markets for Smallholders (AIMS)" and "Agriculture Services for Innovation, Resilience, and Extension (ASPIRE)," the project aims to improve rural road and energy infrastructure, the use of digital technology and skills-base of rural youth entrepreneurs in agriculture around key market centers across the country, including the NTSB. The project's rural agricultural infrastructure improvements, including roads, collection and processing facilities, and renewable energy access, will significantly complement the premium market-based approach in the NTSB. Such infrastructure is an essential enabler of agricultural market development and the necessary conditions for successfully demonstrating adaptation options through alternative agricultural commodities and value chains.
IFAD-led project, "Agriculture Services Programme for an Inclusive Rural Economy and Agricultural Trade (ASPIRE-AT)", currently under development	133	Building on the parallel co-financing for complementary investment results.	As the second phase of the ASPIRE project, the project will use graduation processes to harness natural market forces to grow PG, AC, and union membership to be inclusive of motivated poor individuals in each community to help them achieve scale to attract more buyers and better terms of trade. Such efforts will promote affordable investment pathways for many smallholders, establish affordable initial investment options, and, with reinvestment of profits, generate increasingly higher net incomes. Direct targeting measures will be specifically used to increase women's genuine leadership and promote women and youth into higher status business and entrepreneurship opportunities to serve their communities around the Tonle Sap Lake. The PEARL project will complement ASPIRE-AT by promoting harmonized approaches to climate resilience building (e.g., climate smart practices and technologies and capacity building of agricultural extension services) while drawing on ASPIRE-AT's small-scale agricultural business development expertise and social infrastructure, developed through the AIMS and ASPIRE.
EU-funded project, "Deforestation free agriculture value chains and sustainable food systems" through EU Multi-annual Indicative Programme (MIP) 2021 -2027 under development	TBC (~ Euro 25- 30 million)	Scaling up the impact at the landscape level	The proposed EU-funded project will contribute to Cambodia's efforts to set up a sustainable model for national food production by putting emphasis on higher-value products and increased productivity through the introduction of green technology and digital solutions. Activities will be designed with the aim to improve price and quality competitiveness while ensuring equity and inclusivity and maintaining a balance between conservation and development to foster sustainable impacts. It will target inland fisheries and smallholder farmers through services, including improving financial access. Activities under the project will pay special attention to addressing climate vulnerability and environmental degradation to support the implementation of Cambodia's NDC. Early lessons from the PEARL project will offer helpful knowledge and a solid foundation for the project to design its interventions and approaches to ensure its complementarity with the PEARL project and focus on delivering incremental impact.
Total	>450		

89. Across these initiatives, the importance of rice production as the country's main staple will continue. For rice and other crops, increasing their production capacity while addressing its climate vulnerability is critical. The need for better, more efficient and accessible agricultural infrastructure, including road networks, power grids, and post-harvest storage and processing facilities are all fundamental enablers that these initiatives work together to provide. Having a programmatic approach to ensuring effective coordination and synergies with these initiatives is, therefore, crucial and ensures that a wide range of adaptive options are available to the sector to meet its specific needs and priorities. A more comprehensive list of potential co-financing activities and baseline investments is provided in Annex I of this document.

4.4. Barriers to promoting climate change adaptation through higher-value agriculture in NTSB

90. While reiterating the lack of knowledge and access to finance and technologies as general barriers for smallholder farmers and other local value chain actors in the NTSB, there are also more specific barriers.

91. Despite the growing premium price segments and related opportunities, most smallholder farmers' current production in the NTSB are generally described as low yield, low-quality, and low-value. There are limited value addition activities. These conditions afford most smallholder farmers and other local value chain actors limited means and opportunities to adopt climate-resilient and higher-value practices and livelihoods.

92. The following six broad barriers prevent their transition to climate-resilient and high-value agriculture that often compound one another to contribute to the current baseline situation in which most smallholder farmers and local value chain actors have the very limited adaptive capacity and options to cope with the impact of climate change.

- Lack of reliable and timely agrometeorological forecasting and related advisory services to support farmers' decision-making through anticipatory action and on-farm planning.
- Limited market knowledge among and financial access for smallholder farmers and other local value chain actors to facilitate the adoption of climate-resilient and high-value technologies and techniques.
- Limited awareness of risks and climate-resilient and higher-value options, promoted through extension services, training, social media platforms, and mobile apps.
- Lack of outreach capacity and market-based knowledge of extension services and effective public-private partnerships.
- Sub-optimal watershed management practices to ensure good agroecological conditions and ecosystem services that can also reduce natural disaster risks.
- Lack of favorable regulatory conditions and institutional arrangements to ensure enabling conditions for leveraging effective PSPPs and public and private investment for climate-resilient, high-value and inclusive agriculture.

93. The lack of access to reliable agrometeorological forecasting and advisory services by farmers in the NTSB has hampered progress to adapt farming practices to the changes in the seasonality of monsoon, increased rainfall variability, higher temperatures, and outbreaks of climate-driven pest and diseases. With international support, Cambodia has developed a robust network of hydrometeorological stations to provide general forecasting and early warning services; however, there are significant infrastructural and capacity gaps in the provision and dissemination of agrometeorological forecasting and advisory services. Limited knowledge of climate-related risks, market opportunities, and options for climate-resilient, sustainable, higher-value, and diversified agriculture is also a critical barrier. This is also partly due to their low literacy rate and the fact that

most farmers are busy coping with other livelihood challenges on a day-to-day basis (MAFF, 2013; MoE, 2015b; FAO, 2016).

94. Farmers also have limited knowledge of modern production technologies and techniques that are more sustainable and climate-resilient. As a result, unsustainable practices that exacerbate vulnerabilities – including mono-cropping, the excessive application of chemical fertilizers and pesticides, and poor soil nutrient management – have continued. The increased use of pesticides and other chemicals has, in turn, limited their opportunity to access and export to higher-value markets and affected local ecosystem functions and food safety in the country.

95. Another challenge is posed by limited access to finance to facilitate the adoption of appropriate technologies and techniques by smallholder farmers, ACs, FAs, PGs, and other local value chain actors (MAFF, 2013; Kula, Turner and Sar, 2015; FAO, 2016). Also, higher-value markets are often inaccessible for most smallholder farmers and other local value chain actors. They often lack the necessary knowledge and resources to meet the required production volumes and quality standards. The enabling regulatory and institutional conditions are also lacking to support in removing these barriers and leverage private-sector investment, which is currently confined to a handful of capable farms and businesses.

96. These weaknesses have also been highlighted by a recent assessment of COVID-19 impact on the agriculture sector (MAFF, CARD and FAO, 2020). The assessment identifies several opportunities, including the increased use of the internet of things (IoT) for capacity development and increasing market access. Increased demand for domestic horticultural production in lieu of reduced import capacity in light of the pandemic also suggests an opportunity. The projected impact of climate change and recent experience with the global pandemic cast light on the need and opportunity for smallholder farmers and other local value chain actors to increase their production capacity and quality, diversify their agricultural practices, and reduce their vulnerability to a range of risks.

97. An assessment of more than two dozen relevant existing and planned initiatives was conducted (Annex I). Findings suggest that the following investment gaps. Addressing them would ensure the additionality of the proposed intervention through the premium market approach.

- Development of end-to-end agrometeorological systems that provide site and crop-specific warnings (e.g., for pest and diseases) and advisories for farmers and local value-chain actors (i.e., farm management and market related information), as existing efforts are fragmented and limited, and no centralized system is available to genera harmonized advisory information and ensure the last-mile delivery of such information;
- Promotion of agricultural certification programs in the NTSB to incentivize climate-resilient, sustainable, higher-value, and diversified production and processing;
- Establishment of financial tools that are dedicated to supporting smallholder farmers and other local value chain actors dealing with the target crops for adopting climate-resilient and higher-value practices and technologies;
- Promotion of climate-resilient best practices, technologies, and integrated environmental management approaches to support climate-resilient and sustainable value-chain development efforts; and,
- Establishment of enabling conditions (i.e., regulatory and private sector engagement) to promote agricultural certification programs that incentivize the adoption of climate-resilient and sustainable technologies and practices, while responding to public demand for food safety.

4.4.1. Crop Specific Value Chain Barriers

98. There are barriers that are not specific to one or the other studied value chains, but concern the Cambodian agricultural sector more generally. Addressing the totality of these barriers goes beyond the objectives of PEARL project, yet PEARL activities are designed to address them in part, and support beneficiaries in overcoming them to the extent feasible through the proposed interventions.

99. Limited knowledge of quality standards in extension services: Historically, agriculture extension services (as well as most of the projects from development partners and NGOs) have focused on productivity (with mainly quantitative objectives and indicators). Now that Cambodian agriculture is generating surpluses of many crops, development of export has become a priority.

100. The Cambodian agriculture sector, including the agro-processing industry, sees further development hampered by high costs[6] of logistic, energy, and credit. Ensuring the competitiveness of Cambodian agri-products marketed as unprocessed raw commodities is a significant challenge. Differentiation by quality is seen as a possible option to address this challenge. Consequently, a number of development projects have started to work on quality assurance, standards, and certification to create a differentiation of the products on the market and obtain better prices. But those are still relatively new approaches and there is a lack of trained human resources on topics of quality standards, quality management, and certification.

101. Having said that, the improvement of the quality of agricultural products, and compliance with certain standards won't be adopted if driven by recommendations from extensionists alone. If there is no market or remuneration for quality, encouragements to focus on quality will fail. The primary driver is market demand, and any intervention on quality and certification has to start with the market demand and with the SMEs involved in the processing and/or trade of smallholder agricultural products.

102. Access to finance for smallholder farmers and ACs: Lack of access to finance for smallholder farmers can be a major obstacle for them to benefit from the project, in particular for perennial crops such as cashew and mangoes. Access to finance and cost of credit are also well-acknowledged bottlenecks for the development of SMEs in Cambodia, maybe even more in the agribusiness sector than others, as it is considered to present comparatively high risks for financial institutions. The high cost of financing affects the competitiveness of Cambodian SMEs (for example compared to their counterparts in Vietnam, which have access to less expensive finance), and the difficulties to access loans also hinder the scaling up of activities, and consequently the creation of economies of scale.

103. Awareness, knowledge, and capacities on food safety and quality management: Lack of awareness and capacities of Cambodian SMEs on quality management procedures and standards is a critical barrier to be addressed. Most SMEs in the agro-food industry in Cambodia are not sufficiently aware of food safety issues and good practices for quality management, and are even less aware of food safety standards and certifications related to products or processes. Addressing this constraint is important in order to progressively improve the capacity of these SMEs to get connected to high-end markets and reach client requirements, in particular to meet export requirements.[7]

[6] (Compared for instance to its neighbors, Vietnam and Thailand).

[7] It has to be noted that, in some sectors (notably rice) some of the large millers and exporters have already made this progress and reached certification (in some case with the support of project, such as IFC support to the rice sector). For instance, AMRU-Rice is GMP, HACCP and ISO 22000 certified; Golden Rice holds ISO 9001 certificate.

104. Financial and industrial process management and marketing capacities: While a number of agribusinesses in Cambodia have developed the capacity for management and market development (e.g. SeasonsFresh, AMRU, etc.), the majority of small/recently established SMEs require support to develop similar capacities. Lack of capacity in these areas presents a significant barrier for adoption of improved practices, as financial and process management and marketing are key skillsets for sustaining and expanding any successes gained from certifications that allow access to premium markets.

105. Legal compliance issues: Legal compliance is a barrier to adoption of improved practices. In a 2010 publication,[8] the International Finance Corporation (IFC) underlined difficulties faced by SMEs in Cambodia related to legal compliance. The study highlighted the fact that regulatory compliance costs are relatively high. In addition, the IFC found that registered and unregistered SMEs compete on a shared but uneven playing field. While some SMEs are registered and comply with relevant laws, others providing the same products and services do not comply with the law and so enjoy unfair advantages and cost structures.

106. Lack of access to information on market opportunities: This barrier is similar to that impeding adoption of improved food safety practices. In order to support SMEs to invest in innovative processing techniques and technologies, it is essential that they have regular access to market information. Currently, apart from a few large buyers, SMEs do not have information on market opportunities (both from supply and demand side, niche markets, prices, exports, etc.).

107. Increased pesticide use: A growing population and rising incomes have caused a spike in the demand for food in Cambodia in recent years. In response, farmers have increased the use of pesticides, some of them illegal. Hazardous substances are used not just by farmers but also by retailers who want to ensure the products look fresh for a longer period. The pervasive concept that more pesticides are required as part of the solution to meet the growing demand in Cambodia is a barrier to the adoption of improved practices.

[8] IFC Advisory Services in East Asia and the Pacific, Understanding Cambodian Small and Medium Enterprise Needs for Financial Services and Products, Cambodia Agribusiness series - No. 2, 2010.

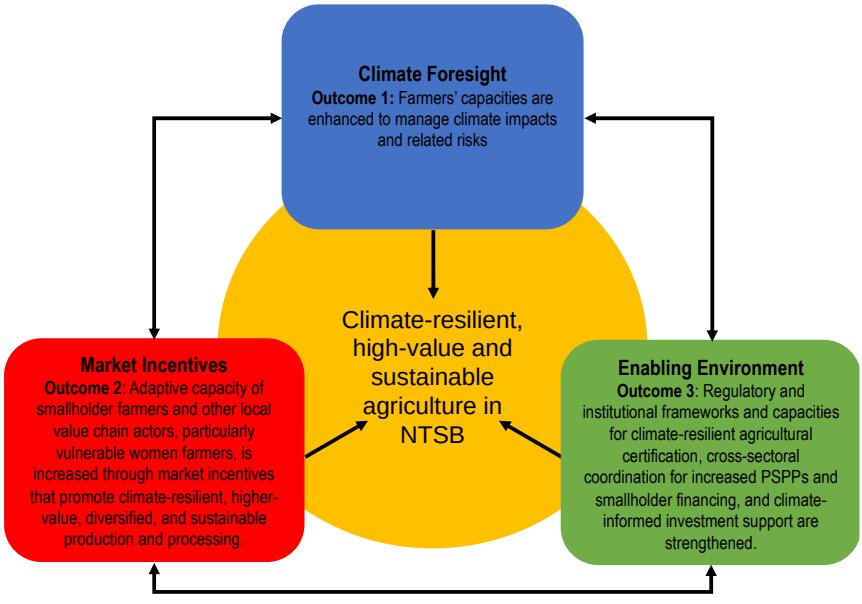
5. PROJECT OBJECTIVE AND EXPECTED RESULTS

5.1. PEARL Project Objective

108. Building on the above-described climate rationale, current agricultural trends, underlying socioeconomic vulnerabilities, and barriers to transformation in the NTSB, FAO, in consultation with the NDA and relevant national and international partners, proposes a GCF project, "Public-Social-Private Partnerships for Ecologically-Sound Agriculture and Resilient Livelihood in Northern Tonle Sap Basin (PEARL).

109. The main objective of the PEARL project is to establish a transformation pathway through a market-based approach to climate change adaptation by supporting smallholder farmers and other local value chain actors in the NTSB to shit to climate-resilient, higher-value and sustainable agriculture. The project will target the production and value addition of cashew, mango, organic rice, and vegetables, particularly in the northern sections of the NTSB (see Figure 30). This focus builds on the current production and market trends in the target areas. These crops represent growing segments of agriculture with significant possibilities for climate change adaptation and livelihood improvement.

110. The PEARL project proposes to achieve its objective through a set of integrated technical, market-based, and governance solutions that build on effective public-social-private partnerships (PSPPs). PSPPs focus not only on maximizing efficiency by bringing the public and private sectors together, but also on creating shared social values and visions by paying closer attention to various public needs and interests. Through PSPPs, smallholder farmers and other local value chain actors' access to agrometeorological and market information, finance, and climate-resilient techniques and technologies, including machinery and small-scale infrastructure such as post-harvest cold storage facilities, will be improved in ways that directly enhance their livelihood quality and options. Effective PSPPs will support the establishment of the necessary conditions for climate-resilient and higher-value agriculture to enhance the overall effectiveness of the GCF investment through the project by crowding in public and private investments in the project outcome areas.



111. Given the increased public interest in safe and sustainably produced food in Cambodia and internationally, this is an opportune timing for establishing such partnerships between government institutions, private sector entities (e.g., traders and exporters, suppliers, retailers, microfinance lenders, and insurers), and farmers and other local value chain actors (e.g., millers and processors) to harness the premium market opportunities for cashew, mango, organic rice, and leafy vegetables for the climate change adaptation of vulnerable farmers and other local value chain actors in the NTSB. The project's market-based and value chain approach will also ensure the long-term sustainability of adopted practices beyond the project's life.

5.2. Expected Outcomes (Project Outcomes)

112. The project sets out to deliver three interlinked outcomes for climate-resilient, higher-value, and sustainable agriculture to achieve its objective. These outcomes address the barriers identified above.

113. **Outcome One (Climate Foresight)** ensures that smallholder farmers and other local value chain actors have a solid understanding of climate-related risks and strategies to reduce climate change risks and potential impacts. The project will key technologies to provide crop-specific agrometeorological and market advisory services (e.g., seasonal forecasts, pest and disease early warning and market trends) to improve local capacity to identify and respond to risks associated with weather and climatic conditions. The project will also develop the necessary institutional arrangements through PSPPs to ensure effective dissemination of such advisory services to end-users. The increased agrometeorological forecasting and advisory capacities will also directly feed into Outcome Two for the development of risk financing products.

114. The project will build on several international support initiatives in this area (Table 5) to focus on remaining capacity gaps. Key capacity gaps mainly exist in providing crop-specific advisory services and getting them to end-users on the ground. For this, there are institutional and technical capacity limitations: translating weather and climate data into specific advisory services for agricultural applications, particularly putting into forms and contexts that are easily digestible by farmers and other local value chain actors, and a dedicated institutional arrangement within MAFF and in partnership with the Ministry of Water Resources and Meteorology (MWRM) to offer consistent and coherent agrometeorological advisory services to end-users. Another area is to strengthen partnerships with ACs, FAs, producer groups, small and medium-sized enterprises (SMEs), extension services and private actors like local radio and TV stations to increase information dissemination capacity and efficacy and demonstrate informed decision-making in farm management and postharvest practices. The project will also coordinate with the FAO-led LDCF project, described above in Table 5, in this area to ensure the sustainability and scalability of the project's investment at the landscape level.

Table 6: Agro-meteorological Forecasting, Warning and Advisory Service Capacity Gaps

EXISTING CAPACITIES AND INITIATIVES	FOCUS/ACTIVITY						
	Data and service production			Last mile: delivery and uptake by farmers			
	Monitoring, data collection and equipment	Capacities of national institutions	Forecasting	Tailored services to agricultural sectors	Dissemination and extension	Participatory engagement of farmers end-users	Farmer training and demo
DOM[9] Monitoring and forecasts							
UNDP-GEF[10] Early warnings for development							
WMO-CIAT[11] Forecasting and insurance				Coffee, rice, sugar,			

[9] Department of Meteorology Cambodia

[10] *Strengthening Climate Information and Early Warning Systems in Cambodia to Support Climate Resilient Development and Adaptation to Climate Change*

[11] De-Risk: https://public.wmo.int/en/projects/de-risk-south-east-asia

				cassava, rubber, dairy, grazing			
FAO-University Southern Queensland[12] Pest and disease alerts				Pest and disease			
WFP-FAO-UNICEF Social protection				Social protection			
Technical Working Group-CARDI-MAFF Agromet bulletin production							
RIMES-SESAME Forecasts and crop advisories							
Shaded areas indicate some level of investment. Their exact contributions will be assessed during the project preparation phase.							
Indicative PEARL project investment focus and level (✓ some ✓✓ strong)	✓	✓		✓✓ Cashew, mango, organic rice, vegetables	✓✓	✓✓	✓✓

115. **Outcome Two (Market Incentives)** relies on various public-private-social partnerships (PSPPs) to promote the adoption of climate-resilient, higher-value and diversified practices and technologies by smallholder farmers, ACs, FAs, producer groups, SMEs, and other local value chain actors through promotion of certification programs to access premium market segments and direct market access to local retailers, restaurants and hotels, sourcing higher-value and quality agricultural products. Table 6 above describes several potential private sector partners with significant potential to ensure the outcome's long-term sustainability. Many of these potential partners are active supporters of higher-value and sustainable agriculture in the country. The majority of their activities currently focus on rice production, as it is the single most important crop for Cambodia with mature value chains. Their business leadership and investment will ensure the economic viability of this outcome to crowd-in further private investment in the climate-resilient and sustainable expansion of the alternative value chains. Preliminary discussions with several of these partners during the CN development have identified several viable areas of collaboration between the PEARL project and these private sector actors. In these areas, the project will establish an enabling environment (i.e., farmers' capacity, extension services, agricultural cooperatives, lending and insurance, legal and regulatory conditions, and institutional arrangements). Ensuring such enabling conditions requires broad and often costly social and institutional capital investment, which goes much beyond the business acumen of these private actors. The PEARL project's support in these areas is, therefore, crucial as they are typically considered non-bankable from the private sector perspective.

116. As the primary focus of this outcome, existing certification standards and processes in the country such as Cambodia's Good Agricultural Practices (CamGap), Geographical Indication (GI) and organic certification will be scaled up to the project's target crop. Through the GI process, the possibility of branding the NTSB as a geographically unique agricultural region will be explored to create an enabling market environment, building on the overall branding effects of GI, to incentivize the adoption of climate-resilient, higher-value and sustainable agriculture across the region. To drive this process, the project will establish a revolving fund mechanism and related financial services in partnership with the Agricultural and Rural Development Bank of Cambodia (ARDB). The revolving fund will operate in conjunction with technical assistance to ensure that the

[12] *Regional program on agrometeorology and plant pests and diseases*

increased financial access results in the creation of a market-based adaptation pathway based on the beneficiaries' improved business and financial literacy and knowledge of climate-resilient and higher-value agricultural practices and technologies and market opportunities. The increased local capacity to identify and manage climate-related risks under Outcome 1 will provide a solid base for delivering this outcome.

117. **Outcome Three (Enabling Environment)** ensures that the necessary regulatory and institutional conditions are in place to increase smallholder farmers' and other local value chain actors' access to higher-value market opportunities to incentivize climate-resilient agriculture. This outcome also ensures increased public spending on critical enablers for Outcomes 1 and 2, such as agrometeorological forecasting and related advisory services, extension support, agricultural infrastructure, and energy access. An effective vertical and horizontal integration of efforts and best practices across relevant sectors, stakeholder groups, and levels of government will also be ensured to support the project in meeting its goal. These enabling conditions will also ultimately increase private sector engagement and investment in climate-resilient and higher-value agriculture. Under this outcome, the project will coordinate closely with another GCF-funded project, "Climate-Friendly Agribusiness Value Chains Sector," led by the Asian Development Bank (ADB) in the Mekong River and Delta regions to ensure policy coherence of the two initiatives.

5.3. Leveraging Private Sector Support for Outcome Delivery

118. Specific arrangements and terms of engagement by these private sector actors, among others, described in Table 7 will be identified during the project inception phase.

Table 7: List of Potential Private Sector Partners

Category	Potential Partners	Potential Area of Collaboration
Agricultural Supply Providers	AGRIBUDDY	Among agricultural suppliers, Agribuddy is a unique and relatively small operator with limited outreach capacity, focusing primarily on rice producers. Their business model promotes higher standards of quality control and sustainable production through a credit guarantor system. The project will strengthen cooperative arrangements of cashew, mango, and vegetable producers and increase farmers' awareness of higher-value production options to support the expansion of their services into these segments. This will increase farmers' interest in quality supplies and credits for adopting climate-resilient and higher-value practices.
Traders/ Exporters	AMRU RICE SeasonFresh SCP	Traders/exporters like AMRU Rice (for organic rice), SeasonFresh (for mango), and Specialized Cambodian Produce (SCP) (for cashew) look to increase the production capacity of their contract farmers, particularly in premium price segments. Their ability to provide extension support to farmers and other local value chain actors to increase their production capacity and quality control measures is limited. Contract farming often offers farmers secure income and access to credits to afford their transition to climate-resilient and higher-value practices. The project will strengthen farmers' and other local value chain actors' capacities for climate-resilient and higher-value production and post-harvest quality control to expand contract farming arrangements that meet both parties' needs. The project will also ensure the necessary regulatory conditions and enforcement capacities (e.g., Law on the Management of Pesticides and Fertilizers, Seed Law, Agricultural Extension Policy, and operationalization of relevant certification schemes).
Retailers/ Restaurants/ Hotels	Natural Garden	Health food retailers/distributors like Natural Garden are still a novelty. This segment is, however, fast-growing due to increased public awareness of safe food and the recent introduction of the Law on Food Safety. Natural Garden supplies organic rice, vegetables, and fruits to over 80 hotels, restaurants, and supermarkets in the country. They also support small groups of farmers (over 70% women) through contract farming, extension

		services, and credit access. However, their direct sourcing and outreach capacities are limited. The seasonality and meeting the necessary volume of production remain a challenge. The project will expand the network of organic producers with the necessary extension services to address this challenge and increase farmers' access to market and income to incentivize climate-resilient and higher-value practices.
Microfinance lenders/ Agricultural Insurers		Microfinance and insurance providers like Agriculture and Rural Development Bank of Cambodia (ARDB) (although not fully a private bank), ACLEDA Bank, Angkor Microhenranhvatho Kampuchea (AMK) and Forte Insurance are leading financial institutions supporting Cambodian agriculture. Their current scope is mainly focused on rice production. Very few smallholder farmers and other small-scale local value chain actors are able to access their loan and insurance products as they lack the necessary collateral or guarantor. These institutions are eager to adopt a social and environmental management system to align with international financing standards. The project will work with these financial partners to increase the project beneficiaries' access to finance to accelerate their adoption of climate-resilient and higher-value practices and technologies through the FARM. For example, the FARM beneficiary groups may use the acquired assets and savings accumulated through the use of the assets as group collateral to increase their access to commercial lending and insurance products and services. The project will also coordinate with these partners to promote and establish a harmonized lending system that favors loan and investment applications with built-in climate de-risking measures. In addition, the project will contribute to the National Crop Insurance Program, led by MAFF, Forte Insurance, and others, by assessing the feasibility of developing insurance parameters for cashew, mango, and vegetable producers.

119. Through these potential partnerships, the PEARL project will promote several food safety, sustainability, and worker welfare certification schemes that are either currently operational (e.g., CamGAP, organic certification, GI, Hazard Analysis Critical Control Point (HACCP)) in Cambodia's food systems or have a potential (e.g., W+13) to provide market-based incentives for transition to higher-value and sustainable agriculture. Since these certification schemes primarily focus on ecological, social, and food safety aspects, the project will retool their certification requirements and processes to ensure that they operate as market enablers for climate-resilient agriculture. Concurrently, the project will also demonstrate and promote the adoption of climate-resilient and agroecologically sound farm management approaches at both the site-specific and landscape levels based on documented best practices and lessons learned through the on-going and past initiatives identified in Annex I. Operational linkages and knowledge sharing opportunities with the initiatives, described in Table 1 above, will also be demonstrated through these activities.

[13] A women-specific standard, measuring women's empowerment and giving a monetary value to results to provide financial resources to women. This certification scheme would particularly be applicable to women farmers involved in vegetable production under this project.

6. RELEVANT POLICY AND INSTITUTIONAL CONTEXTS

120. The above described result areas of the PEARL project are fully aligned with Cambodia's climate commitments and national and sectoral development priorities. There has been a proliferation of policies and strategies concerning climate change and agriculture in recent years, particularly with support from various development partners. Cambodia's Rectangular Strategy for Growth, Employment, Equity and Efficiency (Phase IV) (2018c), implemented by the National Strategic Development Plan (NSDP) 2019- 2023 (2018b), provides an overarching national development framework for these policies and strategies. This section provides a brief overview of relevant climate and sectoral policy instruments that underpin the PEARL project intervention.

6.1. Climate Change and Agriculture

6.1.1. Nationally Determined Contribution (NDC)

121. Cambodia's updated NDC (MoE, 2020b) to the Paris Agreement under the UNFCCC underscores agriculture's essential role in both mitigation and adaptation actions. The NDC brings particular attention to the need to increase the resilience of agriculture as it is one of the most affected and economically essential sectors on which a significant proportion of the country's population directly depends. The NDC highlights the expected negative impact of food systems, increasing the risk of food insecurity and malnutrition, particularly among vulnerable groups, including the poor, women, children and other social minorities. Concerns over how such impacts disproportionately affect female farmers' labor allocation and workload are emphasized to call for gender-responsive action and the need to collect gender-disaggregated data to better understand the effects of climate change on women in agriculture.

122. Out of the 58 priority adaptation actions identified in the updated NDC, 17 focus on agriculture (ibid.). Among such priority adaptation actions, the following ten priority actions are directly relevant to increasing the adaptive capacity of the NTSB through the promotion of climate-resilient and higher-value production of cashew, mango, organic rice, and leafy vegetables among smallholder farmers. For the agriculture sector, the NDC estimates the cost of climate change adaptation at USD 306 million, much of which is expected to come through international support.

- Development of Rice crops for increase production, improved quality-safety; harvesting and post harvesting technique and agro-business enhancement;
- Development of horticulture and other food crops for increase production, improved quality-safety; harvesting and post harvesting technique and agro-business enhancement;
- Development of industry crops for increase in production, improved quality-safety; harvesting and post harvesting technique and agro-business enhancement;
- Improvement of support services and capacity building to crop production resilient to climate change by promoting research, trials and up-scaling climate-smart farming systems that increase resilience to CC and extreme weather events;
- Research for the development and enhancement of agricultural productivity, quality, and transfer through strengthening of crop variety conservation and new crop variety release responding to the impacts of climate change;
- Development of new technologies and increased yields by using new crop varieties which adapt to climate change;

- Enhancing institutional and capacity development on climate change impact, vulnerability assessment, adaption measures and mitigation related to rubber sector;
- Strengthening capacities for risk prevention and reduction, effective emergency preparedness and response at all levels; enhancing livestock and disease-related early warning system, and integrating disaster risk reduction and climate change adaptation measures into recovery and rehabilitation initiatives in the livestock sector;
- Scaled up climate-resilient agricultural production through increased access to solar irrigation systems and other climate- resilient practices; and
- Developing a training manual and providing training on approaches for development of climate-smart and sustainable livelihood to rural poor people.

123. These climate change adaptation actions to increase the resilience of crop systems and agricultural livelihoods also deliver mitigation co-benefits, for instance, through the organic fertilizer and biogas production and improved land management practices for increased agroecological functions and crop suitability. The NDC calls for increased public-private partnerships (PPPs) to unlock private sector investment and promote technology transfer and a market-driven transition towards a climate-resilient and sustainable development pathway. The NDC also stresses the need for improved institutional arrangements and capacity among the MAFF, MOE, and MOWRAM through data collection, analysis, management, monitoring and reporting, ensuring an enabling regulatory environment for PPPs, and advancing the above priority adaptation actions (ibid).

124. The NDC contributes directly to the Cambodia Climate Change Strategic Plan (CCCSP) (2014), which builds on the NSDP and Rectangular Strategy IV.

6.1.2. National Adaptation Plan (NAP) Process

125. Cambodia's NAP process builds on the National Adaptation Programme of Action (NAPA) (2006) and identifies a lack of access to financial, technological, and human resources as the primary challenge and sets out medium and long-term adaptation goals in critically affected sectors, including agriculture and water resources and human health. The NAP process begun in 2014 to advance four key elements: 1) laying the groundwork, 2) working preparatory elements, 3) developing implementation strategies, and 4) setting up reporting and monitoring framework to place the adaptation to climate change at the center of policy agenda (GSSD, 2017). Together with the NDC, the NAP also contributes to NSDP and CCCSP.

6.1.3. Cambodia's GCF Country Programme

126. Building on its NAPA, NAP process, CCCSP, and sectoral climate change action plans, Cambodia's GCF Country Programme (2020a) identifies agriculture, water resources, infrastructure, forestry, health and coastal development as its priority investment areas for climate change adaptation. Agriculture and forestry are also considered key sectors for climate change mitigation. The Country Programme ranks the PEARL project as its top priority adaptation project. Establishing effective PPPs to leverage private investment for supporting adaptation actions is an essential strategy under the Country Programme. Cambodia currently has one Direct Access Entity (DAE), the National Committee for Sub-National Democratic Development Secretariat (NCDD). Increasing the number of DAEs in Cambodia is another priority. In this context, the ARDB is currently considered by the NDA for DAE nomination.

6.1.4. Climate Change Action Plan for Agriculture, Forestry and Fisheries Sector

127. Directly contributing to the CCCSP, the Climate Change Action Plan for Agriculture, Forestry and Fisheries Sector 2016-2020 (CCPAP-AFF) (MAFF, 2016) aims to develop appropriate institutional capacity and human resources in the sector to devise new and innovative technologies and measures. It also aims to increase farmers' awareness of climate-related risks and options and ensure that they have the necessary means to adopt climate-resilient technologies and measures to minimize their crop and livestock damage and loss. The CCPAP-AFF identifies strategic objectives in its sub-sectors - 1) food security and livelihoods; 2) plantation; 3) livestock; 4) forest management; and 5) fisheries – with actions to reduce their greenhouse gas emissions and increase their adaptive capacities to cope with increased floods, droughts, temperatures, and pest and diseases. For food security and livelihoods, priority actions include the promotion of sustainable farming systems and postharvest technologies, development of suitable crop variety and an information system of climate change impacts on agriculture and livelihoods, research and development of climate-smart technologies and techniques, capacity building of agricultural cooperatives and SMEs in climate-smart agriculture.

128. While the CCPAP-AFF sets out a comprehensive plan of action that sets ambitious targets, the less than 50% of the US$ 246 million required for the full implementation of the CCPAP-AFF was secured at the start of its implementation (ibid.). The sources of finance include the Secretariat Working Group on Agriculture, Forestry and Fisheries (SCAFF), government annual budget allocation, loans and grants from the World Bank, Asian Development Bank, and International Fund for Agricultural Development. Although various climate change funds through the United Nations and bilateral agencies also provide additional support, much more is still needed to close the current financial gap.

6.1.5. Cambodian Sustainable Development Goals (CSDGs) Framework (2016-2030)

129. Guided by the NSDP and Rectangular Strategy IV, the CSDGs Framework (2018a) sets out the country-specific targets and indicators to track and monitor its progress towards its 18 goals, adapted from the Global Sustainable Development Goals to meet specific goals national circumstances. The CSDGs particularly relevant to the proposed project include Goal 1 (no poverty), Goal 2 (zero hunger), Goal 5 (gender equality), Goal 13 (climate action), and Goal 15 (life on land). According to the Framework, the average rural poverty rate will be halved, the value of agricultural production per capita will be doubled, and public expenditure on climate actions will also be increased by one percentage point by 2030.

6.1.6. FAO's Country Programme Framework 2019-2023

130. Building on the RGC's national development, sectoral and climate priorities, as briefly described above, and the United Nations Development Assistance Framework (UNDAF) 2019 – 2023, combined with FAO's corporate strategic objectives on Better Environment and Asia-Pacific regional priorities on Accelerating sustainable natural resources management for biodiversity conservation and climate action, FAO in Cambodia aims to achieve three key outcomes:

- Enhanced agricultural productivity, diversification and commercialization, and safe and nutrition-sensitive food systems for poverty reduction and food and nutrition security.
- Equitable and sustainable management of natural resources, and increased capacity to monitor and report climate action.
- Reduction of vulnerability, and improved resilience to climate change and shocks at national, community and household level.

131. The PEARL project contributes to the delivery of these outcomes, for example, by 1) promoting organic agriculture, GAP, and GI and innovative, inclusive, and gender-responsive practices, guided by relevant best

practices and lessons-learned, under Outcome 1, 2) restoring and protecting critical catchments and agroecological functions and connectivity through an equitable approach under Outcome 2, and 3) increasing the resilience and adaptive capacity of vulnerable farmers and other value chain actors through improved access to highly tailored climate risk information, adaptive knowledge, finance and technologies under Outcome 3.

6.2. Environmental Conservation and Agriculture

132. The National Biodiversity Strategy and Action Plan (NBSAP) (2016) underscores the uniquely important role of agriculture in the maintenance and restoration of ecosystem services and biological diversity. Agriculture is described as one of the critical vehicles for promoting biodiversity conservation and ecosystems restoration and addressing factors that lead to habitat loss and degradation (ibid.). Agriculture is also one of the main drivers of deforestation and forest degradation through encroachment and converting forests into cropland, as described in the National REDD+ Strategy (2017). The issue of deforestation and forest degradation is particularly pronounced in the NTSB due to rapid changes in land use for agricultural expansion through economic land concessions (ELCs) (Forest Trends, 2015).

133. Given the sector's critical role in the country's economy, actions within the sector require careful consideration, as they have a significant bearing on the sector's ecological sustainability and the socio-economic wellbeing of rural populations, both of which are necessary enabling conditions for successfully adapting the sector to climate change (NCSD, 2016; RGC, 2018c). From this perspective, both the Agricultural Sector Strategic Development Plan (ASDP) (2015) and CCPAP-AFF call for actions to promote low emission agriculture through sustainable natural resources management at both on-farm and landscape levels and adopt climate-smart practices across value chains to reduce the vulnerability of the country's food systems and rural agricultural communities.

134. Such strategic directions, however, face a number of challenges on the ground. The Law on the Management of Pesticides and Fertilizers (2012) is meant to regulate agrochemicals and ensures that all farmers have access to quality pesticides and fertilizers with labels and instructions in the Khmer language. Nonetheless, counterfeit and poor quality agrochemical products with the labelling and instructions provided in foreign languages flood the market, and neither farmers nor sellers are trained to use these products (Duong and Khin, 2016). This highlights not only the issue of enforcement but also challenges the country face in ensuring intersectoral coordination, for instance, to tighten the import licensing and customs procedures to increase control (ibid.). Furthermore, elevated efforts to institutionalize the National IPM Program and CamGAP across the food systems are needed to increase farmers' and local suppliers' awareness and knowledge of appropriate agrochemical application (e.g., 4Rs -right source, rate, time and place) and agroecological and market benefits of alternative practices such as organic production.

135. In order to build a successful model for climate-resilient and sustainable agriculture, increased efforts and commitments at all levels are needed to improve public awareness, increase public and private investment and technology transfer, and strengthen law enforcement and institutional coordination across the government.

6.3. Agricultural Production and Socioeconomic Development

136. The ASDP and CCPAP-AFF are designed to operationalize sector-specific policies and laws to support agricultural development through climate-proofing, diversification and commercialization. As with the Law on

the Management of Pesticides and Fertilizers, the implementation and enforcement of these policies and laws (Box 3) remain a challenge, mainly due to lack of financial and human resources as well as of horizontal and vertical coordination across levels of government (Kula, Turner and Sar, 2015; Duong and Khin, 2016; Burn et al., 2018).

Box 3: Relevant Sectoral Laws and Policies (non-comprehensive list)

Seed Law (2009) ensures that the seeds distributed in the domestic market are of good quality, and their intellectual property rights are protected. The law stipulates laboratory or field testing of seeds that is guided by the MAFF; however, there are significant limitations in the enforcement of this stipulation to provide farmers easy access to quality seeds, which significantly affects the productivity of farmers, particularly smallholders with limited resources.

Strategy for the Improvement of the Agricultural Market Information Service (2006) aims to establish a fully developed Agricultural Market Information Service that makes time-sensitive market information available to farmers and other value chain actors to aid their decision-making in agricultural production and processing to increase their market competitiveness. However, this system has been hampered by a lack of data sources and irregular data supply and quality as it depends on private partners who have been provided with limited incentives. The awareness of such a system among end-users has also been limited.

Agricultural Extension Policy (2015) ensures that farmers and farming communities have access to extension services that help enhance their agricultural productivity and ensure ecologically-sound, climate-resilient and socially just practices that contribute to the sustainable development of the country. However, mainly due to resource constraints, among other factors, such services are often not fully operational or unavailable to farmers.

Sub-decree on Contract Farming (2011) sets the scope and basic rules of contract farming to ensure the benefits of farmers and contractors. It recognizes the mutually beneficial relationship between the two groups of actors in well-managed contract farming arrangements, especially as they provide a significant production risk buffer for smallholder farmers while providing cost-savings for contractors.

Law on Agricultural Cooperatives (2013) promotes, guides and regulates organizations of Cambodians whose primary occupations deal with agricultural production systems, agro-industries, agribusinesses and agricultural-related services. ACs and FAs provide essential social platforms on which to build effective contract farming arrangements and provide agricultural extension services.

Source: Duong and Khin (2016)

137. As a result, farmers are often not even aware of such laws and policies, and the anticipated benefits of these instruments remain primarily on paper. The interviews and focus group discussions (Kono and Chey, 2017) revealed that the farmers generally felt that support from the government, particularly through extension services, was limited or non-existent. The recent agricultural census (2019) also indicates similar findings.

7. OUTCOME ONE: FARMERS' CAPACITIES ARE ENHANCED TO MANAGE CLIMATE IMPACTS AND RELATED DISASTER RISKS

138. This outcome will provide farmers and local communities with access to tailored and crop-specific agrometeorological advisory services. The outcome will also increase the awareness of climate risks among farmers and other local value chain actors to enhance their ability to identify and manage climate-related risks and vulnerabilities concerning their agricultural production, processing, and livelihoods. Generating and disseminating agrometeorological information will foster co-production of services across relevant institutions, particularly the MAFF and MoWRAM, and incorporate various data sets, including weather forecasts, seasonal forecasts, crop calendars, crop production, and harvest information, and pest and disease information. Concurrently, this outcome will also systematically strengthen the capacity of agricultural extension services in both the public and private sectors and develop effective public and private partnerships to ensure the effective dissemination of agrometeorological advisory information through increased and extended outreach capacities.

7.1. Baseline Conditions – Agrometeorological Services

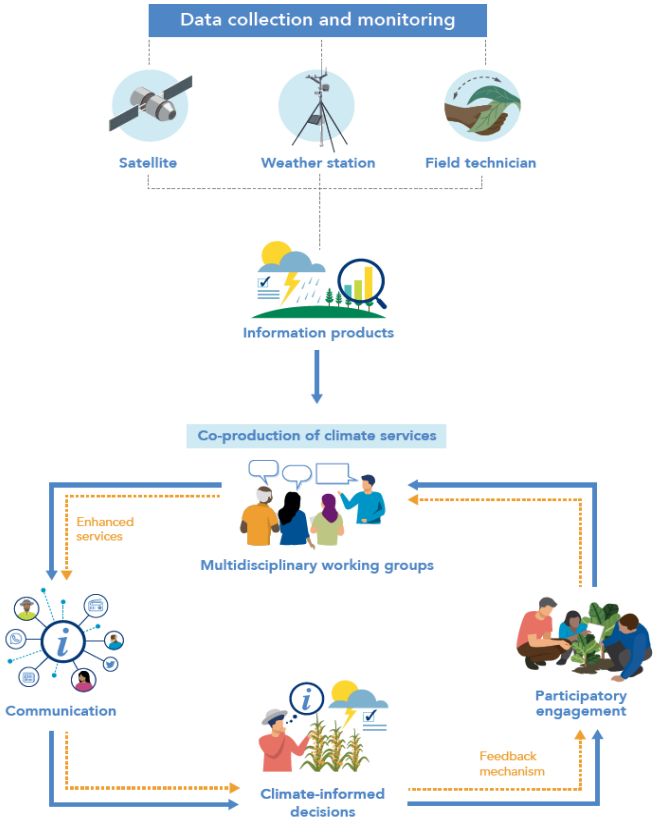
139. Climate services involve the production, translation, transfer, and use of climate knowledge and information for climate-informed decision-making, including at the farm level. Key attributes for effective climate services to meet the needs of users include timeliness, accessibility, dependability, usability and equity. Some of the main barriers to the effective and equitable communication of climate services are the lack of national capacity for communication, lack of client-driven tailoring of services, insufficient translation of relevant services into actionable products, and limited engagement with other actors involved in agricultural value chains (private and public).

140. Cambodia has undertaken various initiatives to increase agrometeorological service capacity through multiple projects over the last decade. These efforts include building weather and agriculture infrastructure and improving agrometeorological forecasting skills in collaboration with development partners such as World Bank, United Nations Development Programme (UNDP), Asian Development Bank (ADB), the United Nations Office for Disaster Risk Reduction (UNDRR), the World Meteorological Organization (WMO) with financial support from the Global Facility for Disaster Reduction and Recovery (GFDRR), Association of Southeast Asian Nations (ASEAN), Sub-Committee on Meteorology and Geophysics (SCMG), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) Germany, Regional Integrated Multi-hazard early Warning System for Africa and Asia (RIMES), Japan International Cooperation Agency (JICA), and Japan Meteorological Agency (JMA).

141. Developing effective climate services for agricultural users is an interdisciplinary process that involves many steps and actors. The general process should be tailored to the local context and to the needs and preferences of the intended users. Another major challenge is the communication and uptake of climate-informed advisories and early warnings. To become a service, a climate product needs to be deemed useful by the user. This requires appropriately testing and validating the services to ensure that they enhance decision-making. Addressing the wide variety of user needs is beyond the capacity of any single organization. It calls for major collaboration between the public and private sector, research institutions and agricultural communities.

142. The framework put forward in Figure 31 from FAO's Global Outlook on Climate Services in Agriculture (FAO, 2021) highlights key steps for the effective provision of climate services, which are fulfilled by various actors depending on the local context. It is important to highlight the gaps at any stage of the framework will jeopardize efforts to develop services that are effectively delivered and applied by intended users. Every aspect of the climate services framework must be strengthened to ensure that the last mile barrier is overcome, and that information can lead to strategic agricultural decision-making.

Figure 31 Value chain for an effective provision of climate services

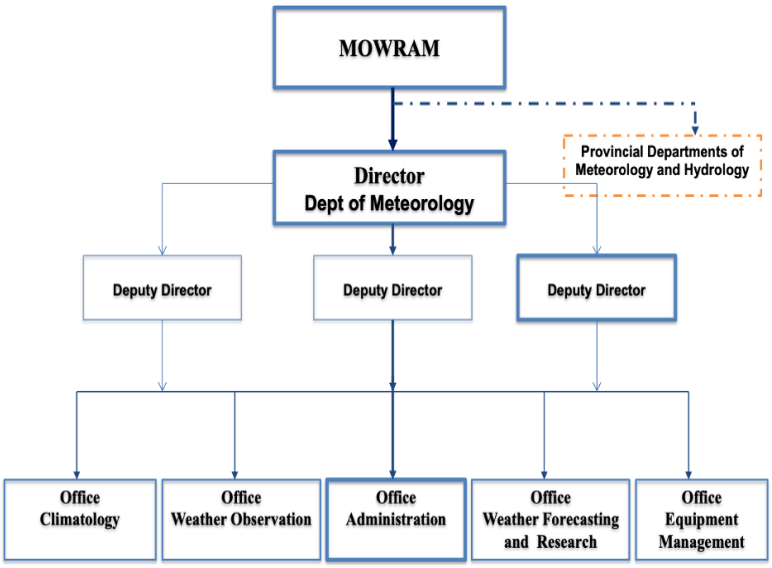


143. It is evident that in Cambodia, current efforts and investments are focused on the first stages of the climate services framework, toward the monitoring and production of information products but far fewer investments are focused toward the later stages of the framework, or the "last mile", which focuses on the tailoring, dissemination and uptake of climate services for farmers (see Table 6 in the previous section). The below summary outlines the current capacities in Cambodia for climate services and highlights how the PEARL project will invest in aspects of the framework that are currently weak and require investment.

7.1.1. Meteorological and Hydrometeorological Capacities

144. The DoM (Department of Meteorology) under the Ministry of Water Resources and Meteorology (MoWRAM) is the provider of weather and climate information services for Cambodia, responsible for meteorological data management, weather forecasts and extreme warnings, and seasonal climate forecasts. The structure of DoM is presented in Figure 32 below, and the institution reported 47 staff members at headquarters in Phnom Penh and 50 meteorological staff in provincial centers.

Figure 32: Structure of DoM and main offices.



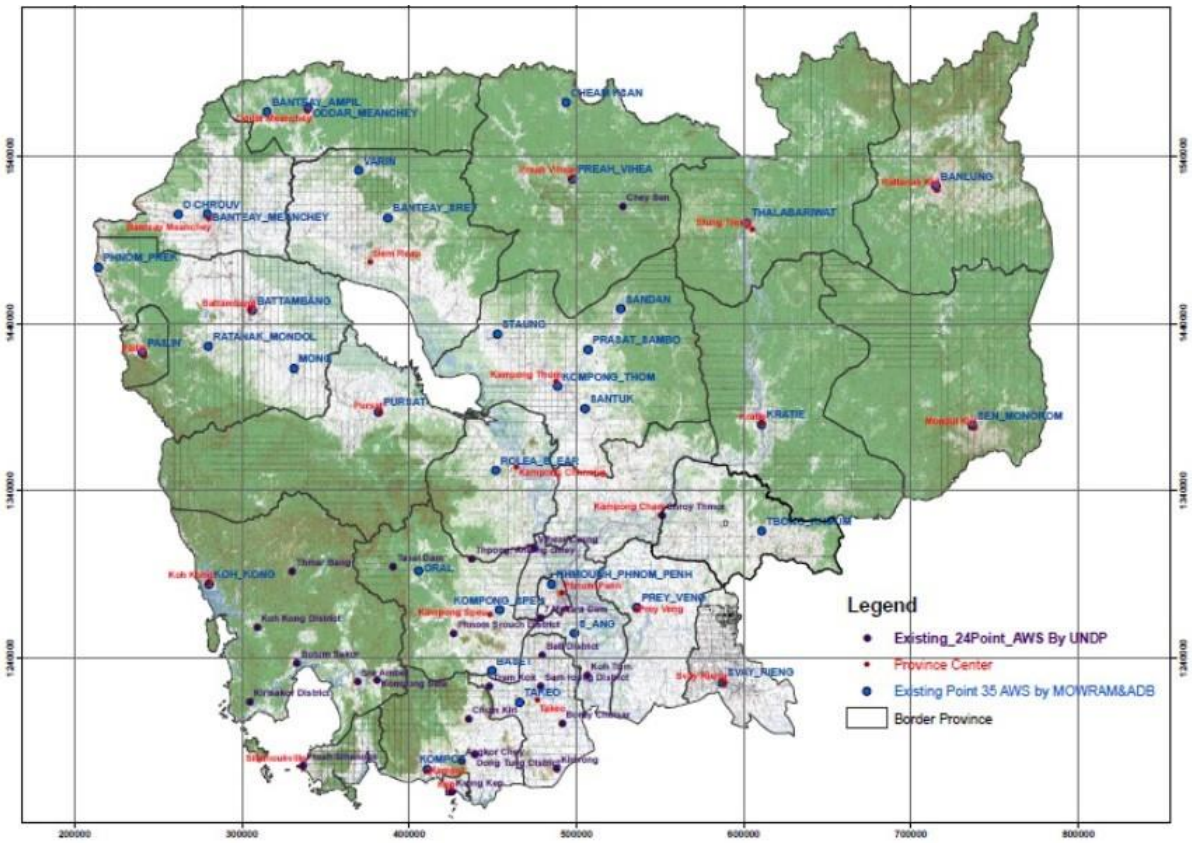
145. Through the website (http://www.cambodiameteo.com/), DoM provides six- hourly weather forecasts of maximum and minimum air temperature, rainfall probability, relative humidity, wind speed, and cloud cover over the next three days with an update frequency of once a day. The six-hourly weather forecasts are produced from the Synergy System of Meteo-France, JMA, RIMES and WMO Regional Association II climate centres. In addition, daily weather forecasts include forecasts of maximum/minimum air temperature, rainfall probability, and cloud cover over the next seven days. Both six-hourly and daily weather forecasts have a spatial resolution of province level. Probabilistic seasonal forecasts for the next three months are issued based on the South Asian Climate Outlook Frum (SASCOF) consensus on regional seasonal forecasts. DoM issues seasonal forecasts for temperature and rainfall variables once a month at the provincial level, but they have not been translated into agriculturally relevant information for the end-users (Seak, 2022).

Table 8: Automatic weather stations in project area, province and funding source.

No	AWS Name	Location	Coor_X	Coor_Y	Date Installation	Province	Fund By
1	Samraong	PDOWRAM	339535	1569404	7/5/2014	Oudar Mean Chey	MoWRAM
2	Banteay Ampil	District office	315261	1566632	6/20/2015	Oudar Mean Chey	ADB
3	Choam Ksan	District office	493926	1572057	6/24/2015	Preah Vihear	MoWRAM
4	Preah Vihear	PDMOWRAM	370114	1531450	7/23/2014	Preah Vihear	MoWRAM
5	Chey Sen	District office	493807	1520292	5/29/2018	Preah Vihear	MoWRAM
6	Varin	District office	370131	1531452	6/21/2015	Siem Reap	ADB
7	Banteay Srey	District office	388092	1503450	6/2/2015	Siem Reap	ADB
8	Kompong Thom	PDMOWRAM	488838	1402335	7/23/2014	Kampong Thom	MoWRAM
9	Sandan	District office	526546	1448717	6/24/2015	Kampong Thom	ADB
10	Prasat Sambo	District office	507009	1424278	10/2/2015	Kampong Thom	ADB
11	Santuk	District office	505220	1388954	8/24/2016	Kampong Thom	ADB
12	Staung	District office	467936	141417	7/30/2016	Kampongg Thom	ADB

146. DoM operates 25 manual weather stations (MWS) and 59 automated weather stations (AWS) (Figure 33). Of these stations, 11 MWSs have more than 20 years of climate records as of the year 2020. Table 8 shows the location, date installed and funding source of the 12 stations in the PEARL project area. Weather data from 25 MWSs are collected every day through phone calls to the stations. Spatial density of all available weather stations (MWSs + AWSs) is 46 km resolution (84 stations/181,035 km2 of total land area or 1/2,155 km2) and all transmit data to a central database of DoM at least once a day. The spatial density of climate stations with more than 20 years of climate data is 128 km (11 stations). Weather and climate data of DoM is accessible upon payment (Table 9).

Figure 33: MoWRAM observational network of stations including provincial centers



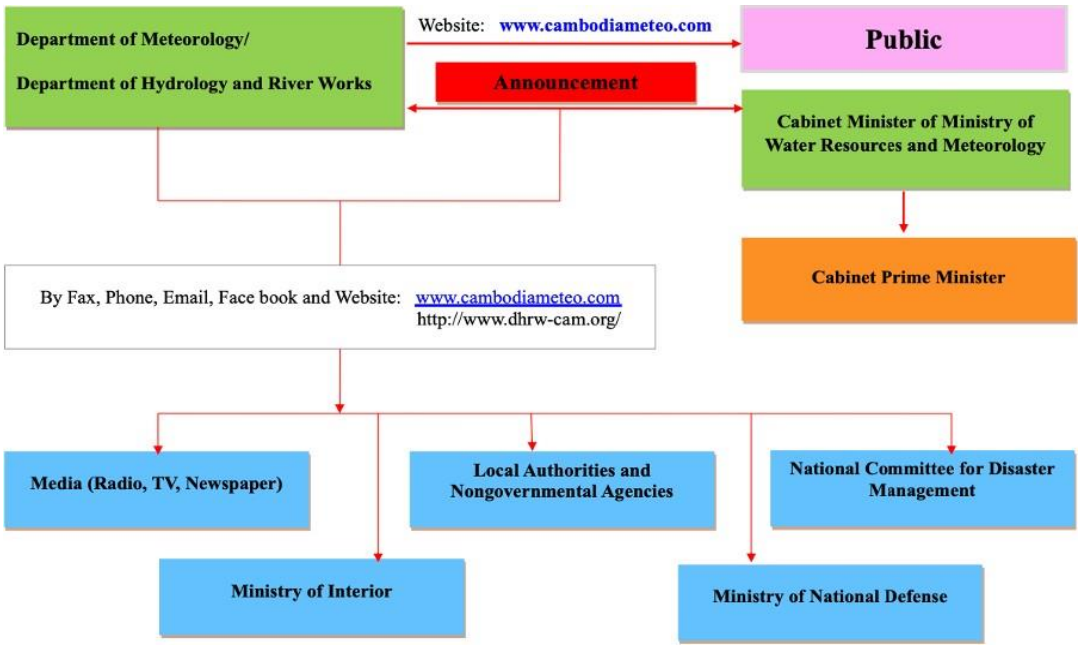
147. Current equipment was purchased by MoWRAM by hiring technical support from international company, namely Sutron Corporation, USA and some works handover to local company as subcontractor with MoWRAM technical officers' cooperation. To date, 70 AWS have been installation in whole country, 60% of AWS using Sutron product and the remaining, product of Germany, Korean, and Japan under various projects.

Table 9: Summary table of meteorological capacities for forecasting, observation and agricultural meteorology. Source: FAO, 2021b.

METEOROLOGICAL FACTORS		CAPACITIES
Weather Forecast	Numerical weather prediction model-based forecasts	NWPs from international centres
	Lead time of weather forecast	7 days
	Weather forecast spatial resolution (grid-size)	12 km
Seasonal Forecast	Probabilistic or deterministic forecasts	Probabilistic tercile
	Seasonal forecast resolution (temporal/spatial)	3 month/Province
	Forecast update frequency	Seasonal
Observation Stations	Weather station density	Monitoring:46km/Climate:128km
	Climate data sharing policy	Payment basis
Agromet structure	Agromet sub-structure (division or section) or designated staff in NMS	None

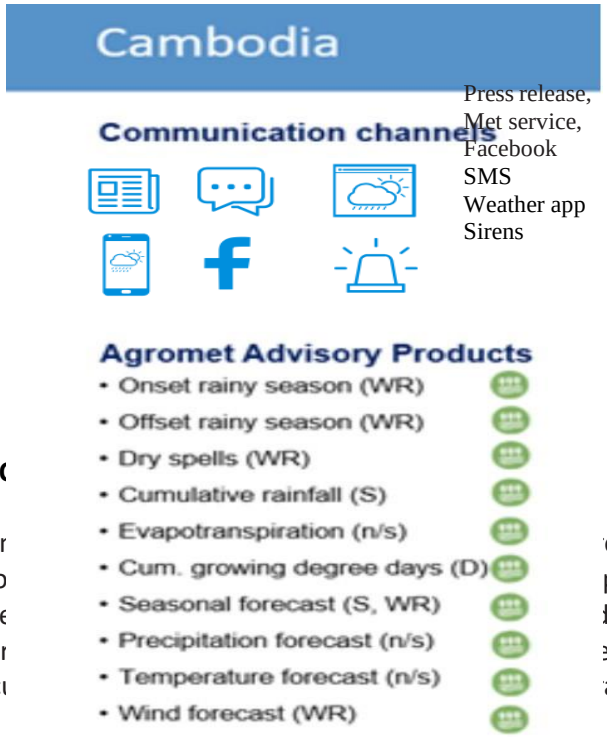
148. In terms of collaboration and coordination of MoWRAM products to other entities or the public, there are various challenges. Currently, the climate data sharing policy for MoWRM is on a payment basis, creating difficulty for others to receive and use data. Currently, the institution do es not have an agrometeorological substructure or any designated staff working on agriculture, and are not collaborating with MAFF in a systematic way. With regards to communication of products, MoWRM presents the below structure for the flow of information to the public and external users (Figure 34).

Figure 34 *Flow of meteorological products to public, ministries, media andothers (MoWRAM presentation)*



149. Based on surveys prepared by FAO and completed by MoWRAM, Figure 35 illustrates the available communication channels for the delivery of services as well as the main productsprepared by MoWRAM relevant for agricultural activities.

Figure 35 Survey results from Cambodia's MoWRAM on deliverymechanisms and agrometeorological advisory products prepared by the institution . Source: FAO, 2021



7.1.2. Agricultural Data C

150. The Department of Plannir estry and Fisheries (MAFF) maintains provincial level cro ple crops. No official crop calendars are available, but pre l sites for baseline analysis. Cambodian Agricultural Resear experimental plots for crop monitoring as a national agricı al data upon request from

collaborating projects. CARDI is anational agricultural research institute under MAFF. CARDI has actively involved in multiple international projects for agrometeorological data, research, or services development. Although it is scattered among different departments, CARDI is equipped with necessary capacities required for agrometeorological services.

151. The Department of Extension for Agriculture, Forestry and Fisheries (DEAFF) is responsible for managing Cambodia's extension and advisory services, with a vertical extension service structure from DEAFF to provincial departments of agriculture, forestry, and fisheries (PDAFF), District Agriculture Office, and Commune Agriculture Center. The Royal University of Agricultureis the potential institution for the technical and scientific support of agrometeorological services. No other regular crop monitoring is taking place. There is no information found for the national level soil profiles digitized in a GIS format (FAO, 2021b).

Figure 36 Crop and pest/disease monitoring capacities of key agricultural institutions. Source: FAO, 2021b

AGRICULTURAL FACTORS		CAPACITIES
Crop production/ harvested area	Spatial resolution of the data	Province
	Data collection frequency and available period	Annual, but no available period information
	Crops for which the crop production/ harvested area data are available	Multiple crops
Crop calendar	Crops for which a crop calendar is available	[From projects] Major crops
	Spatial resolution of the crop calendar data	[From projects] Livelihood zones
Technical or research institutes/ university	National agriculture research institutes that can technically support agromet services	CARDI
	Local universities that can support agromet research and development	Royal University of Agriculture
Extension services	Extension service system from national to local	DEAFF–PDAFF–DAO
Crop and pest & disease monitoring	Crop monitoring system	[From projects] Irregular monitoring
	Spatial resolution for crop monitoring	[From projects] Pilot sites only
	Pest and disease monitoring and reporting system	Irregular monitoring and hardcopy records of historical reporting

152. At a regional level, various programmes and investments also provide relevant information available online or through specialized databases or platforms. Key regional sources of relevant information for Cambodia include:

- Regional Drought and Crop Yield Information Service (RDCYIS). This service provides comprehensive drought monitoring and forecasting models, plus crop yield information, to assist local governments and agricultural sector with seasonal drought forecasting and in implementing short and long term mitigation measures during and in advance of droughts.

- As part of the Regional Integrated Multi-hazard early Warning System for Africa and Asia (RIMES), there is the Specialized Expert System for Agro-Meteorological Early Warning (SESAME) https://www.adaptation-undp.org/sites/default/files/resources/5._annex_4._sesame_guide_for_cambodia.pdf

- Mekong Drought and Crop Watch. Is an integrated web-based information system that is intend- ed to (i) improve the operational, technological, and institutional capabilities to prepare for and respond to droughts in the Lower Mekong region; (ii) support local decision-makers in drought monitoring, analysis, and forecasting (iii) provide policymakers and growers with current and forecast drought indices to facilitate decision-making within the current growing season; (iv) provide ecological and financial forecasting information to inform seasonal cropping seasons. https://mdcw-servir.adpc.net/home/

7.1.3. Pests and diseases capacities

153. Hardcopy records for major pest and disease outbreaks in the Department of Plant Protection Sanitary and Phytosanitary (DPPSP), General Directorate of Agriculture (GDA) of MAFF. However, pest and disease data have not been collected in a systematic way by the responsible governmental entities for various reasons. This includes lack of a standard data template for collecting data (e.g., data types, temporal scale, crop loss, metadata, etc.), lack of the capacity for data analysis and interpretation (e.g., analyzing pest/disease data with corresponding weather and crop data), and traditional data collection methods (manual on paper). Investment and uptake of ICT tools, such as tablets or other smartphone-type devices, are required for efficient and effective data collection in the field. Uptake of the use of a standard data template (e.g., data types, temporal scale, crop loss, metadata) and capacity building in data collection and analysis is required in the region.

154. There is a governmental reporting system for pest and disease outbreaks established from district (or commune) to PDAFF and finally to DPPSP. Real time monitoring for pests and diseases are taking place by district agricultural officers or commune extension workers, but only significant outbreaks are reported to higher government entities. There seems to be no standardized reporting or digitization procedures in place, thus many of the hardcopy reports are periodically missing or damaged.

155. There are very low technical and institutional capacities for pest and disease prediction, monitoring, diagnosis, and control. Prediction takes place based on the crop calendar and past seasonal occurrence of major pests and diseases. There is no modelling-based (statistical/ empirical/ process-based) prediction and surveillance taking place in Cambodia. Diagnosis is primarily based on actual symptoms or sign observations. Upon identification of a pest or a disease, local-specific control measures are recommended to farmers by the extension officers. Investment in pilot programmes for pest and disease modelling and research would benefit the lead time for action on pest and diseases and potential for IPM.

156. There are various efforts to promote awareness and application of pest management and IPM through DPPSP, MAFF, International Rice Research Institute (IRRI) and others. Farmer Field Schools (FFSs) have been established in Cambodia and there are efforts to establish a hotline for consultation on issues around pest and diseases. Key actors have identified a need for further capacity development in this area as well as more investment in the monitoring and management of rice pest and diseases.

7.1.4. Capacities to produce and disseminate agrometeorological bulletins

157. Recently, the Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME) system that is capable of agro-advisory generation was developed in Cambodia by RIMES. However, no agrometeorological bulletin has been produced yet from the SESAME. DeRisk SE Asia (https://deriskseasia.org/) project is also attempting the development of agrometeorological bulletins targeting the upcoming wet season of 2021 in the Battambang and Kampong Speu provinces. The FAO Agrometeorological Programme developed a monthly agrometeorological bulletin for selectprovinces (Seak, 2022). The monthly agrometeorological bulletin contains the following contents:

- Past/present meteorological information: Daily maximum/minimum air temperature and rainfall estimates over the last month are extracted from satellite remotely sensed data and weather models and are presented on the graph. Monthly rainfall and maximum/minimum average temperatures are compared with historical climatology for 1997-2019.

- Past/present agricultural information: Monitoring summary from crop fields provide crop, pests and diseases assessments with current crop phenological stages and any pests and diseases occurrences with general advisories for control measures. Selected pests and diseases are monitored and the incidence or infestation levels are reported on the bulletin.

- Future meteorological information: Descriptive three-day weather forecasts for maximum/minimum air temperatures are provided and compared with the climatological temperature range to estimate possible anomaly conditions over the next three days.

- Future agricultural information: Considering the three-day weather forecasts, management advisories for reported or forecasted pest and disease epidemics are provided.

158. To date, work on the production and dissemination of agrometeorological bulletins remains mainly with support from investment projects and there is little national sustainability and ownership of the process

Table 10 Agrometeorological bulletin services and sustainability in Cambodia. Source: FAO, 2021b

AGRICULTURAL FACTORS		CAPACITIES
Agromet services (bulletins)	Temporal and spatial resolution of the existing agromet services	[From projects] Monthly for 3 pilot sites
	Spatial resolution of the agro-advisories on the agromet services	[From projects] Site-specific advisory
	Existence of four basic components of agromet bulletin	[From projects] 4 components
	Dissemination method	[From projects] paper/email
Agromet service production	Agromet service working group	[From projects] Technical Working Group (CARDI, MAFF)
	Meeting frequency of the working group for agromet service production	[From projects] Monthly meeting
	Financial support for agromet service production	[From projects] Project-financed
Self-sustainability	Self-sustainability of agromet services after the FAO Regional Agromet Programme	None

(Table 10). The institutional sustainability is essential to effectively support farmers in a lasting and meaningful way.

7.1.5. Major Challenges and Recommendations to Overcome Last Mile Barrier to Climate Services in Cambodia

159. Against the framework of climate services, a capacity need assessment in four capacity areas – 1) meteorological and hydrometeorological forecasting; 2) agricultural data; 3) pest and disease forecasting; and 4) outreach and agrometeorological information dissemination – was conducted during the project preparation stage (see Annex 2). The assessment findings suggest challenges and recommend actions in seven critical areas under the climate service framework as seen in Table 11.

Table 11: Major challenges and recommendations to overcome last mile barrier to climate services in Cambodia

Climate services framework	Major challenges	Recommendations for investment
1. Data collection, monitoring and forecasting	• Insufficient observational network (automated and manual) with essential meteorological and agrometeorological variables required for developing agrometeorological services. • Weak technical capacity for data storage.	• Rehabilitate existing weather stations and procure additional stations in NTSB. • Support technical capacity for the maintenance of weather stations and data collection. • Upgrade the forecasting capabilities by improving the access and use of global and regional datasets, products and tools. • Develop dynamic cropping calendars that integrate forecasted precipitation patterns with sufficient time for farmers to adjust their planting dates. • Support agricultural institutions (i.e., MAFF, CARDI and Royal University of Agriculture) with tools and technical capacity for monitoring and digitalization of agriculture data
2. Data sharing and coordination of relevant agencies	• Lack of coordinated and digitalized collection of agriculture and pest/disease data through agricultural ministries (e.g., MAFF, CARDI and Royal University of Agriculture) and research institutions. • No coordinated database or mechanism for data sharing between institutions. • Limited technical, financial, and human resources available to support national staff to collaborate and regularly meet as task force (i.e., Technical Working Group led by MAFF and MoWRAM). • Lack of incentive for collaboration and data sharing. • Insufficient access to necessary technologies for digital and online data collection and sharing. • Data sharing on a payment basis.	• Invest in further strengthening of existing agrometeorological technical working group and support national institutions to join regular meetings. • Strengthen governance arrangements and formalized agreements, including coordination and communication mechanisms within MoWRAM and stakeholders across sectors. • Invest in data collection technologies that facilitate digitalization (tablets, handheld devices) and development of national databases where information can be shared easily between relevant institutions.

3. Co-production of tailored agrometeorological advisories	• Lack of mechanisms for exchange of information among key stakeholders (including private sector, ACs, FAs, etc.). • Lack of standard operating procedures for the coordination and co-production of agrometeorological services by multiple stakeholders. • Weak collaboration or communication between MAFF, MoWRM and other key institutions.	• Prepare concrete national road maps towards strengthening and operationalizing agrometeorological services. • Develop a standardized national framework for data collection, sharing, analysis, translation into actionable services, and last-mile communication processes is systematically documented. • Support sensitization workshops and training sessions to encourage dialogue and bring together key actors, including farmers and end-users.
4. Communication of services to the last mile	• Challenges related to translating climate and agronomic information. • Inadequate means for communicating the information. • Lack of understanding of how farmers in NTSB are accessing information or ICT used.	• Invest in surveys and information collection from farmers and target users to better understand how they prefer to receive information (communication means, format etc.). • Invest in development of products and ICT means based on the needs assessment of farmers. • Establish an effective two-way communication and timely data collection and sharing between information providers and users. • Build the capacity of smallholder farmers, women, poor and socially marginalized groups to use ICT tools.
5. Participatory engagement of last mile	• Lack of awareness of climate and agronomic information generated by MoWRAM, MAFF and other national institutions. • Lack of effective two-way communication between agrometeorological services providers and users	• Promote participatory approaches such as the Participatory Integrated Climate Services for Agriculture (PICSA) approach or FAO Farmer Field Schools (FFSs) to ensure information uptake. • Invest in focused training or FFSs on IPM. • Support participatory scenario planning processes consisting of different interactive and iterative learning processes. • Invest in pilot programs or community outreach initiatives to engage farmers with agrometeorological services. • Financially support the engagement of farmers and end-users in national tasks forces for service production.
6. Climate-informed actions	• Insufficient resources to apply climate informed recommendations even if information is available (e.g., irrigation or land preparation capacity) • Lack of access by farming communities to forecasting information that is translated into actionable climate-resilient advice tailored to the type of production (i.e., for cashew, mango, organic rice, and vegetables). • Lack of timely climate information to the last mile, as it usually reaches households too late to make decisions (e.g., planting and harvesting dates). • Lack of extension or advisory support on how to implement climate information actions.	• Invest in the translation of agrometeorological data into services specific to target crops and relevant for climate sensitive periods of crop production for cashew, mango, organic rice and vegetables. • Support FAs, ACs, and extension services to support farmers with understanding of how to implement climate informed actions. • Through support to FAs and ACs, increase farmers resources and access to necessary equipment, information and financial services, including risk finance products (i.e., insurance) to implement recommended actions.

7.2. Suggested Output and Actions under Outcome 1

160. **Availability and access to agrometeorological advisory services tailored to target value chains improved among smallholder farmers and local value chain actors, particularly women farmers and value chain actors (Output 1.1):** Based on the above recommendations, this output will deliver an improved system of agrometeorological advisory services that are tailored to the project's target crops in these seven critical areas. Meanwhile, those recommendations that are linked to particular risk mitigation options through farm management practices and resource access will be implemented under Outcome 2.

161. This output will benefit a total of 450,000 smallholder farmers (40-60% women) in the NTSB involved in the target value chains over the project lifetime. Furthermore, a total of nearly 1,000 public and private extension providers, including NGOs, will be trained under this output. The output will be implemented under the joint leadership of MoWRAM and MAFF with technical support from FAO Cambodia.

Activities, Descriptions and Sub-Activities
Activity 1.1.1: Increase the spatial scale of agrometeorological data collection and capacity for data processing to produce enhanced agrometeorological forecasts and advisory services tailored for target value chain crops. **Description:** Upgraded agrometeorological data collection and processing capacities will enable an analysis of real-time weather and climate information, seasonal forecasts, historical records, crop parameters, soil moisture and temperatures, and pest and disease characteristics through relevant methodologies to provide crop-specific warnings and advisory services. • Sub-activity 1.1.1.1: Mobilize the TWG-AW to review baseline conditions and capacity and data gaps to validate the priority stations for additional sensor upgrades, strategic locations for adding new agrometeorological stations, and training needs. • Sub-activity 1.1.1.2: Upgrade existing hardware and software at the selected priority stations and install new agrometeorological stations. • Sub-activities 1.1.1.3: Design and roll out an annual training program for station managers, data analysts, and system administrators.
Activity 1.1.2: Develop SOPs for the production and dissemination of agrometeorological advisory services and data sharing needs and architecture, targeting cashew, mango, rice, and vegetables through a variety of mediums. **Description:** Crop-specific SOPs will allow farmers to grow, harvest and store the target crops and other local value chain actors to anticipate yields and processing volumes with reliable information and consistent advisory services to make the target value chains less vulnerable to climate change. The SOPs will ensure coordination among public and private extension services and provide highly tailored information through multiple mediums. The SOPs will be placed under the existing SOP for general hydrometeorological advisory services, developed by the regional FAO project and the University of Queensland and WMO project, to provide highly tailored information. The SOPs will also consider strategies to reduce food loss along each value chain. • Sub-activity 1.1.2.1: Mobilize the TWG -AW with additional stakeholders to develop the SOPs for the production and dissemination of crop-specific agrometeorological advisory information. • Sub-activity 1.1.2.2: Establish a central database based on harmonized data management and sharing agreements under the SOPs with dedicated information dissemination and outreach mediums (e.g., web platform hosted by MAFF, mobile apps (i.e., Tonle Sap App, Chamkar and EcoKasksekor), social media channels, TV and radio programs, community bulletins, community speakers, FFS curricula, and private advisory services through contract farming and input supply sales). • Sub-activity 1.1.2.3: Conduct annual training of extension officers from PDAFF, PDoWRAM, PDoC, PCDM and district administration, commune and village extension agents, and private extension providers, including NGOs on the SOPs.

Activity 1.1.3: Increase awareness of agrometeorological advisory services and the benefits of the application in farm management and value addition activities to support decision-making and reduce smallholder farmers and other local value chain actors' vulnerabilities to climate change, particularly women farmers and value chain actors.

Description: Increased awareness of available services and their application among smallholder farmers and other local value chain actors will effectively reduce their climate vulnerabilities in agricultural production and processing. Increased service demand and user feedback will also create an enabling environment for progressively improving service quality and options.

- Sub-activity 1.1.3.1: Prepare and roll out training of trainer (TOT) curricula through FFS to raise awareness of advisory services and promote the application of agrometeorological advisory services among smallholder farmers and other local value chain actors.
- Sub-activity 1.1.3.2: Support peer-to-peer knowledge sharing and training to further promote advisory services among other members of targeted ACs, FAs, PGs, CPAs, CFs, and agricultural unions with their respective TOT-trained representatives.

8. OUTCOME TWO: ADAPTIVE CAPACITIES INCREASED

162. This outcome is delivered through four distinct but interdependent outputs – 1) Increased premium market access through agricultural certification programs; 2) Increased access to finance and climate-resilient and high-value technologies for vulnerable farmers and value chain actors; 3) Demonstration and promotion of climate-resilient, high-value and sustainable agricultural practices and technologies; and 4) Improved agroecological functions at the landscape level.

163. This outcome will target approximately 124 ACs, FAs, PGs, CPAs, CFs, and agricultural unions, translating to roughly 24,000 farmers and other local value chain actors involved in the target value chains over the project lifetime. The selection of the CPAs and CFs based on specific catchment restoration and protection criteria is presented under Output 2.4. The selection of the ACs, FAs, PGs, and agricultural unions will be finalized at the project's inception based on criteria, including their ambition and potential to adopt climate-resilient and higher-value practices and a moderate risk appetite for exploring new market opportunities. The project formulation team has identified and consulted several candidate beneficiary groups extensively during the formulation process (see Annex 7) as they have demonstrated the potential to champion the outcome and specific outputs. Others will be selected at the inception phase to ensure the selection of appropriate and timely beneficiary groups, particularly considering the fast evolving nature of practice and market trends and other socioeconomic factors in the NTSB.

164. In addition, a total of nearly 1,000 public and private extension service providers, including NGOs, will be trained, and a total of 1,200 local retailers, hoteliers, restauranteurs, and traders/exporters will be engaged to support the delivery of this outcome. The outcome will be implemented under the joint leadership of MAFF and MoE with technical support from FAO Cambodia and the NGO partners (i.e. GRET, Wildlife Conservation Society (WCS) and Institute for research and application of development methods (IRAM)).

8.1. Increased Premium Market Access Through Agricultural Certifications (Output 2.1)

165. A study on agricultural certification programs and value chains was conducted by the Institute for Research and Application of Development Methods (IRAM) (2018) to identify and examine the economic, social, and ecological opportunities and challenges associated with the high-value agricultural crops and their value chains. The study targets three crops identified through expert consultations as suitable vehicles for promoting climate-resilient and sustainable agriculture though certification programs in the NTSB.

166. The target crops are: 1) Rice in Preah Vihear; 2) Mangoes in Oddar Meanchey; 3) Cashew nuts in Kampong Thom and Preah Vihear. The agricultural certification programs that were examined in this study include Geographical Indications (GIs), Organic Certification, and CamGAP.[14] Based on the assessment of baseline conditions and opportunities, the study also provides suggestive actions and cost indications for implementing the actions.

[14] Cambodia Good Agricultural Practices (CamGAP)

8.1.1. Study Approach

167. For each of the agricultural crops and value chains, the objective was to assess the potential and feasibility of several certification schemes based on the assessment criteria and information collected through the sources described in Table 12.

Table 12: Analytical framework of agricultural certifications study

Key element	Assessment Criterion	Source of information
Operational feasibility	• Production areas, volumes and trends, • Producers' practices and production methods, • Presence/number of producers organizations, • Farmers and producers organizations capacities, • Existence of extension service/adaptation to farmers' needs, • Institutional environment, • Challenges, • Constraints/risks/opportunities of certification scheme.	Existing statistics (from MAFF and PDAFF), field survey, interview with key informants, and literature review.
Market potential	• Products, • Organization of the value chain, • Value addition, • Products destination, • Domestic/regional/international demands, • Market characteristics and trends, • Marketing constraints, • Potential impacts of certification scheme.	Interview with key informants, field survey, existing statistics, and literature review.
Environmental/social impact / vulnerability to climate change	• Interests/risks of the production for smallholder farmers, • Environmental issues/Improvement potential, • Current environmental and social conditions of the value chain, • Climate change situation and risks, • Vulnerability of the production system to climate change, • Specific potential impact of certification schemes.	Interview with key informants, field survey, and literature review.
Cost/Benefits	• Investments costs, • Operational costs, • Production and income, • Value added (existing and potential), • Costs and interest of certification schemes.	Interview with key informants, field survey, and literature review.

8.1.2. Data collection

168. Between early January and late May of 2018, data collection through a literature review, field surveys, and key informant interviews in Phnom Penh, Kampong Thom, Oddar Meanchey, Preah Vihear, and Siem Reap was carried out. Over 120 key informants who represented various ACs, FAs, Provincial Departments of Agriculture, Forestry and Fisheries (PDAFFs), MAFF, the private sector, and development partners including FAO, participated in the study.

8.1.3. Limitations

169. Due to the large scope of the study, the assessment relied large part on secondary data and inputs from experts and a small number of AC and FA representatives, particularly regarding cropping practices. Also, data on production of cashew and mango and their market conditions was not always available, and when available, the quality of data was poor, as the production of these crops had just expanded significantly in recent years. Furthermore, there are large uncertainties concerning the

vulnerability of these crops and their value chains to climate change, particularly in light of the lack of reliable historical trend data and crop-specific forecasts. These issues concerning data quality and availability make up the limitations of this study.

8.1.4. Key findings on target value chains and their feasibility

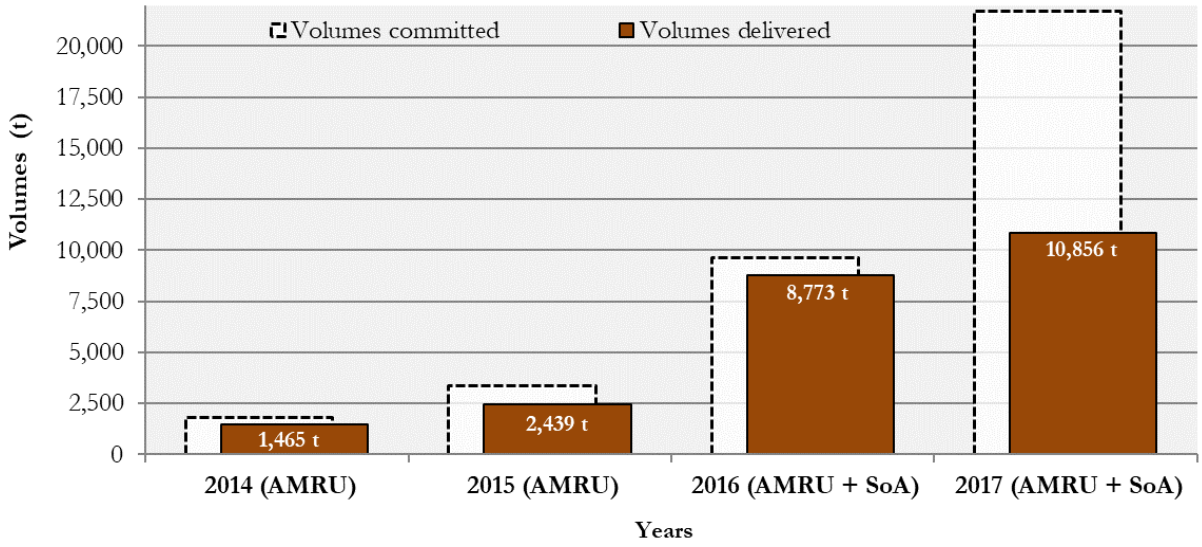
Organic Rice in Preah Vihear

170. Rice production in Preah Vihear remains relatively traditional, which has enabled the development of a significant organic rice sector, involving 26 ACs (more than 4,000 farmers), organized into the Preah Vihear Meanchey Union of Agricultural Cooperatives (PMUAC). This process was primarily assisted by the Support to the Commercialization of Cambodian Rice Project (SCCRP) project, with funding from the Agence Française de Développement (AFD). The PEARL project could support the PMUAC to further expand this organic rice production scheme from the current 10,000 ha to a target of 20,000 ha. Broader efforts are also needed to establish an integrated water resources management (IWRM) regime at the landscape level to ensure the sustainability of organic rice production, which currently relies on individual farm-level practices.

171. As a result of various efforts towards organic rice production, a sizable production mechanism, and supply chain have been operational in the province. Organic rice through the PMUAC is EU and USA/NOP certified. In 2017, the PMUAC delivered more than 10,800 tons of organic rice (Figure 37) to two buyers - AMRU-Rice (AMRU) and Signatures of Asia (SoA).

Figure 37: Evolution of volume of organic rice committed and delivered under Contract Farming agreements in Preah Vihear, from 2014 to 2018

Source: Data from SCCRP project.



172. In 2016, the contract farming implemented between AMRU and twelve ACs paid an average price of USD 74 /tonne higher than the price offered by local collectors for conventional rice (equivalent to + 34 %). Out of this amount, the ACs and PMUAC retained 8.5 USD/t and 12.5 USD/t, respectively, to cover their overhead costs. The rest (i.e., +53 USD/t) reached farmers.

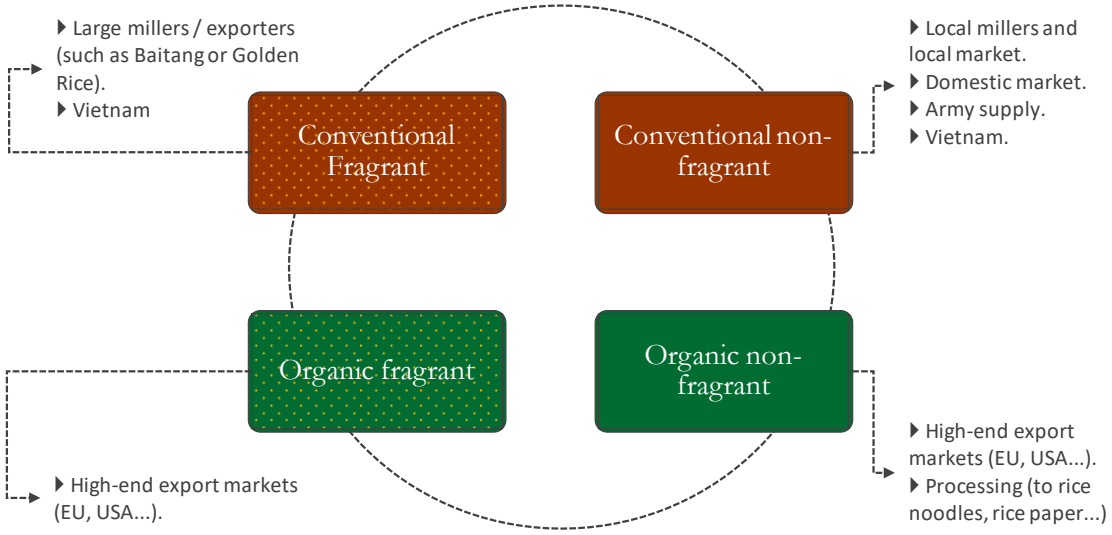
173. Contract farming has proven to be an effective tool for both farmers and buyers, given the traceability and quality control requirements involved in organic production. For buyers, it makes quality control more manageable. For farmers, contract farming guarantees that their efforts for meeting the necessary standards through an internal control system (ICS), facilitated by the PMUAC, are fairly rewarded through a price premium.

174. In Preah Vihear, most rice producers are smallholder farmers. There are only a few large-scale rice producers, cultivating over 100 ha of cropland. Smallholder farmers are typically organized into ACs. According to the data from the PDAFF, there were 42 ACs (ca. 6,828 farmers) registered in Preah Vihear in 2017.

175. The main rice varieties produced in Preah Vihear are broadly categorized into fragrant and non-fragrant varieties through either organic or conventional production methods. These varieties and production methods target different market segments, as seen in Figure 38.

176. Organic rice, particularly the fragrant varieties, certified by Ecocert for the EU and USA organic markets, targets high-end export markets. Exporters like AMRU process some non-fragrant organic rice into rice noodles, paper, and other processed products.

Figure 38 market destinations of rice produced in Preah Vihear



177. Conventional fragrant rice is often processed and sold locally, often within the province, and collected and traded outside the province, often by large collectors/middlemen to large millers, such as Golden Rice and Baitang, or Vietnam. Also, some of the conventional non-fragrant rice is milled and supplied to the Cambodian army. These are several market destinations for the rice produced in Preah Vihear. While Vietnamese buyers, the Cambodian army, and local markets are unlikely to be interested in organic rice, large Cambodian millers and exporters such as AMUR and SoA are increasingly expanding their organic rice markets. Organic rice production presents significant potential for expansion through increased production capacity and an increased variety of certification options (e.g., GI, CamGAP, fair trade, Sustainable Rice Platform (SRP)) as the demand for organic rice grows and diversifies.

178. For organic rice production, the total cultivated area was 16,200 ha, producing 45,360 tons of organic rice, and 6,174 households were involved under the PMUAC in 2017. According to the PDAFF data, the total rice production area in the province was 85,839 ha in the same year. Based on this, there is potential to increase organic rice production in the province by 60,000 tons.

Table 13 Estimation of organic rice expansion potential in Preah Vihear

No.	Type of rice production	Total land size (ha)	Potential organic rice land comparing to total land size in Preah Vihear		Estimated yield (t/ha)	Estimated annual organic rice (paddy) production (t)
			Percentage (%)[15]	Land size (ha)		
1	Short-term varieties	9,141	50%	4,571	2.8	12,799
2	Mid-term varieties	48,711	50%	24,356	2.8	68,197
3	Long-term varieties	25,205	25%	6,301	2.8	17,643
4	Up-land rice	2,780	90%	2,502	2.8	7,006
5	Floating rice	0	0%	0	n.a	n.a
Total		**85,837**		**37,730**	**2.8**	**105,645**

179. Among these certification options, GI offers a unique opportunity for organic rice production in Preah Vihear. While more specific studies would be necessary at the project's inception to identify specific details, preliminary findings suggest that aromatic rice from this province has a unique organoleptic quality, suitable for a GI. It is important to note that, in developing an IG product, the pace of certified rice production must meet with an adequate level of market development efforts and investment, based on the lessons learned from other GI development in the country. By the end of the PEARL project, it would be reasonable to expect a target of 1,000 ha of GI-certified rice production, with even more expansion potential.

180. GI-rice production in Preah Vihear could also contribute to climate change adaptation and mitigation through improved agroecological practices and household economies, mainly through better management of organic matters. The cost of transition to GI-rice production should be minimal as the province has already adopted widespread organic rice production. In designing GI specifications and Code of Practices, climate adaptation, and mitigation benefits could be mainstreamed to maximize its climate contribution.

181. SRP rice is another certification program with general alignment with the PEARL project; however, its markets are not well established with only a few large agro-industry multinational buyers, and there is a limited to no price premium. These circumstances suggest limited potential for using SRP rice certification to trigger transformational change through the PEARL project logic.

Cashew in Kampong Thom and Preah Vihear

182. Due to the growing regional demand, particularly from Viet Nam, and favorable prices, cashew production is currently booming in Cambodia. Kampong Thom is the leading producer of cashew in the country. The total cashew production area in the province was 54,609 ha (20% of the national

[15] Normally, there is higher risk of contamination on long-term varieties and lower risk on upland rice. Therefore, the estimated percentage of the area considered as potential for organic rice production takes into account these different risk levels.

total) in 2019 (NIS, 2019). The production area in Kampong Thom had more than quadrupled between 2013 and 2019. The production area for cashew in Preah Vihear is much smaller but 22,205 ha in 2019, which had grown almost 50 times larger than in 2013. The production volumes in 2019 reached 24,700 and 4,200 tonnes, respectively, in Kampong Thom and Preah Vihear.

183. In Kampong Thom, cashew is currently the third crop cultivated after rice and rubber and before cassava; however, cashew has been becoming increasingly more popular. The province is one of the priority provinces for cashew development under a memorandum of understanding (MoU) signed between the MAFF and Vietnamese Cashew Sector Association (VINACAS).

184. Both Kampong Thom and Preah Vihear show a real potential to develop the cashew sector. While Kampong Thom already has an expanding market share, Preah Vihear may present a specific opportunity to develop a certified cashew value chain, building on its existing capacity to grow organic rice.

185. There are 14 varieties of cashew cultivated in Cambodia. Among the most common varieties, including M23, M04, 809, and M1, most Kampong Thom and Preah Vihear farmers cultivate M23 (e.g., 80% in Kampong Thom). The so-called "local varieties" are also grown (e.g., more common in Preah Vihear). However, the local varieties are being rapidly replaced by M23 because it gives a higher yield, between 1 to 2 MT of raw cashew nuts (RCNs)/ha, compared to 700 kg/ha with the traditional varieties. Given this trend, many cashew orchards grow both varieties as they go through the transitional cycle.

186. M23, although presenting a higher yield, is more susceptible to diseases and insect pests. The incidence of pests and disease are on the rise due to prolonged droughts and increased temperatures. The cultivation of this variety thus often goes hand in hand with an intensification of production methods and an increased use of chemical inputs. However, many farmers have devised practices that keep the production 'near organic'. Therefore, increased research and extension work, including the promotion of integrated pest management (IPM), could be supported by the PEARL project to develop and promote a systematic and harmonized approach to climate-resilient and sustainable cashew production. Although meeting the organic certification standards would be difficult, CamGAP certification would provide an opportunity for earning a price premium, which may be used to incentivize farmers to adopt climate-resilient and sustainable practices.

187. Most smallholder cashew farmers sell their harvested RCNs to collectors/middlemen. Since contract farming is not common, cashew farmers sell their harvests to collectors on a first-come-first-served basis. Most collectors/ middlemen are not concerned with the product quality as they apply different pricing based on RCN size and quality to target different buyers. This practice keeps both the quality and value of RCN low.

188. Some middlemen also provide informal low-interest credit to farmers. The middlemen then collect their harvests and repayments at the collection. Many farmers consider this mechanism a more convenient and flexible way to access finance than microfinance loans from private and public financial institutions. However, this mechanism places farmers in a disadvantaged position as it makes price negotiations difficult and leaves little to no room or incentive for quality improvements.

189. In the absence of contract farming opportunities, collective sales by ACs are limited in the cashew sector. While a few exceptions exist, ACs usually lack the necessary working capital to purchase RCNs

from their members to organize collective sales agreements with buyers directly or set up value-addition processing facilities to increase their production value. As a result, the sense of collective ownership and mutual benefits among their members towards ACs is limited, and farmers prefer selling their RCNs individually to middlemen despite the downsides.

190. Middlemen usually collect and sell RCNs to large buyers with warehouse capacity in the district and provincial centers. From there, the majority of collected RCNs are sold to Viet Nam. Most Cambodian buyers sell to their counterparts in Viet Nam, and minimal direct market development efforts exist as they lack the necessary finance and knowledge to expand beyond Cambodian borders.

191. Domestically, high price volatility characterizes the cashew market. Large price sways make price negotiations difficult, and farmers sell their harvests at the first offer instead of storing them to wait for better offers or add value by processing their RCNs. The price volatility is coupled with the following circumstances to keep cashew production relatively low-value agriculture in a circular relationship:

- Urgent need for cash due to limited diversification and profitability, and to service debts to middlemen right after harvesting;
- Lack of storage and processing capacity and postharvest quality control measures leading to significant postharvest loss;
- Perception of value loss through drying and processing due to reduction in bulk volume among farmers (also a lack of market knowledge); and,
- Limited interest from buyers in dry nuts from farmers (a lack of value chain development for processed cashew nuts, and limited trust from buyers and quality control capacity among farmers).

192. Prices are different for M23 and smaller local variety nuts. The difference is usually around 500 Riel (USD 0.10)/kg, but it can sometimes reach 1,000 Riels (USD 0.25)/kg. Table 14 below shows the average price of the two types of cashew for the season 2017.

Table 14 Price of RCN in Kampong Thom and Preah Vihear province in 2017

Beginning of the season (March)		**Main season (April)**		**End of the season (May)**	
Local variety	M23	Local variety	M23	Local variety	M23
8,000 KHR/kg	8,500 KHR/kg	7,000 KHR/kg	7,500 KHR/kg	6,000 KHR/kg	6,500 KHR/kg
2,000 USD/T	2,125 USD/T	1,750 USD/T	1,875 USD/T	1,500 USD/T	1,625 USD/T

193. The price fluctuates throughout the season, and it usually reaches the highest at the beginning of the season when the African cashew nuts have not yet entered the market. The demand from Viet Nam usually peaks around this time. The price then drops towards the end of the season as the market becomes saturated with Africa's cashew nuts. However, the price drop is also associated with quality control issues as higher humidity tends to affect RCNs around this time.

194. Aside from these international market trends, the capacity of farmers to ensure the quality of their harvests through postharvest storage and treatments can be improved to avoid significant price fluctuations. For example, the Sambo Cashew Association has managed to ensure postharvest quality throughout the season and process their RCNs for retail buyers to receive premium prices for their

products. By processing, packaging, and directly selling their products to domestic retailers and foreign buyers, their cashew nuts are sold for between USD 13,000 to 18,000/t, which added a significant premium to the prices of RCNs (Kono and Chey, 2017).

195. Despite these value addition opportunities, cashew production in Cambodia is not geared towards value addition through processing and certification. Cambodia is a raw material producer for Viet Nam, and cashew is considered a commodity.

196. Value-addition processing and packaging present a viable avenue for increasing the value of cashew production and income of cashew farmers while noting the importance of market development in parallel. In terms of value addition through agricultural certification, GI registration is unviable since there is no evidence of cashew nuts from Kampong Thom or Preah Vihear being geographically unique. CamGAP would promote sound environmental and climate-resilient practices, but there is limited demand and no premium for GAP-certified cashew nuts in the existing market. Market development efforts would be required to promote CamGAP certified cashew nuts internationally in the EU, U.S, and regional markets and domestically in major tourist destinations.

197. There is a potential for organic cashew production in some parts of Preah Vihear and Kampong Thom (approximately 2,000 ha). This geographical limitation relates directly to the organic rice production in those specific areas. Heavy reliance on pesticide and herbicide use in the other parts of these provinces makes organic conversion challenging. There is a strong demand for certified organic cashew kernels (IFC, 2010).

198. IFC's pilot testing of organic cashew production in Cambodia (ibid.) suggests several lessons. First, organic certification and market development efforts are critical; however, these efforts must be combined with sufficient efforts to develop robust value chains to ensure all necessary value chain actors are involved to ensure an enabling environment. For instance, the involvement of middlemen rather than excluding them to establish a specific role for middlemen in the organic value chain through training to improve the handling of RCNs during transport should be considered part of such an environment. Also, the empowerment of ACs and FAs to promote collective negotiations with large buyers and experts and standardized quality control measures (e.g., an ICS under the PMUAC) should add to the efforts.

199. Another lesson calls for an enabling regulatory and institutional environment that enables effective public and private partnerships and crowd in private investment. For instance, there is a much-needed investment in processing capacity, which would require support from the private sector to promote organic cashew products from Kampong Thom and Preah Vihear in the international market. There is also a limited but growing demand for organic cashew from niche retailers (e.g., Natural Garden). The domestic market for organic cashew nuts alone would be too small to justify the cost of organic conversion and certification.

200. Also, as a relatively drought-tolerant, perennial crop, cashew has a higher carbon sequestration potential than alternative cash crops such as cassava, which exacerbate soil degradation. From these perspectives, the PEARL project could build on these opportunities to support the development of an organic cashew production scheme by setting up critical value chain capacities from production to market development. Such efforts will diversify and improve farmers' income, directly translating to higher adaptive capacity to manage climate risks and cope with impacts. With sustainable land management practices, cashew production through agricultural certification should also contribute

to improved resilience of ecosystems to climate change to act as a natural buffer against natural disasters.

Mango in Oddar Meanchey

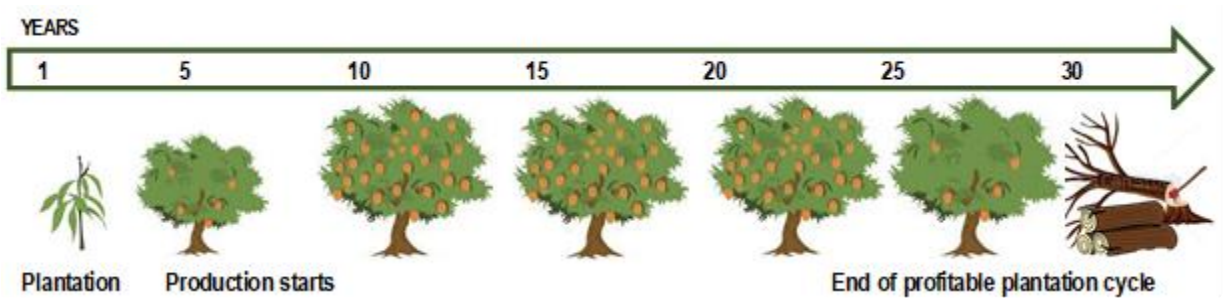
201. Mango orchards have been expanding rapidly across Oddar Meanchey, due to high prices of mangoes with increasing demand from China, Thailand, Viet Nam, and others. Mango production in Oddar Meanchey is split between comparatively large and financially well-resourced plantations, and smallholder farmers who lack the resources necessary to improve their adaptive capacities.

202. Many of the smallholder mango famers in Oddar Meanchey have begun cultivation only relatively recently compared to the larger established mango plantations. There are more than 7,000 ha of mango orchards in the province, with only approximately 3,000 ha already productive(PDAFF Oddar Meanchey, 2017).

203. The trend of adoption of mango cultivation by smallholders in the region is clear, with several thousand hectares of new mango orchards planted in 2017. Evidence suggests that popularity of mango cultivation is growing rapidly among smallholder farmers and agricultural cooperative members. In a study conducted by IRAM they estimate that by the end of 2017 there may have been as many as 10,000 ha of mango orchards, with as little as half already productive.

204. Mango orchards are estimated to be productive for 25 to 30 years from the beginning of fruiting (5 or 6 years after planting). (See Figure 39).

Figure 39: Life cycle of mango tree



205. The most prevalent variety of mango under cultivation in the province is *Kaev Lmiet*, which is considered by local stakeholders to be the most in demand, particularly for export markets. This variety is grown throughout Cambodia. Nurseries for mango seedlings have recently been established in Oddar Meanchey, whereas in the past farmers bought them from other provinces.

206. The natural fruiting season is March-April. Paclobutrazol is widely used to induce out-of-season flowering. It is a common practice in the province to have two harvests, with the first occurring in February-March, and the second in October-November.

207. Most mango producers in Oddar Meanchey are not currently organized into legally recognized cooperatives, although the prevalence of cooperatives is growing. Smallholder mango farmers in the province typically sell to either Cambodian trading companies (for example SeasonsFresh) or to local middlemen who are often associated with the larger mango plantations in the province. It is also

common for collectors from Thailand to come into Oddar Meanchey to purchase mango at a discount from their own local production. This appears to be taking place through informal cross-border trade, as much of the mango production in the province takes place in the northern areas along the Thai border.

208. The farm-gate price for mango varies widely, both by season and by grade. High season, high quality mango can receive up to 83,100KHR/Kg, whereas low season, low grade mango may be sold as low as 700KHR/Kg.

209. There is almost no processing of mango in the province with the exception of the local practice at the household level of soaking mango in salty water. This means that mango is crated and removed from the province immediately post-harvest, without value addition activities taking place.

210. With highly limited extension support, most mango orchards are managed intensively with chemical inputs, including fertilizers, insecticides, florigen, and glyphosate, without proper instructions and guidelines. Some producers will even repeat insecticide treatments after only 48 hours if the pests are still visible. Current production practices, therefore, suggest that organic certification is not feasible.

211. The PEARL project should initially aim for more modest objectives to improve the current practices by promoting the adoption of more sustainable technologies and techniques. Building this, interested producers with the necessary resources and capacity could be targeted to work towards GAP certification. Such efforts would consolidate the gains in terms of improvement of the practices through commercial valuation to access higher premium markets.

212. Meanwhile, it is also important to note that many buyers and exporters are sourcing mangoes from Oddar Meanchey to offset a seasonal supply drop from other regions within Cambodia and in neighboring countries. Within Cambodia, GAP certification of mangoes from Oddar Meanchey, for example, will be more valuable as part of broader GAP certification efforts in provinces like Kampong Speu where mango production is more mainstream. In addition, the GAP certification efforts should also be combined with HACCP and ISO 22000 certification schemes to improve handling, processing, and packaging capacities as a value addition strategy.

213. GAP certification of mango in Oddar Meanchey has the potential to reduce production costs by cutting down the excessive use of pesticides, improve food safety and organoleptic quality of the fruits, and improve farmer health by reducing exposure to chemical inputs. These benefits of achieving GAP certification standards are expected to significantly improve farmers' adaptive capacities.

214. Oddar Meanchey is among the driest and most drought prone areas of Cambodia. Although heat stress can have severe negative impacts on mango, the trees are remarkably resilient to the effects of extreme heat and drought, making them comparatively climate resilient compared to other crops.

215. Regarding climate change stakes, mango orchards that are cultivated by smallholder farmers can be part of a strategy of diversification of agricultural production, which contributes to their resilience. Mango production is relatively drought resistant and presents high profitability. In terms of mitigation, planting mango orchards on fields previously used for annual crops such as cassava would contribute to increase carbon sequestration. However, if mango orchards are developed on existing forests, the

impact in terms of carbon storage will be negative. It is therefore important to coordinate the work on mango production through a landscape approach under the PEARL project.

Table 15: Summaries of Trends, Concerns and Climate-resilient Agriculture Potential with Target Crops

Value chains	Organic Rice in Preah Vihear	Cashew in Kampong Thom and Preah Vihear	Mango in Oddar Meanchey
Baseline Conditions	• Suitable cultivated area size/yield volume to be viable. • Improved enabling conditions for agroecological improvement and sustainable agriculture through ongoing expansion and maturing of organic practices.	• Rapid expansion of cashew production. • Drought tolerant and perennial crop with some carbon sequestration capacity. • Increased chemical use due to cultivation of M23 which is more susceptible to diseases and pests.	• Raid expansion of mango plantations, driven by high prices and growing international demand. • Drought tolerant and perennial crops with some carbon sequestration capacity. • Intensive and uncontrolled use of agricultural chemicals.
Issues and Concerns	• Need for improved restoration of soil organic matter, which would increase water retention capacity in soils, thus reducing. drought impacts. • Need for an IWRM at landscape level to ensure the sustainability of organic production.	• Growing incidence to pest and diseases due to changes in precipitation patterns and temperatures. • Need for systematic promotion of IPM to reduce the use of chemical fertilizers and herbicides. • Limited market demand for organic cashew nuts and consumer awareness.	• Agrochemical related food safety concerns with limited consumer awareness and regulation (IPM and GAP). • Need for land use planning and enforcement to avoid deforestation. • Limited supply capacity and seasonal demand fluctuation.
Feasibility Considerations	• Expansion of organic paddy production up to 20,000 ha. • Support needed to maintain existing ICS for organic production. • Significant potential for developing a GI rice product (e.g. feasible to achieve at least 1,000 ha certified by end of project). • Further research needed to confirm link between quality and geographical characteristics for GI development. • Limited potential of Sustainable Rice Platform (SRP) due to limited price premium.	• Potential to grow (near) organic cashew in some limited areas (mainly Pear Vihear and some areas in Kampong Thom). • Significant potential for establishing a common approach to climate-resilient and sustainable cashew production through systematically promoting of GAP and IPM. • Two-prong approach needed to support GAP and IPM compatible production of M23 and traditional varieties in different farm systems and appropriate market incentives.	• Limited potential for organic certification. • Significant potential for establishing a common approach to climate-resilient and sustainable cashew production through systematically promoting of GAP and IPM. • Significant potential to increase premium market access through value addition processing that meet international standards such as HACCP and ISO 22000. • Further research needed to increase sustainable supply and develop steady market access.

8.1.5. Cross-cutting Issues

216. In proceeding with the above identified feasibility considerations, several issues that are not just specific to one or more of these crops and their value chains but often more generally applicable across the Cambodian agriculture sector. These are, therefore, cross-cutting issues that should receive adequate attention during the design of the PEARL project.

Crop Selection and Switching Based on Market Trends

217. At present, prices for both mangoes and cashew nuts are high in international markets, and Cambodia is becoming an emerging supplier for these products. This drives a very strong increase in the production of these crops among both industrial farmers and smallholders, who have switched from other crops such as cassava. As the current high prices of these products are not unique to Cambodia but are also seen in other countries across Southeast Asia, there is a risk of overproduction, which is usually followed by price decreases. Such a shift in prices would prompt farmers to switch to another crop with higher prices, thus posing a notable investment risk for the project. The development of certified products and market access may only partially address this risk.

Limited knowledge and awareness toward quality and standards in extension services

218. In the past decades, agricultural extension services, with support from many development partners, have focused on productivity based on quantitative objectives and indicators. Having achieved these objectives, the sector is generating significant surplus products, particularly rice within the domestic market, the development of export markets and high-value products has now become a priority.

219. Cambodian agriculture and agro-processing industry has been disadvantaged by the higher costs of operation, energy and finance, compared to its neighbours like Thailand and Viet Nam. Cambodian agricultural products are often marketed and sold as unprocessed raw commodity as a result. From this perspective, product differentiation by quality and value addition is, therefore, an important strategy for Cambodia's agriculture sector in moving forward. Several development projects have started to work on quality assurance, standards and certification to move toward this direction. However, as these are still relatively new approaches, there is a lack of trained human resources in the country to support this transition at the rate that is necessary.

220. In the public sector, the knowledge and experience of extension officers in quality management and standards are generally limited to specific areas of rice production such as seed quality control. Similarly, farmers, ACs and FAs also lack knowledge and awareness of quality orientation and standards. Both the extension services and farmers tend to focus solely on crop yields as a performance indictor, rather than looking at both the yields and profitability of their farming systems. To address this challenge, coordinated efforts and investments are needed to develop the awareness and capacity of various actors who are involved in the target value chains at all levels, not just farmers and extension officers. Suppliers, collectors, traders, microfinanciers, educational institutions that train extension workers need to take part in this effort at the national and subnational levels. Most importantly, the primary driver of this transition is the market, and therefore, establishing effective linkages between producers, retailers and consumers is crucial.

Capacities and limits of Cambodian SMEs in the agro-food industry

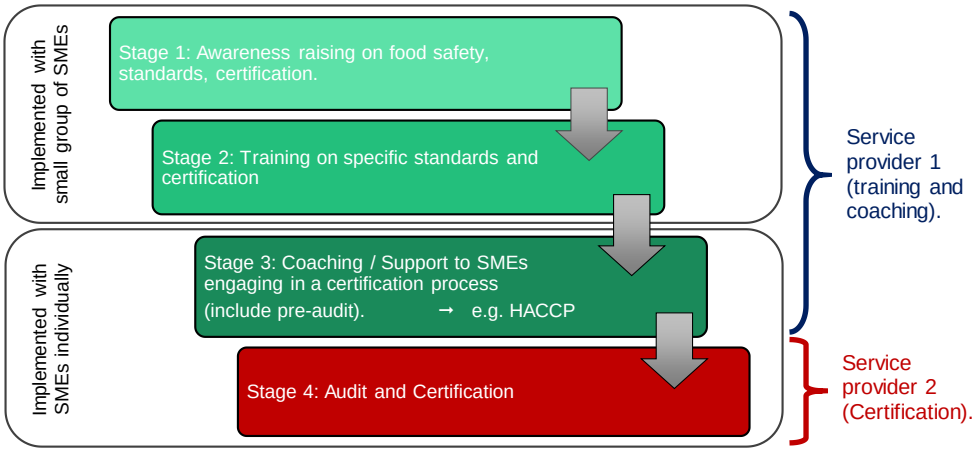
221. The development of certified Cambodian agricultural products requires a full commitment of the private sector, particularly from SMEs in food processing. The Cambodian agro-food industry is still in its infancy. There are a number of weaknesses or challenges to address to succeed in quality certification approaches along the target value chains. The investment by the PEARL project to support their capacity development to meet international quality standards should be considered a crucial element within its value chain approach as its success hinges on the balance between its ability to create market demand and capacity to meet the demand to make market-based incentives work.

Awareness, knowledge, and capacities on food safety and quality management

222. A first issue is the lack of awareness and capacities of Cambodian SMEs on quality management procedures and standards. Most SMEs in the agro-food industry in Cambodia are not well aware of food safety issues and good practices for quality management, and even less aware of food safety standards and certifications related to products or processes. Addressing this constraint is important in order to progressively improve the capacity of these SMEs in order to access premium markets by meeting client requirements, in particular for export[16].

223. There is a clear need for communicating these issues with SMEs to progressively increase their knowledge, capacities as well as commitment to work closely with farmers and other relevant value chain actors to meet their certification requirements. The PEARL project's support in this process of capacity development and coordination among the value chain actors will be crucial. Figure 40 below shows recommended steps to be taken by the PEARL project in providing support to SMEs.

Figure 40 Process to raise awareness, capacities and support SMEs on food safety and quality standards and certification



224. Many, particularly new and small, SMEs could benefit from support to develop their managerial and marketing skills and their operational capacities. Training, coaching and mentoring of these SMEs including relevant ACs, FAs, and agricultural unions by the PEARL project should be considered a

[16] It has to be noted that, with some crops like rice some of the large millers and exporters have already made much progress and reached certifiable standards, in some case with the support of project, such as IFC support to the rice sector. For instance, AMRU-Rice is Good Manufacturing Practices (GMP), HACCP and ISO 22000 certified and Golden Rice holds ISO 9001 certificate.

priority action. As part of such support, the project should also consider ways to make access finance by these SMEs easier, as the agro-food industry is often considered high risk by financial institutions and as a result of which many, particularly new and small, SMEs lack the capacity to create economies of scale to compete against SMEs from neighboring Thailand and Viet Nam.

225. According to the International Finance Corporation[17], SMEs in Cambodia also face difficulty in terms of legal compliance, as the cost of meeting regulatory compliance and formal business registration are costly for many small SMEs. The PEARL project should, therefore, consider providing both technical and financial support to SMEs in meeting compliance and registration requirements as well as working with regulators to make these legal processes more affordable.

226. Similar to the issue of food safety practices, having access to up to date market information to identify appropriate opportunities is critical for SMEs to stay competitive (e.g., reading market trends, identifying niche markets, competitive pricing). However, many, particularly small SMEs lack access to such information. Support by the PEARL project to improve access to market information by SMEs would be beneficial.

In-country consumer demand for safe and quality food

227. To meet the growing demand for food in the country due to population growth, agriculture has been intensified with the increased application of pesticides and other agricultural chemicals, some of them illegal. Hazardous substances are used not just by farmers but also by retailers who want to ensure that products look fresh for a longer period.

228. One study[18] reports that over 50% of the consumers, interviewed, considered food safety as the most important factor when buying food. In Phnom Penh, there is growing awareness of food safety among the growing middle-class consumers. For fruits and vegetables, the market share of chemical-free products, although still small, is steadily expanding. A Phnom Penh-based health food retailer, Natural Garden[19], for instance, has reported an increased customer base among Cambodian consumers, while expats and foreign tourists are their largest customer group. Nonetheless, the awareness of food safety is lagging behind in rural areas. The issues of pesticides and health risks are just starting to be taken up by the Cambodian media, and there is also a lack of civil society organisations that are raising awareness particularly in rural areas.

229. Although consumers in urban areas, particularly in Phnom Penh, have become increasingly concerned about food safety issues, they also demand low-cost food products. Overall, the concept of consumer protection is gaining momentum and becoming part of public policy debate. There is no specific comprehensive law that covers the full scope of consumer protection in Cambodia. A law on food safety has been drafted in 2015 but it has not yet been approved.

230. Another issue affecting consumer's awareness and demand is product traceability and labelling. Some products make fraudulent claims that they are organic or natural without any proof (i.e., lab

[17] IFC Advisory Services in East Asia and the Pacific, Understanding Cambodian Small and Medium Enterprise Needs for Financial Services and Products, Cambodia Agribusiness series - No. 2, 2010.
[18] Cheng Mengchou and Miriam Spengler, How (un)healthy and (un)safe is food in Cambodia, Konrad-Adenauer foundation, 2016.
[19] One of the leading organic food retailers handling organic rice and vegetables and other organic fresh produce and food products with an aim to promote safe food and responsible agricultural practices: http://www.ngkhmer.com

test results, traceability information). For example, in the case of cashew nuts, none of the products examined during the study with a word "natural" in their labels did not have any proof that the products were organic or chemical free.

Market characteristics of key certification programs

231. Supporting value chains through the certification of agricultural products requires targeted efforts that are unique to each certification program. One important aspect of such efforts is marketing and promotion and/or consumer awareness raising. As each certification scheme presents unique market characteristics and, therefore, requires an understanding of specific needs for marketing and promoting. The following analysis (Table 16) shows such needs for the five certification programs most relevant for the target crops of the PEARL project.

Table 16: Key agricultural certification programs in Cambodia

International organic standards (EU, USA's NOP,…):	International organic standards and their respective logos of the US and EU have already been well-recognized by consumers in those markets. Nevertheless, the understanding of specific market opportunities and quality standards associated with these US and European organic markets among value chain actors in Cambodia needs improvement, which could be supported by the PEARL project. Cambodian exporters of organic products may also benefit from support in promoting their products to potential buyers in these export markets.
Cambodian organic standards:	At present, there are no national standards for organic agriculture in Cambodia (but this could happen soon, as MAFF is working on it). There is a private set of organic standards and an associated logo that are owned by the Cambodian Organic Agriculture Association (COrAA). For both the COrAA and an anticipated upcoming Cambodian Organic standards, significant efforts will be needed to increase public and consumer awareness about what their logos represent in terms of production quality and food safety in order to build the necessary public trust and justify their premium pricing. Quality assurance and consumer awareness efforts would benefit from support by the PEARL project.
GAP:	For export markets, GAP compliance has become a standard requirement of buyers rather than an additional label of quality to differentiate the products. This suggests no further need for promotion as in the case with organic standards in the destination markets; however, this standardized practice requiring GAP compliance limits its premium pricing potential. Support in meeting GAP compliance by the PEARL project would, therefore, benefit many farmers with limited resources to meet the required standards. Cam-GAP, which is Cambodia's national GAP brand that follows the ASEAN GAP standards, focuses more on addressing food safety concerns of domestic consumers while also meeting the export requirements. As Cam-GAP implementation has been gradually ramped up through the development of a certification program and expansion of target crop types, the PEARL project's engagement with this process to support the implementation of Cam-GAP as a standard practice for its target crops would greatly benefit its public awareness and promotion efforts with farmers, consumers and other value chain actors.
GI:	Unlike the EU's logo for its GI products, consumer awareness of the Cambodian GI logo and its reputational value is limited outside of Cambodia. Therefore, setting up a GI as suggested for rice in Preah Vihear would require a significant effort of promotion. Also, each GI comes with its own set of specific standards that are unique to the product and its geographical association. Although Preah Vihear rice is gaining its recognition as organic

	product, much more efforts are required to promote both Preah Vihear's unique geographical features as a rice producing region and the quality of its rice to attract buyers and consumers in both the domestic and international markets.
SRP (for rice):	For the time being, the SRP logo is not used as part of product labels. Its use is only limited for the SRP's institutional communication and promotional purposes. Although SRP has become a requirement of buyers such as Mars Food or EBRO, its application to justify premium pricing has thus far been limited. The opportunity for the PEARL project to engage with SRP is, therefore, limited considering its focus on premium markets.

232. The above analysis describe different ways in which the PEARL project may engage with these certification programs for the development of market-based instruments to promote climate-resilient and sustainable agricultural practices through a value chain approach.

The ITC "sustainability map": a possible tool to promote for Cambodian companies

233. The PEARL project could consider establishing a partnership with the International Trade Center to promote the ITC sustainability map (https://sustainabilitymap.org/home). This online tool could ease SMEs' access to information on different standards, help them to benchmark their current situation and the gap to compliance with those standards. It could be used to map their supply chain to make themselves visible and identified as suppliers by potential clients, globally. SMEs could use sustainability self-assessment tools through this platform to evaluate their compliance against various sustainability standards and measure the effort they have make in order to reach full compliance. Supply-chain mapping can go down to the level of individual smallholder farms.

8.2. Suggested Actions under Output 2.1

234. Building on these crop-specific and certification opportunities in each province, the project will first form an inter-value chain committee to develop a roadmap at the provincial level to match the target crop with the most timely and relevant certification(s) for promoting high-value and climate-resilient agriculture. Based on the roadmap, the project will support ACs, FAs, PGs, CPAs, CFs, and agricultural unions in developing and implementing crop-specific and climate-resilient business plans. This will be combined with training beneficiary farmers and other local value chain actors to develop their financial and business literacy and entrepreneurial skills and extension providers to support the roadmap and business plans implementation. The project will also build direct partnerships with champion SMEs and traders/exporters to expedite the transformation process. Also, add-on guidelines and tools will be developed to ensure that the chosen certifications consider climate risks and impacts adequately.

Activities, Descriptions and Sub-Activities
Activity 2.1.1: Develop and operationalize inter-value-chain-actors roadmaps at the provincial level and action/business plans for climate-resilient, inclusive and gender-responsive premium value chain development and identify specific certification programs as key vehicles. **Description:** Inclusive and gender-responsive value chain development roadmaps, linking various value chain actors, will establish strategic directions at the provincial level for supporting ACs, FAs, PGs, CPAs, CFs, and agricultural unions in adopting climate-resilient, high-value and sustainable agriculture. Each roadmap will assess and identify appropriate certification programs as essential vehicles for accessing premium price markets. ACs,

FAs, PGs, CPAs, CFs, and agricultural unions in the target districts will prepare their crop-specific action/business plans, guided by their district roadmaps to increase market access. Their business plans will feed into Activity 2.2.1.

- Sub-activity 2.1.1.1: Establish an inter-value-chain committee to prepare provincial-level roadmaps to identify a target certification program(s) *(e.g., CamGap, PGS, GI, SRP and organic for production, and ISO 2200 and HACCP for processing)* for climate-resilient and high-value value chain development.
- Sub-activity 2.1.1.2: Operationalize the roadmaps by establishing institutional arrangements, product specifications, quality control mechanisms for the selected certification schemes and marketing tools, ensuring legal registration, and conducting training.
- Sub-activity 2.1.1.3: Support the provincial-level Inter-value-chain committees with focus on ACs, FAs, PGs, CFs, and agricultural unions to carry out branding, marketing (e.g., attending trade fairs, consumer awareness raising, and brokering purchase agreements) and sourcing and quality control activities.
- Sub-activity 2.1.1.4: Support the provincial-level Inter-value-chain committees with focus on CPAs to carry out branding, marketing and sourcing and quality control activities.
- Sub-activity 2.1.1.5: Conduct annual training of extension providers at the provincial level to operationalize the roadmaps to roll out the roadmaps through FFS curricula and other support programs for smallholder farmers and other local value chain actors.
- Sub-activity 2.1.1.6: Assist 78 ACs, FAs, PGs, including up to 2 agricultural unions in preparing crop-specific action plans/business plans to operationalize the provincial-level roadmaps.
- Sub-activity 2.1.1.7: Assist 30 ACs, FAs, and PGs and 4 CFs in preparing crop-specific action plans/business plans to operationalize the provincial-level roadmaps.
- Sub-activity 2.1.1.8: Assist 16 CPAs in preparing crop-specific action plans/business plans to operationalize the provincial-level roadmaps.
- Sub-activity 2.1.1.9: Assist ACs, FAs, PGs, CPAs, CFs in forming crop-specific agricultural unions, where appropriate and strategic, to leverage pooled resources and capacities through action and business planning processes.
- Sub-activity 2.1.1.10: Organize national and provincial annual dialogues between the beneficiary bodies (i.e., ACs, FAs, PGs, CPAs, CFs, and agricultural unions) and direct purchase agreement providers (i.e., traders/exporters, retailers, hoteliers, and restauranteurs) to establish operational partnerships for market development and implementing crop-specific action/business plans.

Activity 2.1.2: Develop voluntary add-on supplementary guidelines, tools, and training materials to consider specific climate risks, mitigation impact and strategies for the certification programs identified under Activity 2.1.1. (e.g., CamGap, GI and organic for production, and ISO 2200 and HACCP for processing) for the target value chains (linking to Activity 3.1.1. on PLR and institutional arrangements concerning these certification programs).

Description: Climate-proofing of the agricultural certification programs identified in the provincial roadmaps will be crucial for harnessing their market potential for assisting smallholder farmers and other local value chain actors in adopting climate-resilient, high-value, and sustainable agriculture and livelihoods.

- Sub-activity 2.1.2.1: Establish a multistakeholder TWG for the certification programs identified in the provincial roadmaps to review and update/develop relevant supplementary guidelines, training materials, and tools to consider climate-related risks, climate-resilient approaches, and interventions.
- Sub-activity 2.1.2.2: Prepare and implement training programs for regulatory and independent verification bodies.
- Sub-activity 2.1.2.3: Prepare and implement TOT programs for public and private extension providers, including NGOs and representatives of ACs, FAs, PGs, CPAs, CFs, and agricultural unions to operationalize the supplementary guidelines, training materials, and tools.
- Sub-activity 2.1.2.4: Explore the possibility of adopting and operationalizing W+ Standards to empower women farmers, particularly in the vegetable sector.

8.3. Access to Technologies and Finance for Smallholder Farmers, ACs, FAs, and SMEs (Output 2.2)

235. Lack of access to finance among smallholder farmers, ACs, FAs, and SMEs is a major obstacle in making the necessary transition towards more quality and value focused production and processing, particularly with perennial crops such as cashew and mango. The PEARL project could establish partnerships with microfinance institutions (MFI) or banks that are well established in the provinces (e.g., Angkor Mikroheranhvatho Kampuchea (AMK) and Rural Development Bank20 (RDB)) to develop favourable and targeted credit programs to meet specific needs.

236. As an essential enabler of this transformation, a Farmer-led Agricultural Resilience Mechanism (FARM) is proposed under the PEARL project to assist smallholder farmers and other local value chain actors who would otherwise not have access to the necessary finance to adopt climate-resilient and market competitive practices and technologies. Accelerated technological improvements by smallholder farmers and other local value chain actors are also expected to increase agribusinesses' opportunities to expand their services for climate-resilient agriculture and value chain development and public sector investment in climate-resilient agriculture and rural livelihoods.

237. The objective of FARM is to provide interest-free or low-interest credits to legally registered agricultural unions, cooperatives, associations, and producer groups, including Community Protected Areas (CPAs) and Community Forests (CFs), in the NTSB for procuring technologies and infrastructure assets essential for adopting climate-resilient and higher-value agriculture. The FARM will also ensure that such technologies and assets are chosen and used in a gender-responsive, inclusive and equitable manner.

238. In designing the FARM, the project design team considered best practices and lessons learned through the past and ongoing initiatives in the sector (see Annex 1). One of such initiatives is the Tonle Sap Poverty Reduction and Smallholder Development Project (TSSD)21, implemented by the ADB and IFAD. The project supports ID Poor farmers in improving their livelihood options. The project established and has assisted more than 1,000 small groups of ID Poor farmers in establishing membership-based savings schemes through commercial banks to provide individual members with access to a line of credit backed by a group guarantee system. This mechanism has successfully increased financial and technological access, the entrepreneurial spirit, and a sense of ownership of livelihood improvement actions among the beneficiaries, while the social support network has notably reduced default payments and business failure risks. Please see Annex 3 for a more detailed description of the TSSD's experience.

239. Target technologies and infrastructure include a solar-powered cold storage facility, a solar-powered irrigation system, and an energy-efficient value-added processing facility (see Annex 4 for more information). The beneficiary groups will be responsible for managing the acquired technologies and infrastructure assets and making repayments, which will be reinvested to accelerate their transition to climate-resilient and high-value agriculture.

240. FAO considers two innovative approaches to supporting the beneficiaries and using repayments for reinvestment through FARM. The first approach would provide loans at below-market or zero interest rates to support the beneficiaries in acquiring the technologies and infrastructure necessary

[20] RDB has provided ACs with dedicated credit programs since 2016 with support from the SCCRP project.

[21] https://www.tssdcambodia.org

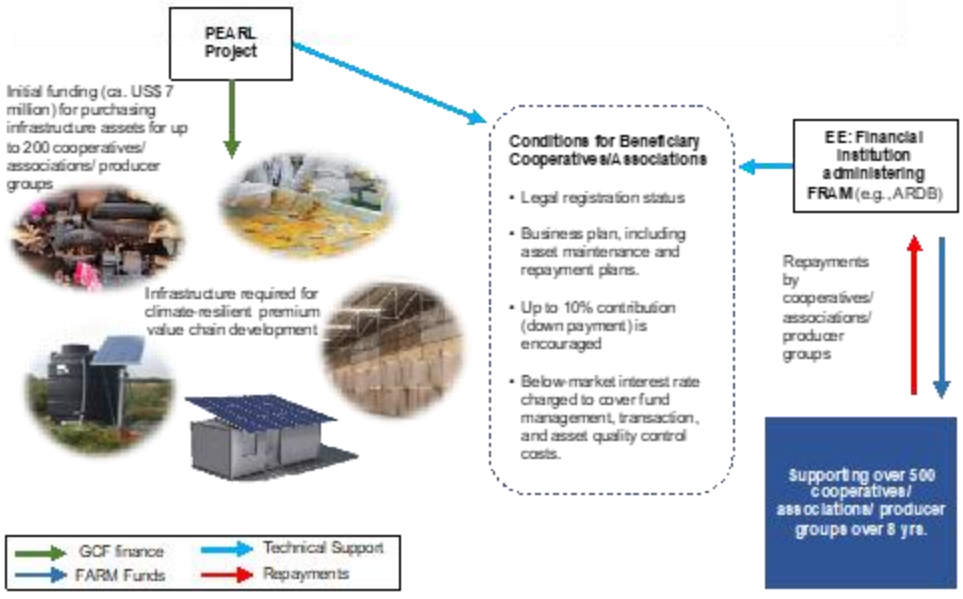
for the envisioned transformation. Their repayments would then be used to expand the number of beneficiaries over the project's lifetime. The second approach would reinvest their repayments to establish membership-based trust funds to finance further climate-resilient and high-value agriculture actions. The critical difference between the two approaches is that the first is extensive while the latter is intensive. These approaches are described further in the next section.

241. This report assesses the feasibility of these two approaches and potential design options under each approach. The report will first outline the two approaches and then discuss design options under each approach. The design options will be evaluated based on their strengths, weaknesses, opportunities, and threats (i.e., SWOT analysis) from impact-potential, operational, and institutional perspectives. Based on the SWOT results, the report will recommend which of the two approaches should be deployed by the PEARL project. Finally, the report will provide a simple, sensitivity analysis of the chosen approach based on set variables to demonstrate its impact potential.

8.3.1. First Approach: Extensive model

242. As shown in Figure 41, the first approach would provide interest-free or low-interest credits to legally registered groups of beneficiaries for procuring technologies and infrastructure assets that would enable their transition to climate-resilient and high-value agriculture. The beneficiary groups would manage the acquired assets and make repayments. The project would support the beneficiary groups in developing business plans, including growth strategies using the procured assets through climate-resilient value chain development, asset management, and repayment plans. As part of the business plan development process, the groups would be encouraged to contribute to purchasing the infrastructure assets (i.e., down-payments). Informal cooperatives, associations, and producer groups would also be actively supported in becoming fully registered entities or unionized to access the FARM benefits.

Figure 41: FARM extensive model

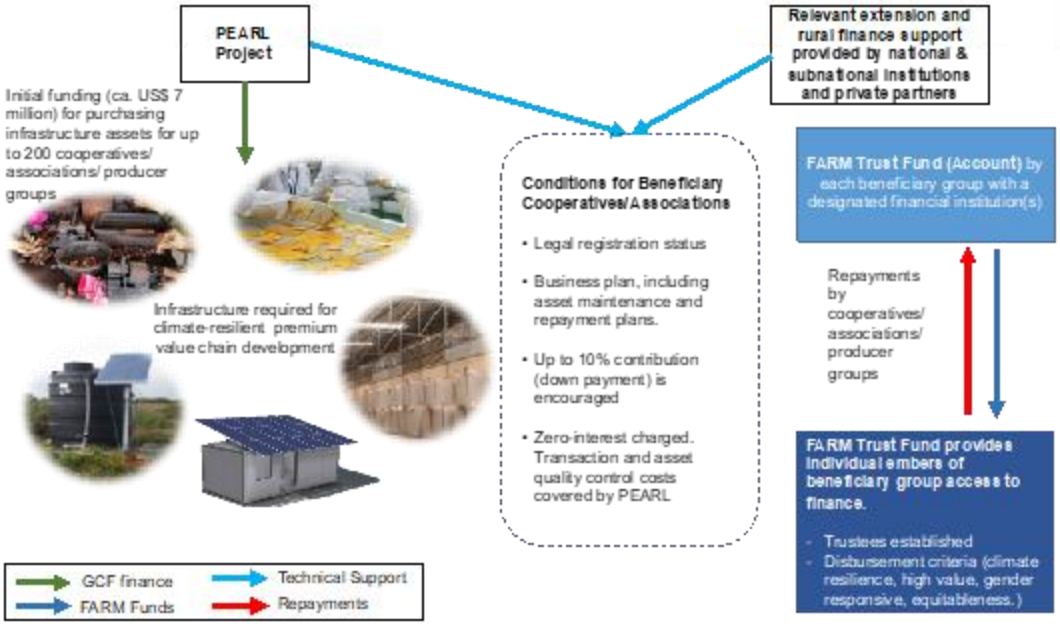


243. Aligning with FAO's accreditation and the Accreditation Master Agreement (AMA) between FAO and the GCF, a national financial institution would be engaged to collect repayments and manage and redistribute funds to a new set of beneficiary groups on a revolving basis. The financial institution would operate as one of the co-Executing Entities (co-EEs) under the PEARL project. An ideal EE for the revolving fund is a Direct Access Entity (DAE) or Direct Access Applicant (DAA) under the GCF. From this perspective, the Agricultural and Rural Development Bank of Cambodia (ARDB) is currently considered a suitable candidate as it is being nominated for GCF accreditation by the NDA.

8.3.2. Second Approach: Intensive Model

244. In contrast with the first approach focusing on scalability, the second approach (Figure 42) provides targeted support to a limited number of beneficiary groups through their transitions to climate-resilient and higher-value agriculture. Selecting the right beneficiary groups would become a critical success factor in this context. The selection criteria would include their financial management ability, capacity to govern inclusively, gender-responsively and equitably, and viability and impact potential of their business plans.

Figure 42: FARM intensive model



245. Under this approach, each beneficiary group (i.e., union, cooperative, association, producer group, CPA, or CF) would establish a FARM Trust Fund account with a designated financial institution. The project would seek a partner financial institution(s) for making FARM Trust Fund arrangements with individual beneficiary groups. A designated partner financial institution or multiple institutions would be selected from the private or/and public sector(s). The repayments made by each beneficiary group would be held in its FARM Trust Fund. Every FARM Trust Fund would be served by a board of trustees, comprising representatives of the beneficiary groups, local authority (i.e., a commune chief), and the MAFF to oversee fund disbursements from the Trust Fund. Disbursement decisions would be made based on quality control/screening criteria, including climate resilience, high-value agriculture, gender responsiveness, and equity, to ensure funds directly support climate change

adaptation and related efforts. The beneficiary groups or their members may also use the FARM Trust Funds as collateral to access standard micro-finance and agricultural loan products.

8.3.3. Commonality between the Two Approach

246. Under the two approaches, the PEARL project will support the beneficiary groups in financial and business literacy building, business planning, revenue management to ensure that their increased access to finance directly translates to their accelerated adoption of climate-resilient and higher-value practices and technologies in an inclusive, gender-responsive and equitable manner. As part of this effort, the project will also strengthen the capacity of agricultural extension providers in both the public and private sectors to assist the beneficiary groups and their members in financial and business planning.

247. The project will also support in identifying technical specifications of assets to be procured and maintaining the acquired assets in optimal operating conditions.

248. In addition, the project will work with the national financial regulator and their partners to design a lending scorecard system together with a user manual to consider climate-resilience and sustainability as main eligibility criteria for screening loan applications from smallholder farmers and other local value chain actors with limited to no collateral to create an enabling lending environment.

8.3.4. Design Options Under First Approach

249. Table 17 outlines two design options under the first approach. The descriptions of these approaches are provided below.

Table 17: FARM Design Options under the first approach

Term	Option 1	Option 2
a. Funding Basis	Standalone	Co-Financing
b. Target Customers	• Registered Agricultural Cooperatives • Registered Agricultural Associations • Registered Agricultural Unions • Registered Producer Groups	Same
c. Loan Size	Up to USD 50,000	Up to the upper limit of ARDB loan product. FAO will share up to USD 50,000. (up to USD 200,000 as per Agricultural Cooperative Loan (ACL) in ARDB website).
d. Loan Tenor	Up to 5-7 years	Up to the loan tenor under ARDB product (up to 7 years as per ACL in ARDB website).
e. Interest Rate	• Depend on ARDB (should be around 7% p.a.) • Processing fees of 0.5% to 1.0% of the approved loan amount	• Depend on the ARDB rate on that particular product (9.5% as per ACL in ARDB website) • Processing fees of 0.5% to 1.0% of the approved loan amount
f. Payment Methods	Monthly, Quarterly, Semesterly, or depend on cash flow patterns of the borrowers and the	Same

	availability of payment modes in the ARDB core banking system.	
g. Security Requirements	• Not required landed collateral. • Require a guarantee from a representative of the AC or all the management team of the AC. • Propose a specific charge on the asset(s) being financed.	• Real estate property. • Cash Deposit Certificate
h. Required Documents	• Representative's Khmer Id Card (copy) • Registration certificate of agricultural cooperative • Agricultural cooperative statues • Income-expense information, business plan, and repayment plan. • Minutes of general meeting of shareholder or that of executive management on decision authorization borrowing from the bank	• Representative's Khmer ID Card (copy) • Registration certificate of agricultural cooperative • Agricultural cooperative statues • Income-expense information, business plan, and repayment plan. • Minutes of general meeting of shareholder or that of executive management on decision authorization borrowing from the bank • Land title for collateral
i. Eligible Loan Purpose	Acquisition of fixed assets to support or improve agricultural business activities	Same (not allow to fund Working Capital Requirement)
j. Loan Disbursement	• FAO to procure the assets and deliver them to borrowers. • Borrower to make a loan repayment to ARDB. • ARDB to continue to use that fund on an ongoing basis to serve the specified target customers under this loan product.	Follow Standard Operating Procedure of ACL.
k. Pre-Disbursement Condition	Sales and Purchase Agreement of the asset to be acquired.	Sales and Purchase Agreement of the asset to be acquired.
l. Post-Disbursement Condition	Perform regular service checks and maintenance (~25% of asset value, paid annually, at a 50% subsidized rate).	Perform regular service checks and maintenance (~25% of asset value, paid annually, at a 50% subsidized rate).
m. Funding Ratio	• For the asset costing less than or equal to USD 50,000, the down payment is between 5%-20%. • For the asset costing more than USD 50,000, the down payment is between 10%-20%. • Depending on the borrower's financial capacity, a higher percentage of a down payment than the set limits may be encouraged.	• For the asset costing less than or equal to USD 50,000, the down payment is between 5%-20%. • For the asset costing more than USD 50,000, the down payment is between 10%-20%. • Depending on the borrower's financial capacity, a higher percentage of a down payment than the set limits may be encouraged.

8.3.5. Funding basis

250. *Standalone*: In this option, the project may finance the asset on a standalone basis. This option is simple, without having to park the FARM under the EE's facility, which would involve several complex processes. Portfolio performance could also be easily tracked and monitored. However, funding on a

standalone basis would limit the loan size, which may not accommodate some borrowers' needs to acquire larger assets that cost more than USD 50,000 (the maximum loan size offered in this program).

251. *Co-Financing*: Co-financing would enable the project to offer a larger loan size by joining with the EE, targeting a broader spectrum of borrowers, particularly those looking to acquire larger or more advanced assets to support their business activities. However, co-financing can be challenging for several reasons. First, the recording, reporting, and monitoring of the loan portfolio are complex and time-consuming, particularly in the early stage of the project. Second, such a financing scheme can be complicated because the pricing of the loan is different between the project sponsor and the EE. Third, co-financing requires some legal paperwork, which can add another level of complexity in practice. Given the project's relatively small financial scope, it should focus on having a simple mechanism to ensure its effectiveness and efficiency.

Target Customers

252. Funding individuals is not only costly but also operationally intensive. Therefore, to jumpstart more efficiently, the FARM approach should target well-structured borrowers, such as legally registered agricultural cooperatives, associations, unions, and producer groups, which ultimately benefit small-scale and/or individual farmers.

Loan Size

253. As discussed under the Funding Basis section, on a standalone basis, the FARM approach would fund a maximum loan amount of USD 50,000, which is the approximate price of a combine harvester, a small-size cold storage facility, and a similar small-sized physical asset. However, some deviations on the funding size should also be considered with the view toward the potential impacts of their business proposal on upgrading agricultural value, improving climate resilience, and other social/economic effects on the borrowers and their communities.

254. On a co-financing basis, the FARM approach could finance up to the upper limit of ARDB's Agricultural Cooperative Loan (ACL) of USD 200,000. The project may share up to USD 50,000 of the total cost, while ARDB may cover the rest. Although such a mechanism could be complex, it would increase the lending capacity of FARM to support beneficiaries who need larger assets.

Loan Tenor

255. The loan tenor should be up to 5-7 years, which is the average useful life of the fixed assets, like machinery and equipment. The actual tenor for each loan shall depend on the useful life of the specific asset being financed. This shall also require regular maintenance to ensure usability and prevent fast deterioration. This offering aligns with the loan tenor under ARDB's ACL loan, up to 7 years.

Pricing of Loan

256. *Interest Rate*: The interest rate of this loan should target to cover only the operating cost of the lending institution. There are advantages and disadvantages to this option. The positive aspect of

this pricing model is that the interest rate is relatively low for the borrowers, which helps them access low-cost financing to support or expand their business. However, there are several drawbacks. First, this pricing model would subject the lending institution to determine its operating cost for this project, which is deemed complex and time-consuming. Second, given the complexity of the implementation, it may demotivate the lending institution to support and sell this product to their customers. Third, this pricing model may impact the FARM approach's sustainability because the lending institution may not want to continue offering this fund given the return from this lending is relatively low, and the credit risk is relatively high since it is not secured by landed collateral. In conclusion, it would be challenging to implement the FARM and ensure its sustainability with this pricing model. The alternative should be considered, especially in the long run, mainly when sustainability becomes a concern.

257. *Processing Fee*: 0.5% to 1.0% of loan approved amount: The processing fee is usually part of a loan's pricing package and is a one-off upfront charge. The cost is typically between 0.5% to 1.0% of the approved loan amount. However, since the loan under the FARM is not intended for profit-making, such a fee should be waived or not included in the pricing package to avoid unnecessary pricing and cost determination complications. As stated earlier, the interest charged should only cover the necessary operating costs borne by the lending institution.

Payment Methods

258. Repayment methods are crucial in loan design, as they concern how loans are repaid. It is designed to meet the cash flow pattern of different business types. There are several repayment methods such as (1) monthly, (2) quarterly, (3) semesterly, and (4) bullet repayment (Gutierrez and Dalsted, 2012; Hofstrand, 2013). Bullet payment, which is a type of repayment mode that requires the borrower to make a lump sum (total) principal payment at the loan maturity, can be divided into two types: (1) monthly interest payment and total principal payment at maturity and (2) both interest and principal payments at the loan maturity. The first option is typically preferred, given it can provide an early warning sign if the borrower is facing any financial hardship.

259. Concerning the regular repayment modes, a grace period when borrowers only repay interest payments on the loan should be considered to provide some time for their assets to generate cash flow through implementing their business plans. The grace period should only be allowed for the loan with a monthly payment mode. The less frequent payment modes, semi-annually or longer, will automatically have the first few months of the loan tenor without paying down the principal.

Security Requirements

260. Security is the secondary source of loan repayment if the primary source of repayment from the business's cash flow fails. Security requirements usually are devised into two options: (1) unsecured (no landed collateral) and (2) secured (required landed collateral or cash deposit certificate).

261. The first option aims to overcome the challenge of many small and medium-sized agricultural enterprises (SMAEs) that do not have landed collateral; however, it is of high credit risk when a loan is not secured by immovable collateral. To mitigate this risk, the lending institution typically necessitates two options: (1) requires a specific charge on the asset(s) being financed and/or (2) requires a personal guarantee from the representative or all the management team of

the borrowing SMAE. Determining the specific charge on the asset(s) can be performed at the Secured Transactions Filing Office (SETFO) at the Ministry of Commerce (MoC) with a fee of KHR 40,000 (~USD 10) for registering, amending, renewing, or de-registering the charge (SETFO, 2021). SETFO acts as the governing body for determining a moveable asset charge or commercial enterprise mortgage, which is the same the cadastral office serves as the governing body for the land title pledging activities.

262. To register a moveable asset at SETFO, the financial institution needs to follow through a few steps. First, it must register its entity names at the SETFO website and create a user profile. Second, the institution must obtain the asset's ownership document and/or identity a document(s) to be registered. Third, it must log in to the site and register the assets. If there is an error, the institutions can amend the registration; however, there will be an additional charge (i.e., ~USD 10). Fourth, after the loan has been paid off, the institution must de-register the assets (which costs about USD 10 per transaction) and release the charges on the assets accordingly. In sum, these four steps are the fundamental activities to register a moveable asset from the start to the end of the facility cycle.

263. Regarding asset financing, there are two options for managing asset ownership: (1) the lending institution is the registered asset owner, or (2) the borrower is. There are advantages and disadvantages to both options. If the lending institution is the asset owner, there is a lower risk of illicit grey market sales; however, the facility will be treated as a financial lease and subject to a financial lease license. In addition, such practice involves regulatory complication concerning value-added tax (VAT), which may be charged twice, borne by the lending institution at the start of the lease and by the leasee (borrower) at the maturity of the lease (upon the transfer of ownership from the lending institution to the lease). Moreover, a complex process in recording accounting entries must be established to accommodate this practice. Hence, most financial institutions choose the other option where the borrower is the asset owner. Although this can resolve the issue mentioned above with VAT, it comes with another risk - the liquidation of the asset by the registered owner (i.e., borrower) of the asset before completing their payments. For instance, the asset could be sold in the grey market, although it may be fully registered at SETFO due to a communication gap between MoC and other relevant ministries to restrict the sale of any asset with a specific charge. To mitigate this risk, the lending institution usually keeps the asset ownership document and prepares a sales and purchase agreement (SPA) in advance (with the borrower, the so-called seller in the SPA, already thumb printed or signed thereon). In case of default, the lending institution works out with the beneficiaries to identify a possible solution for repayment, and at the last resort, may liquidate the asset.

264. It is also advised that the borrowers must buy insurance for the financed assets to prevent any unfortunate events which may physically or functionally damage the assets. Of the information collected from general insurance companies, there are several insurance products for this purpose.

265. In addition to a specific charge, the lending institution may also request a personal guarantee from the representative or all the management team of the borrowing entity. In this practice, it is not recommended to offer the loan to individual farmers given that it lacks the shared responsibility element, which makes the guarantee weak and cannot mitigate the credit risk of an unsecured loan.

266. For the second option, it is usually the safest that the lending institution requires landed collateral or cash deposit certificate as the collateral. Landed collateral provides a more secure second way, given it is an immovable asset while a cash deposit certificate is a highly liquid collateral.

However, requiring these types of collateral is not practical for agricultural unions, cooperatives, and associations because they usually lack landed assets or sufficient cash to be used as loan security.

Required Documents

267. There are two options: (1) for unsecured financing, which does not require a land title for collateral, and (2) for secured financing, which requires a land title for collateral. Below are the generally required documents for unions, cooperatives, associations, or producer groups to present to the financial institution to obtain financing:

- Option 1: Unsecured financing:
    - Representative's Khmer ID Card (Copy)
    - Registration Certificate Of Agricultural Cooperative
    - Agricultural Cooperative Statues
    - Income-Expense Information, Business Plan, and Repayment Plan.
    - Minute Of General Meeting Of Shareholder Or That Of Executive Management On Decision Authorization Borrowing From The Bank

- Option 2: Secured financing:
    - Representative's Khmer ID Card (Copy)
    - Registration Certificate Of Agricultural Cooperative
    - Agricultural Cooperative Statues
    - Income-Expense Information, Business Plan, and Repayment Plan.
    - Minute Of General Meeting Of Shareholder Or That Of Executive Management On Decision Authorization Borrowing From The Bank
    - Land Title for Collateral

Eligible Loan Purpose

268. Farming businesses often require loans: (1) to finance working capital, i.e., to purchase raw materials (farm input supplies), farm produce, or finished products for production or resell; and (2) to fund capital expenditure, i.e., to purchase farm machinery, improve infrastructure, and/or enhance production facilities. Under FARM, the fund should be used to finance the capital expenditure rather than working capital financing because capital expenditure is more straightforward in the financing process and has tangible assets which can be easily traced. Working capital financing requires more complex processes and technical knowledge to proceed, and the financed assets are short-lived, making it harder to monitor and track. Some working items, such as accounts receivable, are even intangible. Therefore, as a starting point for the project and an easier take-up, the project should first target to finance the capital expenditure of the target borrowers.

Loan Disbursement

269. FAO is to procure the assets and deliver them to borrowers. The borrowers would then make loan repayments to ARDB, and ARDB would continue to use the collected funds on an ongoing basis to serve the specified target customers under this loan product and follow the Standard Operating Procedure (SOP) of ACL.

Pre-Disbursement Condition

270. There are two options for the pre-disbursement condition. First, if FAO procures the assets and delivers them to the beneficiaries, there is no pre-disbursement condition to be fulfilled since FAO will procure from reliable suppliers, and there is no chance of asset price manipulation or potential misuse of funds. Second, if the beneficiaries can procure the asset by themselves, a sales and purchase agreement (SPA) of the asset must be obtained before loan disbursement. In addition, the asset has to be purchased from one of the approved suppliers. Appendix 1 shows a sample list of approved suppliers used by a local financial institution.

Post-Disbursement Condition

271. After disbursement, the beneficiaries must perform regular service checks and maintenance on the assets. The project may consider subsidizing up to 50% of the maintenance cost during its implementation phase. After the project completion, the beneficiaries will bear all mandatory maintenance costs.

Funding Ratio

272. The funding ratio refers to the percentage of the asset value that the EE finances. There are two options for the funding ratio against the total cost of funding for obtaining the initial asset. First, for the asset costing less than or equal to USD 50,000, the borrower should be asked to put down a down payment between 5 and 20% of the total cost. Second, for the asset costing more than USD 50,000, the down payment should be between 10 and 20%. However, a higher percentage than these set limits may be requested depending on the borrower's financial capacity.

8.3.6. Design Options under the Second Approach

273. Table 18 outlines two design options under the second approach. The descriptions of these approaches are provided below.

Table 18 FARM Design Options under the second approach

Term	Option 1	Option 2
a. Funding Basis	Standalone	Same
b. Target Customers	• Registered Agricultural Cooperatives • Registered Agricultural Associations • Registered Agricultural Unions • Registered Producer Groups	Same
c. Loan Size	Up to USD 50,000	Same
d. Loan Tenor	Up to 5-7 years	Same
e. Interest Rate	No interest rate	Same
f. Payment Methods	Semesterly or annually.	Same

g. Payment Mechanism	Pay back into a Trust Account held under the association's name with the Board of Trustees, comprising a Head/Chief of the Association, Chief of Commune, and one of the Provincial Department of Agriculture, Forestry, and Fishery staff. The fund can be used by all association members, subject to the submission of their business proposal, details of asset to be procured, and the approval from the Board of Trustees.	Pay back into a Trust Account held under the association's name with the Board of Trustees comprising Head/Chief of the Association, Chief of Commune, and one of the Department of Agriculture staff. The fund can only be used for the communal purpose of the association and the approval from the Board of Trustees. The purpose must align with their climate and climate-resilient business plan.
h. Security Requirements	• Not required landed collateral. • Require cross guarantee from a representative of the AC or all the management team of the AC. • Propose a specific charge on the asset(s) being financed. • Alternatively, the project to withhold an asset ownership document. • For the subsequent drawdown of the fund, all borrowing members must provide a cross guarantee to each other in a small group (suggest to have a group of five).	• Not required landed collateral. • Require cross guarantee from a representative of the AC or all the management team of the AC. • Propose a specific charge on the asset(s) being financed. • Alternatively, the project to withhold an asset ownership document. • For the subsequent drawdown of the fund, the association will continue to provide the security, as listed above.
i. Account Maintenance Fee	Account Maintenance Fee is the bank fee to maintain the Trust Account. The details of the fee charges are illustrated in the description in Table 3 below.	Same
j. Required Documents	• Representative's Khmer Id Card (copy) • Registration certificate of agricultural cooperative • Agricultural cooperative statues • Income-expense information, business plan, and repayment plan. • Minutes of general meeting of shareholder or that of executive management on decision authorization borrowing from the bank	Same
k. Eligible Loan Purpose	Acquisition of fixed assets to support or improve agricultural business activities	Same
l. Loan Disbursement	• FAO to procure the assets and deliver them to borrowers. • Borrower to make a loan repayment to Trust Fund Account. • The Board of Trustees to continue to use that fund on an ongoing basis to serve the specified target customers under this loan product. • The cooperative/association members can withdraw funds to purchase assets by themselves; however, it must be from the Approved Suppliers listed in Appendix 1.	• FAO to procure the assets and deliver them to borrowers. • Borrower to make a loan repayment to Trust Fund Account. • The Board of Trustees to continue to use that fund on an ongoing basis to serve the specified target customers under this loan product. • For the subsequent drawdown, the association can withdraw funds to purchase assets by themselves; however, it must be from the

		Approved Suppliers listed in Appendix 1 (FARM Feasibility Report)
m. Pre-Disbursement Condition	Sales and Purchase Agreement of the asset to be acquired.	Same
n. Post-Disbursement Condition	Perform regular service checks and maintenance (to be stated in the legal agreement between the project and the Beneficiary Group)	Same
o. Funding Ratio	• For the asset costing less than or equal to USD 50,000, the down payment is between 5%-20%. • For the asset costing more than USD 50,000, the down payment is between 10%-20%. • Depending on the borrower's financial capacity, a higher percentage of a down payment than the set limits may be encouraged. • The down payment is to be chipped in equally or proportionately by all association members. Each member can borrow up to 10 times their contribution to the down payment.	• For the asset costing less than or equal to USD 50,000, the down payment is between 5%-20%. • For the asset costing more than USD 50,000, the down payment is between 10%-20%. • Depending on the borrower's financial capacity, a higher percentage of a down payment than the set limits may be encouraged. • The down payment is to be chipped in equally or proportionately by all association members. However, each beneficiary group should be given some degree of flexibility in generating the necessary down payment. • The down payment is required for any procurement of an asset – both for the first and subsequent procurement.

Funding basis

274. *Standalone*: The second approach neither requires mandatory repayments nor charges interest on the funding. Also, co-financing with any lending institution is deemed improbable. Therefore, financing under this approach would be done on a standalone basis. This option does not require setting up the FARM under the EE's facility, which would involve several complex processes. Portfolio performance could also be easily tracked and monitored. However, funding on a standalone basis would limit the loan size, which may not accommodate some borrowers' needs to acquire larger assets that cost more than USD 50,000 (the maximum loan size offered in this program).

Target Customers

275. Funding individuals is not only costly but also operationally intensive. Therefore, to jumpstart more efficiently, the FARM should target well-structured borrowers, such as legally registered agricultural cooperatives, associations, unions, and producer groups, which should ultimately benefit small-scale and/or individual farmers.

Loan Size

276. As discussed in the Funding Basis section, on a standalone basis, the FARM would fund a maximum loan amount of USD 50,000, which is the approximate price of a combine harvester, a small-size cold storage facility, and a similar small-sized physical asset. However, some deviations on the funding size should also be considered with the view toward the potential impacts of their business proposal on upgrading agricultural value, improving climate resilience, and other social/economic effects on the borrowers and their communities.

277. For the fund request that is much larger than the pre-determined size above (i.e.,>50% or higher), a detailed calculation and assessment of the borrower's repayment capacity must be performed before making an approval decision.

Loan Tenor

278. The loan tenor should be up to 5-7 years, which is the average useful life of the fixed assets, like machinery and equipment. The actual tenor for each loan shall depend on the useful life of the specific asset being financed. However, this shall require regular maintenance to ensure usability and prevent fast deterioration.

Interest Rate

279. Under the second approach, no interest is charged. This ensures that the beneficiaries have access to the lowest cost of funds to transform their business operations into climate-resilient and higher-value ones.

Payment Methods

280. Repayment methods are crucial in loan design because they determine how loans are repaid. Since no lending institution is involved in the second approach, the repayment mode should be simplified. Since the target beneficiaries are mainly agricultural unions, associations, and cooperatives, their income is likely seasonal, and it only comes in once or twice a year. Therefore, only two repayment methods should be considered under this approach: (1) semesterly and (2) annually. The fund is then equally divided by the number of installments (based on the loan tenor), and repayments shall be made to the Trust Fund Account set up by each borrowing entity. The repayment schedule can be flexible in accordance with the cash flow pattern of each entity and/or the seasonality of the commodity produced.

Payment Mechanism

281. Both options under the second approach share the same practice for the first disbursement. Each beneficiary group would establish a Trust Fund Account with a designated financial institution. The project would seek a partner financial institution(s) for making the Trust Fund arrangements with the beneficiary groups. A designated partner financial institution or multiple institutions would be selected from the private or/and public sector(s). The repayments made by each beneficiary group would be held in its Trust Fund Account. Every Trust Fund would be served by a board of trustees,

comprising the representatives of the beneficiary group, local authority (i.e., commune chief), and representative of MAFF.

282. For the subsequent disbursement (using the funds collected as repayments for the initially procured asset), there are two options: under Option 1, the funds are made available for all members of the beneficiary group, and they can request up to 10 times of the down payment they contributed for acquiring the initial asset. The request to drawdown from each member shall comprise an individual business plan and a repayment plan and must be assessed and approved by the Board of Trustees. The voting mechanism of the Board of Trustees requires unanimous support from all board members to approve the request. Under Option 2, the funds can only be used for the beneficiary group's collective action toward advancing its climate-resilient business plan. The approval process of the subsequent disbursement is the same as the first option.

Security Requirements

283. Under the second approach, given there is no involvement of a lending institution, it is not practical to require landed collateral as the security. In addition, if a moveable asset (the asset being financed) is used as the collateral, the project cannot subscribe and use the service of the SETFO because it usually is for registered private companies, financial institutions, and lending individuals. The project may alternatively request FAO or one of the EEs to register and perform collateral filing under the SETFO. Nevertheless, it would be most straightforward for the project to keep the assets' ownership documents, i.e., in a safe at FAO or any field office with proper records and documentation. This can prevent the assets from being sold off before completing the repayments, especially for those highly moveable ones, such as tractors, combined harvesters. In case of default, the project can choose to workout with the beneficiaries to identify a possible solution for repayment, and at the last resort, may proceed to liquidate the asset.

284. It is also advised that the borrowers must buy insurance for the financed assets to protect themselves from any unfortunate events which may physically or functionally damage the assets. Of the information collected from general insurance companies, standard insurance products are available for this purpose.

285. The lending institution could also request a personal guarantee from the representative or all the management team of the borrowing entity (i.e., a union, cooperative, association, or producer group). Under this condition, it would not be recommended, however, to offer loans to individual farmers, as the lack of shared responsibility makes the guarantee weak and cannot mitigate the credit risk of an unsecured loan.

286. For the subsequent disbursements using the funds collected through repayments for the financed assets, there are two options: (1) the members of the borrowing entity form a group of at most five members and provide cross guarantee to each other, and (2) the borrowing entity adheres to the security arrangements described above. Under the first option, solidarity group lending ensures that the group members provide a cross guarantee to each other, and if any member fails to make a repayment, the other group members will contribute their share to cover the missed repayment. In the case of the second option, the subsequent drawdown of the funds is only limited to communal use to advance their business plan implementation.

Account Maintenance Fee

287. An account maintenance fee shall be charged directly to the Trust Account by the financial institution. For instance, a local bank, ACLEDA Bank, charges an annual fee for maintaining a Trust Account based on the account size, as follows:

Table 19 Trust fund fees

Account Limit (USD)	Fee Charge (USD)
USD 0 to 50,000	50
> 50,000 to 100,000	100
> 100,000 to 150,000	150
> 150,000 to 200,000	200
> 200,000 to 250,000	250
> 250,000 to 300,000	300
> 300,000 to 350,000	350
> 350,000 to 400,000	400
> 400,000 to 450,000	450
> 450,000	500

Required Documents

288. For both options under the second approach, the following are the generally required documents for the borrower cooperatives/ associations to obtain financing:

- Representative's Khmer ID Card (Copy)
- Registration Certificate Of Agricultural Cooperative
- Agricultural Cooperative Statues
- Income-Expense Information, Business Plan, and Repayment Plan.
- Minutes of General Meeting Of Shareholder Or That Of Executive Management On Decision Authorization Borrowing From The Bank

Eligible Loan Purpose

289. The basic financial requirements for farming businesses are a) to finance working capital, i.e., to purchase raw materials (farm input supplies), farm produce, or finished products for production or resell; and b) to fund capital expenditure, i.e., to purchase farm machinery, improve infrastructure, and/or enhance production facilities. In this project, the funds should be used to finance the capital expenditure rather than working capital financing because capital expenditure is more straightforward in the financing process and has tangible assets which can be easily traced. Working capital financing requires more complex processes and technical knowledge to proceed, and the financed assets are short-lived and hard to monitor and track. Some working items, such as accounts receivable, are even intangible. Therefore, as a starting point for the project and an easier take-up, the project should first target to finance the capital expenditure of the target borrowers.

Loan Disbursement

290. FAO is to procure the assets and deliver them to borrowers. The beneficiary groups will repay to their Trust Fund Account held at the partnered financial institution(s). The Board of Trustees will continue to monitor and allow the fund to be reinvested on an ongoing basis.

Pre-Disbursement Condition

291. There are two options for this pre-disbursement condition. First, if FAO procures the assets and delivers them to the beneficiaries, there is no pre-disbursement condition to be fulfilled since FAO will procure from reliable suppliers, and there is no chance of asset price manipulation or potential misuse of funds. Second, if the beneficiaries can procure the asset by themselves, a sales and purchase agreement (SPA) of the asset must be obtained before loan disbursement. In addition, the asset has to be purchased from one of the approved suppliers as stated in Appendix 1 – List of Approved Suppliers.

Post-Disbursement Condition

292. After disbursement, the beneficiaries must perform regular service checks and maintenance on the assets. The project may consider subsidizing up to 50% of the maintenance cost during its implementation phase. After the project completion, the beneficiaries will bear all mandatory maintenance costs.

Funding Ratio

293. Similar to the first approach, there are two options for the funding ratio against the asset's total cost. First, for the asset costing less than or equal to USD 50,000, the borrower should be asked to put down a down payment between 5 and 20% of the total cost. Second, for the asset costing more than USD 50,000, the down payment should be between 10 and 20%. However, a higher percentage than these set limits may be requested depending on the borrower's financial capacity.

294. For obtaining the first asset, each member of the beneficiary group may be asked to contribute towards the down payment, either equally or proportionately to their shareholdings in their cooperative/association, under both options. However, each beneficiary group is given a degree of flexibility to arrange how they raise the down payment.

295. For the subsequent disbursement(s), the first option allows the down payment-contributing members to borrow up to 10 times their contribution towards the first asset. However, the second option only allows the beneficiary groups (not individual members) to reinvest the funds towards the further advancement of their business plans.

8.3.7. SWOT Analysis

SWOT Analysis of First Approach - Option One	
Strengths	**Weaknesses**

• Imposes repayment commitment to the beneficiary groups, given it involves interest charges and other penalty charges in case of default. • Has more repayment options for the beneficiary groups. • Has a robust monitoring mechanism, particularly on the investment's portfolio quality, asset utilization, and economic performance, translating into timely repayment of the loan. • Can register landed collateral, if any.	• Offers high-cost financing due to the interest charges involved. • Provides only small funding (loan) size. • Has a complicated process integrating the partnered lending institution, especially in the lending process and pricing mechanism. • Has limited outreach to individual members of the beneficiary groups as the fund can only be re-used by the groups. • May have a negative social impact through the default funding (loan) enforcement.
Opportunities	**Threats**
• The market needs unsecured financing for agricultural associations/cooperatives, particularly their capital expenditure support. • The partnered lending institution has high replication potential to offer matching products.	• Relatively weak legal framework governs the pledging of moveable assets. • Lack of good governance at the beneficiary group level. • Complex bureaucracy of the partnered lending institution.

SWOT Analysis of Second Approach - Option Two	
Strengths	**Weaknesses**
• Imposes repayment commitment to the beneficiary groups, given it involves interest charges and other penalty charges in case of default. • Has more repayment options for the beneficiary groups. • Has a robust monitoring mechanism, particularly on the investment's portfolio quality, asset utilization, and economic performance, translating into timely repayment of the loan. • Can register landed collateral, if any. • Can offer larger funding (loan) size.	• Offers high-cost financing due to the interest charges involved. • Has a complicated process integrating the partnered lending institution, especially in the lending process and pricing mechanism. • Requires a high level of complexity in designing and implementing a co-financing scheme. • Has limited outreach to individual members of the beneficiary groups as the fund can only be re-used by the groups. • May have a negative social impact through the default funding (loan) enforcement.
Opportunities	**Threats**
• The market needs unsecured financing for agricultural associations/cooperatives, particularly their capital expenditure support. • The partnered lending institution has high replication potential to offer matching products.	• Relatively weak legal framework governs the pledging of moveable assets. • Lack of good governance at the beneficiary group level. • Complex bureaucracy of the partnered lending institution.

SWOT Analysis of the Second Approach - Option One

Strengths	Weaknesses
• Offers low cost of financing for the beneficiary groups and their members. • Provides financing opportunities to individual members, reinforced by the cross guarantee among the members. • Does not require any integration with a partnered lending institution, thus straightforward implementation. • Imposes soft action on the beneficiary groups in case of default, offering a more amicable approach.	• Affects its sustainability and effectiveness due to the lack of repayment monitoring, which may lead to a higher default rate. • Provides only a small funding size. • Has limited options for repayment methods. • Cannot register landed collateral. • May have limited participation by the members of the Board of Trustees. • Can be challenging to manage and monitor the subsequent disbursements given a potentially large number of individual members accessing the funds.
Opportunities	**Threats**
• The market needs unsecured financing for agricultural associations/cooperatives, particularly their capital expenditure support. • There may be potential support from local governments/authorities as it offers a low cost of financing and climate-resilience funding.	• Lack of information on the overall indebtedness of the beneficiary groups and their members (in the subsequent disbursement). • Lack of good governance at the beneficiary group level.

SWOT Analysis of the Second Approach - Option Two	
Strengths	**Weaknesses**
• Offers low cost of financing for the beneficiary groups and their members. • Provides a streamlined process as it focuses on communal investments of the beneficiary groups, while benefits are expected to trickle down to individual members. • Does not require any integration with a partnered lending institution, thus straightforward implementation. • Imposes soft action on the beneficiary groups in case of default, offering a more amicable approach.	• Affects its sustainability and effectiveness due to the lack of repayment monitoring, which may lead to a higher default rate. • Provides only a small funding size. • Has limited options for repayment methods. • Cannot register landed collateral. • May have limited participation by the members of the Board of Trustees. • Has limited outreach to individual members of the beneficiary groups as the fund can only be re-used by the groups.
Opportunities	**Threats**
• The market needs unsecured financing for agricultural associations/cooperatives, particularly their capital expenditure support. • There may be potential support from local governments/authorities as it offers a low cost of financing and climate-resilience funding.	• Lack of information on the overall indebtedness of the beneficiary groups and their members (in the subsequent disbursement). • Lack of good governance at the beneficiary group level.

8.3.8. Recommended Approach

296. The second option under the second approach is recommended based on the following rationales. The second approach is recommended because it:

- **Provides the lowest cost of financing to the target beneficiaries**, which is much more affordable than the two options under the first approach bearing interest charges. This is consistent with the project's overall objective, i.e., enabling the agricultural cooperatives, producer groups, and associations to access low-cost finance to improve farm productivity and climate change resilience.
- Offers **a quick and straightforward process** as it does not require any process and procedural integration and alignment with the partnered financial institution(s). This saves a great deal of time and cost compared to the first approach.
- Operates as a (revolving) grant rather than lending, which may subject the borrowers to aggressive payment collection methods and legal repercussions in case of default. The project intends to follow soft action on the beneficiary groups in case of default to **avoid causing negative socioeconomic implications**.
- Address the need for **unsecured financing for agricultural cooperatives and associations** to support their capital expenditure investment. However, given the concessions offered and the high credit risk taken by the project, it should focus on high capacity cooperatives, associations, and producer groups and **ensure that the beneficiaries have proper business plans, including** concrete approaches in dealing with climate change, comprehensive execution strategies and are in good financial position.
- Has the potential to leverage **support from local governments/authority** as it offers a low cost of financing and climate-resilience funding. Such support would ensure integration of the beneficiary groups' investments with commune and district level planning and investment activities to increase climate change resilience and financial availability at the community level.

297. Furthermore, the second option under the second approach is recommended as the best option because it targets only the beneficiary groups instead of the first option where their members also gain access to finance. Serving the individual members can be operationally taxing and complex, thus costly. This option alleviates these issues and focuses on the communal investment needs of the beneficiary groups, guided by their climate-resilient business plans, which ultimately benefit their members.

298. Nevertheless, the second option under the second approach also presents the following challenges and risks that the project should consider carefully to develop clear mitigation strategies:

- The approach lacks a mechanism for monitoring repayment progress, which can lead to a higher default rate and reduce the project's sustainability and effectiveness. Then project should establish a clear monitoring mechanism to conduct regular checks on repayments from the beneficiary groups, i.e., quarterly or semi-annual. If there are any missed repayment, the project should make a courtesy call to the beneficiary group and remind them to fulfill their obligation, and particular attention should be given to repeated missed payments as a warning sign. With a proper monitoring mechanism, the effectiveness of the fund can be maximized, and any irregularities can be timely identified and resolved.
- Second, another challenge stems from the lack of information from the beneficiary groups. The information, particularly on their indebtedness, is crucial. However, this

information will be limited to the project because the project is not a licensed financial operator who can demand credit bureau records on its borrowers/ beneficiaries. Alternatively, the project may request each beneficiary group to submit a credit health check report, which is a self-checked credit bureau record and can be obtained through the Credit Bureau of Cambodia (CBC) mobile application or at any branch office of financial institutions (such as AMK, Prasac – etc.).

- Third, limited information on the beneficiary groups' governance capacity can pose an operational risk. Without proper administration, the financed assets may not be used for the intended purpose or benefit the members of the beneficiary groups in an equitable and gender-responsive manner. Poor governance and management can also lead to a high default rate. To mitigate this issue, the project should set out clear criteria for selecting its beneficiary groups based on assessing their business operations, business plans, institutional records, management structure, financial performance, investment viability, repayment plans, etc.

299. Considering these challenges and risks, the project should provide governance capacity development support to the selected beneficiary groups. Particularly the training of their boards of trustees would add significant value. In conclusion, there is no risk-free decision; however, taking calculated and well-thought-through risks are vital in ensuring the success and effectiveness of the FARM under this project.

8.3.9. Sensitivity Analysis of Recommended Approach

300. A fund flow analysis of the second option under the second approach is performed based on two scenarios: (1) a projected default rate of 5% (Table 20) and (2) a projected default rate of 20% (Table 21. The analysis is based on a set of five variables – i) total finance available, ii) number of beneficiary groups, iii) average funding size, iv) fund tenor, and v) default rate. Several assumptions applied in the projections are also detailed in the spreadsheets below:

Table 20:FARM scenario one

Scenario 1: Default Rate of 5%		Assumptions:
Fund Limit	7000000	- Unpaid amount (default amount) is written off immediately as it is not added back to the outstanding fund.
Target Number of Beneficiaries	200	- Fund size is of the same size and the same tenor.
Average Fund Size	35000	- Default rate is estimated at 5% of each year repayment.
Fund Tenor (Year)	6	- The net repayment amount will be fully disbursed (re-used) after being collected during the year.
Estimated Default Rate	5%	- New disbursement is expected to be identical as the previous in term of fund size and fund tenor.

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
New Disbursement	**7,000,000**	**1,108,333**	**1,283,819**	**1,487,091**	**1,722,547**	**1,995,284**	**2,311,203**	**1,568,811**	**1,641,719**	**1,698,387**	**1,731,842**	**1,733,314**	**1,691,835**	**1,593,769**	**1,597,721**
Outstanding Fund Year 1	7,000,000	1,108,333	1,283,819	1,487,091	1,722,547	1,995,284	2,311,203	1,568,811	1,641,719	1,698,387	1,731,842	1,733,314	1,691,835	1,593,769	1,597,721
Outstanding Fund Year 2	-	5,833,333	923,611	1,069,850	1,239,242	1,435,456	1,662,736	1,926,003	1,307,342	1,368,100	1,415,323	1,443,202	1,444,428	1,409,863	1,328,141
Outstanding Fund Year 3	-	-	4,666,667	738,889	855,880	991,394	1,148,365	1,330,189	1,540,802	1,045,874	1,094,480	1,132,258	1,154,561	1,155,543	1,127,890
Outstanding Fund Year 4	-	-	-	3,500,000	554,167	641,910	743,545	861,273	997,642	1,155,602	784,405	820,860	849,194	865,921	866,657
Outstanding Fund Year 5	-	-	-	-	2,333,333	369,444	427,940	495,697	574,182	665,095	770,401	522,937	547,240	566,129	577,281
Outstanding Fund Year 6	-	-	-	-	-	1,166,667	184,722	213,970	247,848	287,091	332,547	385,201	261,468	273,620	283,065
Total Beginning Outstanding Fund	**7,000,000**	**6,941,667**	**6,874,097**	**6,795,829**	**6,705,169**	**6,600,154**	**6,478,512**	**6,395,943**	**6,309,536**	**6,220,148**	**6,128,998**	**6,037,771**	**5,948,727**	**5,864,844**	**5,780,754**
Repayment Amount Year 1	1,166,667	184,722	213,970	247,848	287,091	332,547	385,201	261,468	273,620	283,065	288,640	288,886	281,973	265,628	266,287
Repayment Amount Year 2	-	1,166,667	184,722	213,970	247,848	287,091	332,547	385,201	261,468	273,620	283,065	288,640	288,886	281,973	265,628
Repayment Amount Year 3	-	-	1,166,667	184,722	213,970	247,848	287,091	332,547	385,201	261,468	273,620	283,065	288,640	288,886	281,973
Repayment Amount Year 4	-	-	-	1,166,667	184,722	213,970	247,848	287,091	332,547	385,201	261,468	273,620	283,065	288,640	288,886
Repayment Amount Year 5	-	-	-	-	1,166,667	184,722	213,970	247,848	287,091	332,547	385,201	261,468	273,620	283,065	288,640
Repayment Amount Year 6	-	-	-	-	-	1,166,667	184,722	213,970	247,848	287,091	332,547	385,201	261,468	273,620	283,065
Total Repayment Amount	**1,166,667**	**1,351,389**	**1,565,359**	**1,813,207**	**2,100,298**	**2,432,846**	**1,651,380**	**1,728,126**	**1,787,776**	**1,822,992**	**1,824,541**	**1,780,879**	**1,677,651**	**1,681,811**	**1,674,478**
Default Amount Year 1	58,333	9,236	10,698	12,392	14,355	16,627	19,260	13,073	13,681	14,153	14,432	14,444	14,099	13,281	13,314
Default Amount Year 2	-	58,333	9,236	10,698	12,392	14,355	16,627	19,260	13,073	13,681	14,153	14,432	14,444	14,099	13,281
Default Amount Year 3	-	-	58,333	9,236	10,698	12,392	14,355	16,627	19,260	13,073	13,681	14,153	14,432	14,444	14,099
Default Amount Year 4	-	-	-	58,333	9,236	10,698	12,392	14,355	16,627	19,260	13,073	13,681	14,153	14,432	14,444
Default Amount Year 5	-	-	-	-	58,333	9,236	10,698	12,392	14,355	16,627	19,260	13,073	13,681	14,153	14,432
Default Amount Year 6	-	-	-	-	-	58,333	9,236	10,698	12,392	14,355	16,627	19,260	13,073	13,681	14,153
Total Default Amount	**58,333**	**67,569**	**78,268**	**90,660**	**105,015**	**121,642**	**82,569**	**86,406**	**89,389**	**91,150**	**91,227**	**89,044**	**83,883**	**84,091**	**83,724**
Total Ending Outstanding Fund	**6,941,667**	**6,874,097**	**6,795,829**	**6,705,169**	**6,600,154**	**6,478,512**	**6,395,943**	**6,309,536**	**6,220,148**	**6,128,998**	**6,037,771**	**5,948,727**	**5,864,844**	**5,780,754**	**5,697,030**

	Amount	Outreach
Original Fund	7,000,000	200
Revolved Fund	23,165,676	662
Total Fund	**30,165,676**	**862**

Table 21: FARM scenario two

Scenario 2: Default Rate of 20%			Assumptions:
Fund Limit	7000000		- Unpaid amount (default amount) is written off immediately as it is not added back to the outstanding fund.
Target Number of Beneficiaries	200		- Fund size is of the same size and the same tenor.
Average Fund Size	35000		- Default rate is estimated at 20% of each year repayment.
Fund Tenor (Year)	6		- The net repayment amount will be fully disbursed (re-used) after being collected during the year.
Estimated Default Rate	20%		- New disbursement is expected to be identical as the previous in term of fund size and fund tenor.

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
New Disbursement	**7,000,000**	**933,333**	**1,057,778**	**1,198,815**	**1,358,657**	**1,539,811**	**1,745,119**	**1,044,468**	**1,059,286**	**1,059,488**	**1,040,911**	**998,544**	**926,376**	**817,210**	**786,909**
Outstanding Fund Year 1	7,000,000	933,333	1,057,778	1,198,815	1,358,657	1,539,811	1,745,119	1,044,468	1,059,286	1,059,488	1,040,911	998,544	926,376	817,210	786,909
Outstanding Fund Year 2	-	5,833,333	777,778	881,481	999,012	1,132,214	1,283,176	1,454,266	870,390	882,739	882,906	867,425	832,120	771,980	681,008
Outstanding Fund Year 3	-	-	4,666,667	622,222	705,185	799,210	905,771	1,026,541	1,163,413	696,312	706,191	706,325	693,940	665,696	617,584
Outstanding Fund Year 4	-	-	-	3,500,000	466,667	528,889	599,407	679,328	769,906	872,560	522,234	529,643	529,744	520,455	499,272
Outstanding Fund Year 5	-	-	-	-	2,333,333	311,111	352,593	399,605	452,886	513,270	581,706	348,156	353,095	353,163	346,970
Outstanding Fund Year 6	-	-	-	-	-	1,166,667	155,556	176,296	199,802	226,443	256,635	290,853	174,078	176,548	176,581
Total Beginning Outstanding Fund	**7,000,000**	**6,766,667**	**6,502,222**	**6,202,519**	**5,862,854**	**5,477,902**	**5,041,622**	**4,780,505**	**4,515,683**	**4,250,811**	**3,990,584**	**3,740,947**	**3,509,354**	**3,305,051**	**3,108,324**
Repayment Amount Year 1	1,166,667	155,556	176,296	199,802	226,443	256,635	290,853	174,078	176,548	176,581	173,485	166,424	154,396	136,202	131,151
Repayment Amount Year 2	-	1,166,667	155,556	176,296	199,802	226,443	256,635	290,853	174,078	176,548	176,581	173,485	166,424	154,396	136,202
Repayment Amount Year 3	-	-	1,166,667	155,556	176,296	199,802	226,443	256,635	290,853	174,078	176,548	176,581	173,485	166,424	154,396
Repayment Amount Year 4	-	-	-	1,166,667	155,556	176,296	199,802	226,443	256,635	290,853	174,078	176,548	176,581	173,485	166,424
Repayment Amount Year 5	-	-	-	-	1,166,667	155,556	176,296	199,802	226,443	256,635	290,853	174,078	176,548	176,581	173,485
Repayment Amount Year 6	-	-	-	-	-	1,166,667	155,556	176,296	199,802	226,443	256,635	290,853	174,078	176,548	176,581
Total Repayment Amount	**1,166,667**	**1,322,222**	**1,498,519**	**1,698,321**	**1,924,764**	**2,181,399**	**1,305,585**	**1,324,108**	**1,324,359**	**1,301,138**	**1,248,181**	**1,157,969**	**1,021,512**	**983,636**	**938,239**
Default Amount Year 1	233,333	31,111	35,259	39,960	45,289	51,327	58,171	34,816	35,310	35,316	34,697	33,285	30,879	27,240	26,230
Default Amount Year 2	-	233,333	31,111	35,259	39,960	45,289	51,327	58,171	34,816	35,310	35,316	34,697	33,285	30,879	27,240
Default Amount Year 3	-	-	233,333	31,111	35,259	39,960	45,289	51,327	58,171	34,816	35,310	35,316	34,697	33,285	30,879
Default Amount Year 4	-	-	-	233,333	31,111	35,259	39,960	45,289	51,327	58,171	34,816	35,310	35,316	34,697	33,285
Default Amount Year 5	-	-	-	-	233,333	31,111	35,259	39,960	45,289	51,327	58,171	34,816	35,310	35,316	34,697
Default Amount Year 6	-	-	-	-	-	233,333	31,111	35,259	39,960	45,289	51,327	58,171	34,816	35,310	35,316
Total Default Amount	**233,333**	**264,444**	**299,704**	**339,664**	**384,953**	**436,280**	**261,117**	**264,822**	**264,872**	**260,228**	**249,636**	**231,584**	**204,302**	**196,727**	**187,648**
Total Ending Outstanding Fund	**6,766,667**	**6,502,222**	**6,202,519**	**5,862,854**	**5,477,902**	**5,041,622**	**4,780,505**	**4,515,683**	**4,250,811**	**3,990,584**	**3,740,947**	**3,509,354**	**3,305,051**	**3,108,324**	**2,920,676**

	Amount	Outreach
Original Fund	7,000,000	200
Revolved Fund	15,566,704	445
Total Fund	**22,566,704**	**645**

8.3.10. Third Approach: Hybrid Model

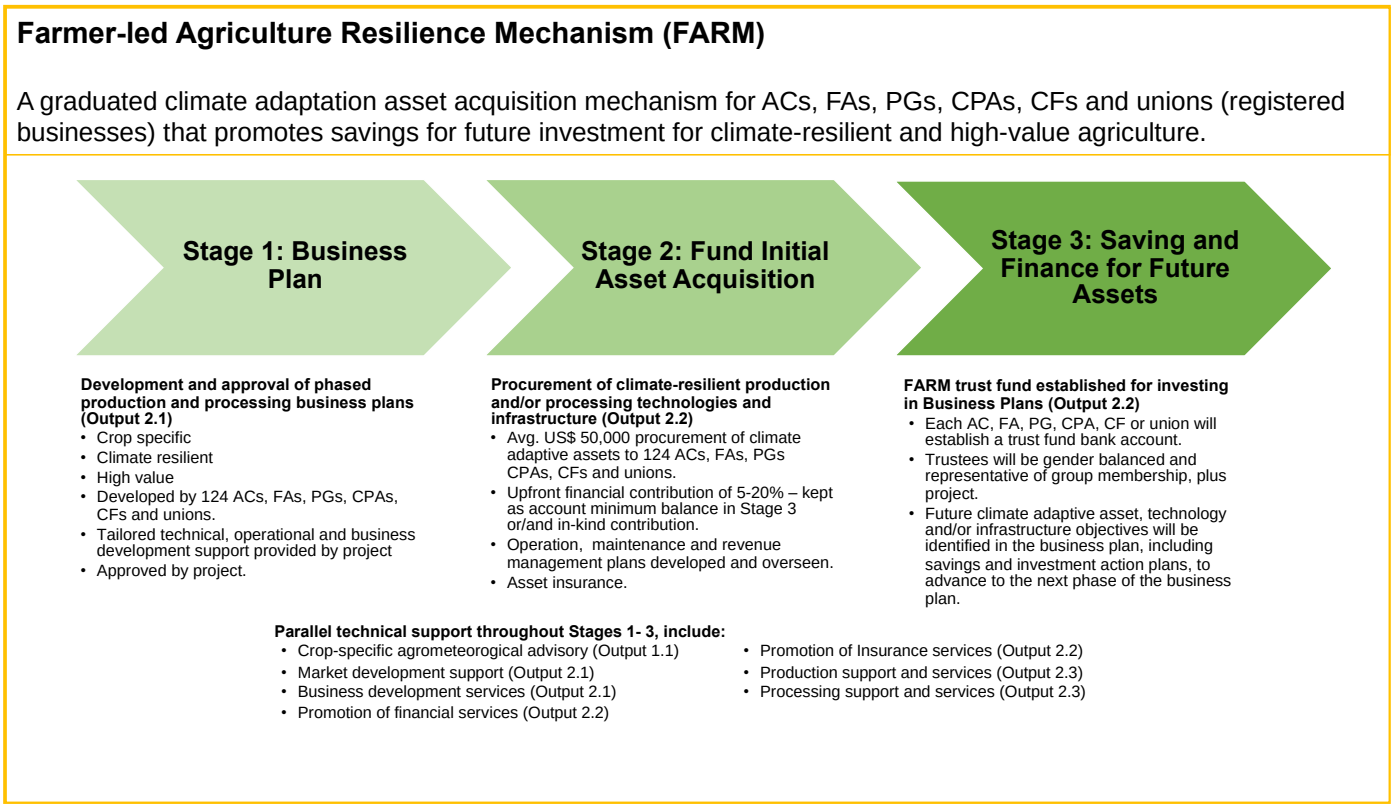
301. The project design team considered the above analysis and recommendations concerning the two design approaches, including their options, FAO's internal regulations, and GCF accreditation limitations. This has resulted in the decision by the project design team to develop a third approach, which builds on the recommended option under the second approach.

302. This hybrid model, described below, reduces the level of financial responsibility for the beneficiary groups to enable their focus on business ideas and entrepreneurial skills development during the project. The FARM will support the operationalization of business plans on a trial-and-error basis. During this period, the revenue generation potential remains relatively low; therefore, a high level of concessionality is required. In the post-project environment, these beneficiary groups will have developed the adequate financial ability and business know-how to access finance at a much lower level of concessionality.

8.4. Suggested Actions under Output 2.2

303. The FARM will be implemented in three stages as a graduation programme (see Figure 9). Beneficiary groups will be required to successfully complete the activities of each stage in order to graduate to the next stage of the programme. The **first stage** begins under Output 2.1 to develop crop-specific and climate-resilient production and processing business plans with the beneficiary groups. The project will also ensure that the business plans complement relevant Commune Development and Investment Plans (CDPs and CIPs) to contribute to climate resilience building at the local level. The project will provide various technical and operational agriculture value chain and business development support services to the beneficiary groups during this stage. Each business plan will include growth strategies using a phased approach, an assessment of resource needs, asset acquisition, and revenue management plans, which includes access to private financial capital and insurance services. The project will set up a business plan review committee whose members comprise representatives of the project[22], agricultural extension services, and private value chain leaders selected through the AE's ongoing screening process. The committee will establish specific review criteria to screen and approve business plans to ensure their climate adaptation benefits, business viability, quality control measures (see Table 8) and commune and district -level sustainable development contribution (e.g., youth employment, green jobs).

Figure 43: FARM Stages



304. In the **second stage**, following the completion and acceptance of the business plans, the project, in consultation with each beneficiary group, will identify a technology(ies) or/and infrastructure

22 FAO, MAFF, and MoE will jointly represent the project. As the EE responsible for this output, FAO will have the ultimate authority for the final approval of the business plans.

asset(s) that is/are essential for operationalizing the initial phase of their business plan. The project will develop standardized technical specifications for the proposed asset(s) and select vendors and procure the chosen technology (ies)/infrastructure asset(s) for the beneficiary group. At this point, each beneficiary group will be encouraged to make an upfront financial contribution (e.g., between 5 to 20 % of the total value) towards the purchase. In addition, the beneficiary group may provide a non-financial contribution (e.g., labor hours) during the installation of the acquired infrastructure asset(s). The upfront financial contribution towards the purchase of the asset(s) will be used as start-up funds in the beneficiary group's trust fund account (see Stage 3) and held as a minimum balance until the completion of the full handover schedule or project completion. Although the project will transfer the ownership[23] of the procured asset(s) to the beneficiary group immediately upon the attainment of technical installation clearance, the project will withhold[24] ownership documents and prepare a full handover schedule to prevent any fraudulent activities or illegal disposition of the asset(s) not according to the business plan. The beneficiary group will assume the full duty of care upon completion of ownership transfer. The project will also support the beneficiary group in preparing and implementing an asset maintenance plan for keeping the asset(s) in optimal operating conditions. The beneficiary group will also be required to purchase an insurance policy for the asset(s) against the total loss or damage.

[23] FAO's Manual Section 503 on Asset Management, including sub-sections on asset disposal and transfer to financial beneficiaries, will guide beneficiary selection, legal agreement, and asset transfer processes and procedures to prevent fraudulent and illegal practices, including money-laundering and terrorist financing.

[24] FAO, as the AE, will undertake this responsibility.

FARM Quality Control Measures		
Stage 1: Business Plan	**Stage 2: Fund Initial Asset Acquisition**	**Stage 3: Saving and Finance for Future Assets**
Each Business plan, assessed by Review Committee, includes: • Phased business graduation strategy and action plan, including revenue forecasts and management (e.g., set in 3 phases) • Asset acquisition plan, including technology and infrastructure needs and specifications for each phase. • Technical and financial monitoring plans and reporting procedures. • In-kind or/and upfront financial contribution commitment and its use (i.e., a minimum account balance in Stage 3). • Terms and conditions of asset transfer and full handover. • Asset maintenance and operation plans, including insurance (through fees and revenues). • Regular financial contribution level and schedule based on revenue forecasts and management plan, financial capacity, harvest cycle, etc. • Governance arrangements (i.e., a gender-balanced board of trustees, gender-responsive decision-making procedures, a dispute resolution mechanism, disbursement monitoring and reporting responsibilities, and post-project arrangements).	***QC instruments for asset acquisition and transfer include:*** • FARM grants manual (developed at inception). • FAO's internationally competitive procurement standards and procedures. • Grant agreement, including upfront in-kind (e.g., labor hours) or/and financial contribution commitment and arrangements. • Asset transfer agreement, including withholding legal documents to prevent any fraudulent activities or disposition of the asset(s) not in line with business plans and full handover terms and schedule.	***Terms and arrangements of Trust Fund accounts include:*** • List of project's recommended microfinance banks and service packages for beneficiary groups. • Trust account per beneficiary group (124 accounts in total) using a standard trust account package of commercial banks (e.g., ACLEDA, AMK). • Upfront financial contribution used as a minimum balance until full handover/project completion. • Expected regular contribution of average US$ 5,000 (ca. US $33 per individual member) annually guided by the business plans – specific schedule TBD based on harvest cycles, etc. • Sources of regular contribution include membership fees and revenues from business plan implementation. • Estimated banking fees – US$ 50 a year for up to US$ 50,000 in deposit, plus transaction fees. • Board of trustees per account – the trustees, including the project, consult with members to make disbursement decisions executed by the bank. • Customized disbursement/withdrawal criteria per account (primarily for business plan advancement). • Biannual business plan progress reporting by each beneficiary group (financial and technical), including board meeting minutes and bank statements.

305. Each beneficiary group will develop and cover the cost of maintenance and operation plan and insurance through their membership fees[25] or/and revenues generated through the implementation of its business plan. As part of its asset acquisition plan, the project will support the beneficiary groups in making regular financial contributions for the use of the assets(s) (e.g., a proportion of the revenues generated through their business plan implementation) to increase the sense of ownership of their

[25] Most beneficiary groups have an established mechanism to collect membership fees from their members regularly for a group savings scheme or/and to cover operating costs. The project will support each beneficiary group in identifying ways to cover the cost of insuring and maintaining the acquired asset. One such way is to agree among its members to increase their membership fee contribution level.

acquired asset(s) and business plans. The financial contribution schedule will be prepared based on crop-specific harvest cycles (e.g., biannual, annual), the business activities of the beneficiary group and the financial ability of each beneficiary group. Based on the financial scenarios provided in Annex 2, the project expects each beneficiary group to be able to make a regular contribution of approximately US$5,000 annually or based on an alternative contribution schedule, as described above. This figure is estimated based on a standard loan principal repayment level with the MFIs in Cambodia and the project financial impact of the project demonstrated in Annex 3. For instance, an average beneficiary group comprises 150 members, which equates to US$33 per member annually to make the annual contribution. The project expects to contribute to a yearly household income increase of US$200-300 (Annex 3), and this estimated individual contribution level is considered feasible. However, any higher contribution or financial commitment level would make the mechanism unviable for the beneficiary groups as it would further reduce the already marginal household income increase delivered by the project. Directing the increased household income as much as possible to enhance the individual beneficiaries' adaptive capacity is the primary objective during this business incubation period.

306. In parallel, the project will provide ongoing technical support to the beneficiary groups in implementing their business plans, including demonstrating and supporting the adoption of relevant climate-resilient and high-value practices and technology applications under Output 2.3.

307. The GCF resources (roughly US$ 7 million) will be used as initial funding for the procurement of the technologies and infrastructure assets and to support the establishment of the FARM. According to the conservative estimate from the feasibility study (see Annex 2 for the detailed calculation), the initial funding will generate roughly US$ 20 million over the project life to finance a range of activities by the beneficiary groups for their transition to climate-resilient and high-value agriculture. However, much of these activities will focus on capacity development efforts related to the operationalization of the business plans on a trial-and-error basis; therefore, a high level of concessionality through GCF finance is required to support this incubation process during which the revenue generation potential remains relatively low.

308. In the **third stage**, the project will assist[26] each beneficiary group in establishing a trust fund account with a local commercial microfinance bank (e.g., ACLEDA, AMK – see Table 5). The account will be established using a commercial banking product with standard services. Most commercial microfinance banks in Cambodia offer a trust account service, which charges US$ 50 for an annual service fee for an account holding up to US$ 50,000 and requires a board of trustees and customized transaction criteria. The beneficiary group will then place their financial contributions for the acquired asset(s) in the trust fund. A board of trustees, comprising of beneficiary group members (gender balanced) will be established to oversee fund disbursements/transactions. The trustees include the project for quality assurance, and the project will support the board in developing post-project governance arrangements. The disbursements[27] will be used to advance the implementation of the beneficiary group's business plan (e.g., completing the initial phase and initiating the second phase

[26] The project will work with each beneficiary group to identify the most suitable commercial bank to set up its trust fund account. The process will consider factors such as their physical accessibility, the beneficiary group's previous and existing business relationship and experience with the bank, and product and service competitiveness. As part of the screening process for identifying private partners, FAO, as the AE, will also screen several large agricultural microfinance banks to identify a list of recommended banks. The project will also assist each beneficiary group in selecting an appropriate service package (i.e., trust fund arrangements) with the identified bank. The beneficiary group will be responsible for opening the trust fund account.

[27] Disbursements will finance various activities, including purchasing additional equipment and agricultural supplies and quality control-related activities identified in the business plan.

with clear action plans and graduation strategies). Disbursement decisions will be monitored and advice provided by the PEARL project, to ensure that the disbursements will directly support climate change adaptation and related efforts and that gender responsiveness, and equity considerations are assured. The project working with the beneficiary groups will establish customized disbursement criteria for each beneficiary group based on its specific needs and actions identified under its business plan. Specific quality control measures for each stage are provided in the table above.

309. Concurrently, the project will provide governance capacity development support to the beneficiary groups through establishing and training boards of trustees and beneficiary group members to ensure risk-free and inclusive decision-making, transparency, and accountability. The project will also increase the beneficiary groups' awareness of financial products and services (e.g., savings, investments, and loans) and risk financing (i.e., insurance) available in the country that would be complementary to the FARM to advance the implementation of their business plans. The beneficiary groups may use the acquired assets and trust fund accounts as group collateral to access such products and services. This overall expansion of financial access underscores the fundamental rationale for the FARM: it strategically bundles technical and financial assistance to ultimately de-risk and lower the cost of lending and borrowing, insurance, and public and private investment for the climate change adaptation of smallholder farmers and other small-scale local value chain actors.

310. In addition, the PEARL project will work with the National Agricultural Insurance Program, led by MAFF in partnership with the country's leading insurance providers (e.g., Forte Insurance), to explore additional risk insurance options, particularly for cashew, mango, and vegetable producers and related local value chain actors. They currently do not have many opportunities to protect themselves from perils. The National Agricultural Insurance Program intends to make subsidized insurance available for farmers to reduce the overall impact of climate change-related agricultural and livelihood loss and damage. In this context, private sector partners have few financial incentives to invest in research and development (e.g., prototype development); therefore, a high level of concessionality through GCF finance is also required in this effort. During the project design phase, consultations with private insurance providers and the National Agricultural Insurance Programme identified a critical capacity gap. Without the project intervention to support risk profiling of these crops to establish the baseline information for the insurance providers to lower the cost of insurance product development, especially for the perennial crops, insurance options for producers of these crops would remain limited. The project will thus develop and pilot prototype products under the overall framework of the National Agricultural Insurance Program. The project's specific outputs will be directly owned and managed by MAFF under the National Agricultural Insurance Program. Furthermore, the project will increase the beneficiaries' awareness of the available financial support products to improve their financial access.

Activities, Descriptions and Sub-Activities
Activity 2.2.1: Establish a Farmer-led Agricultural Resilience Mechanism (FARM), for ACs, FAs, PGs, CPAs, CFs, and agricultural unions to assist their members' transition to climate-resilient and high-value agriculture in an inclusive and gender-responsive manner. **Description:** An innovative climate adaptation asset acquisition mechanism, FARM, will be established to support the operationalization of the action plans/business plans developed by a total of 124 ACs, FAs, PGs, CPAs, CFs, and agricultural unions under Activity 2.1.1. This will include the preparation of a FARM grants manual, technical specifications and procurement packages in consultation with beneficiary groups and procurement of identified infrastructure assets and technologies. In preparing the technical specifications and procurement packages, attention will be paid to the specific and different needs of men and women.

- Sub-activity 2.2.1.1: Train ACs, FAs, PGs, CPAs, CFs, and unions of cooperatives annually to develop financial and business literacy and entrepreneurial skills (with particular focus on youth, women, and other socially excluded minorities) for preparing and updating business plans, including maintenance and operation plans and private finance and insurance plans.
- Sub-activity 2.2.1.2: Procure an initial set of agricultural assets based on the approved business plans to operationalize FARM (average cost of USD 50,000 per beneficiary group with co-financing of between 5 – 20% by the beneficiary group; however, an agricultural union or a group of cooperatives/associations may access a larger amount by pooling funds.
- Sub-activity 2.2.1.3: Establish a FARM account (trust fund) for each beneficiary group to advance its business plan with clearly defined governance arrangements and ongoing business development support (i.e., FARM grants manual, Board of trustees, disbursement eligibility criteria, fiduciary and performance monitoring mechanisms).

Activity 2.2.2: Assess the feasibility of developing additional risk finance options for cashew, mango, and vegetable producers, particularly women farmers.

Description: A feasibility study will be conducted to assess risk financing opportunities for cashew, mango, and vegetable producers to lessen their financial risks due to climate-induced crop loss and damage. Concurrently, the lack of insurance products for supporting agricultural unions, often providing internal quality control for meeting certification standards in bad harvest years, will be addressed to ensure business continuity in assisting individual farmers. The activity builds on the existing agricultural (index-based) insurance products for rice and other crops.

- Sub-activity 2.2.2.1: Train PDAFF, PDoE and PDoC staff, district administration officers, commune and village extension agents, and NGOs, through TOT programs on the costs and benefits of index-based and other insurance products to raise awareness.
- Sub-activity 2.2.2.2: Establish an expert working group to identify index-based risk financing parameters linked to agrometeorological information for cashew, mango, and vegetable production and explore the possibility of developing and piloting prototype index-based insurance products.

Activity 2.2.3: Raise awareness of available financial support products and services in Cambodia systematically among smallholder farmers and local value chain actors, particularly women farmers and value chain actors.

Description: A comprehensive list of various financial institutions as well as types of financial support and risk financing options will be made available for ACs, FAs, PGs, CPAs, CFs, unions, and their individual members to ensure the beneficiary groups have the information necessary to make the needed trust account arrangements and access complementary financial products and insurance services.

- Sub-activity 2.2.3.1: Compile and regularly update a menu of financial support and insurance products and services available for ACs, FAs, PGs, CPAs, CFs and agricultural unions and their individual members in NTSB as part of FFS curricula and demonstration activities and through existing user interfaces (i.e., Tonle Sap App, Chamkar and EcoKasksekor).

8.5. Climate-resilient and High-value Techniques and Technologies Adopted (Output 2.3)

8.5.1. Climate impacts and suitability of rice, cashew nut, mango, and vegetable production in the Northern Tonle Sap Basin for the PEARL project

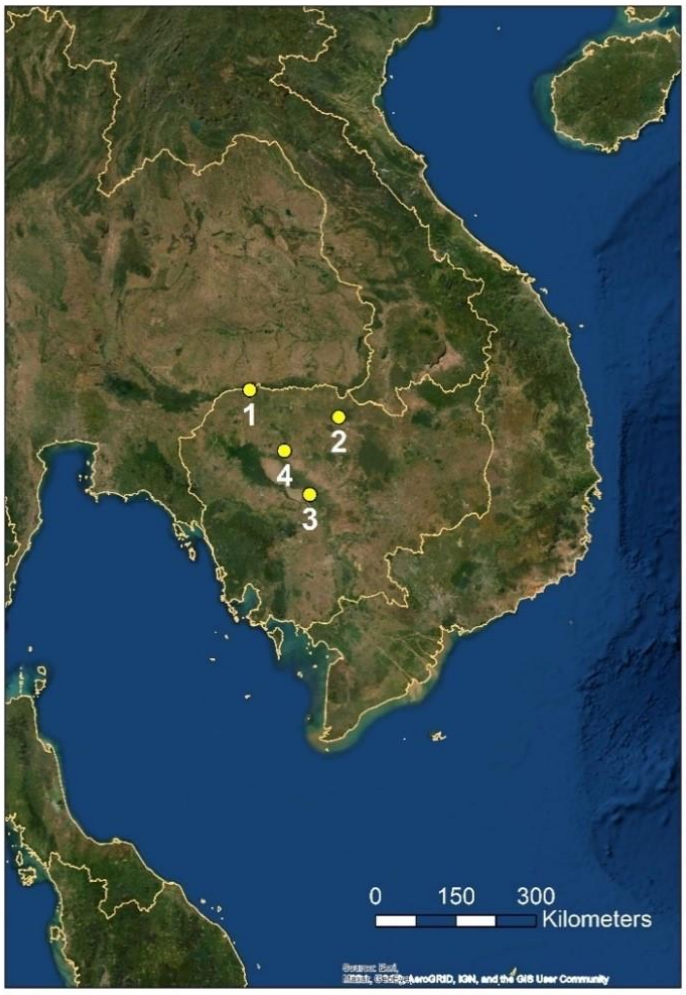
311. Farmers in the NTSB are expected to face increasing challenges as a result of increasing temperature, shorter wet season and potentially more intense rainfall events. Traditional farming practices, heavily dependent on natural water supply and rain-fed systems, will need to respond

to increasing climate risks and complemented by resilient and economically feasible alternatives. In addition to negative climate impacts, the stagnating global agricultural commodity prices, rising labour costs and the limited scope for cropland expansion in the country will challenge the agriculture sector (WB, 2015).

312. The PEARL project intends to support Cambodia's agriculture sector to focus on more efficient, higher-value and higher-quality production and processing that are resilient to the effects of climate change and commodity price volatility to ensure economic viability of the sector, thereby safeguarding the country's food security, labour market and sustainable development prospects.

313. The analysis to follow identifies the various drivers and aspects of climate-related risks to each of the target value chains in the PEARL project: rice, cashew nut mango and vegetables. The analysis emphasizes that **climate will have multifaceted impacts on each agricultural system,** but the most effective adaptation measures will increase resilience and adaptive capacity to the identified risks, based on the robust understanding of climate hazards and impacts in each system. FAO crop specific analysis for dry/wet season rice and vegetables (tomato, long bean and pak choi) was prepared using four targeted locations as displayed in Figure 43. Results are presented in Annex II.

Figure 44: Selected points used for downscaling climate information and running the AquaCrop model along the Northern Tonle Sap basin



314. In Preah Vihear (PV), rice is mainly grown by smallholder farmers, therefore there is great potential for improved livelihoods and added income through sustainable improvement of rice production practices and value chains. In terms of development of organic rice production in PV, ACs play an important role in the supply of certified paddy. Certified organic rice production in PV has increased due to market demand, and especially contract farming between organic rice ACs and AMRU or SoA. Despite this growth, there are still challenges for organic rice producers including major climate and environmental impacts. The summary table of this chapter highlights the baseline practices of rice producers in PV, major climate impacts, and key interventions of the PEARL project.

315. Consultations with organic rice farmers corroborate the results of the climate analysis, which identifies increased heavy rainfall events over

shorter time periods, often resulting in washing away of broadcasted seeds for direct sowing at the onset of the wet season. Organic rice production in small paddy fields across uneven topography provides abundant food sources for natural enemies of pests to keep the pest level manageable. In addition to the increased heavy rainfall events, the climatic analysis identified a shortening of the wet season and more extended dry spells as a prevailing challenge in the targeted areas. Oddar Meanchey is considered as highly vulnerable to both floods and droughts, and Preah Vihear is highly vulnerable to droughts. Frequency of floods and droughts events is not among the highest in these provinces, but the vulnerability indicator is increased due to relatively low adaptation capacities.

8.5.2. Value chain mapping and climate risks to the rice value chain

316. While analyses of climate change risks to the agriculture sector often focus on impacts on production and yields (results above), food and economic losses caused by climate-related risks can be incurred at all stages of the agri-food value chain, from storage to transport and market, with compounded effects on agri-food value chain and economic development.

317. A climate-focused stakeholder consultation and value chain analysis was performed through the delivery of an online survey to key PEARL project stakeholders involved in different steps of the rice value chain and integrated with a dedicated in-person workshop with local agricultural cooperatives. The aim of the consultation was to identify climate impacts at each stage of the value chain with an emphasis on post-harvest systems, going beyond the production step at the crop field level. In addition, the consultation aimed to define key climate resilient practices that value chain actors are already implementing at the time of the research, as well as further practices that stakeholders would be interested in implementing in the future through the support of the PEARL project. Finally, a key component of the analysis involved the state of development of climate services, including climate information and agricultural advisory products, that value chain actors benefit from at the time of the research and would be interested in benefitting further through the support of the PEARL project.

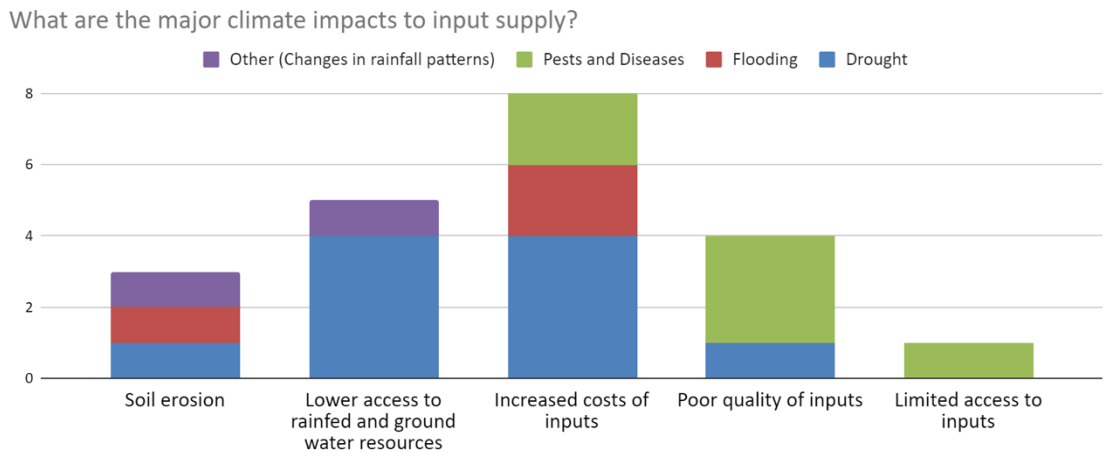
318. A total of 9 stakeholders involved at different steps of the rice value chain from public and private sectors as well as research and development institutions took part in the online survey, such as representatives of the national ministry of Environment, Agriculture, the department of crop seed and provincial departments of agriculture, forestry, and fisheries of Oddar Meanchey, Siem Reap, and Preah Vihear, the Cambodian Institute for Research and Development, international trade organizations and agricultural development consulting companies.

319. The below analysis outlines the impacts of climate at each stage of the rice value chain as identified from the literature and integrated with results from the climate-focused stakeholder consultation. A simplified schematic of the rice value chain based on FAO assessment is highlighted below.

Input supply and harvest (rice)

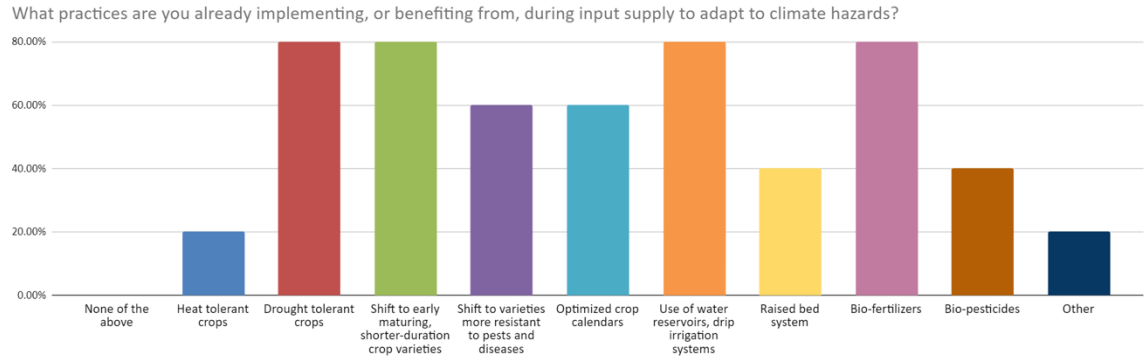
320. Respondents of the climate-focused value chain survey identified drought and flooding events, pests and diseases, and changes in rainfall patterns, as the main climate hazards affecting the rice value chain. Such hazards primarily affect the cost and quality of inputs applied, increasing soil erosion, and reducing the access to rainfed and ground water resources (Figure 44).

Figure 45 Major climate impacts to input supply



321. Respondents of the online survey mentioned a few key practices implemented during input supply and application, which primarily consist of the shift towards drought tolerant and early maturing, shorter-duration crop varieties. Stakeholders benefit from the use of water reservoirs and drip irrigation systems to address drought's impacts on the access to water resources. VC actors also mentioned the use of bio-fertilizers among the most implemented climate resilient practices. Another practice reported by one respondent consisted of direct planting of rice grain on dried soil at early rainy season (Figure 45).

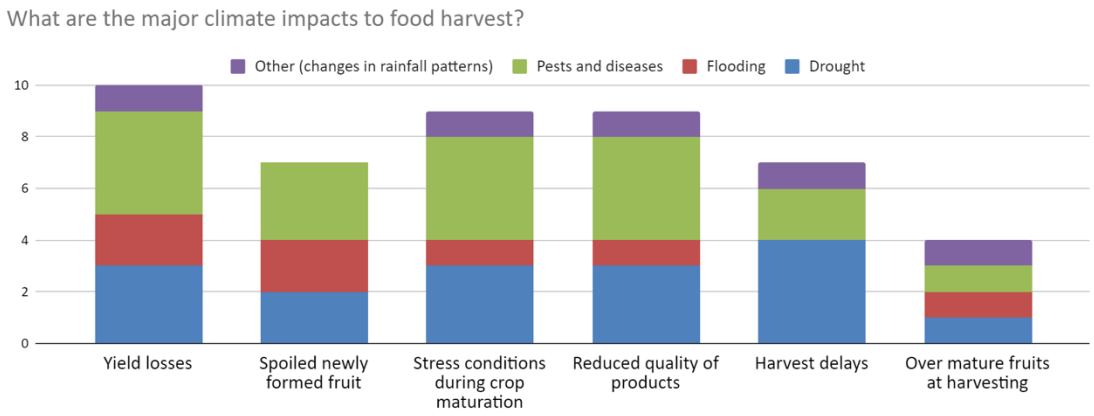
Figure 46 Practices implemented during input supply to adapt to climate hazards



Harvest (rice)

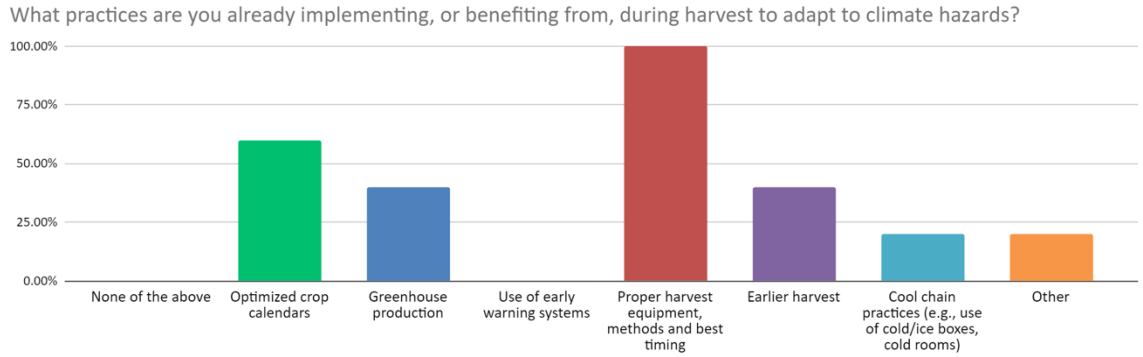
322. At the harvesting stage, farmers and collectors often have limited capacities to define the most adequate harvest timing according to weather conditions to withstand changes in rainfall patterns, heavy rainfall, drought and flooding events causing water shortages, stress conditions to the crop and spoiled newly formed fruit (Figure 46).

Figure 47 Major climate impacts to rice harvest.



323. To adapt to climate hazards at the harvest stage, stakeholders mentioned the use of proper harvest equipment, methods, and best timing based on optimized crop calendars to avoid the occurrence of extreme weather events and hazards at the time of harvesting (Figure 47).

Figure 48 Practices implemented during rice harvest to adapt to climate hazards



Collection (rice)

324. In Preah Vihear, conventional paddy is mainly sold by farmers to local collectors/middlemen at a relatively low price due to the relative remoteness of the province and the little competition between buyers. In addition, conventional paddy is collected and traded outside Preah Vihear and Oddar Meanchey (Burn et al., 2018).

325. Organic paddy is collected at a premium price by large millers/exporters such as AMRU Rice, Signatures of Asia, and Golden Rice only when a full volume (5-ton trucks) is available at agricultural cooperatives. The buyers are responsible for paying the certification service, while the agricultural cooperatives must cover the costs for the Internal Control System. While large buyers prefer the longer-duration variety due to higher market demand at international level, the shorter-duration variety would be more suitable to climate and weather-driven impacts such as drought, heat, and pests and diseases (Burn et al., 2018)

326. If farmers do not manage to achieve the set volume in time, they might prefer to sell to non-organic collectors even at lower prices to repay earlier their depts. Overall, high dependency on

contract farming with international trading companies such as AMRU Rice, Signatures of Asia, and Golden Rice, increases agricultural cooperatives' capacity to deal with market trends and vulnerability to prices set by those companies (Burn et al., 2018).

Storage, Drying, and Milling (rice)

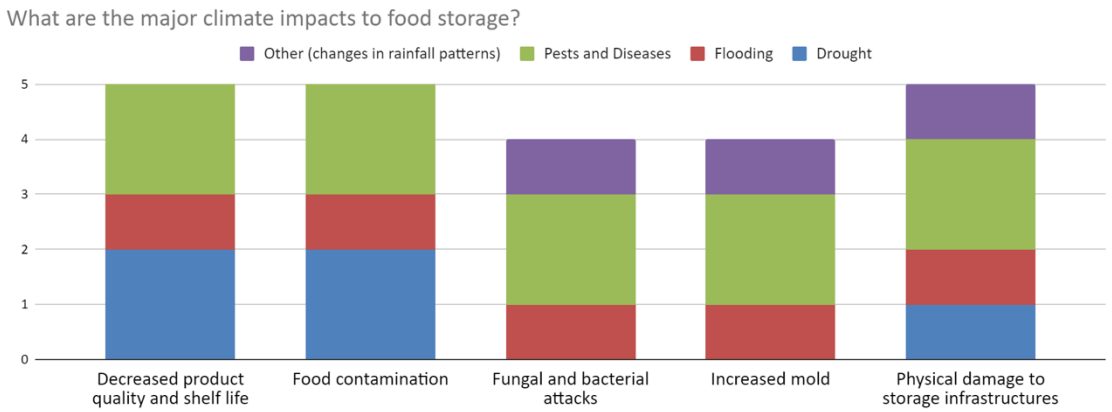
327. Rice storage capacity in Cambodia is still limited and insufficient compared to the country's annual exportation targets(USAID, 2019). According to agricultural cooperatives' representatives during the dedicated workshop, many ACs do not have any facilities for storage and processing and depend on private companies to access these facilities. In addition, after harvesting paddies are often dried on the ground using traditional drying techniques and without using harvesting machines. In the case of rainfall or humidity, without intervention the paddy can become wet and reduce substantially the quality of the seed for market.

328. Processing agri-business in Cambodia is mainly focused on the rice value chain, leaving limited space for other food commodities to deliver adding-value activities post-harvest (USAID, 2019) Large millers include Golden Rice of Baitang, for part of the fragrant paddy grown in Oddar Meanchey, but much of the milling takes place in Vietnam due to lack of infrastructure in Cambodia. More widely across Cambodia, rice is exported to Thailand and Vietnam, where it is milled and either locally distributed or further exported to other countries as milled rice. AMRU Rice is one of the main exporting companies in Cambodia. It is particularly relevant due to its involvement in the creation of semi-processing facilities in the country, for rice milling, polishing and packaging(Burn et al., 2018).

329. This lack of infrastructure in Cambodia results in a huge lost opportunity for Cambodian rice millers and traders to add value, export directly, and create employment locally. In addition, limited access to services and information is creating a lack of awareness and understanding of the standards and preferences of the international rice market. Traditional and ineffective techniques for processing and packing products, and the absence of adequate infrastructure, all result in high food and value losses when high moisture content in temperate/warm and humid climates undermine food products by increasing the spread of mold (Puri, 2016). Some ACs in the region rent out storage space and support farmers to link with markets, according to consultations in the field. The lack of infrastructure in place to process foods immediately after harvest, significantly reduces the adaptive capacity of farmers and the likelihood of losses (Rezaei et al., 2017). In the project area only a few ACs have the capacity for value-added processing (drying and milling) to access direct sales markets locally and nearby urban buyers. However, new drying, milling, and storage capacities were developed by AMRU. Without effective drying and storage facilities great economic losses can be incurred for producers.

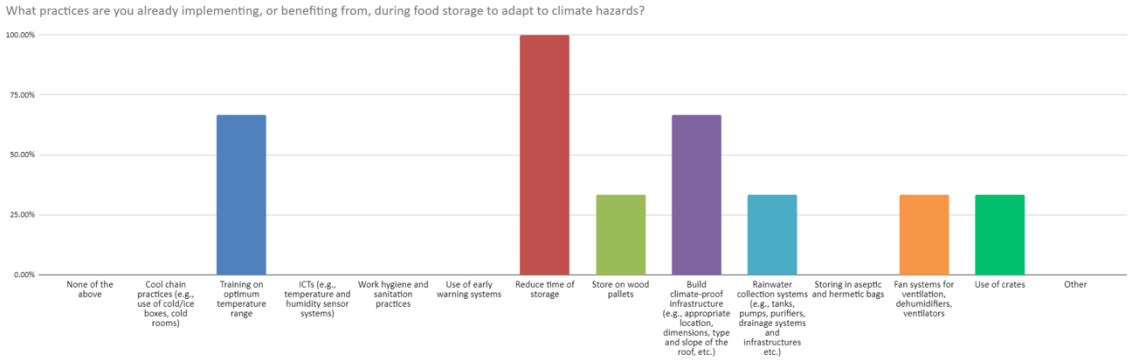
330. As identified from the results of the climate-focused value chain survey, during storage, flooding, changes in rainfall patterns, and spread of mold affect the quality and shelf life of the product, as well as the storage infrastructure. Flooding, drought, pests and diseases also cause food contamination and decrease product quality (Figure 48).

Figure 49 Major climate impacts to rice storage



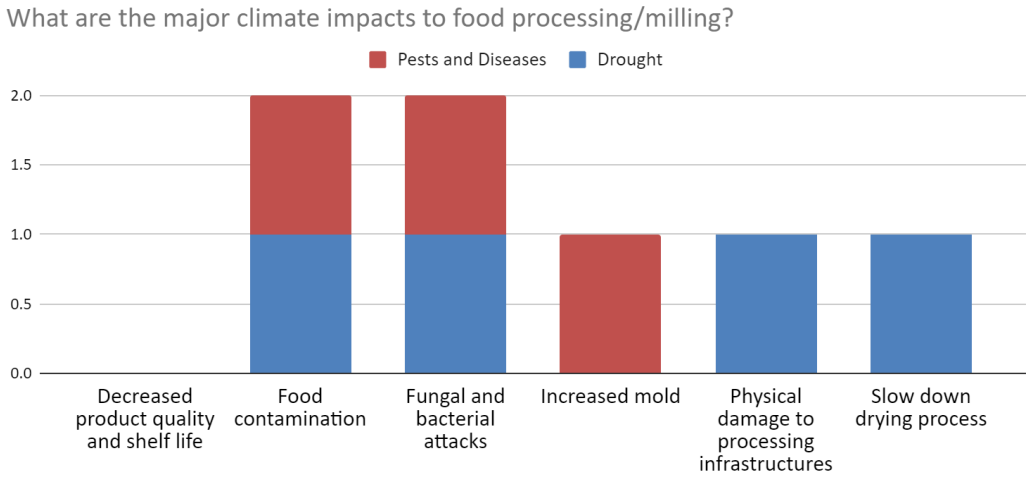
331. Online survey respondents selected the reduction of time for storage as the main climate resilient practices adopted to address climate hazards at the storage level, followed by training and learning of optimum temperature range to preserve rice grain (Figure 49).

Figure 50 Practices implemented during storage to adapt to climate hazards



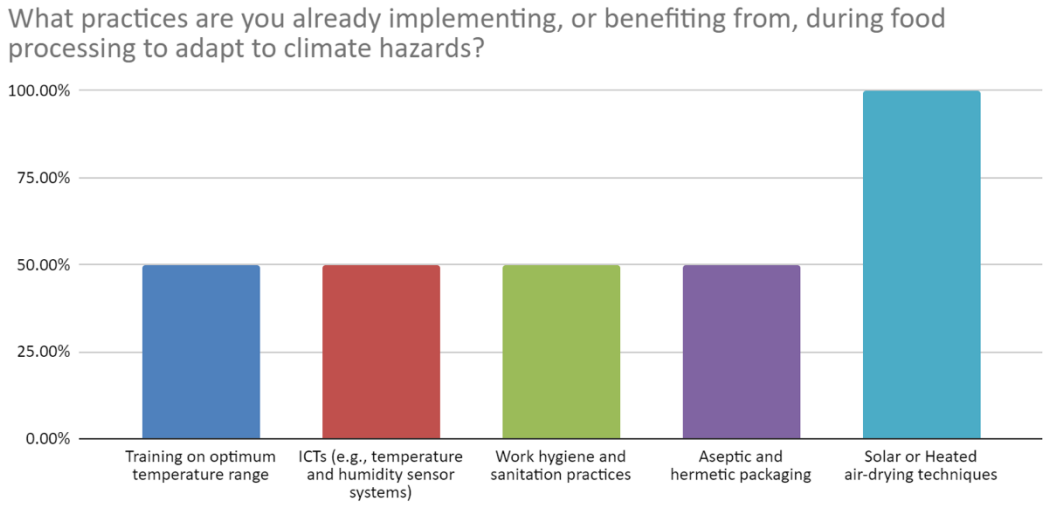
332. During processing, respondents of the climate-focused value chain survey selected the risk of food contamination, fungal and bacterial attacks from pests and diseases. Droughts may cause physical damage to processing infrastructure due to water shortages. In addition, drought periods before and during harvest may also affect the nutritional quality of the food product and slow down the rice drying process (Figure 50).

Figure 51 Major climate impacts to rice processing/milling



333. At the processing level, 2 rice VC actors mentioned the use of solar or heated air-drying techniques to dry rice and reduce moisture content to facilitate the storage and milling process (Figure 51).

Figure 52 Practices implemented during rice processing to adapt to climate hazards.



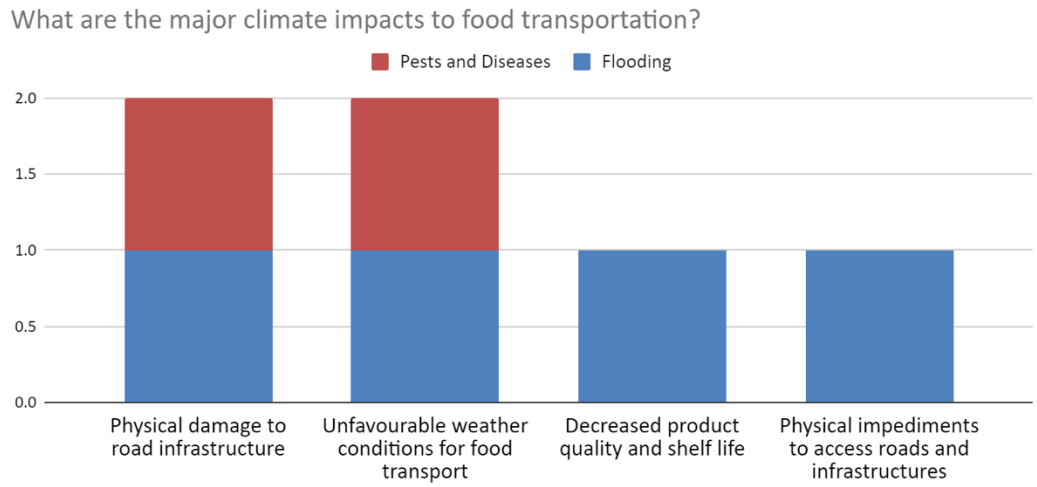
Transportation, Export, and Market (rice)

334. Rice trade is primarily managed by international companies such as AMRU Rice and Signatures of Asia, interested in the domestic product and its exportation worldwide. This causes limited knowledge of market opportunities among farmers and ACs, particularly in Preah Vihear compared to provinces with higher tourism trends such as Siem Reap. Market targets also differ between conventional rice, which is processed and sold locally or to large national and international millers, and organic rice, which is directed to high-quality exportation markets.

335. Organic paddy is sold at a premium price by ACs to millers/exporters. It is estimated that organic rice receives 33% higher price than conventional paddy. The net premium for farmers is 53 USD/ton for farmers after the payment of 8.50 USD/t to the ACs and 12.50 USD/t to the Union of Cooperatives to cover costs of the internal control system(Burn et al., 2018).

336. By 2030, Cambodia aims at becoming one of the main 3 world exporters of fragrant rice(USAID, 2019). 138Mn dollars are allocated to achieve value chain targets, combined with policy regulations and capacity building programs. Overall, rice transportation is mainly impacted by flooding events and unfavorable weather conditions causing physical damage to road infrastructures and their access by value chain actors and drivers (Figure 51).

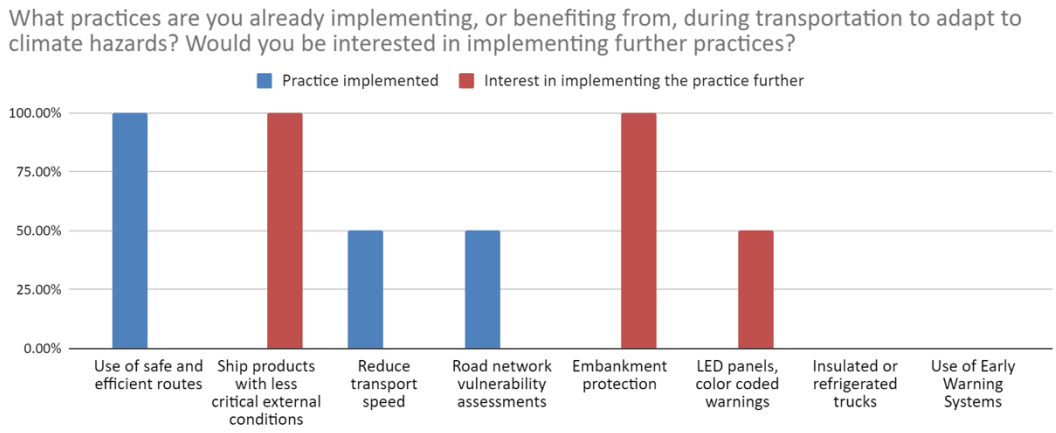
Figure 53 Major climate impacts to rice transportation



337. Food value chains that are competitive require sustainable and efficient transportation and infrastructure systems. It is fundamental that rural areas are properly linked to urban center and market areas through provincial and national roads. At the same time, in Cambodia the road network is still underdeveloped, particularly for the condition of rural roads that often are not paved. Roads and the conditions of vehicles are susceptible to heavy rains and flooding events, consequently impacting the transported food products and the final costs(Asian Development Bank, 2020).

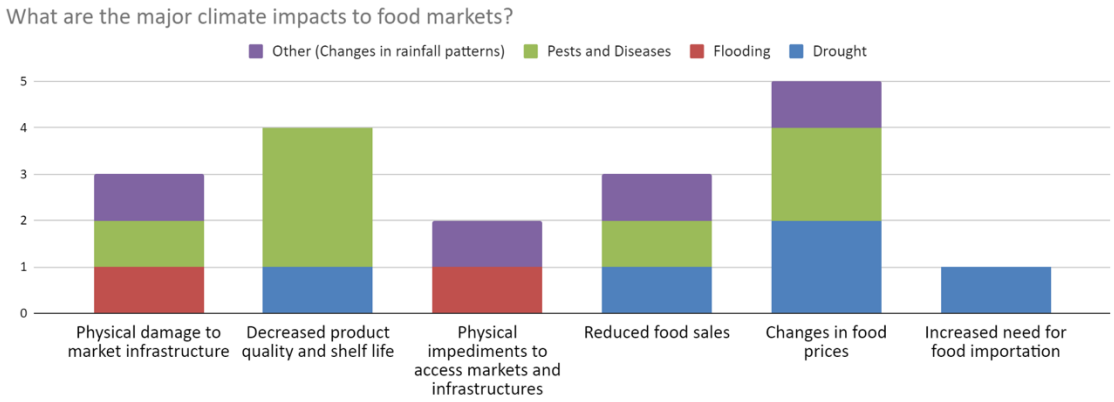
338. According to the online survey results (Figure 53), only 2 of 9 rice value chain actors are involved in rice transportation. While they are aware of the use of safe and efficient routes and practices such as reduction of transport speed to preserve food quality and drivers' safety, they would be interested in managing food shipment according to external weather conditions, as well as seeing embankment protection, panels, and color-coded warnings development.

Figure 54 Practices implemented during rice transportation and interest in implementing further practices.



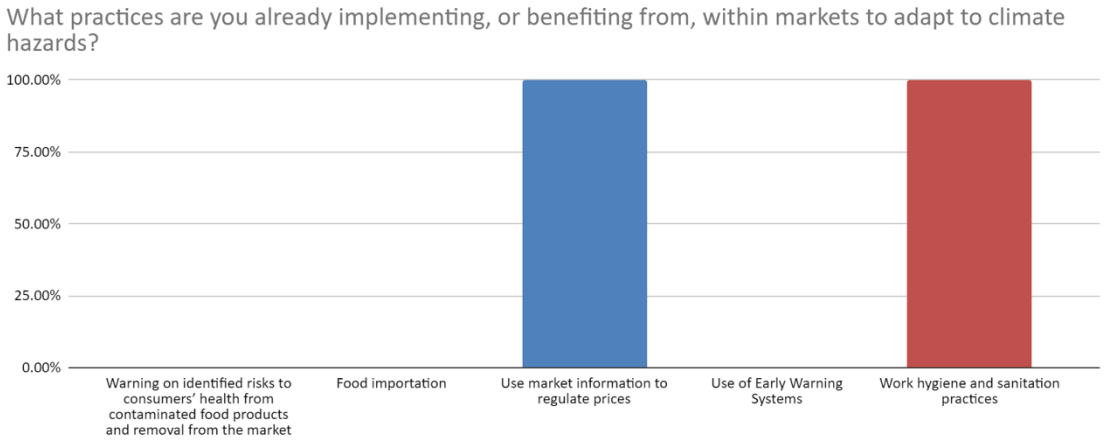
339. According to the results of the climate-focused value chain survey, while flooding and changes in rainfall patterns have major impact on the access to market infrastructure, drought influences changes in food prices, linked to food productivity, while pests and diseases have an impact on the final product quality and shelf life at markets (Figure 54).

Figure 55 Major climate impacts to rice markets



340. Responses of the online survey on the use of climate resilient practices all conveyed into the use of market information to regulate prices, as well as the sanitation of work practices and facilities (Figure 55).

Figure 56 Practices implemented within markets to adapt to climate hazards.



Climate-resilient practices in the rice value chain

341. As highlighted in Table 22, to counteract the main climate hazards affecting the NTSB (flooding, drought, pests and diseases, and changes in rainfall patterns as identified by survey respondents), value chain actors primarily suggested to adopt climate resilient practices such as the utilization of organic pests and diseases products (e.g., bio-pesticides) while reducing the cost of inputs. The harvest stage should be supported using early warning systems, for it to not coincide with the occurrence of flooding events and pests and diseases attacks and combined with the use of immediate covering of food products right after being harvested with aseptic and hermetic bags.

342. Appropriate measures should be adopted within storage facilities to ensure the products are not contaminated (e.g., by storing on wood pallets and increasing hygiene and sanitation practices). In addition, climate resilient practices suggested by agricultural cooperatives during the dedicated workshop include increasing producers' access to harvesting machines as well as large-scale milling facilities, combined with advisory on relative humidity monitoring during harvesting, drying, and storage. This would counteract the risks for producers which after harvesting dry the paddy on the ground using traditional harvesting by hand and drying, with the risk for the products of getting wet and causing complains from the consumers.

343. The transportation stage should be well aligned with updates on the weather conditions to avoid the occurrence of extreme weather events while carrying food. More infrastructural interventions should concern the improvement of embankment protections. Finally, the market stage should place further attention on the quality of food products available to reduce food contamination and insecurity for consumers' health.

Table 22 Climate resilient practices requested by survey respondents at production and post-harvest stages

INPUT SUPPLY	▪ HEAT TOLERANT CROPS (40%) ▪ OPTIMIZED CROP CALENDARS (40%) ▪ RAISED BED SYSTEM (40%) ▪ BIO-PESTICIDES (40%) ▪ DROUGHT TOLERANT CROPS (20%) ▪ SHIFT TO EARLY MATURING, SHORTER-DURATION CROP VARIETIES (20%) ▪ SHIFT TO VARIETIES MORE RESISTANT TO PESTS AND DISEASES (20%) ▪ USE OF WATER RESERVOIRS, DRIP IRRIGATION SYSTEMS (20%) ▪ COVER CROPS AND GREEN FERTILIZER ON RICE FIELD (20%)
HARVEST	▪ OPTIMIZED CROP CALENDARS (20%) ▪ USE OF EARLY WARNING SYSTEMS (60%) ▪ EARLIER HARVEST (20%) ▪ COOL CHAIN PRACTICES (E.G., USE OF COLD/ICE BOXES, COLD ROOMS) (40%)
STORAGE	▪ COOL CHAIN PRACTICES (E.G., USE OF COLD/ICE BOXES, COLD ROOMS) (33,3%) ▪ TRAINING ON OPTIMUM TEMPERATURE RANGE (33,3%) ▪ ICTS (E.G., TEMPERATURE AND HUMIDITY SENSOR SYSTEMS) (66,7%) ▪ WORK HYGIENE AND SANITATION PRACTICES (33,3%) ▪ USE OF EARLY WARNING SYSTEMS (66,7%) ▪ STORE ON WOOD PALLETS (33,3%) ▪ STORING IN ASEPTIC AND HERMETIC BAGS (66,7%) ▪ FAN SYSTEMS FOR VENTILATION, DEHUMIDIFIERS, VENTILATORS (33,3%)
PROCESSING	▪ BUILD CLIMATE-PROOF INFRASTRUCTURE (E.G., APPROPRIATE LOCATION, DIMENSIONS, TYPE AND SLOPE OF THE ROOF, ETC.) (100%) ▪ IMMEDIATE DRYING TECHNIQUES (100%) ▪ PRESERVING TECHNIQUES (E.G., DRYING, CHILLING, FREEZING, HEATING, SALTING, ETC.) (50%) ▪ FAN SYSTEMS FOR VENTILATION, DEHUMIDIFIERS, VENTILATORS (100%) ▪ RAINWATER COLLECTION SYSTEMS (E.G., TANKS, PUMPS, PURIFIERS, DRAINAGE SYSTEMS AND INFRASTRUCTURES ETC.) (50%) ▪ RENEWABLE OR ENERGY EFFICIENT INFRASTRUCTURE AND TECHNOLOGIES E.G. FOR MILLING, DRYING, GRATING (50%) ▪ VAPOR HEAT TREATMENTS (50%)
TRANSPORTATION	▪ SHIP PRODUCTS WITH LESS CRITICAL EXTERNAL CONDITIONS (100%) ▪ EMBANKMENT PROTECTION (100%) ▪ LED PANELS, COLOR CODED WARNINGS (50%)
MARKETS	▪ WARNING ON IDENTIFIED RISKS TO CONSUMERS' HEALTH FROM CONTAMINATED FOOD PRODUCTS AND REMOVAL FROM THE MARKET (100%) ▪ USE OF EARLY WARNING SYSTEMS (66,7%)

Climate resilient interventions for rice value chain

344. Organic rice production offers many benefits incusing increased resilience to climate change through adaptation (increase moisture storage in soils, hence improved resilience to drought) and mitigation (carbon storage in soils, reduced carbon footprint embedded in chemical fertilizer use in conventional practices). Some key areas identified by the present analysis to increase climate resilience include (Table 23):

Table 23: Recommended climate-resilient measures for rice based on the observed and projected climate impacts along the food value chain

Rice Stage/ activity	Baseline vulnerability	Climate impacts	Recommended resilience measures
Soil preparation	• Mechanized ploughing and harrowing. Lowland rice soil is predominantly sandy soil with low organic matter content	• Increasing temperatures will accelerate the decomposition of organic matter and reduce carbon storage in the soil • Drought and higher evaporation will increase soil-compressibility, mostly of fine-grained soils	• Provide accurate and timely weather services before rain events. • Promote minimum soil disturbance practice, minimum tillage, introduction of leguminous crop cover, etc. • Promote laser land leveling where appropriate to reduce water requirements. • Promote postharvest crop residue management. • Promote erosion control and water retention techniques.
Seeds and Seeding	• Use of low quality seeds (do not meet market requirements and low production) • Limited availability of quality seeds, stress-tolerant seeds (heat, water logging, drought etc.) • Broadcasting or direct seeding with high volume of seed • Labor shortages due to labor migration	• Heavy rainfall over short periods will wash away broadcasted seeds • Drought damage to seedling nurseries	• Promote quality seed supply and seed testing. • Build local seed production capacity (e.g., seed certification) • Provide crop-specific agro-met information (e.g., climate-informed crop calendar). • Promote stress-tolerance, early maturing, shorter-duration (fragrant) varieties. • Promote mechanization - sowing and transplanting and elements of System of Rice Intensification.
Production (wet season)	• Production area of medium and long cycle varieties is largest • The yields of short cycle varieties is highest than that of medium and long cycle varieties, but requires high chemical fertilizer application	• Increasing heat-stress conditions, intra-annual rainfall variability and relative humidity will elevate the exposure of medium/long-cycle varieties to weather hazards and pests & diseases • CO_2 concentration increase will benefit rice production by increasing photosynthesis, growth and grain yield while reducing	• Promote quality seed supply and seed testing. • Build local seed production capacity (e.g., seed certification) • Provide crop-specific agro-met information (e.g., climate-informed crop calendar). • Promote stress-tolerance, early maturing, shorter-duration (fragrant) varieties. • Promote mechanization - sowing and transplanting and elements of System of Rice Intensification.

		or stabilizing water requirements	
Production (dry season)	• Dry season rice production area is low and limited to areas with high irrigation capacity • Competitive use of water due to water scarcity • Water is not efficiently used	• Dry season rice production shows a slight and moderate yield increase under RCPs 4.5 and 8.5 • Increasing inter-annual rainfall variability during the rainy season elevates the risk of conflict among water resources over the dry season • Future increases in air temperature will raise evapotranspiration rates and will result in an increase in water requirements overtime	• Invest in irrigation needs of dry season rice producers, including advisory support for farmers to grow dry season rice. • Explore the use of underground water for irrigation where feasible. • Develop tailored water use and management advisories linked to agro-met information.
Inputs (wet season)	• Lack of organic fertilizers	• High temperatures will increase the volatilization rates, with adverse economic and environmental consequences • Intensification of heavy rainfall events will increase the risk of leaching into sensitive areas	• Strengthen agricultural extension capacity/technical functions for providing coherent and relevant guidance and training to farmers. • Provide fertilizer advisory based on soil type. • Increase organic fertilizer production capacity. • Identify a list of quality input suppliers to share with farmers, ACs, FAs, PGs, and unions. • Increase governance capacity, including quality control, of ACs and unions to ensure enabling conditions for climate-resilient and sustainable practice uptake
Inputs (dry season)	• Lack of organic fertilizers • Use of chemical fertilizers and pesticides is low in Preah Vihear, but higher in other provinces, especially for dry season production	• High temperatures will increase the volatilization rates, with adverse economic and environmental consequences	
Pest control	• Mechanical or organic pest control in PV • Chemical pesticides used in other provinces	• Higher temperatures and increased period of rains will speed-up pest cycles and worsen the current phyto-sanitary conditions of rice crops • Extended droughts can lower the resistance of rice plants to grasshoppers, and stronger winds can accelerate the spread of brown plant hoppers	• Invest in modeling and research and development of rice pest and diseases to improve understanding of spatial distribution of risks. • Promote IPM linked to provision of tailored agro-met services. • Improve tailored pest and disease warnings and advisories.

Irrigation	• 80% of rice production in the region depends on rain fed systems. • Reservoirs, lakes and ponds • Groundwater is also used to provide water during periods of short rainfall	• Drought has severely affected organic rice production in Kampong Thom • Upland Preah Vihear has higher resilience to drought conditions • Yield losses from river floods are double compared to yield losses from drought, particularly in lowland areas around the Tonle Sap Basin.	• Integrated watershed management • Improve water management both during the rainy season (water conservation infrastructure and techniques) and during dry season (operational decision-making through irrigation schedules) • Promote fixed-water supply (bringing the soil-water levels to field capacity every 7 days) to reduce water losses from direct evaporation • Promote irrigation scheduling by investing in soil moisture sensors that measure water levels in the root zone and apply water when there is a shortage
Post-harvest drying	• Mainly traditional drying practices on tarps in the sun • Recent introduction of drying and storage facility by AMRU, but limited capacity in the region	• Increasing temperatures and exposure to UV light • Increasing relative humidity resulting in losses without effective processing facilities	• Immediate drying after harvest • Invest In drying and storage facilities (e.g., fan systems for ventilation, dehumidifiers, ventilators) linked to ACs • Knowledge about temperature and humidity conditions for drying and storage • Use of digital communication tools to spread information for value chain actors
Storage	• Lack of sufficient post-harvest storage facilities	• Increased temperature and mold will result in spoilage post-harvest	• Investment in storage facilities through ACs • Invest in renewable energies to support storage • Awareness raising about negotiating power when storage facilities keep product for longer period • Increase access and use of temperature and humidity sensor systems • Store in aseptic and hermetic bags
Milling	• Sold at premium price to millers/exporters	• Food contamination from fungal and bacterial attacks and increased mold caused by drought events and pests and diseases attacks at earlier stages of the value chain	• Climate-proof rice storage and processing facilities and techniques scaled-up and supported through ACs

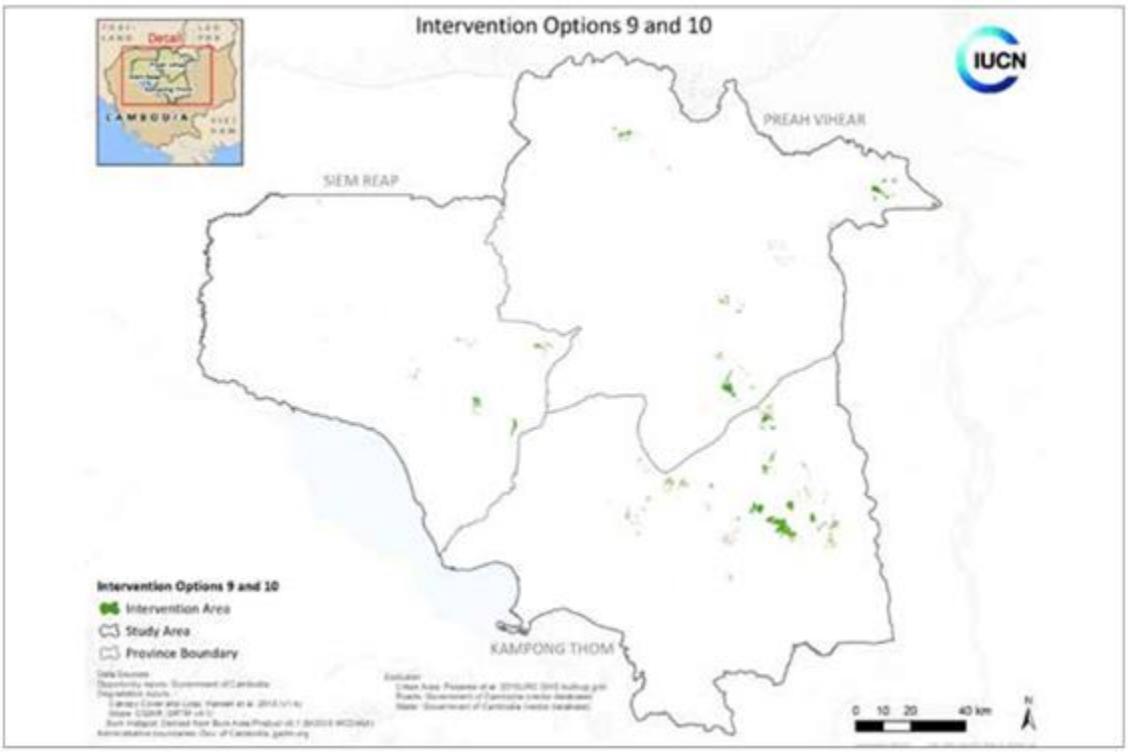
Sales/buyer	• Middlemen/buyers buy at farms during the harvest, load into the trucks and transport (often to millers or exports to Vietnam) • In PV exporters are contracting the Certification Body (paying for the certification service) but ACs must cover the costs for the Internal Control System	• Yield losses and harvest delays influenced by drought events and pests and diseases attacks may have an impact on the food quality as well as changes in food prices	• Make market information available as part of services for farmers and other local value chain actors through existing market apps (e.g., by IFAD AIMS, ASPIER projects) • Support adoption of CamGAP, GI, organic certification, including Ibis Rice, and other appropriate value-adding certifications. • Establish a close link between target certifications and climate resilience for further value addition. • Build PSPPs to increase collaboration and coordination across value chains (e.g., market networks, trade fairs, matching services). • Increase farmers' and other local value chain actors' business, market and financial literacy. • Raise awareness of climate-resilient and high-value products and their benefits among buyers, exporters, and consumers. • Promote contract farming and direct purchase agreements for increased demand and supply. • Invest in labeling and traceability capacity.

8.5.3. Restoration and mitigation through cashew production

345. Cashew yields generally initiate in the third year post-planting and will produce cashews for decades. While agroforestry and cashew cropping has the potential for restoration and carbon sequestration, due to the lack of biodiversity and high disturbance levels, tree plantations do not have the same ability to store carbon or improve water quality as a native forest (IUCN, 2018). One key benefit of "luxury timber" or cashew plantation is the financial incentives which will encourage private landowners to convert unused lands, or agricultural lands into timber plantations with long generation times. This may provide benefits for soil erosion and carbon storage as compared to lands that are under continual cultivation and tilling.

346. Cashew production has a relatively short time for investment return and because the plantation will not require seasonal plowing, it is likely preferable to cassava in regard to erosion and reduction of soil fertility. Additionally, the associated NPV of growing cashew is quite high. However, cashew presents some concerns as a land use option as it requires the use of fertilizer, pesticides, and irrigation during the dry season. In addition, cashew has been perceived in recent years as incentivizing land conversion in and around protected areas. If done sustainably cashew production could even help prevent further land conversion(IUCN, 2018). Figure 56 below shows restoration opportunities for cashew plantation and bamboo in 3 target provinces of the PEARL project.

Figure 57 Restoration opportunities for intervention of cashew plantation (option 9) and bamboo (option 10) according to the IUCN, 2018.

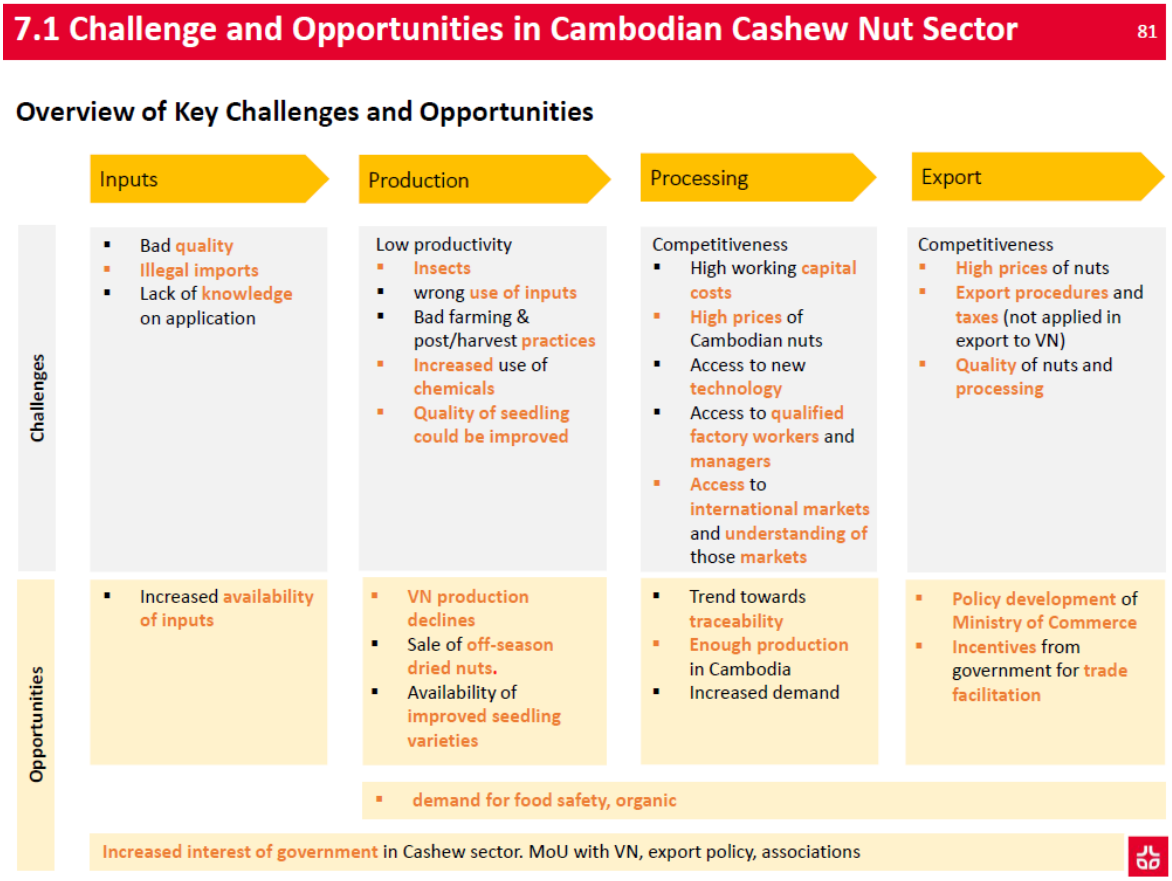


Climate risk along the cashew value chain

347. A climate-focused stakeholder consultation and value chain analysis was performed through the delivery of an online survey to key PEARL project stakeholders involved in different steps of the cashew value chain and integrated with a dedicated in-person workshop with local agricultural cooperatives. The aim of the consultation was to identify climate impacts at each stage of the value chain with an emphasis on post-harvest systems, going beyond the production step at the crop field level. In addition, the consultation enabled to define key climate resilient practices that value chain actors are already implementing at the time of the research, as well as the further practices that stakeholders would be interested in implementing in the future through the support of the PEARL project development. Finally, a key component of the analysis involved the state of development of climate services, including climate information and agricultural advisory products, that value chain actors benefit from at the time of the research and would be interested in benefitting further through the support of the PEARL project.

348. A total of 6 stakeholders involved at different steps of the cashew value chain from public and private sectors as well as research and development institutions took part in the online survey, such as representatives of the national department of agro-industry, international non-governmental organizations, agricultural service providers and wholesale plant nurseries. The below analysis outlines the impacts of climate at each stage of the cashew value chain as identified throughout the literature and integrated with results from the climate-focused stakeholder consultation. A simplified schematic of the cashew value chain based on FAO assessment is highlighted below.

Figure 58 Challenges and opportunities for the cashew value chain in the NTSB.



Source: (Swiss Church Aid, 2019).

Input supply, land preparation, and production (cashew)

349. The demand for cashew nuts from Kampong Thom and parts of Preah Vihear is rapidly growing. In Kampong Thom, cashew production is the main activity in terms of land occupation and income. In fact, rice farms are present but mainly for household consumption. The M23 variety is the most common, productive, and profitable, representing up to 80% of the planting area (Burn et al., 2018). According to statistics performed in 2018 on the state of development of cashew production, around 15000 households grow cashew in Kampong Thom (Sereyvath and Rotana, 2019).

350. In Preah Vihear, cashew is used as a complementary crop to rice and cassava. According to statistics performed in 2018 on the state of development of cashew production, around 6,500 households grow cashew in Preah Vihear (Sereyvath and Rotana, 2019). However, due to lack of statistical data, cashew cultivation in Preah Vihear could be higher than expected, with substantial

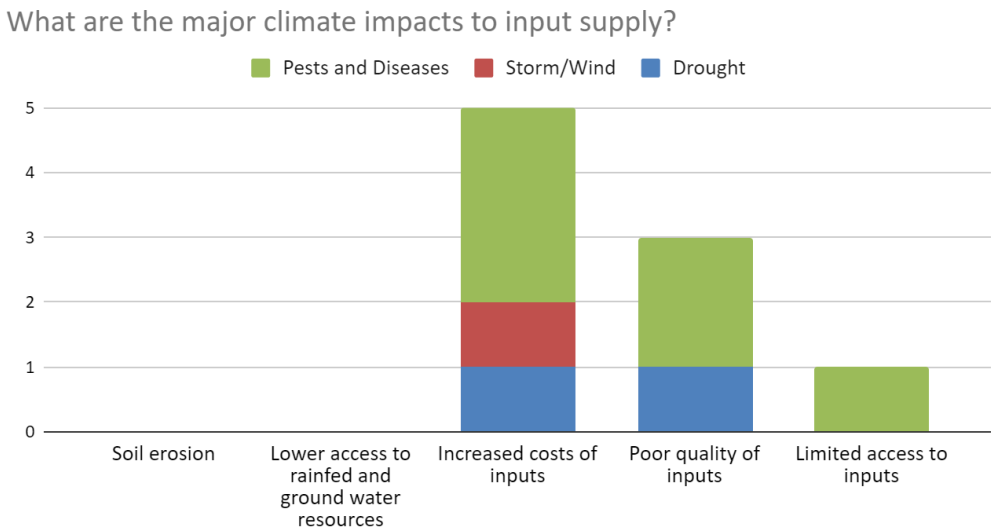
opportunities to develop certified cashew value chains and scale-up climate adaptation practices (Burn et al., 2018).

351. These crops' economic importance has steadily increased in the NTSB, thus offering a climate-resilient alternative to conventional rice production due to agroforestry potential and a diversification opportunity for rural livelihoods to increase their adaptive capacity by accessing ecological services such as sustainable fuelwood, and catchment protection areas across the NTSB(Bernacki *et al.*, 2018)

352. Cashew plantations do not overlap with rice cultivation but occupy different parts of the landscape. Most cashew plots were traditionally planted on newly deforested land but there is now a shift to change some plots from cassava (and rubber) to cashew due to higher prices and revenues, after cassava yields start to decline after three years of cultivation in the same plot (Burn *et al.*, 2018). There were a notable number of farmers who were interested in (near-) organic production methods. Farmers who were growing the M23 variety through near-organic methods with a limited quantity of agricultural inputs indicated soil enrichment benefits through such methods.

353. Agricultural input suppliers consist of organizations and companies providing fertilizers, pesticides, herbicides, seedlings, and equipment for water use primarily to cashew producers and, often in collaboration with agricultural cooperatives, training producers on the use of their products(Sereyvath and Rotana, 2019). As a result of the climate-focused value chain survey (Figure 58), cashew value chain actors involved in input supply selected pests and diseases, combined with droughts and the occurrence of storms and extreme wind in a minor percentage, as climate and weather-related hazards reducing the effectiveness, in terms of quality, accessibility, and costs, of the inputs applied. This is exacerbated using fertilizers and pesticides or insecticides that are not tailored to the specific pest attacking the crop.

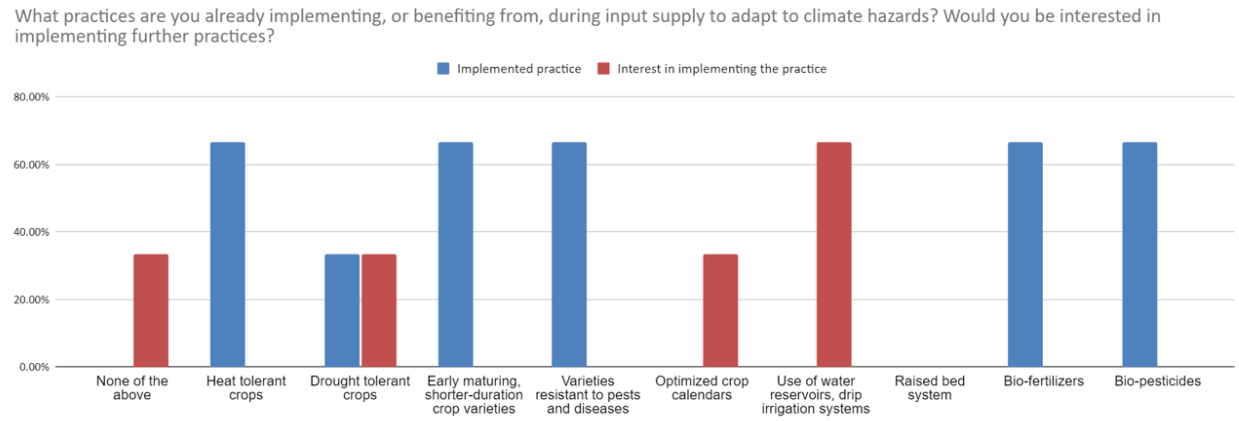
Figure 59 Major climate impacts to input supply



354. Overall, cashew producers utilize crop varieties that are resistant to heat, drought, and pests and diseases. In addition, during the survey they mentioned the use of bio-fertilizers and pesticides which reduces food contamination by chemical residues and increases quality. Stakeholders would be

interested in optimizing crop calendars for the application of inputs as well as improving access to water reservoirs and drip irrigation systems (Figure 59).

Figure 60 Practices implemented and interest in implementing further practices during input supply to adapt to climate hazards.

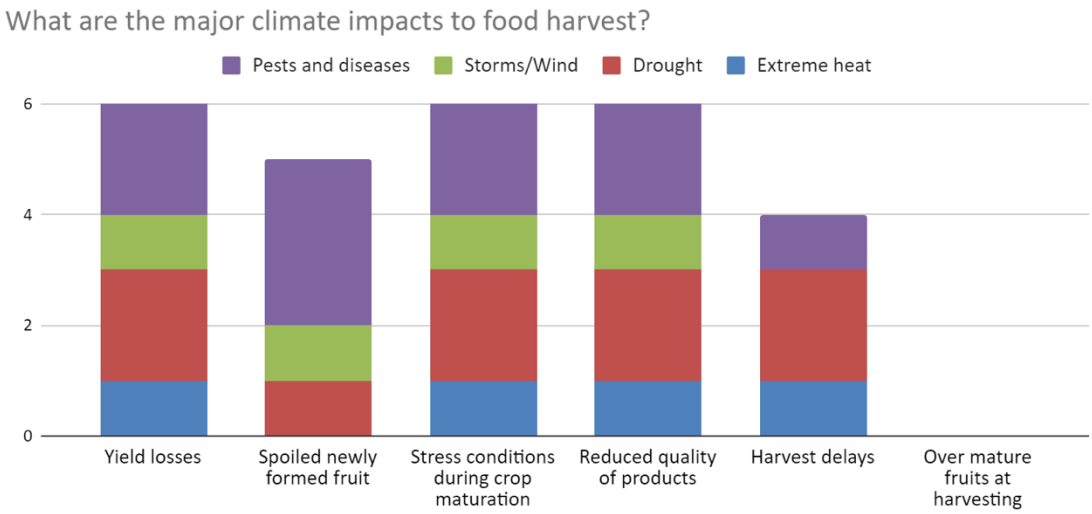


Harvest (cashew)

355. Harvesting of cashew is done at the end of the dry season from March to May, with a production peak in April, when farmers are not very busy on other agriculture activities, since it is very labor-intensive, implying each worker to harvest around 50 kg of nuts in one day. The main factors affecting production mentioned by farmers are pest and diseases attacks of the cashew plantations. Cashew tree is subject to attacks of a multitude of diseases, but most of them do not have strong economic consequences. This is an issue to consider for the development of the value chain, especially as there is a labor shortage in the agriculture sector in Cambodia, which leads to an increase in labor costs (around 5 USD/day).

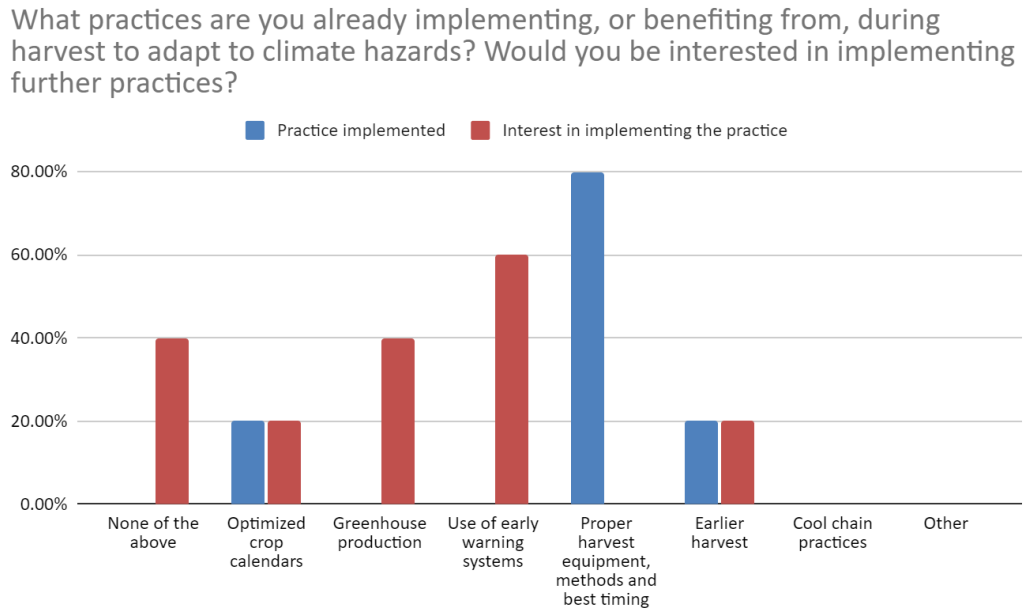
356. Cashew apples are usually left unutilized as a by-product for processing and trade. They are left on the ground during harvest to decompose and used as a source of organic matter or used to feed animals. Pests and diseases and droughts were identified by the survey respondents as the main hazard affecting the harvest stage causing stress conditions during crop maturation as well as harvest delays, food losses and reduced quality. In addition, value chain actors selected extreme heat and weather events such as storms and winds affecting the quality of the food product at harvesting. These results are related to the responses of the agricultural cooperatives during the dedicated workshop, which see productivity decreasing due to insect attacks at pre-harvest stages and increased moisture levels which increase mold (Figure 60).

Figure 61 Major climate impacts to cashew harvest



357. At the harvest stage, most respondents stated that they use proper harvest equipment, methods, and timing, for example they might know to harvest earlier according to optimized crop calendars. At the same time, their requests for the implementation of further climate resilient practices concern the use of early warning systems to counteract extreme weather events and optimize even more the harvesting timing, as well as improving greenhouse production systems (Figure 61).

Figure 62 Practices implemented and interest in implementing further practices during cashew harvest to adapt to climate hazards



Cooperatives (cashew)

358. There are 17 Agricultural Cooperatives (ACs) of cashew producers currently receiving support from PDAFF on financial management, bookkeeping and business management skill (1 session per year). ACs are working on processing cashew nuts – they collect from their members and sell to market. World Vision used to support 1 AC on warehouse construction, cashew nuts processing materials and training, but the project ended at the end of 2018. 11 ACs located in Preah Vihear (supported by IVY; plan: 13 AC) are working specifically on organic cashew nuts. 8 of these ACs receive support from PDAFF to supply to processor Santana Agro Products. Contract faming of cashew nuts has not been initiated until recently, mostly because of the lack of local processors(Sereyvath and Rotana, 2019) In 2019, 5 agricultural cooperatives (ACs) in Preah Vihear went into contract farming of organic cashew nuts (Swiss Church Aid, 2019).

359. Several cashew agricultural cooperatives and associations exist in Kampong Thom, although they are not formally registered in any list, particularly because of their different types of status, such as ACs registered with the MAFF, associations registered at the Ministry of Interior, or business associations registered at the Ministry of Commerce of Tourism. There are few incentives for farmers to join associations and ACS, which struggle to gain enough management and technical capacities, business plans, and profits (Burn et al., 2018).

Collection and middlemen (cashew)

360. Climate hazards do not affect producers only: for example, when production is low because of a drought, collectors and middlemen's volumes and profit decrease as well (Burn *et al.*, 2018). Middlemen in collaboration with ACs play a key role in managing the quality of the products and influencing producers to implement climate resilient practices that comply with near-organic international standards and premium market requirements.

361. Overall, there is limited value addition capacity (i.e., for the development of facilities and technologies for storage, processing, quality control, packaging, branding and market stages of the value chain). Public or private extension services are limited and frequently linked to agrochemical suppliers' services which discourage near-organic production by promoting chemical based input products.

362. To overcome farmers and agricultural cooperatives' lack of value-adding infrastructure such as for processing and packaging, they connect producers with larger scale warehouses, processing, transportation, and market facilities owned by large buyers from different provinces which purchase cashew independently from the province of origin, by paying middlemen in advance(Kono and Chey, 2019).

Post-harvest handling and quality (cashew)

363. Producers are not interested in post-harvest cashew nut handling and value-adding activities, since they receive higher prices for bigger nuts and no price premium for dried nuts. Therefore, they have no incentives in selling them after drying since the weight and therefore the price would be reduced. A primary grading is performed by farmers to distinguish the M23 variety from the smaller varieties to avoid receiving a bulk price, first in Kampong Thom, and recently in Preah Vihear provinces (Burn et al., 2018).

Drying (cashew)

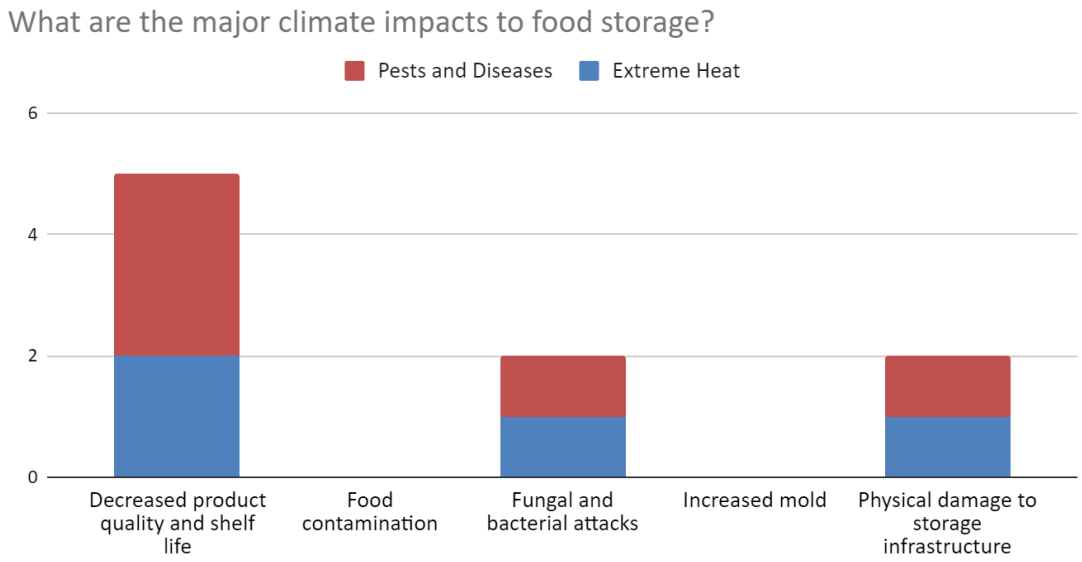
364. It is fundamental to dry cashew nuts right after harvesting to avoid kernel deterioration due to high relative humidity which may spread mold and bacterial attacks. This usually occurs on a cement drying ground for one or two days (Burn et al., 2018) under the sun. One option for the optimization of drying of cashew nuts is by superheated steam (Eang and Tippayawong, 2017).

Storage (cashew)

365. After harvesting and drying, cashew nuts are usually stored in warehouses managed by agricultural cooperatives, before being processed and shelled. Warehouses are relatively clean, although storing conditions could be improving by increasing ventilation systems, separating equipment from food products within the warehouse, store on wood pallets instead of on the ground to avoid contamination, ensure distance to the wall and hygiene (Burn et al., 2018).

366. According to middlemen, some sacks are suitable because they allow the air to circulate, but others are affecting quality (by encouraging the development of mold, or even spoiling the nuts by causing them to rot) (Burn et al., 2018). Good practices for raw cashew nuts' bagging and storage usually require that the nuts are stored in jute bags instead of plastic bags to reduce the risk of mold and spoilage. However, this is not usually the case in Cambodia, where nuts are stored in plastic sacks that do not let the air circulate. The main climate and weather-related hazards identified by survey respondents consist of extreme heat and pests and diseases attacks causing fungal and bacterial contamination, thus decreasing products' quality and shelf life, as well as damages to storage facilities (Figure 62).

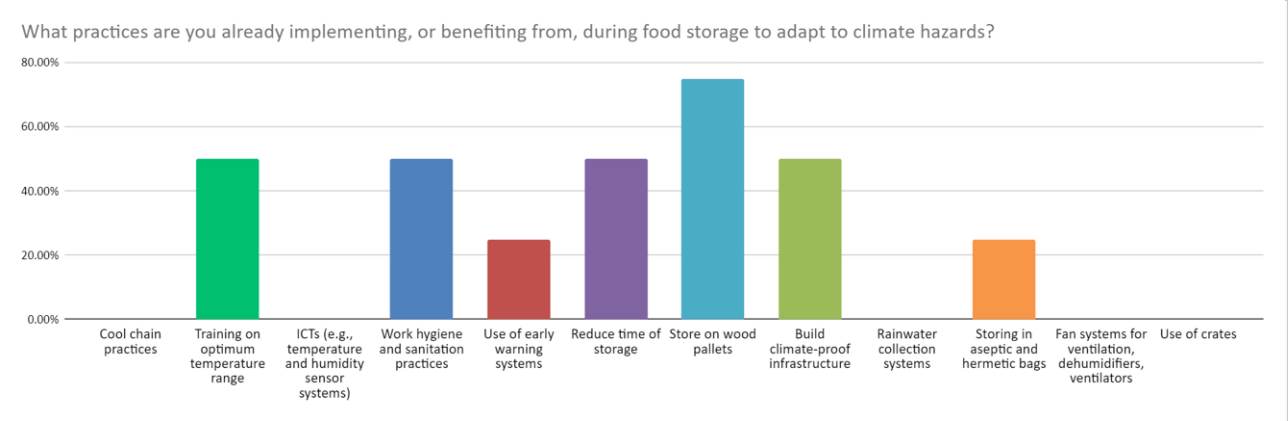
Figure 63 Major climate impacts to cashew storage



367. Survey respondents demonstrate an adequate level of adaptive capacity to climate and weather-related hazards. In fact, they are already implementing climate resilient practices, in particular the elevation of cashew kernels above the floor using wood pallets to prevent food contamination and wetting, while benefitting from the access to climate-proof infrastructure for storage. In a minor percentage, they mentioned the implementation of combined practices which contribute to food

quality and quantity preservation, such as training on optimum temperature range, compliance of work hygiene and sanitation practices, and reduction of the time of storage according to temperature and humidity trends. A few stakeholders also mentioned the use of aseptic and hermetic bags and early warning systems to prevent food contamination and extreme weather events respectively (Figure 63).

Figure 64 Practices implemented during cashew storage to adapt to climate hazards



Processing (cashew)

368. Only a very small percentage of the nuts produced in Cambodia are then processed in the country. According to agricultural cooperatives representatives in Kampong Thom, Ac members work together to process cashew nuts and collaborate to improve their access to markets, although they have limited understanding and experience in high value cashew. However, they see productivity decreasing due to insect attacks at pre-harvest stages and increased moisture levels which increase mold. Consequently, they advocate for the improvement in the use of bags that allow air to transpire (e.g., cotton or jute bags) to prevent moisture content, as well as the use of pallets to raise the storage bags from the floor within storage facilities.

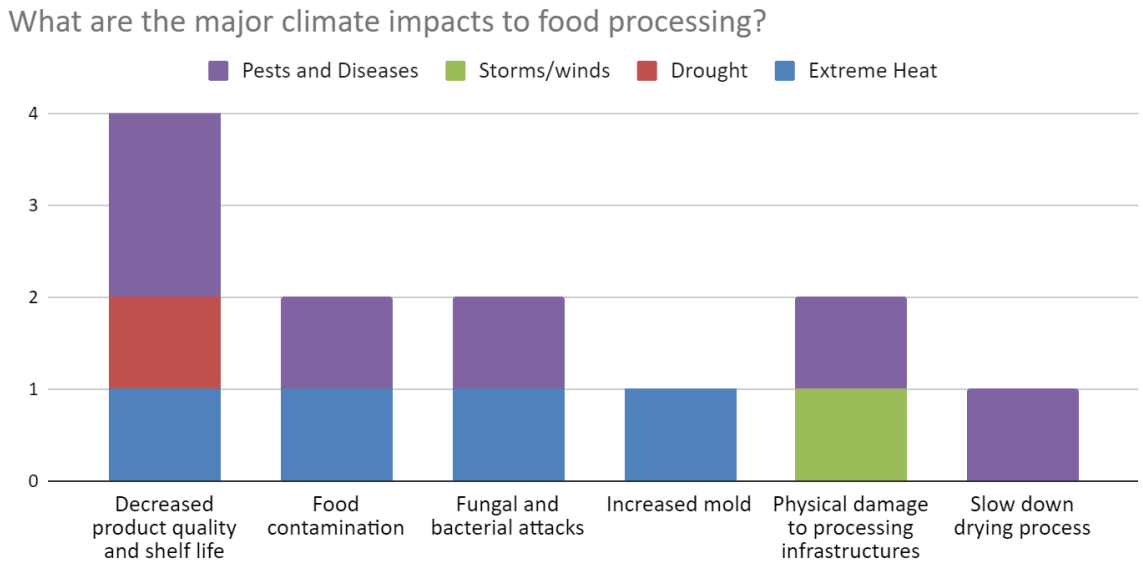
369. At the time of the research, the Specialized Cambodian Products (SCP) company owns an active modern processing unit in Phnom Penh, whereas the rest of processing is performed at small-scales and with traditional processing equipment and techniques in Kampong Thom (Sambo Prey Kuk Tourism Community Cashew nuts processing center and Santuk Mountain Agricultural Cooperative cashew processing unit) and Preah Vihear (Santana Agro products' cashew nuts processing factory) or directly in another country (Sereyvath and Rotana, 2019).

370. According to Swiss Church Aid (2019), 4 processing firms shell RCN by semi-mechanized processing machine and partly manual. The total volume of processed cashew is only the 3% of the production, due to limited capital to buy raw cashew nuts, limited technical resources and capacity to maintain processing technologies, lack of international buyers, all which result in high costs and limited profitability. At the same time, the development of cashew processing facilities could be promoted as a relatively low investment opportunity which would imply efficient use of technology and human resources(Burn et al., 2018). As mentioned above, the cashew nut is very difficult to shell by virtue of its hard shell, awkward shape and the presence of the toxic CNSL. The economics

of cashew processing depends largely on the proportion of kernels extracted without being broken or damaged. Mechanized or semi mechanized shelling broke up to 60% of the kernels, as opposed to 15-20% in the manual process. Indeed, in the 1980s and 1990s, the cashew producing countries were littered with failed mechanized factories (IFC, 2010). The potential for Cambodia to improve processing units is low due to the lead taken by Vietnam and India (USAID, 2019). At the same time, attempts to increase local cashew processing are increasing.

371. Survey respondents identified pests and diseases as the main hazard affecting food processing, followed by extreme heat. While the former was deemed responsible for decreased product quality and shelf life because of attacks at pre-harvest stages which contaminate food by fungal and bacterial spread, the latter directly affects the spread of mold, fungal and bacterial contamination which consequently reduce the effectiveness to dry, clean, and package cashew kernels (Figure 64).

Figure 65 Major climate impacts to cashew processing



Shelling (cashew)

372. Nuts are shelled by using a cutting tool which grips the nuts and cuts the shell that is then separated by hand. These machines are pedal operated. ACs have around 10 to 20 of these tools available for shelling (Burn et al., 2018).

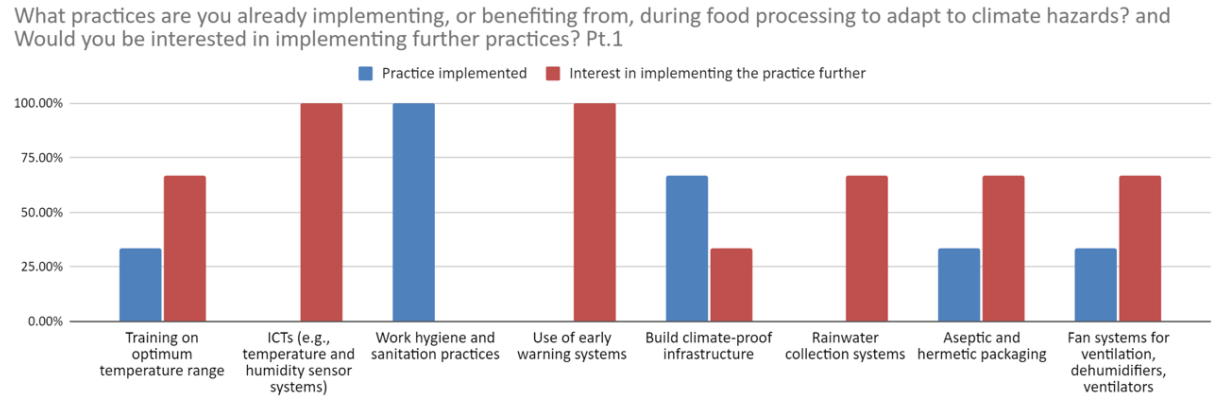
Grading, cleaning and packaging (cashew)

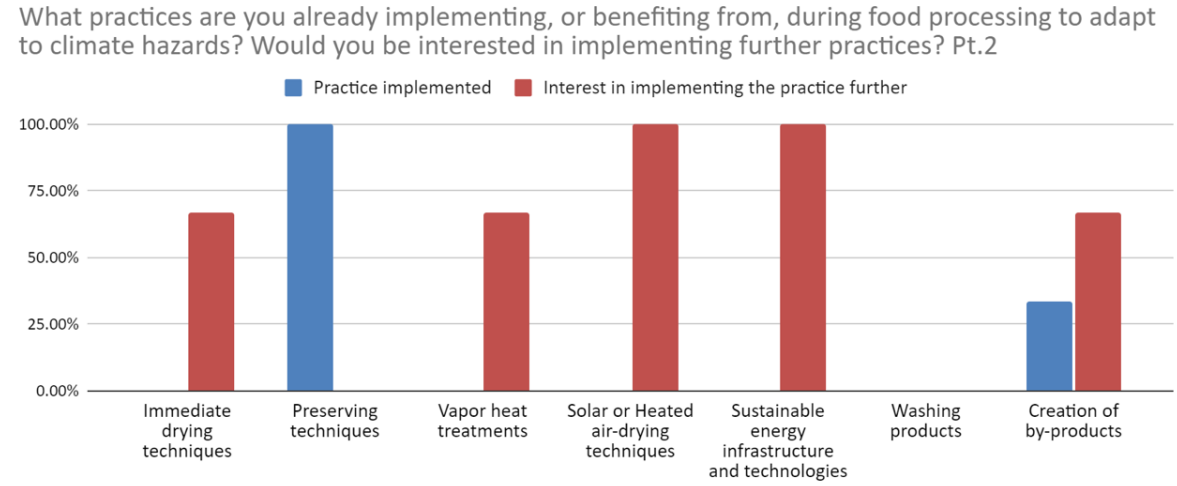
373. Agricultural cooperatives do not grade the products and directly pack them in simple plastic bags. The Sambo Cashew Association obtained the capacity to label cashew from ACs through the support of a previous project. However, this was not renewed, and they are now using only the remaining labels (Burn et al., 2018).

374. As expressed by stakeholders during the online survey, the main practices implemented to address climate hazards impacting the processing stage consist of the improvement of working

hygiene and sanitation practices, as well as the adoption of tailored preserving techniques. Most value chain actors benefit from the access to climate-proof facilities for cashew processing (Figure 65).

Figure 66 Practices implemented and interest in implementing further practices during cashew processing to adapt to climate hazards.





Transportation (cashew)

375. Food value chains that are competitive require sustainable and efficient transportation and infrastructure systems. It is fundamental that rural areas are properly linked to urban center and market areas through provincial and national roads. At the same time, in Cambodia the road network is still underdeveloped, particularly for the condition of rural roads that often are not paved. Roads and the conditions of vehicles are susceptible to heavy rains and flooding events, consequently impacting the transported food products and the final costs (Asian Development Bank, 2020).

376. Raw cashew transportation from Cambodia to Vietnam primarily occurs through trucks or motorbikes (Swiss Church Aid, 2019). This is usually managed by local traders and collectors. A small

amount (5%) of formal and more regulated exportation with regards to certificates of origin and phytosanitary certificates, is managed through seaport.

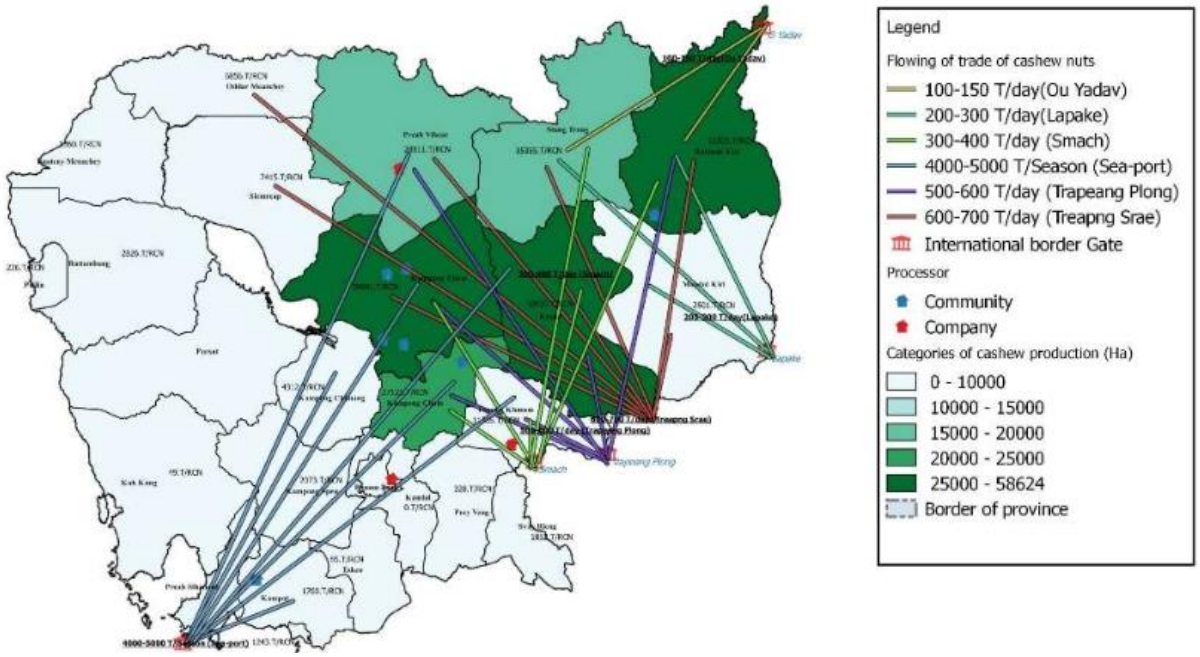
Markets/Retail (cashew)

377. There is limited understanding of and access to different markets among small-scale farmers and agricultural cooperatives, combined with excessive and unregulated use of pesticides which prevents them to enter organic markets. Traceability of cashew trade is very limited (Figure 66).

378. Overall, wholesale buyers manage cashew trade, by selling raw products directly to Vietnamese buyers which informally regulate the exchanges with limited set rules on the quantity and quality of cashew, and its cost. The main concerns among buyers include the use of chemicals which is acknowledged to reduce the quality and safety of the products. Santana Agro products Co., Ltd is the only national export company for cashew (Sereyvath and Rotana, 2019).

379. The lack of knowledge, information, and control among farmers and ACs causes limited profits as well as value-addition opportunities for farmers to invest in climate resilient and sustainable practices such as integrated pest management which could increase their market share, for example with Chinese buyers which are particularly interested in Cambodian cashew production for its natural quality (Burn *et al.*, 2018).

Figure 67 Trade of cashew nuts and producers/buyers (Swiss Church Aid)

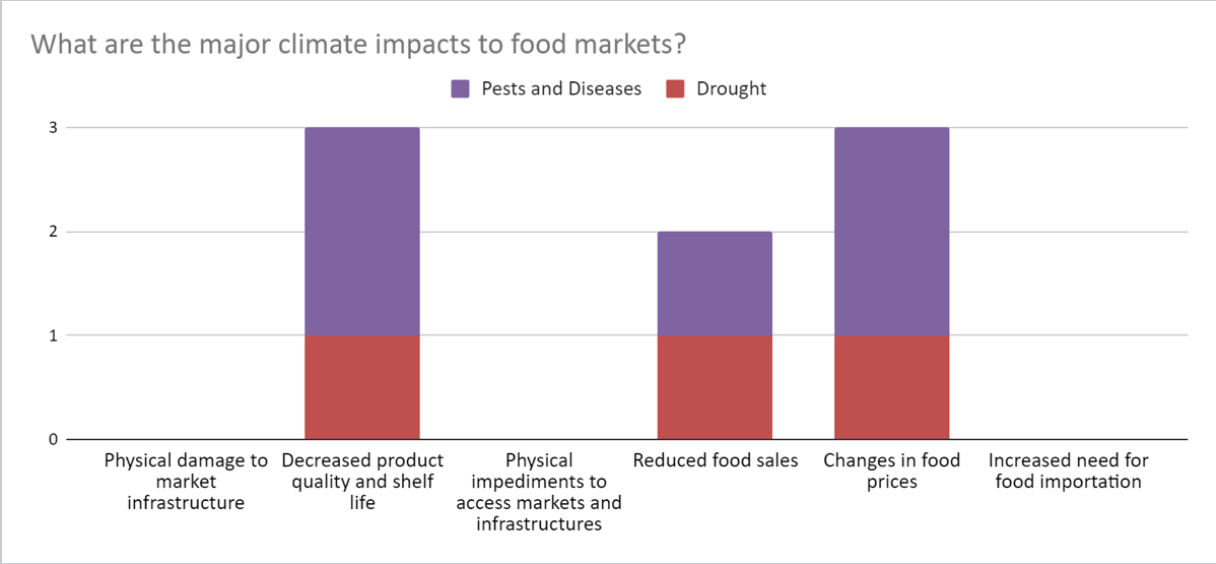


380. Survey responses showed that food quantity and quality losses caused by drought and pests and diseases at pre- and post-harvest stages of the cashew value chain have final impacts on the cashew trade and markets by changing food prices according to the final quality available and shelf life, with consequences on reduced food sales (Figure 67).

381. While shifting to organic production would provide a price premium of 25%, this is still not as profitable as producing the M23 variety which benefits of substantial productivity, although is not resistant to pests and diseases. Therefore, farmers have very little incentive to invest in organic production (Burn *et al.*, 2018). Fair-trade cashew sales have developed, but unlike fair-trade cocoa and coffee, development remains slow. The 'fair-trade' and organic brand is growing in Europe and the US, but there has been no formal progress on the development of pricing for grades of fair-trade cashews, other than WW320. Over 2008 and 2009, cashew kernel prices were closer to the fair-trade price than ever before.

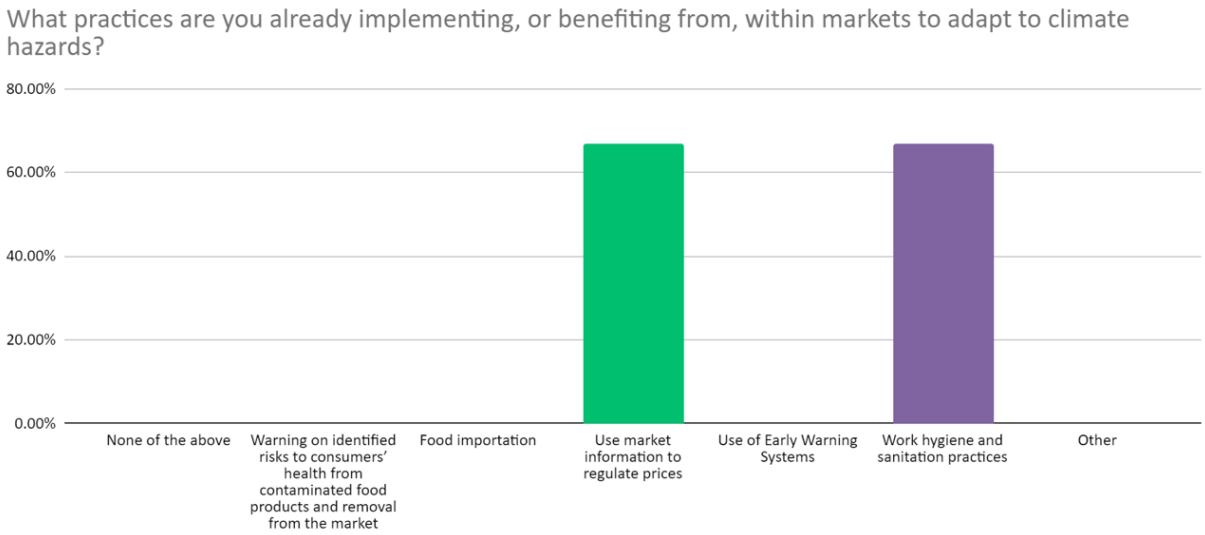
382. International demand for cashew has been increasing, for example, in China, Japan, and South Korea (Burn *et al.*, 2018). Companies such as Specialized Cambodian Products (SCP) are interested in expanding cashew trade from local markets by integrating exportation. By 2030, Cambodia aims at becoming the world leader in organic cashew production (USAID, 2019).

Figure 68 Major climate impacts to cashew markets.



383. Within markets and trade, given the scarce involvement of value chain actors, few stakeholders selected the use of market information to regulate prices combined with the compliance with working hygiene and sanitation practices to reduce the impact of climate and weather-related hazards (Figure 68).

Figure 69 Practices implemented within cashew markets to adapt to climate hazards



8.5.4. Climate-resilient practices in the cashew value chain

384. To counteract the main climate hazards affecting the NTSB (pests and diseases, droughts, and extreme heat), value chain actors suggested to adopt integrated water management practices including the use of water reservoirs and drip irrigation systems. The harvest stage should be supported using early warning systems, for it to not coincide with the occurrence of pests and diseases attacks and combined with greenhouse production.

385. Appropriate measures should be adopted within storage facilities to ensure the products are not contaminated (e.g., by introducing fan systems for ventilation and increasing hygiene and sanitation practices). At the processing stage, the most requested practices and technologies include the use of ICTs to monitor temperature and humidity, combined with the use of early warning systems and the adoption of further drying infrastructure and techniques. The transportation stage should be well aligned with updates on the weather conditions to avoid the occurrence of extreme weather events while carrying food. More infrastructural interventions should concern the improvement of embankment protections, appropriate lighting, and paved roads.

386. Finally, at the market stage respondents selected the use of market information to better regulate prices according to national and international trends (Table 24). Climate resilient practices suggested by agricultural cooperatives during dedicated workshop included increasing participatory training (learning by doing) on fertilizers use, integrated pest management practices particularly at seedling (dry the cashew seed to avoid moisture) and flowering. Improvements in the reduction of relative humidity at post-harvest stages (drying-storage-processing) were requested, using transpiring bags (e.g., jute-cotton bags) to avoid moisture and use of wooden pallets to raise the storage bags from the floor at storage facilities.

Table 24 Climate resilient practices requested by survey respondents at production and post-harvest stages.

INPUT SUPPLY	▪ OPTIMIZED CROP CALENDARS (33%) ▪ DROUGHT TOLERANT CROPS (33%) ▪ USE OF WATER RESERVOIRS, DRIP IRRIGATION SYSTEMS (66.7%)
HARVEST	▪ OPTIMIZED CROP CALENDARS (20%) ▪ USE OF EARLY WARNING SYSTEMS (60%) ▪ GREENHOUSE PRODUCTION (40%) ▪ EARLIER HARVEST (20%)
STORAGE	▪ FAN SYSTEMS FOR VENTILATION, DEHUMIDIFIERS, VENTILATORS (75%) ▪ WORK HYGIENE AND SANITATION PRACTICES (50%) ▪ USE OF EARLY WARNING SYSTEMS (25%) ▪ ICTS (E.G., TEMPERATURE AND HUMIDITY SENSOR SYSTEMS) (25%) ▪ REDUCE TIME OF STORAGE (25%) ▪ BUILD CLIMATE-PROOF INFRASTRUCTURE (E.G., APPROPRIATE LOCATION, DIMENSIONS, TYPE AND SLOPE OF THE ROOF, ETC.) (25%) ▪ RAINWATER COLLECTION SYSTEMS (E.G., TANKS, PUMPS, PURIFIERS, DRAINAGE SYSTEMS AND INFRASTRUCTURES ETC.) (25%)
PROCESSING	▪ ICTS (E.G., TEMPERATURE AND HUMIDITY SENSOR SYSTEMS) (100%) ▪ USE OF EARLY WARNING SYSTEMS (100%) ▪ SOLAR OR HEATED AIR-DRYING TECHNIQUES (100%) ▪ RENEWABLE ENERGY OR ENERGY EFFICIENT INFRASTRUCTURE AND TECHNOLOGIES E.G. FOR MILLING, DRYING, GRATING (100%) ▪ TRAINING ON OPTIMUM TEMPERATURE RANGE (66.7%) ▪ RAINWATER COLLECTION SYSTEMS (E.G., TANKS, PUMPS, PURIFIERS, DRAINAGE SYSTEMS AND INFRASTRUCTURES ETC.) (66.7%) ▪ ASEPTIC AND HERMETIC PACKAGING (66.7%) ▪ FAN SYSTEMS FOR VENTILATION, DEHUMIDIFIERS, VENTILATORS (66.7%) ▪ IMMEDIATE DRYING TECHNIQUES (66.7%) ▪ VAPOR HEAT TREATMENTS (66.7%) ▪ CREATION OF BY-PRODUCTS (66.7%) ▪ BUILD CLIMATE-PROOF INFRASTRUCTURE (E.G., APPROPRIATE LOCATION, DIMENSIONS, TYPE AND SLOPE OF THE ROOF, ETC.) (33%)
TRANSPORTATION	▪ USE OF SAFE AND EFFICIENT ROUTES, E.G. ELEVATED ROADS ABOVE FLOOD-PRONE AREAS, APPROPRIATE LIGHTNING (50%) ▪ BUILDING PAVED ROADS (50%)
MARKETS	▪ USE OF EARLY WARNING SYSTEMS (33,3%) ▪ USE MARKET INFORMATION TO REGULATE PRICES (33,3%)

8.5.5. Recommended climate resilient interventions for cashew

Table 25 Recommended climate-resilient measures for cashew based on the observed and projected climate impacts along the food value chain

Stage/ activity	Baseline vulnerability	Climate impacts	Recommended resilience measures

Soil and land management	• Land preparation is made either with a tractor or with hand tractor. Tractors are usually rented; hand tractors are rented if the household does not own one.	• Increasing temperatures will accelerate the decomposition of organic matter and reduce carbon storage in the soil	• Support CF/CPA management planning to restore primary and secondary forest cover, mixed with sub-sections for agroforestry, agriculture, and other livelihood activities (e.g., NTFPs, apiculture, tourism). • Prevent unsustainable expansion into forested areas. • Promote intercropping and mulching schedule methods (e.g., with leguminous crops). • Promote slope agriculture land technology where applicable.
Varieties/ Seeding	• Cashew producers are either directly planting seeds in their farms (only for local varieties) or planting seedlings (produced by them or purchased in a nursery). There is no common practice to all farmers concerning planting density (around 6 to 10 m) • Lack of clarity concerning the origin of planting material, no variety registration. • M23 variety is widespread e.g., in Kampong Thom, it accounts for about 80% of the cultivated areas • There is tendency that farmers replace the local varieties with M23 as M23 gives much higher yield.	• Uncertainty of rainfall patterns	• Promote local and other varieties that are more resistant to droughts, pests, and diseases. • Promote propagation and grafting techniques. • Support farmers' networks to promote suitable varieties.
Inputs	• Farmers apply fertilizer at planting time (100 kg per hectare, one bag of 50 kg costs 40 USD) • Farmers use hormones to induce flower	• High temperatures will increase the volatilization rates, with adverse economic and environmental consequences for fertilized agricultural land	• Strengthen agricultural extension capacity/technical functions for providing coherent and relevant guidance and training to farmers (e.g., appropriate agrochemical application). • Provide fertilizer advisory based on soil type. • Increase organic fertilizer production capacity and access, including bio-digesters • Establish a public-private sector coordination mechanism to promote controlled agrochemical

			product labeling appropriate and minimal agrochemical application. • Identify a list of quality input suppliers to share with farmers, ACs, FAs, PGs, and unions. • Increase governance capacity, including quality control, of ACs and unions to ensure enabling conditions for climate-resilient and sustainable practice uptake.
Pest control	• Farmers apply pesticide and hormones and are often not aware of the exact content of what they are applying. • Widely used M23 variety is very susceptible to pest and diseases, and require high level of pesticide application	• Heavy rains cause spread of mold and fungal diseases, pests and diseases at flowering and fruiting. • High costs and low quality of inputs, limited knowledge on the use of specific pesticides decrease capacity to face pests and diseases attacks	• Improve research and data collection on key pest and diseases on cashew production to develop tailored IPM measures. • Strengthen extension services to promote IPM, climate-informed practices, and risk management using agro-met services. • Promote local "traditional" varieties that are resilient to pests and diseases. • Improve tailored pest and disease warnings and advisories. • Use of herbicide alternatives.
Flowering	• Flowering period is the most sensitive period of the cashew production to climate conditions	• High temperature (>34°C) and low humidity during flowering causes the drying out of flowers, which leads to yield reduction. • The occurrence of heavy rains or storms during flowering also leads to a drop in flowers, which affects the yields. Strong winds can also lead to the same result.	• Tailor climate services based on calendar and sensitive periods to prevent damage. • Develop farm-level training/FFS on water-saving practices, organic fertilizer production, managing pest and disease on mango production (i.e., IPM), incorporating traditional knowledge.
Irrigation	• Compared to neighboring countries, Cambodian cashew farmers receive very little support for irrigation infrastructure	• Drought has severely affected production in Kampong Thom, upland PV has higher resilience to drought conditions	• Establish IWM mechanisms to improve water availability and pollution control. • Develop natural canal and pond networks. • Monitor water flow and quality and crop water requirements to provide tailored agro-met advisories. • Promote climate-smart irrigation systems and schedules to optimize water resources.

Harvest	• The harvesting of cashew nut is very labor-intensive. Farmers interviewed mentioned that one worker usually harvest around 50 kg of nuts in a day. Harvest is done regularly during all the production months. During the month of April, when the production is at its peak, workers may harvest cashew nuts up to two times a week.	• During harvest, while nuts are on the ground, the rain will rot the nuts.	• Promote climate-resilient harvest techniques linked to agro-met advisories. • Provide tailored climate services and early warning systems to inform farmers' decision to harvest with appropriate timing and methods • Promote immediate drying after harvesting.
Post-harvest storage and processing	• Lack of storage, drying, processing, quality control, packaging facilities, infrastructures, qualified workers; lack of public and private extension services to support near-organic production • Drying mainly sun	• Increasing temperatures and extreme hot days decrease product quality and shelf life • Humidity resulting in losses without effective processing facilities • Contaminated food products due to pests and diseases attacks at production stages • fungal and bacterial attacks at post-harvest	• Promote storing nuts in jute bags and other techniques to decrease mold. • Increase awareness of optimum thermal processing and storage techniques. • Increase use of fan, dehumidifiers, and ventilators to reduce storage loss. • Increase knowledge and use of temperature and humidity sensor systems (e.g., ITCs). • Promote better use of by-products. • Invest in research and development for value-addition processing options.
Market	• Currently, it seems there is no certified organic (based on an international organic standard) cashew in Kampong Thom and Preah Vihear provinces. In 2009-2012 a project supported by IFC promoted the development of organic plantation for cashew	• Pests and diseases attacks at production have final impact on food quality, changes in food prices, and decreased sales	• Make market information available as part of services for farmers and other local value chain actors through existing market apps (e.g., by IFAD AIMS, ASPIER projects) • Support adoption of CamGAP, GI, organic certification, including Ibis Rice, and other appropriate value-adding certifications. • Establish a close link between target certifications and climate resilience for further value addition. • Build PSPPs to increase collaboration and coordination across value chains (e.g., market networks, trade fairs, matching services).

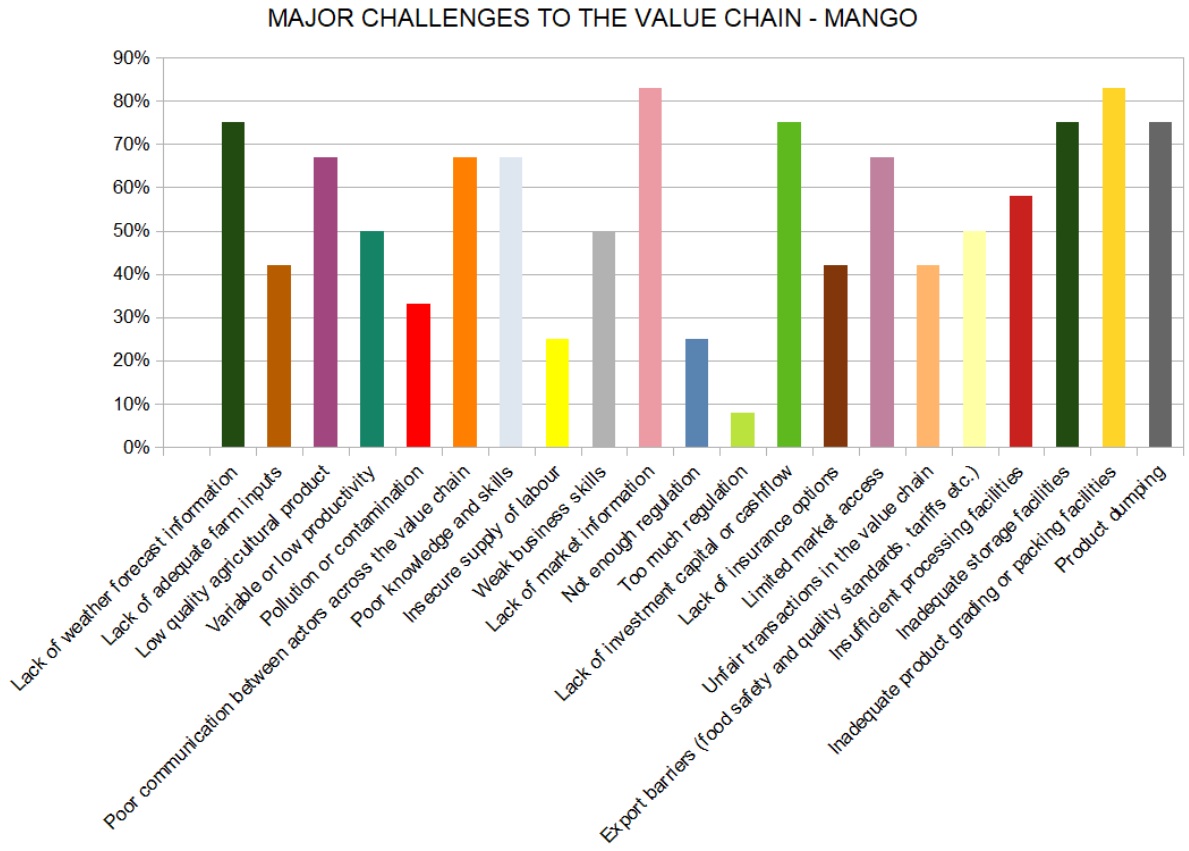
- Increase farmers' and other local value chain actors' business, market and financial literacy.
- Raise awareness of climate-resilient and high-value products and their benefits among buyers, exporters, and consumers.
- Promote contract farming and direct purchase agreements for increased demand and supply.
- Invest in labeling and traceability capacity.

8.5.6. Climate change impacts on mango value chain

387. While climate hazards may impact the quantity and quality of production, except for young plantations, the risk of destruction of the orchard and loss of the entire investment is low. Mango trees are relatively more resilient to climate impacts during the growing cycle; however, it is important to consider the impacts of climate also after harvest of the mango fruit. In the case of Cambodia, the value chain for mango production is not very well developed and therefore loss and waste of product occurs post-harvest, making the product less sustainable and resilient.

388. A value chain analysis performed by ICEM through the delivery of an e-survey (2020) with 12 respondents and follow-up workshop (2021), identifies major challenges to the mango value chain (Figure 69). These primarily consist of lack of market information, inadequate product grading or packing facilities (selected by 80% of respondents). These are followed by lack of weather forecast information, lack of investment capital or cashflow, product dumping, insufficient storage and processing facilities (as selected by around 70% of respondents). Around 60% of the respondents also identified low quality of agricultural products, poor communication between VC actors, poor knowledge and skills, and limited market access, as key challenges to the mango value chain.

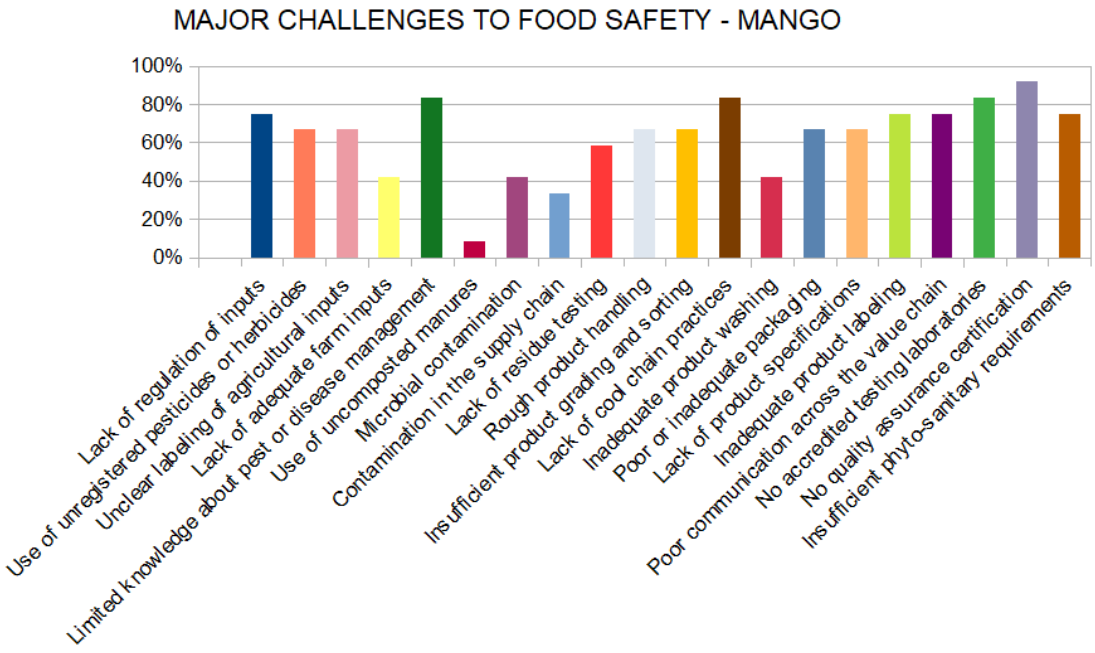
Figure 70 Major challenges to the mango value chain.



Source: adapted from ICEM e-survey (2020)

389. In addition, survey respondents identified key challenges specifically to food safety across the mango value chain (Figure 70). In particular, the lack of quality assurance certification is identified as the major challenge, also due to the lack of accredited testing laboratories for food quality and followed by limited knowledge about pest or disease management which impedes producers to apply tailored and near-organic pesticides. In addition, the lack of cool chain practices affects the quality of mangoes at post-harvest which are more susceptible to product degradation due to food contamination, spread of mold and rot.

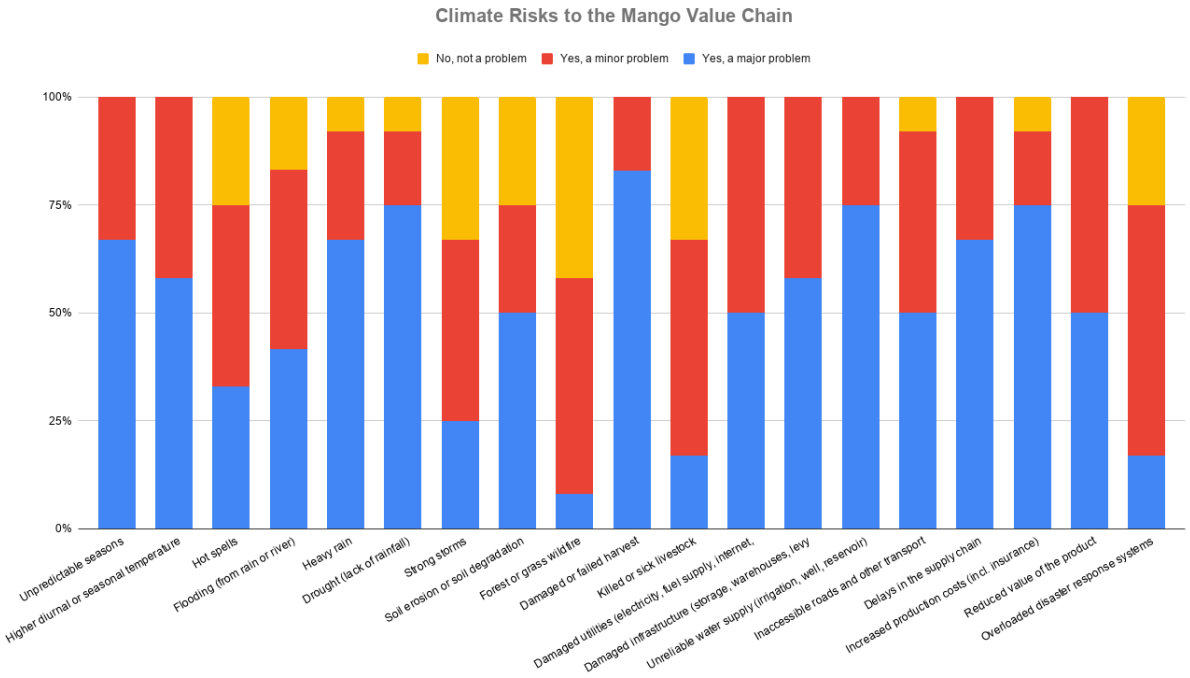
Figure 71 Major challenges to food safety across the mango value chain



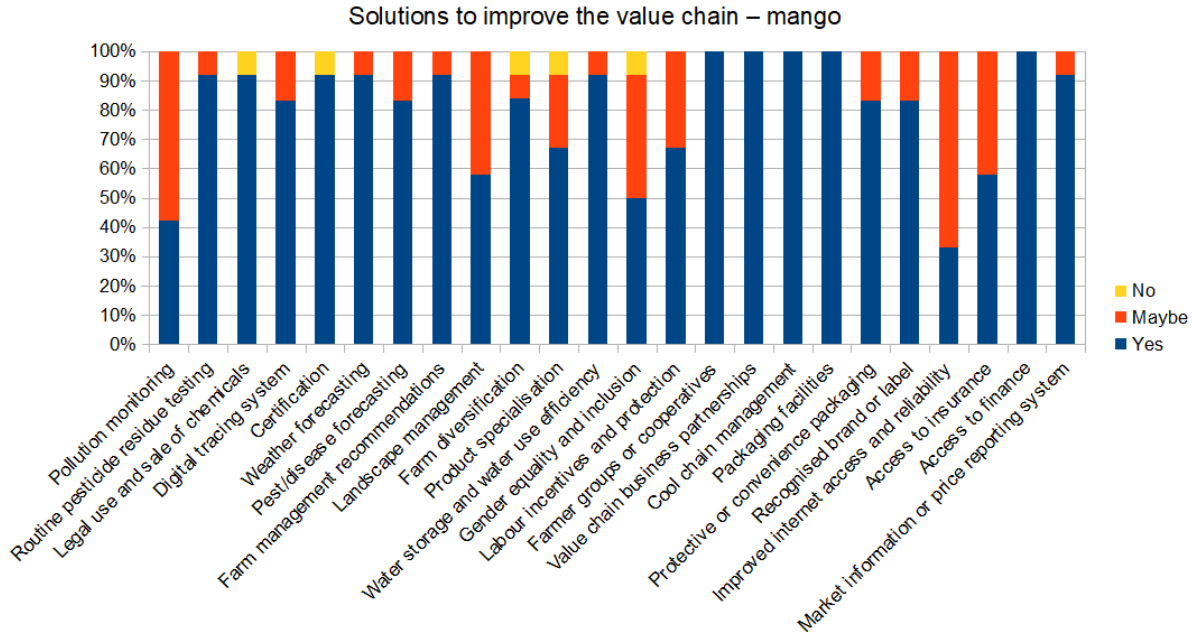
Source: adapted from ICEM e-survey (2020)

390. More specifically to the climate risks across the mango value chain, respondents identified as major challenges unpredictable seasons, thus changes in rainfall patterns and drought and flooding events damaging products at harvest, causing unreliable water supply, as well as overall delays in the supply chain (Figure 71). These overall damage infrastructure and utilities across the value chain with impacts on the final quantity and quality of the food product.

Figure 72 Climate risks to the mango value chain



Source: ICEM e-survey (2020)



Source: ICEM e-survey (2020)

8.5.7. Climate risk and climate resilience of the mango value chain

391. A climate-focused stakeholder consultation and value chain analysis was performed through the delivery of an online survey to key PEARL project stakeholders involved in different steps of the mango value chain and integrated with a dedicated in-person workshop with local agricultural cooperatives. The aim of the consultation was to identify climate impacts at each stage of the value chain with an emphasis on post-harvest systems, going beyond the production step at the crop field level. In addition, the consultation enabled to define key climate resilient practices that value chain actors are already implementing at the time of the research, as well as the further practices that stakeholders would be interested in implementing in the future through the support of the PEARL project. Finally, a key component of the analysis involved the state of development of climate services, including climate information and agricultural advisory products, that value chain actors benefit from at the time of the assessment and would be interested in benefitting further through the support of the PEARL project.

392. A total of 4 stakeholders from the private sector took part in the online survey, involved at different steps of the mango value chain, such as organic producers, international trade organizations, logistics services, and agricultural service providers. Two of them had also participated in the ICEM's e-survey (2020).

393. The below analysis outlines the impacts of climate at each stage of the mango value chain as identified throughout the literature and integrated with results from the climate-focused stakeholder consultation and value chain analysis from secondary data collection (ICEM e-surveys and workshop, 2021). A simplified schematic of the mango value chain based on FAO assessment is highlighted below.

Harvest (mango)

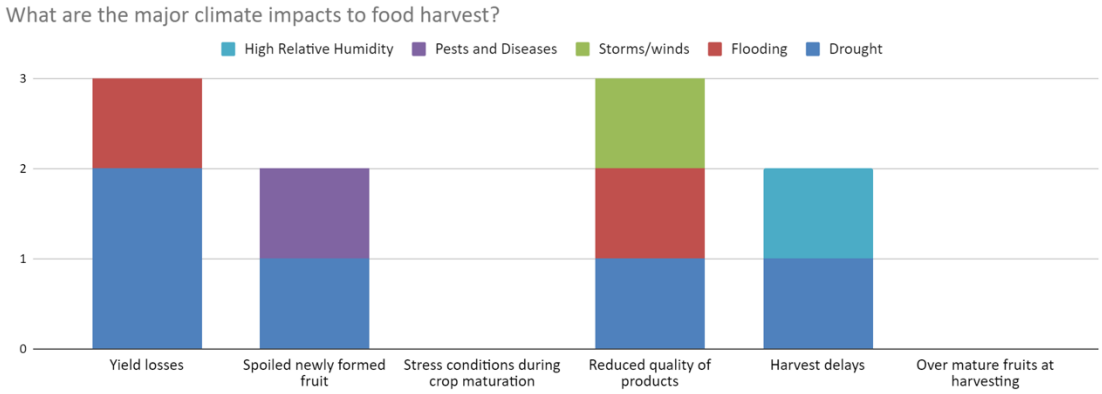
394. Respondents of the online survey identified droughts as the main climate hazard affecting the mango value chain, affecting the quality and quantity of fruits at harvest as well as harvest delays. Fruit spoilages are also exacerbated by flooding events, pests and diseases, and high relative humidity at pre- and harvest stages.

395. According to agricultural cooperatives representatives through the dedicated workshop held in December 2021, between 200 AC members, only 19 apply CamGAP practices which were introduced by the PDAFF in Oddar Meanchey. The rest of the farmers are waiting for the results of those 19 farmers to decide whether to follow this process or not, by understanding the main outcomes and revenues.

396. Overall, mango producers do not have enough information on the use of pesticides to address pests and diseases attacks particularly during the flowering stage, which consequently affects the quality of the product at harvesting. ACs get information from pesticide companies although they need to find a reliable company or service that can provide them with an adequate type of pesticide to apply, combined with further advisory on integrated pest management practices.

397. Heavy rains have also substantial impacts on mango fruits that start degrading due to increased moisture and turning black, thus causing decreased sales within markets due to lower consumers' acceptance of the product. Agricultural cooperatives need to support farmers with capacity to wrap mangoes in plastic bags to reduce moisture levels. However, the use of more adequate packaging equipment such as cotton or jute bags would reduce the moisture level substantially by allowing air to transpire.

Figure 73 Major climate impacts to mango harvesting.



Storage and Processing (mango)

398. Mangoes are relatively perishable post-harvest and are difficult to store. Post-harvest processing has a key role to play in extending the product shelf-life while ensuring sustainable revenues for the producer through value-addition opportunities and by creating better access to premium international markets (FAO, 2018). In general, mangoes are not processed in Oddar Meanchey (except for small household-level processing techniques, such as conservation in salty water), but are directly transported in cases after harvest under the control of the buyer itself (Burn *et al.*, 2018). The lack of appropriate post-harvest handling and ripening methods, as well as of sanitary conditions and the availability of crates affects the shelf-life of mangoes which start maturing and ripening after harvest. The use of evaporative cooling chambers which are energy and cost efficient could be an effective and low cost means of extending the shelf-life after harvesting and before transportation (FAO, 2018).

399. Due to a lack of collection, storage and processing capacities that meet international standards, most mangoes from Cambodia are brought to Thailand by collectors and traders and processed and sold as Thai products. High costs of establishing collection, storage and processing facilities and the lack of public and private investments make it difficult for farmers, ACs and FAs to develop post-harvest facilities, quality control and packaging capacities, and to access international premium markets without the support from the public and private sectors(Kono and Chey, 2019). The incapacity to meet international standards impedes Cambodia to develop market opportunities with countries such as China, South Korea, and Japan were the demand for mangoes is increasing(Kono and Chey, 2019).

400. Investments for processing (ripening, washing, WHT) and packaging of mangoes are concentrated in Kampong Speu province. Hyundai Agro (Cambodia) Co., Ltd. is currently building a processing and packaging unit in Kampong Speu province (Burn *et al.*, 2018).

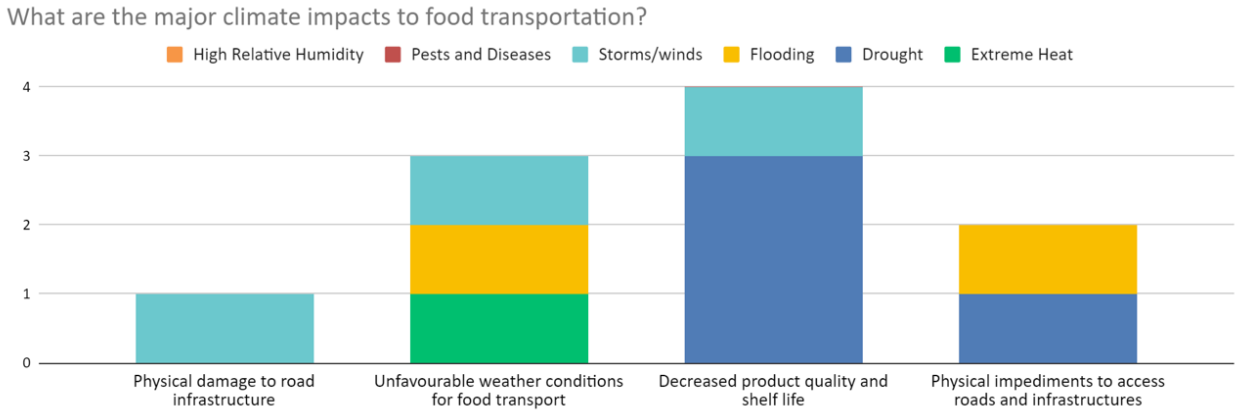
Transportation (mango)

401. Most of the logistics and transportation companies in Cambodia manage non-perishable products, combined with limited funding, infrastructure, technical resources and capacities to build and maintain roads particularly during the rainy season, which overall increase costs of transportation (USAID, 2019). In addition, Oddar Meanchey is quite a distant province from the location of the available processing plants in Kampong Spey, and the transportation of fresh products like mangoes over a long distance frequently must deal with logistical challenges as mentioned above (Burn *et al.*, 2018).

402. Food value chains that are competitive require sustainable and efficient transportation and infrastructure systems. It is fundamental that rural areas are properly linked to urban center and market areas through provincial and national roads. At the same time, in Cambodia the road network is still underdeveloped, particularly for the condition of rural roads that often are not paved. Roads and the conditions of vehicles are susceptible to heavy rains and flooding events, consequently impacting the transported food products and the final costs (Asian Development Bank, 2020).

403. Transportation factors including proper packaging material such as plastic crates, condition of the vehicles, transportation distance, road conditions, cold chain, play a key role in reducing food loss. Fruit may also be damaged because of improper handling. In fact, fresh mangoes are often transported from Cambodia to Vietnam and Thailand without being washed or packed, causing substantial loss of value and incapacity to use appropriate labels to directly access premium markets. During transportation, mangoes touching the sides of boxes and on the bottom layer can be easily damaged. This increases mangoes' exposure to climate hazards as identified by the online survey respondents, impacting the physical conditions for food transportation and accessibility of roads, as well as on food contamination and its quality and shelf life for trade and markets.

Figure 74 Major climate impacts to mango transportation.



404. The use of crates could reduce these losses considerably; however, the main problem is to return the crates from distant markets, which would incur additional transport costs. The current practice is to use corrugated boxes that are generally provided by the contractor or the aggregator. Preservation

of Keo Romeat mangoes under long term storage conditions experienced during shipments by sea freight of up to 21 days is key to achieving successful exports. Control of postharvest fungal rots such as stem end rot is mandatory for successful out-turns of fruit.

405. Proposed interventions suggest market yards would rent crates to transport the fruit to the distant markets which would improve the storage conditions within vehicles and reduce qualitative and quantitative food losses. In addition, this form of collaboration would increase the participation of market yards in the value chain and connection with producers, while also improving product volume and quality tracking across the value chain (FAO, 2018).

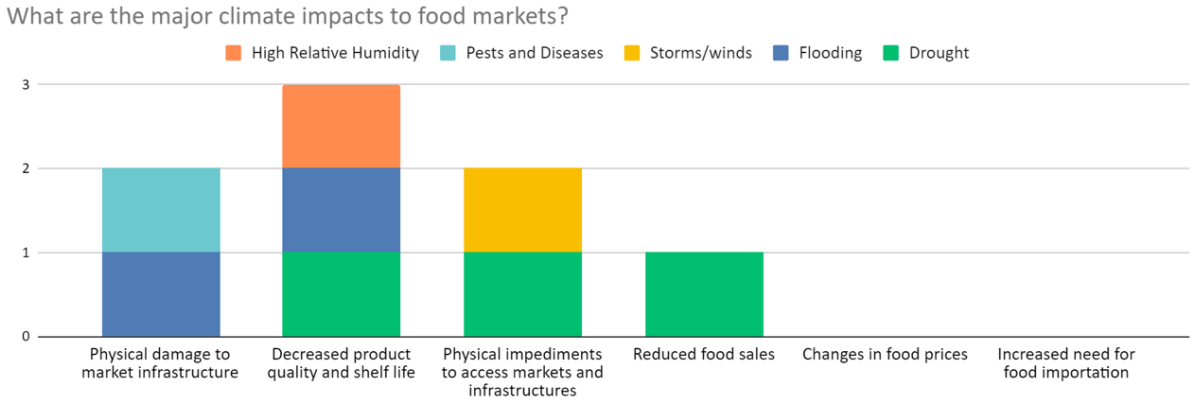
Markets/Retail (mango)

406. The demand for mango from Oddar Meanchey has been increasing substantially. However, smallholder farmers, agricultural cooperatives, associations, and small-medium enterprises are unequipped to sustain such market opportunities due to limited market access, knowledge of domestic and international market and value addition opportunities, particularly due to the frequent use of chemical pesticides. This limits their sale to wholesale buyers and disincentives farmers to adopt climate resilient and sustainable practices. However, by 2030, Cambodia aims at becoming one of the 5 main global exporters of high-quality fresh mango (USAID, 2019).

407. Major market challenges include the poor understanding of existing domestic markets, and potential export markets (Hickey, 2019). Mangoes for export are packed in 25kg plastic crates, whereas product for the local market tends to be packed into plastic bags. Packaged mangoes attract the highest price at the farm-gate as this reduces packaging costs further down the supply chain.

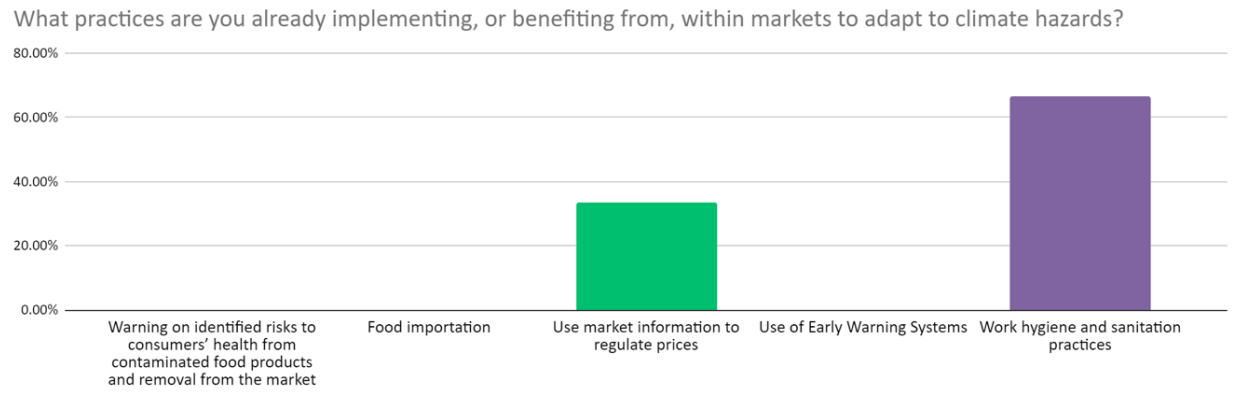
408. Quantitative loss of mango primarily caused by drought and flooding events as identified by the online survey respondents impacts the direct sales income of retailers at pre- and post-harvest stages of the value chain. In fact, qualitative and quantitative losses impede the capacity of producers to extend the sales period and to obtain a premium price for high quality fruit due to food spoilage and contamination (FAO, 2018)

Figure 75 Major climate impacts to mango markets.



409. Since farmers have limited knowledge of market information and opportunities, they are taken advantage of by contractors and buyers which instead are more aware of domestic and international market trends and prices. One potential solution would be to increase farmers information on the price of the product across the chain which could incentivize producers to introduce climate resilient practices to increase their revenue and improve their capacity to negotiate prices and make climate and market-informed decisions, overall increasing transparency of transactions and empowering farmers to better deal with international buyers. The development of market linkages for value-added products and sorted fruits would particularly support farmers, women, and youth in investing in mango processing or value addition activities as a sustainable and climate resilient enterprise (FAO, 2018).

Figure 76 Practices implemented within markets to adapt to climate hazards.



Climate-resilient practices suggested by mango value chain actors

Table 26 Climate resilient practices requested by survey respondents at pre- and post-harvest stages.

HARVEST	▪ OPTIMIZED CROP CALENDARS (33%) ▪ GREENHOUSE PRODUCTION (33%)
STORAGE	▪ TRAINING ON OPTIMUM TEMPERATURE RANGE (50%) ▪ WORK HYGIENE AND SANITATION PRACTICES (50%) ▪ USE OF CRATES (50%)
TRANSPORTATION	▪ REDUCE TRANSPORT SPEED (50%) ▪ SHIP PRODUCTS WITH LESS CRITICAL EXTERNAL CONDITIONS (25%)
MARKETS	▪ USE OF EARLY WARNING SYSTEMS (33.3%)

410. Climate resilient practices requested by agricultural cooperatives during dedicated workshop:

- Promote good practices (criteria, outcomes, profits) from AC members applying GAP certification to inspire the following of the process to obtain it (e.g., integrated pest management practices, use of organic pesticides at flowering).
- Select appropriate harvest timing to avoid heavy rains ruining fruits.

- Improve packaging equipment and techniques (e.g., use of crates and jute-cotton bags to avoid mold and rot).

Recommended climate resilient interventions for mango

Table 27 Recommended climate-resilient measures for mangoes based on the observed and projected climate impacts along the food value chain.

Stage/ activity	Baseline vulnerability	Climate impacts	Recommended resilience measures
Soil and land management	• New mango plantations being set up on recently deforested/ cleared land • Farmers/orchard owners generally rent the services of tractor to prepare the land for a new orchard plantation • Herbicide use has negative impact on soil nutrients	• Increase GHG emissions from deforestation • Increased erosion due to flooding and heavy rainfall events	• Support CF/CPA management planning to restore primary and secondary forest cover, mixed with sub-sections for agroforestry, agriculture, and other livelihood activities (e.g., NTFPs, apiculture, tourism). • Prevent unsustainable expansion into forested areas. • Promote climate-informed expansion to reduce flash flooding and landslide risks. • Promote sustainable soil enrichment and organic fertilizer production and use. • Promote intercropping and mulching schedule methods (e.g., with leguminous crops). • Promote slope agriculture land technology where applicable.
Seeding	• Keo Romeat variety is predominant, and the most demanded especially for the export market • Seedlings purchased from different provinces or nurseries in Oddar Meanchey	• Uncertainty of rainfall patterns	• Support water management and micro-irrigation infrastructure for nurseries. • Promote research for climate resilient variety development. • Promote propagation and grafting techniques. • Support famers' networks to promote suitable varieties.
Inputs	• Chemical fertilizers are applied twice a year during the non-productive stage • Weeding, which is done mechanically (ploughing between tree lines) and chemically (use of glyphosate) once or twice a year • Do not received formal technical advices on mango production	• High temperatures will increase the volatilization rates, with adverse economic and environmental consequences • High temperature will increase growth of weeds • Droughts cause lower access to rainfed and	• Strengthen agricultural extension capacity/technical functions for providing coherent and relevant guidance and training to farmers (e.g., appropriate agrochemical application). • Provide fertilizer advisory based on soil type. • Increase organic fertilizer production capacity and access, including bio-digesters • Establish a public-private sector coordination mechanism to promote controlled agrochemical product

		groundwater resources	labeling appropriate and minimal agrochemical application. • Identify a list of quality input suppliers to share with farmers, ACs, FAs, PGs, and unions. • Increase governance capacity, including quality control, of ACs and unions to ensure enabling conditions for climate-resilient and sustainable practice uptake.
Pest control	• Pesticides are intensively used and insecticide treatments frequently applied on a weekly basis • Chemical herbicide used (glyphosate), systematic use of paclobutrazol to control the period of flowering and fruiting, etc.	• Heavy rains cause spread of mold and fungal diseases, pests and diseases at flowering and fruiting. • Increased pest and insect-related damage during the flowering seasons in Oct-Nov and April-May.	• Strengthen agricultural extension capacity/technical functions for providing coherent and relevant guidance and training to farmers (e.g., appropriate agrochemical application). • Provide fertilizer advisory based on soil type. • Increase organic fertilizer production capacity and access, including bio-digesters • Establish a public-private sector coordination mechanism to promote controlled agrochemical product labeling appropriate and minimal agrochemical application. • Identify a list of quality input suppliers to share with farmers, ACs, FAs, PGs, and unions. • Increase governance capacity, including quality control, of ACs and unions to ensure enabling conditions for climate-resilient and sustainable practice uptake.
Flowering	• Large producers said that they could slightly stage the flowering induction between their different orchards to stage the production on a slightly longer period. • Off-season production requires the use of hormones to induce flowering leads to reduced ecosystem functions and services (e.g., bees-decline to affect the natural pollination process)	• Heavy rains at the flowering stage, there can be rust/fungus attacks, which affects the production. • Early-onset of the dry season and drier and longer dry season, combined with increased temperatures, increasing pests at flowering and fruiting stages.	• Develop farm-level training/ FFS on water-saving practices, organic fertilizer production, managing pest and disease on mango production (i.e., IPM). • Trailor climate services based on calendar and sensitive periods to prevent damage.

Fruiting		• Heat stress at the flowering stage or beginning of fruiting would affect the yields: many small-formed fruits will fall on the ground and will not be carried by the tree.	• Tailor climate services based on calendar and sensitive periods to prevent damage.
Irrigation	• Irrigation has been developed in a number of mango orchards, often using ponds/small reservoirs on foothills as a source of water.	• Oddar Meanchey is relatively exposed to drought and dry periods are expected to increase in duration into the future • Increased water demand for mango • Increase occurrence of wildfires due to high evaporation rates	• Promote smart irrigation systems (e.g., drip irrigation and ponds) and schedules to optimize water resources. • Monitor crop water requirements to provide tailored agro-met advisories.
Harvest	• Mechanical harvest • On-season harvest: Mar-May, off-season harvest Sep-Nov, and possibly 3rd off season harvest Dec-Feb	• Heavy rains cause spoiled fruits at harvest • Use of inadequate harvest equipment (e.g., plastic bags) increases spread of mold and spoiled fruits	• Promote climate-resilient harvest techniques linked to agro-met advisories. • Provide tailored climate services and early warning systems to inform farmers' decisions to harvest with appropriate timing and methods. • Invest in immediate cold storage capacity.
Processing and storage	• Mangoes are not processed in Oddar Meanchey (except for small household-level processing, such as conservation in salty water) and they are normally put in cases and transported immediately after harvest. • Post-harvest handling, transportation, packing and storage are mainly traditional in Cambodia, and thus considerable post-harvest losses can be assumed. Based on an FAO study, at the processing level, processors estimated overall losses at 5–15	• Heavy rains, pests and diseases, rust/fungus attack cause damage and loss without proper storage	• Invest in post-harvest treatment capacity such as hot water treatment to reduce loss and meet international standards. • Promote quality control and certificated processing measures. • Increase knowledge and use of temperature and humidity sensor systems (e.g., ITCs). • Invest in collection centers with cold storage capacity. • Invest in research and development for value-addition processing options.

	percent, mainly because of overripe mangoes.		
Transportation	• Mangoes are transported long distance by trucks and there is no refrigeration. It takes 3 to 4 days for the mangoes to reach the distant markets • Fruit touching the sides of the boxes and those on the bottom layer are damaged (10- 15%) • Use corrugated boxes that are generally provided by the contractor or the aggregator	• Increased temperatures during transport results in mold, fungal attacks, damage and loss during transport without proper storage • Delays due to heavy rainfall events or associated hazards impact loss and waste	• Invest in sustainable and transport damage-proof packaging.

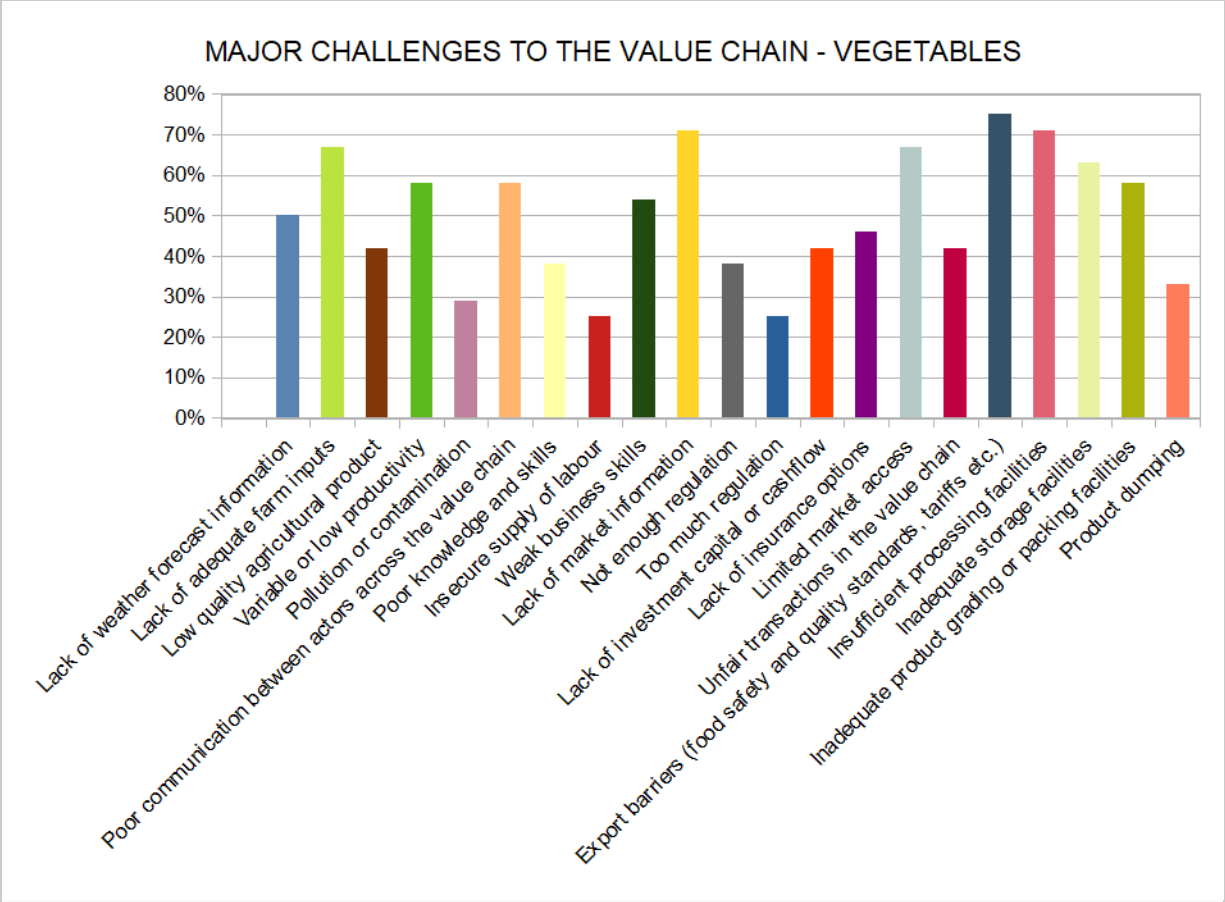
411. Information from ICEM observations and surveys. They illustrate some of the practices currently found in the province, but the number of producers interviewed being very limited, these descriptions do not pretend to be representative of all the farmers' practices in Oddar Meanchey.

8.5.8. Climate risk to the vegetables value chain

412. Vegetable's production in Cambodia primarily involves traditional techniques and manual work (Duong and Khin, 2016). In addition, the adoption of the good agricultural practices (GAP) is weak or almost non-existent. Misuse of agro-chemicals and unregistered agro-chemicals is widespread, largely affecting farmer's health and food safety. Vegetable smallholders have very limited resources and techniques related to harvest and post-harvest, resulting in the quality of the stored vegetables prone to be degraded, which in turn leads to lower selling price for vegetables. Other value chain actors (i.e., *collectors, wholesalers, retailers*) are also found to have limited financial resources and low level of education. Their storage knowledge and techniques are primitive, which may lead to further degradation of domestic vegetable quality during storage and transportation.

413. A value chain analysis performed by ICEM through the delivery of an e-survey (2020) with 24 respondents and follow-up workshop (2021), identifies major challenges to the vegetables value chain (Figure 76). These primarily consist of export barriers, due to a focus on local production and importation of vegetables, combined with lack of market information and access, and weak business skills. In addition, post-harvest value-adding activities are limited due to insufficient storage and processing, product grading or packing facilities.

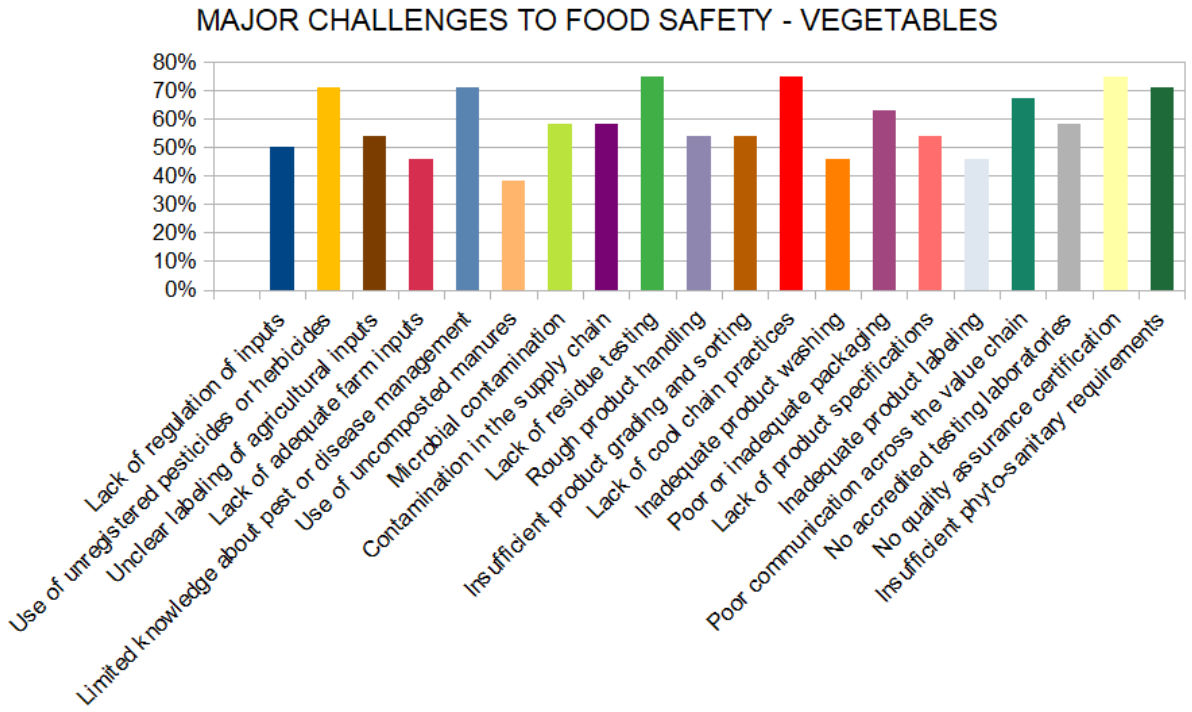
Figure 77 Major challenges to the vegetables value chain



Source: ICEM e-survey (2020)

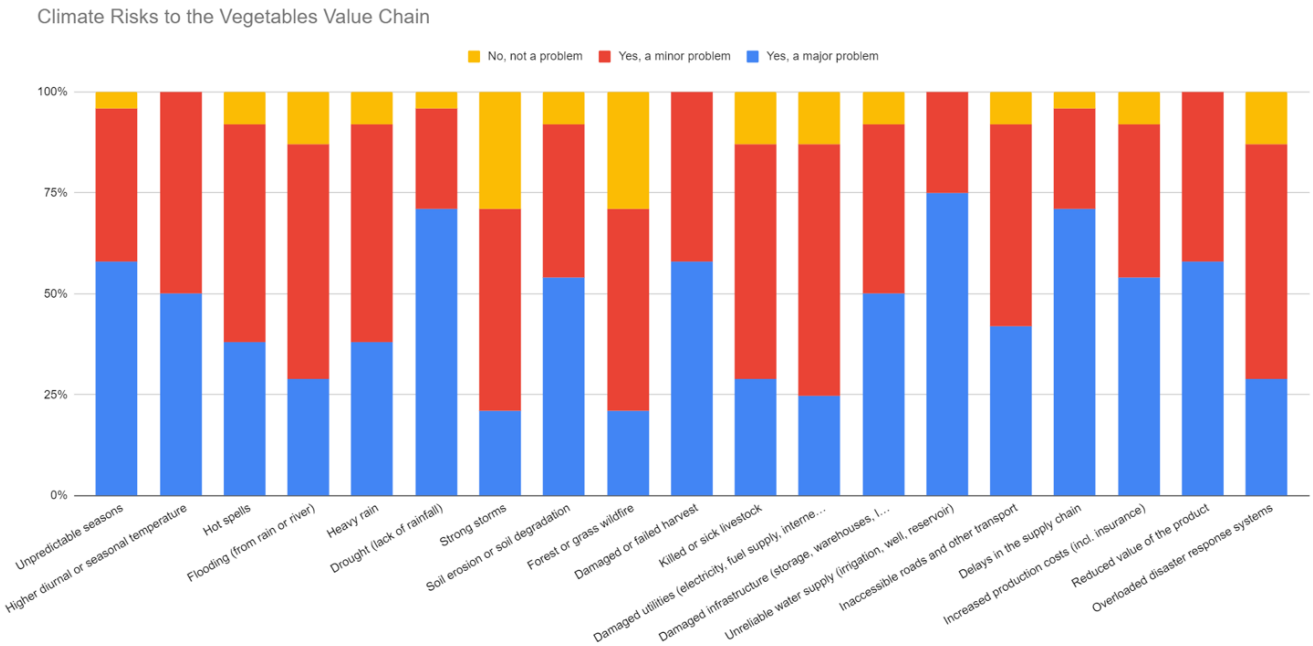
414. ICEM e-survey (2020) respondents also selected the main challenges to food safety across the vegetables value chain (Figure 77). These primarily consist of the lack of residue testing and of cool chain practices for vegetables storage which cause food contamination and risk to food safety for consumption by the spread of mold as well as by unregistered chemical pesticides and herbicides caused by limited knowledge of pests and diseases management. There are no quality assurance certifications and phytosanitary requirements to incentivize producers to adopt quality standards and practices.

Figure 78 Major challenges to food safety in the vegetables value chain

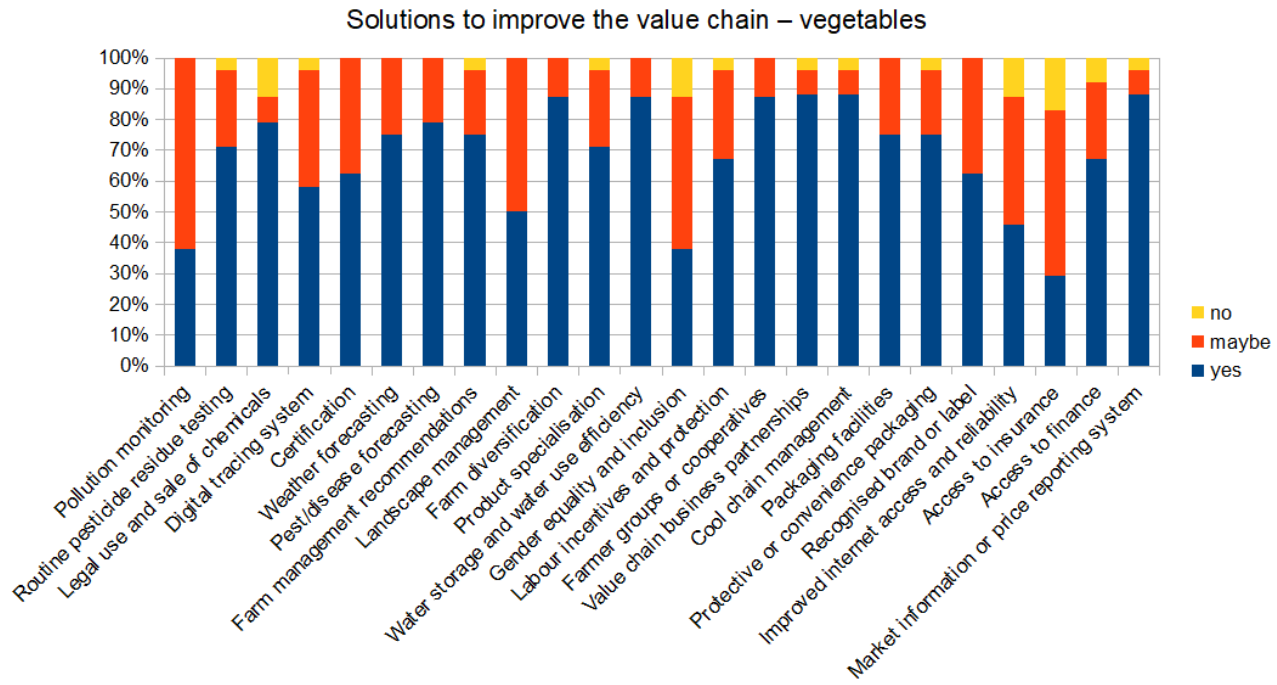


Source: ICEM e-survey (2020)

Figure 79 Climate risks to the vegetables value chain



Source: ICEM e-survey (2020)



Source: ICEM e-survey (2020)

Climate risk and climate resilience of the vegetables value chain

415. A climate-focused stakeholder consultation and value chain analysis was performed through the delivery of an online survey to key PEARL project stakeholders involved in different steps of the vegetables value chain and integrated with a dedicated in-person workshop with local agricultural cooperatives. The aim of the consultation was to identify climate impacts at each stage of the value chain with an emphasis on post-harvest systems, going beyond the production step at the crop field level. In addition, the consultation enabled to define key climate resilient practices that value chain actors are already implementing at the time of the research, as well as the further practices that stakeholders would be interested in implementing in the future through the support of the PEARL project. Finally, a key component of the analysis involved the state of development of climate services, including climate information and agricultural advisory products, that value chain actors benefit from at the time of the research and would be interested in benefitting further through the support of the PEARL project.

416. A total of 14 stakeholders involved at different steps of the vegetables value chain from public and private sectors as well as research and development institutions took part in the online survey, such as representatives of the national ministry of Environment, Agriculture, and Commerce, the provincial department of agriculture, forestry, and fisheries of Preah Vihear, microfinance institutions, international project developers and trade organizations, non-governmental organizations, fruit and vegetable markets, and agricultural development consulting companies.

417. The below analysis outlines the impacts of climate at each stage of the vegetables value chain as identified throughout the literature and integrated with results from the climate-focused stakeholder consultation. A simplified schematic of the vegetables value chain based on FAO assessment is highlighted below.

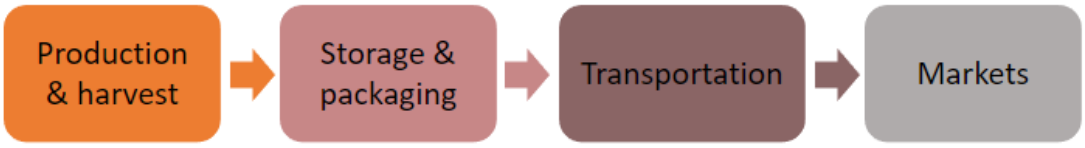
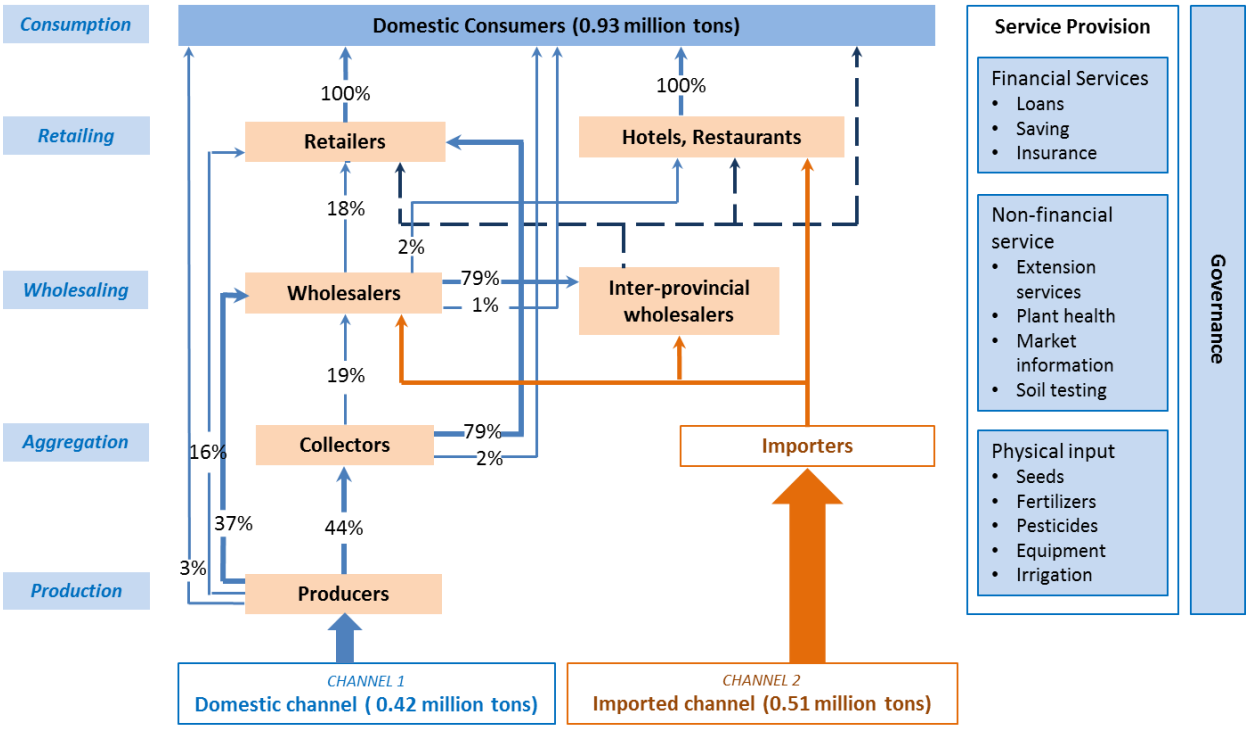


Figure 80 schematic representation of the current vegetables value chain in Cambodia

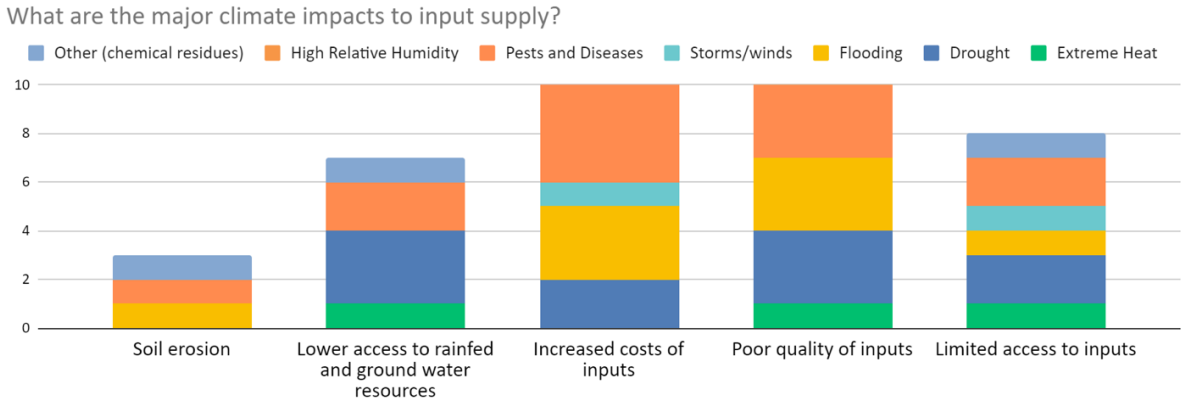


Input supply (vegetables)

418. Vegetable's farmers generally apply chemical fertilizers and pesticides manually since they do not dispose of dripping systems which is a prerogative of vegetable producers in neighboring countries such as Vietnam from which vegetables are commonly imported(Duong and Khin, 2016). Organic fertilizers are not commonly used due to the limited knowledge of benefits and accessibility. Due to manual application techniques, agricultural inputs are spread over vegetable fields unequally, resulting in some areas on the fields being applied more inputs while other areas not receiving enough. This unequal application of agricultural inputs, in turn, leads to the problem of inconsistent sizes of vegetable crops which undermines domestic market opportunities compared to uniform vegetables imported from Vietnam (Duong and Khin, 2016). Irrigation systems are limited, and smallholder farmers heavily depend on natural sources of water such as river and lake sources, wells and rain.

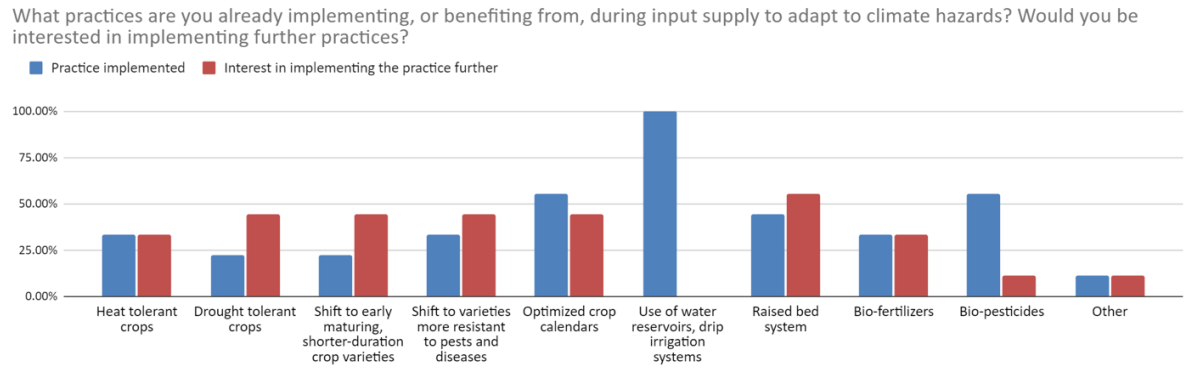
419. Pests (e.g., flea beetle, cut worm, leaf folder, army worm, aphid, lady beetle, snail, butterfly) and diseases (e.g., root rot, bacteria wilt) constitute one of the main challenges for vegetable farmers. The spread of pests and diseases is mainly driven by extreme weather conditions such as hot temperatures, droughts and heavy rains. In fact, respondents of the online survey selected pests and diseases, drought, and flooding events as the major hazards causing increased costs and reduced effectiveness of inputs such as pesticides and lower access to rainfed and groundwater resources, followed by extreme heat, storms and strong winds, and high relative humidity. Finally, participants also mentioned chemical residues and pathogenic contamination as other key hazards, in alignment with findings from the literature review (Figure 80).

Figure 81 Major climate impacts to input supply



420. All survey respondents involved in input supply make use of water reservoirs and drip irrigation systems to counteract drought impact on access to water resources. In addition, optimized crop calendars and the application of bio-pesticides are climate resilient practices implemented by half of the respondents, to reduce food contamination from chemical residues (Figure 81).

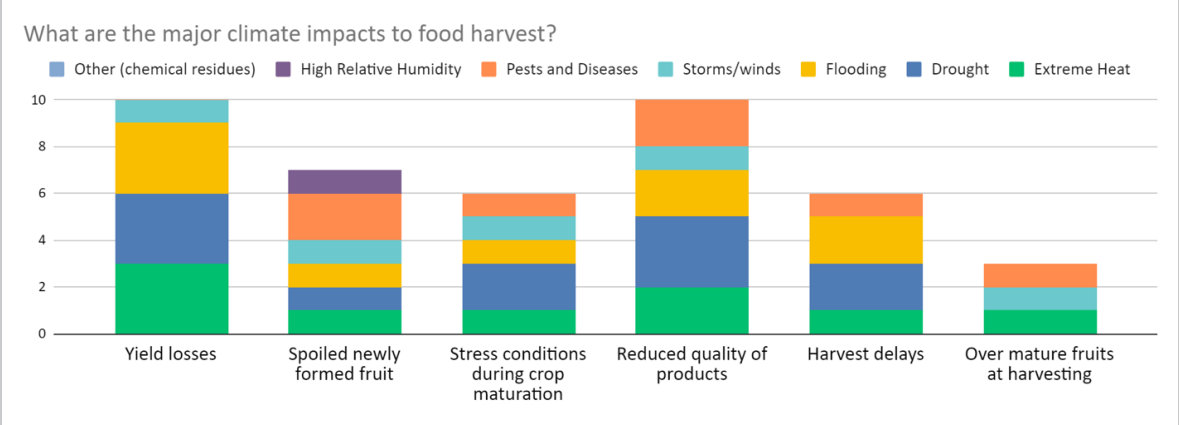
Figure 82 Practices implemented, and requested to be implemented further, during input supply to adapt to climate hazards.



Harvest (vegetables)

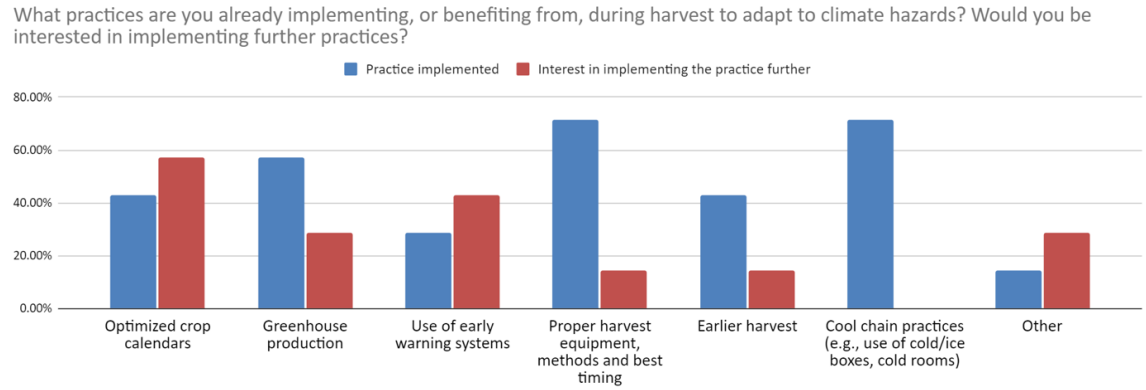
421. Vegetable harvesting is particularly suitable for smallholder farmers in Cambodia with limited natural and labour resources, due to the shorter duration of maturity, time for harvest and rapid return on investment and alternative sources of income. The techniques and equipment used by farmers to harvest and post-harvest handling is quite basic and traditional, whereas buyers also participate in the harvesting process and have deeper knowledge about the most appropriate techniques to use (Duong and Khin, 2016). Yield losses and reduced quality of products at harvest are extremely susceptible to climate and weather-related hazards such as pests and diseases, drought and flooding events, and extreme heat (Figure 82).

Figure 83 Major climate impacts to vegetables harvest.



422. Most respondents of the online survey utilize proper harvest equipment and methods, such as best timing and earlier harvest according to weather conditions and optimized crop calendars. In addition, they implement cool chain practices to preserve food quality and shelf life after harvest, such as using cold/ice boxes (Figure 83).

Figure 84 Practices implemented, and requested to be implemented further, during vegetables harvest to adapt to climate hazards.



Cooperatives (vegetables)

423. Despite the establishment of agricultural cooperatives being increasingly advocated by governments and NGOs, there is no causal evidence that membership has so far affected agricultural incomes or the value or amounts of agricultural inputs. At the same time, results provide evidence that membership has affected information transmission through coordinated technological trainings, use of water saving irrigation technologies and credit access. Other results contrast earlier findings that membership in vegetable cooperatives in Cambodia has led to greater household income (e.g.,Chen et al., 2018). This insufficient and weak coordination among vegetable smallholders decreases their bargaining power with buyers (traders) and increases their cost of marketing vegetables as they conduct transactions individually (Ofori et al., 2019). Few vegetable farmers are members of farmers organizations or cooperatives, which however have limited participation in the value chain, and lack capacity building, training, and marketing skills. A useful service provided is the facilitation of savings and loans for farmer members. Overall, since most farmers work individually, they have limited resources and capacities to deal with buyers and traders, to manage prices and transactions.

Collection (vegetables)

424. The term "collector" refers to those who purchase vegetables directly from vegetable growers at the village level; and "wholesaler" refers to those who purchase vegetables either directly from vegetable growers or collectors and then mainly sell in large quantity to retailers, hotel and restaurants. Collectors are based in the villages while wholesalers operate across villages and provinces even though they can share the same buyers such as retailers. Collectors are usually smaller businesses than wholesalers.

Storage (vegetables)

425. Storage services in Cambodia mainly manage non-perishable products, and they are not tailored to agricultural products (USAID, 2019). Due to a lack of cold storage facilities, vegetables storage is challenging and suffers from almost 50% of losses due to heat.

426. The vegetable sector in Cambodia is faced with various challenges and constraints. Vegetable produce is highly perishable that requires delicate handling and proper storage facilities. However, storage facilities are not widely available in Cambodia. In addition, storing vegetables requires specific temperature and humidity conditions that are not commonly known by producers, collectors, nor wholesalers (Duong and Khin, 2016). Many collectors and wholesalers do not use any cooling system but simply place vegetable in cool places during storage and use wet clothes, with substantial impacts on post-harvest food losses. Vegetables are then packed in plastic sacks or crates without any additional packaging and then are transported to markets, mostly by motorcycles. The consequence from inappropriate and poor harvesting, storage and packaging techniques is that domestic vegetables are not at their most mature and best state when reaching the markets, resulting in lower prices for domestic vegetables.

427. Inappropriate techniques for handling vegetables at the storage level are exacerbated by climate and weather-related hazards that affect storage infrastructure as well as the food products directly. Respondents of the online survey selected pests and diseases attacks as the primary hazard causing food contamination and decreasing product quality and shelf life, compounded with drought and flooding events, as well as extreme heat and high relative humidity increasing the spread of mold (Figure 84).

Figure 85 Major climate impacts to vegetables storage.

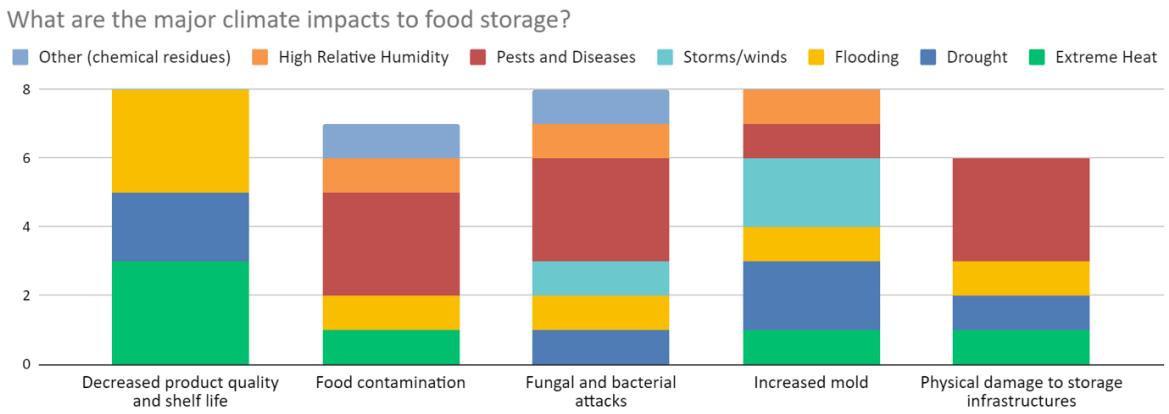
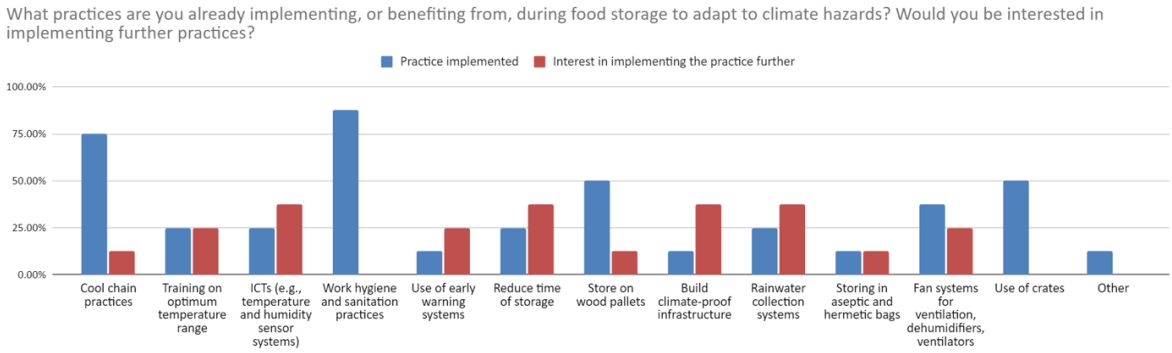


Figure 86 Practices implemented and requested to be implemented further during vegetables storage to adapt to climate hazards.



Processing and Packaging (vegetables)

428. Vegetable producers are not involved in processing and exportation activities but majorly produce for domestic markets and consumption. Large-scale processors and exporters are missing in Cambodia. The only by-products obtained from small-scale vegetables processing family businesses are pickles or animal feeds. At the same time, the development of vegetable processing facilities could serve as an opportunity for up-scaling small-holder farmers' businesses (Duong and Khin, 2016).

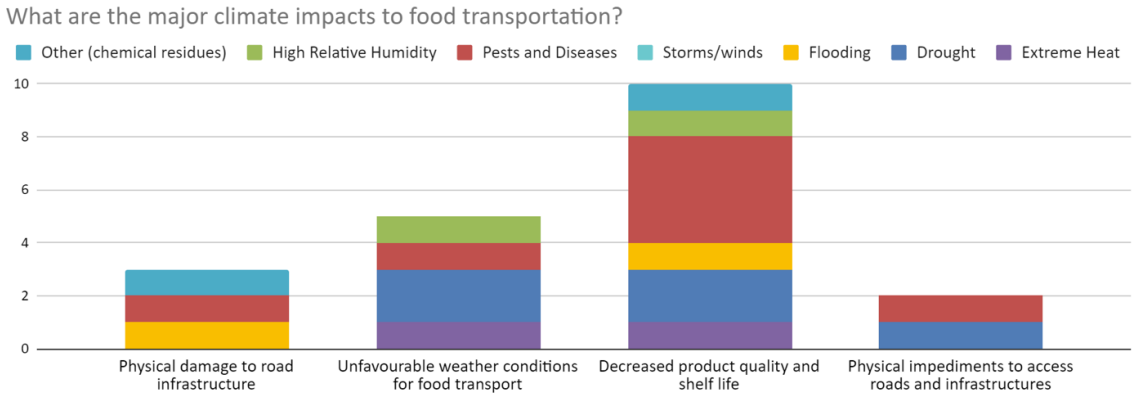
429. Agricultural cooperatives representatives, during the dedicated workshop, confirmed that vegetables producers are not involved in post-harvest activities. In fact, ACs sell vegetables directly to the store. Packing techniques are also basic. Few farmers wash their produce after harvesting and grading/sorting takes place occasionally. Plastic sacks/crates are the most common means for packing, followed by baskets. This leads to limited shelf life and quality degradation for vegetables after being harvested particularly due to increased mold among fresh products, leading to reduced prices at markets.

Transportation (vegetables)

430. Food value chains that are competitive require sustainable and efficient transportation and infrastructure systems. It is fundamental that rural areas are properly linked to urban center and market areas through provincial and national roads. At the same time, in Cambodia the road network is still underdeveloped, particularly for the condition of rural roads that often are not paved. Roads and the conditions of vehicles are susceptible to heavy rains and flooding events, consequently impacting the transported food products and the final costs (Asian Development Bank, 2020).

431. Vegetables are transported from the field to the market by collectors using motorbikes or sometimes trucks three times throughout the day, and the timing for transportation is usually unknown. If not properly managed, this might cause detrimental consequences for food shelf-life due to vegetables contamination, spread of mold, and spoilage during transportation and weak post-harvest handling without the support of any machine (Duong and Khin, 2016). Overall, the lack of adequate packaging equipment reduces vegetables' quality and shelf life from storage to transportation towards markets. The lack of transportation equipment is exacerbated by extreme heat and high relative humidity further decreasing product quality and shelf life before reaching markets, combined with drought flooding events damaging road infrastructure and causing impediments to access roads (Figure 86).

Figure 87 Major climate impacts to vegetables transportation.



Markets and consumption (vegetables)

432. Vegetable's trade is primarily managed locally and supported by food importation from neighboring countries. Vegetable markets are driven by consumers' demand and are mainly imported from Vietnam and Thailand with limited food safety controls (Duong and Khin, 2016). High vegetables importation is primarily due to high seasonality of local vegetables production and insufficient offer compared to the demand, combined with cheaper international prices compared to local products, despite the higher quality of local vegetables. Farmers usually transport vegetables to local and provincial markets directly to sell to collectors, wholesalers, retailers (such as wet markets, supermarkets, hotels, and restaurants), and consumers, without any intermediation or written contract with collectors, which could support the efficiency of the selling-purchasing activity and

transaction costs (Swiss Agency for Development Cooperation (SDC), 2014). Overall vegetable farmers do not have direct links with buyers, collectors, wholesalers, or retailers. This also causes an unfair distribution of costs and revenues (Duong and Khin, 2016). On the contrary, wholesalers play an important role in the vegetables value chain since they primarily manage the trade of domestic and imported vegetables, operating both within and between provinces. Collectors instead are mainly involved in vegetables collection only as a secondary activity for additional income (Duong and Khin, 2016).

433. Key impacts to food quality and shelf life within markets are caused by extreme heat and pests and diseases. Drought and flooding events as well as pests and diseases attacks affecting vegetables production also have final implications on the prices at which products are sold within markets, which may increase due to lower quality, thus causing reduced food sales which then need to be offset by vegetables importation. Finally, chemical pesticide residues in the final products at markets place a substantial risk to food safety for consumption (Figure 87).

434. In 2016, the MAFF established a USD 20 million initiative to improve the rice and vegetables value chain by adopting GAP standards. A key aim of the project was to reduce national dependence on imported unsafe vegetables. The program established contracts with farmers to provide them with technical training, infrastructure such as water pipes, and improved inputs, thanks to the technical support provided by the Center for Policy Studies. In 2019 however, the initiative managed to supply one third of the planned number of vegetables per day, particularly due to high national production costs and consequent prices, combined with limited improvement of regulations for food safety and to reduce the importation of cheaper vegetables products (USAID, 2019).

435. By 2030, Cambodia aims at becoming largely independent on safe vegetable production (USAID, 2019). USD 27M are allocated to achieve vegetables value chain targets, combined with policy regulations and capacity building programs.

Figure 88 Major climate impacts to vegetables markets

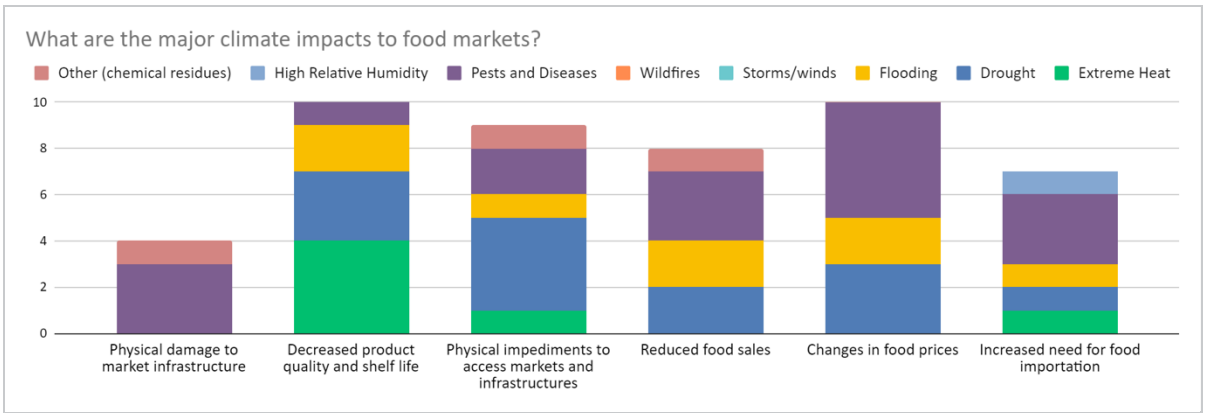
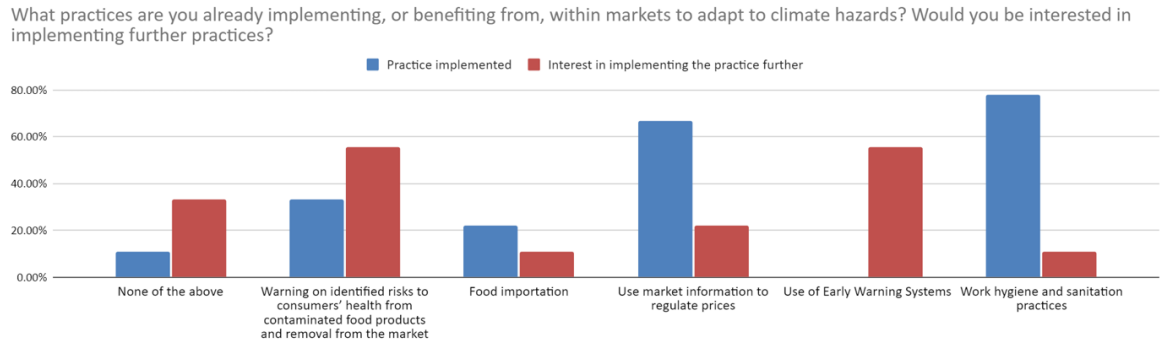


Figure 89 Practices implemented and requested to be implemented further within vegetables markets to adapt to climate hazards.



Climate-resilient practices in vegetable value chain

436. To counteract the main climate hazards affecting the NTSB (pests and diseases, droughts, floods, and extreme heat), within the online survey value chain actors suggested to build raised bed systems using sustainable products to replace concrete, combined with the shift towards shorter duration crop varieties more resistant to drought and pests and diseases. In addition, climate resilient practices requested by agricultural cooperatives during dedicated workshop include the use of high wooden instead of concrete raised bed systems to address pests' attacks (at least 70cm).

437. The harvest stage should be supported by the optimization of crop calendars and the use of early warning systems for example using tailored apps, to prevent extreme weather events as well as pests and diseases attacks and combined with greenhouse production. Appropriate measures should be adopted within storage facilities to ensure the products are not contaminated (e.g., by introducing rainwater collection systems and improve the utilization of ICTs for temperature and humidity monitoring).

438. At the processing stage, the most requested practices and technologies include the use of ICTs to monitor temperature and humidity, combined with training on optimum temperature ranges. Investments should be placed in rainwater collection systems and fan systems to prevent heat and humidity, as well as in the development of aseptic and hermetic packaging to reduce food contamination. Vapor heat treatment was also supported as a beneficial practice to reduce rots. In fact, agricultural cooperatives also suggested to increase value-adding activities such as adequate packaging (use of cotton-jute bags and crates for storage and transportation to markets to facilitate transpiration).

439. In addition, the transportation stage should be well aligned with updates on the weather conditions and early warning systems to avoid the occurrence of extreme weather events while carrying food. More infrastructural interventions should concern the improvement of led panels, embankment protection, vehicles' insulation and refrigerating technologies, as well as advisory on safest and most efficient routes to take according to road network vulnerability assessments.

440. Finally, at the market stage respondents primarily selected the use of market information to better regulate prices according to national and international trends combined with rapid information on food contamination to reduce risks to consumers' health. Another request by

agricultural cooperatives consisted of promoting the conversion from fresher to drier food production which would increase products' quality and shelf life at post-harvest stages up to markets and consumption (Table 28).

Table 28 Climate resilient practices requested by online survey respondents at pre- and post-harvest stages.

INPUT SUPPLY	1. RAISED BED SYSTEM (55%) 2. DROUGHT TOLERANT CROPS (44%) 3. SHIFT TO EARLY MATURING, SHORTER-DURATION CROP VARIETIES (44%) 4. SHIFT TO VARIETIES MORE RESISTANT TO PESTS AND DISEASES (44%) 5. OPTIMIZED CROP CALENDARS (44%) 6. HEAT TOLERANT CROPS (33%) 7. BIO-FERTILIZERS (33%) 8. BIO-PESTICIDES (11%)
HARVEST	9. OPTIMIZED CROP CALENDARS (57%) 10. USE OF EARLY WARNING SYSTEMS (43%) 11. GREENHOUSE PRODUCTION (28,5%) 12. USE OF APPS (E.G., ANGKOR SALAD APPS) (28.5%) 13. EARLIER HARVEST (14%) 14. PROPER HARVEST EQUIPMENT, METHODS, AND BEST TIMING (14%)
STORAGE	15. BUILD CLIMATE-PROOF INFRASTRUCTURE (E.G., APPROPRIATE LOCATION, DIMENSIONS, TYPE AND SLOPE OF THE ROOF, ETC.) (37.5%) 16. RAINWATER COLLECTION SYSTEMS (E.G., TANKS, PUMPS, PURIFIERS, DRAINAGE SYSTEMS AND INFRASTRUCTURES ETC.) (37.5%) 17. ICTS (E.G., TEMPERATURE AND HUMIDITY SENSOR SYSTEMS) (37.50%) 18. USE OF EARLY WARNING SYSTEMS (25%) 19. FAN SYSTEMS FOR VENTILATION, DEHUMIDIFIERS, VENTILATORS (25%) 20. REDUCE TIME OF STORAGE (37.5%) 21. COOL CHAIN PRACTICES (E.G., USE OF COLD/ICE BOXES, COLD ROOMS) (12.5%) 22. TRAINING ON OPTIMUM TEMPERATURE RANGE (25%) 23. STORE ON WOOD PALLETS (12.5%) 24. STORING IN ASEPTIC AND HERMETIC BAGS (12.5%)
PROCESSING	25. TRAINING ON OPTIMUM TEMPERATURE RANGE (100%) 26. ICTS (E.G., TEMPERATURE AND HUMIDITY SENSOR SYSTEMS) (100%) 27. USE OF EARLY WARNING SYSTEMS (100%) 28. BUILD CLIMATE-PROOF INFRASTRUCTURE (E.G., APPROPRIATE LOCATION, DIMENSIONS, TYPE AND SLOPE OF THE ROOF, ETC.) (100%) 29. RAINWATER COLLECTION SYSTEMS (E.G., TANKS, PUMPS, PURIFIERS, DRAINAGE SYSTEMS AND INFRASTRUCTURES ETC.) (100%) 30. ASEPTIC AND HERMETIC PACKAGING (100%) 31. FAN SYSTEMS FOR VENTILATION, DEHUMIDIFIERS, VENTILATORS (100%) 32. VAPOR HEAT TREATMENTS (100%) 33. RENEWABLE OR ENERGY EFFICIENT INFRASTRUCTURE AND TECHNOLOGIES E.G. FOR MILLING, DRYING, GRATING (100%)
TRANSPORTATION	34. USE OF EARLY WARNING SYSTEMS (75%) 35. LED PANELS, COLOR CODED WARNINGS (50%)

	36. SHIP PRODUCTS WITH LESS CRITICAL EXTERNAL CONDITIONS (25%) 37. ROAD NETWORK VULNERABILITY ASSESSMENTS (25%) 38. EMBANKMENT PROTECTION (25%) 39. INSULATED OR REFRIGERATED TRUCKS (25%) 40. USE OF SAFE AND EFFICIENT ROUTES, E.G. ELEVATED ROADS ABOVE FLOOD-PRONE AREAS, APPROPRIATE LIGHTNING (25%)
MARKETS	41. WARNING ON IDENTIFIED RISKS TO CONSUMERS' HEALTH FROM CONTAMINATED FOOD PRODUCTS AND REMOVAL FROM THE MARKET (55.5%) 42. USE OF EARLY WARNING SYSTEMS (55.5%) 43. USE MARKET INFORMATION TO REGULATE PRICES (22%) 44. FOOD IMPORTATION (11%) 45. WORK HYGIENE AND SANITATION PRACTICES (11%)

Climate resilient interventions for vegetables

Table 29 Recommended climate-resilient measures for vegetables based on the observed and projected climate impacts along the food value chain.

Pak Choi Stage/ activity	Baseline vulnerability	Climate impacts	Recommended resilience measures
Soil preparation & seeding	• Soil is kept moist until the seeds have germinated • Seeds are soaked in water before sowing	• High precipitation and warmer temperatures will favor weed expansion	• Promote horticultural operations (e.g., mulching to reduce evaporation, raised beds) • Market information on where to procure climate-resilient seeds
Production	• Pak choi has a high tolerance to heat-stress conditions • Growing conditions are favorable between Dec-Jan • Plant spacing varies depending on the variety (15 to 20 cm for the Spey kmoa variety) and sowing density rate is 100-150g/100m2	• High/low relative humidity under high temperatures (35/28ºC day/night-time temperatures) will reduce the leaf net photosynthetic efficiency, yield, and quality of pak choi • Increasing CO2 concentrations will benefit crops with a C3 photosynthetic pathway, including pak choi. • Increasing evaporation will result in higher salinity in the soil, and the growth and development of Chinese cabbage will be significantly affected by salt stress	• Promote spatial and temporal (year-round) production. Based on AquaCrop simulations, yields will increase under both RCPs and year-round • Apply salt models to better estimate the effect of salinity on plant growth • Promotion of short cycle varieties to reduce the effect of heat-stress conditions at key phenological phases and minimize crop water requirements during the growing season • Agroforestry systems reduce evaporation from direct sunlight and decrease air and soil surface temperature • Invest in shade houses to minimize the effects of heat-stress conditions on crops • Increase application of organic matter in areas where the decomposition is likely to accelerate because of increasing temperatures

Inputs	• Counterfeit and poor quality agrochemical products with the labelling and instructions provided in foreign languages flood the market • Excess pesticide residues were found in imported cabbage • Leafy vegetables require more nitrogen, and the normal fertilization rate is 100-150kg/100m2 of compost and 1-2kg/100m2 of urea	• Intensification of heavy rainfall events will increase the risk of leaching into sensitive areas	• Train farmers on appropriate pesticide use • Promote control labelling of agrochemical products • Promote the use of bio-digester effluent to increase yields • Strengthen the use of climate-informed agronomic advisory for appropriate application and timing of inputs
Pest and diseases	• Pak choi is susceptible to a wide number of pests and diseases (aphids, cabbage whitefly, caterpillars, snails etc.)	• Warm temperatures and high humidity will provide suitable conditions for pathogens • High costs and low quality of inputs, limited knowledge on the use of specific pesticides decrease capacity to deal with pests and diseases attacks	• Integrated Pest Management linked to provision of tailored climate services • Improve information available for pest control measures • Promote control measures, including long rotation of crops, draining soil, mechanical control and weed management
Irrigation	• Hand watering or furrow irrigation • Pak choi has shallow roots so needs low amounts of water	• Increasing temperatures will rise evapotranspiration rates and will increase water requirements overtime • Droughts cause lower access to rainfed and groundwater resources	• Apply crop water models to better understand crop water requirements throughout the growing cycle. Based on AquaCrop simulations, the lowest crop water productivity is observed during the pre-monsoon months (March-April) • Promote the installation of low-cost drip irrigation systems
Harvest	• Farmers start harvest late in the morning to shorten the storage time before pick up by collector • Poor postharvest management, high food risks and lack of understanding of market opportunities with fragmented information flow along supply chains	• High temperatures, inadequate shading and water loss after harvest can result in Vitamin C loss and shortening the post-harvest life	• Sensitize farmers of the importance of harvesting early in the morning to avoid heat-stress and UV light • Promote the use of bamboo crates and cover them with wet clothes to minimize water loss from vegetables

Processing & storage	• Cooling facilities are not available for pak choi supply chain. Hence, farmers are forced to sell their products at low-prices	• Increasing relative humidity, heat-stress conditions and UV light decrease product quality and shelf life • Low quality of packaging to face relative humidity and extreme heat	• Disseminate best storage practices across value chains • Catalyze innovations in on-farm storage for farmers and cooperatives • Promote cold chain capacity (e.g., solar powered storage facilities, cool-bot equipped cool rooms) • Shift from fresh to drier Khmer food varieties produced locally that require less packaging
Transportation	• Poor road connectivity and limited private sector engagement in logistics • Cold chain transportation is not available for pak choi supply chain	• Road conditions are likely to worsen with increasing extreme weather events • Unfavorable weather conditions for food transportation	• Explore innovative low-cost transport equipment for farmers and cooperatives • Build cold chain infrastructures and technologies such as ventilation, pre-cooling and air conditioning • Build sustainable energy infrastructure to support temperature-controlled storage • Enhance linkages between transport actors and other VC actors and access to climate information
Markets	• High vegetables importation is primarily due to high seasonality of local vegetables production and insufficient offer compared to the demand • cheaper international prices compared to local products, despite the higher quality of local vegetables	• Extreme heat and chemical residues decrease product quality and shelf life • Pests and diseases reduce food quality, causing changes in food prices and decreased sales	• Increase use of market information to regulate prices • Build cold chain infrastructures and technologies such as ventilation and air conditioning • Promote local vegetables consumption to reduce food importation • Increase communication between VC actors to promptly identify risks to consumers' health from contaminated food products and removal from the market

Tomato Stage/ activity	Baseline vulnerability	Climate impacts	Recommended resilience measures
Soil preparation & seeding	• Tomato is difficult to grow during the rainy season	• Heavy rainfall events that result in water-logging make difficult land preparation	• Improve drainage with raised beds & organic matter additions to the soil • Promote agro-ecological practices such as mulching to suppress soil-borne diseases • Market information on where to procure climate-resilient seeds
Production	• Oversupply of domestic production during the peak-season (Nov-Jan)	• Heat-stress conditions (>33ºC) are likely to adversally impact tomato plants during sensitive phenological phases (e.g.,	• Support farmers with inputs and information necessary for year-round production of vegetables • Selection of heat/drought resistant varieties

	• Imports from Vietnam are very high during the low season	flowering). Based on AquaCrop simulations, strong yield decline is projected when transplanted between Jan-April (e.g., 55% decline when transplanted in January) • Increasing temperatures are likely to reduce the growing cycle of tomato	• Invest in drip irrigation, shade house etc. to reduce heat stress • Promotion of short cycle varieties to reduce the effect of heat-stress conditions at key phenological phases and minimize crop water requirements during the growing season • Agroforestry systems reduce evaporation from direct sunlight and decrease air and soil surface temperature • Invest in shade houses to minimize the effects of heat-stress conditions on crops • Increase application of organic matter in areas where the decomposition is likely to accelerate because of increasing temperatures
Irrigation	• Managing irrigation water efficiently is a major challenge in Cambodia • Irrigation practices differ between producers	• Future increases in air temperature will rise evapotranspiration rates and increase crop-water requirements overtime	• Promote drip-irrigation which has a much higher crop water productivity than furrow/net irrigation • Promote effective water management as a critical element in ensuring year-round production • Identify the most suitable irrigation schedules (timing and amount) based on crop-water productivity models • Provide adequate watering to enhance transpiration and cooling effect
Inputs	• Counterfeit and poor quality agrochemical products with the labelling and instructions provided in foreign languages flood the market • Fertilizer is applied at the following rate: N, P_2O_5, K_2O at 75, 30, 100 kg/ha • Well-composted with manure from cattle at a rate of 20 ton/ha	• Increasing high temperatures will favor macronutrient volatilization • Heavy rainfall events will increase the risk of leaching into sensitive areas	• Raise awareness on fertilizer and pesticide misuse • Promote climate-informed agronomic advisory for appropriate application and timing of inputs

Pest and control	• Disease infection is high in tomatoes harvested during the rainy season • Greenhouse production is increases, minimizing the risks of crop failure from pest and diseases • Misuse of pesticides may result in pest problems where they previously did not exist	• Increasing temperatures and drought will favor the spread of two-spider mite (*Tetranychus urticae*)	• Use pest and disease models to better understand the exposure to biotic stresses • Promote IPM and conduct workshops/trainings • Promote grafting of tomato with eggplant to avoid bacterial wilt, fusarium wilt and root nematodes • Strengthen the use of climate-informed advisory services into agricultural decision-making
Harvest	• Farmer's do the sorting based on a combination of fruit quality attributes. Most farmers use lining materials as ground cover to prevent pathogens at harvest • 12.5% product loss due to immaturity, insect damage and rotten/decay	• Increasing temperatures and relative humidity will contribute to harvest losses • Hot temperatures during harvest	• Promote technological innovations that minimize fruit damage from handling • Promote harvesting early in the morning to obtain best quality products • Strengthen uptake of climate information services (e.g., to avoid harvesting if raining) • Optimize crop calendars • Greenhouse production
Processing & storage	• Poor storage facilities increase fruit weight loss • From farm to retailer, it is estimated that the sum of all losses amounts to 246kg of tomato per 1000kg (25%)	• Increasing relative humidity, heat-stress conditions and UV light	• Promote bamboo basket and crates packaging than conventional HDPE packaging • Strengthen tomato storage facilities, including cooling chambers. Low temperature storage is known for prolonging the life of fresh products • Increase access and use of ICTs for temperature and humidity sensor systems • Reduce time of storage • Use aseptic and hermetic packaging
Transportation	• Poor road connectivity and limited private sector engagement in logistics • Farmers transport the harvested product from the field to the farmhouse mostly by motorbikes, followed in importance by bicycles and/or by foot • Collectors rely on motorbikes while retailers rented vehicles. Finally, suppliers of	• Heavy rainfall events result in delays throughout the whole value chain	• Promote modern supply chains including ice-cooled cargo compartment of a truck for transport to the distribution center • Identify shorter chain routes to minimize delays in distribution • Identify local buyers near tourists centers such as Siem Reap

	wholesalers usually transport tomato by car		

Long bean Stage/ activity	Baseline vulnerability	Climate impacts	Recommended resilience measures
Soil preparation	• Raised-beds are generally used for planting long bean	• Heavy rainfall events can result in waterlogging	• Promote narrow rows (30cm) on active floodplains and alluvial loamy soils with adequate soil water • Identify agricultural strategies to avoid waterlogging (raised beds and field dredging) • Minimum tillage reduces disturbance of soil structure and organic matter found in the soil. Minimum tillage enhances infiltration and ensures less resistance to root growth due to improved soil structure, allowing crops to germinate and develop faster with additional soil moisture
Seeding	• 3-4 seeds per pit, with a plant-to-plant distance of 50cm and a line-to-line distance of 60cm	• Increasing evapotranspiration rates will have a negative impact at early growing stages	• Promote seed priming (process of regulating the germination process by managing the seed moisture content) can have a positive impact on the yield performance of yard-long bean • Market information on where to procure climate-resilient seeds
Production	• Nov-Jan are the most common sowing dates • The average planted area in Cambodia is 0.14ha and the marketable yield is of 12.5ton/ha	• Heat-stress conditions and increasing evapotranspiration rates will elevate the crop's exposure to abiotic stresses • Long bean will benefit of increasing atmospheric CO_2 concentrations and its fertilization effect, where higher CO_2 concentrations will lead to a higher number of pods and seeds, as well as higher seed weight overtime	• Promote its spatiotemporal production. Based on the AquaCrop simulations, yields are expected to increase by 30% by the end-century (average of sowing dates, climate scenarios and irrigation schemes)

Input	• Counterfeit and poor quality agrochemical products with the labelling and instructions provided in foreign languages flood the market • In Cambodia, yard long bean is fertilized around 3-4 times during the growing cycle • Limited knowledge of health risks from pesticides	• Intensification of heavy rainfall events will increase the risk of leaching into sensitive areas	• Promote plant breeding to enhance the resilience of yard-long bean to abiotic stresses, including its drought and heat-stress tolerance • Biochar and bio digestate increase the yield of yard-long bean and improves soil properties, as shown in Laos • Strengthen the use of climate-informed agronomic advisory for appropriate application and timing of inputs • Promote control labelling of agrochemical products
Pest control	• Diseases are spread during wet and windy weather with temperatures ranging between 18-25ºC. For instance, larvae of pea blue and gram blue butterflies feed on flowers and seeds	• The occurrence of aphids and legume pod borer (Maruca vitrata) is likely to increase in a warmer climate	• Strengthen the provision of climate services (short-range weather forecasts) to enhance pest and disease control measures • Promote IPM and reduce its costs to unlock agriculture from conventional pesticides • Combine bio-pesticides with chemical pesticides to control (Maruca vitrata) has significantly increased yard-long bean yields in test-plots in southeast Asia
Irrigation	• Year-round irrigation for vegetable cultivation is a common problem for many households in rural Cambodia. • Ring wells and ponds are a source of water • Water is scarce during the warm and dry months of Feb-April	• Warmer temperatures will increase evapotranspiration rates and, consequently, increase crop-water demands	• Promote irrigation systems which have a higher water efficiency at field level. Based on AquaCrop simulations, water savings are large (+15%) when using drip irrigation rather than furrow and net irrigation • Apply crop-water productivity models to identify the time of the year when crop water requirements (CWP) and yields are highest. Based on AquaCrop simulations, Nov-Jan are the most suitable sowing months in terms of CWP • Identify agronomic practices that reduce losses from direct evaporation (e.g., mulching, low-cost drip irrigation systems)
Harvest	• Losses are highest during the wet season and lowest at the end of the dry season.	• Hot and humid weather during harvest are among the main reasons for yard long bean postharvest loss at farm level	• Strengthen the use of climate services to collect the product during cool weather • Implement cold chains to remove heat from vegetables quickly after harvesting • Practice early harvest and conduct training on best harvesting time

Processing & storage	• Most losses occur at farm level (8%), retailer (6%), wholesaler (5%) and collector (3%) • Vegetables are usually packed in plastic bags, bamboo baskets, sacks or tied up using branches or plastic	• High temperature and humidity in storage facility • UV light exposure	• Ensure cool temperatures and low humidity in storage areas • Support good packaging and use of cool storage rooms • Switch from sun drying to other drying techniques
Transportation	• The yard long bean is collected at the farm by collectors, who are also responsible for transport to wholesalers.	• Heavy rainfall events disrupt the supply chain	• Strengthen the uptake and use of climate information to reduce the food losses from delays • Provide training and advice on food storage manufacturing techniques to reduce losses during transportation • Build cold chain infrastructures and technologies such as ventilation, pre-cooling and air conditioning • Build sustainable energy infrastructure to support temperature-controlled storage

8.5.9. Clearinghouse Mechanism for Demonstrating and Scaling Most Relevant Solutions

441. To support the demonstration of the above-identified measures for the project's target crops and value chains, the project will develop a clearinghouse system to ensure these measures build on relevant knowledge (including traditional), lessons learned, and best practices available in the country and elsewhere to increase their chances of being adopted successfully.

442. The digital clearinghouse will be a single-source platform, linked to the existing agricultural information mobile apps (i.e., Tonle Sap App and EcoKaskur), that collates, organizes, consolidates, and facilitates systematic adoption and upscale of existing knowledge systems, technologies, good practices, roadmaps of climate-resilient, inclusive, gender-responsive, and high-value agriculture through cooperation and knowledge exchange amongst different stakeholders. Specifically, the key objectives of the system will be to facilitate:

(i) Collection and validation of knowledge and technologies through a systematically adopted semi-automatic peer-review mechanism;
(ii) Transfer of validated knowledge and technologies to various stakeholders for further upscaling and implementation. This includes the extension services, ACs, FAs, PGs, unions, CPAs, CFs, individual farmers, and other value chain actors;
(iii) Exchange and dissemination of knowledge assets through different mediums (social media) and channels for creating awareness, adoption, and use;
(iv) Implementation of roadmaps and business plans (Activity 2.1.1) by connecting and interlinking different stakeholders on a single platform and;
(v) Exchange of knowledge assets amongst stakeholders for easy adoption and use of technologies at different cycles.

Description of clearinghouse

443. The proposed clearinghouse for PEARL will leverage the available relevant knowledge, technologies, lessons from the past and ongoing initiatives for promoting climate-resilient, high-value, and sustainable agriculture practices and technologies across similar agroecological zones to support the implementation of the roadmaps and business plans under Activity 2.1.1. These knowledge assets are sparsely located, and this needs to be appropriately identified, collated, validated, and promoted. It is essential for this effort not to create another knowledge system but to contribute to the further improvement of already popular platforms, namely Tonle Sap App and EcoKaskur, by adding enhanced knowledge management functions.

444. One of the key barriers identified is that the stakeholders and policymakers are confronted with either a lack of appropriate solutions for specific problems or, on the other hand, are overwhelmed with too many technology solutions presented to them. The issue of too many is that the technologies need to be validated adapted for an inclusive, context-specific setting. The clearinghouse will support the context-specific application and demonstration of such solutions under Activity 2.3.2.

445. The clearinghouse will bridge the gap between the theoretical knowledge and the practical implementation by targeted linking of the users to the technical know-how and solutions. The platform will help the project's stakeholders to understand the current trends, information, and knowledge on climate-resilient practices and how this could be adapted and scaled. The clearinghouse will be designed and deployed to be a one-stop-shop source for accessing technology solutions for the PEARL project and similar projects and will be easily accessible to all the stakeholders, including the government staff, extension workers, CAs, FAs, PGs, individual farmers, etc.

446. The key features and functions of the platform are described below:

(i) **Well-defined taxonomy-based knowledge asset base:** The structure of the clearinghouse will be based on a well-defined knowledge taxonomy to systematically organize, retrieve and disseminate the knowledge assets that will support the easy content acquisition, processing, and dissemination. The clearinghouse will adopt a hierarchical organization of domain-specific terminology with synonyms. By virtue of its hierarchical nature, the broader term (parent term) and narrow term (child term) will be defined.

(ii) **Knowledge asset acquisition system:** A seamless and intuitive web-based system will be developed to facilitate stakeholders submitting knowledge assets into the system. The system will be designed to avoid erroneous submission and, at the same time, will not overbear the users who submit with too complex submission forms.

(iii) **Crawler-based content identification system:** based on the taxonomy, the PEARL clearinghouse will entail web crawlers that will automatically search the web to identify suitable and appropriate knowledge assets relevant to the stakeholders.

(iv) **Structured review system:** based on the pre-determined parameters, the system will categorize and auto-tag the knowledge assets, which will be sent for peer review and final validation.

(v) **Peer-review system:** A well-designed peer-review system will be established to support the knowledge partners to seamlessly peer review the knowledge assets and validate them for appropriate dissemination.

(vi) **Target-based knowledge dissemination engine:** based on the end-user profiles and the meta-analysis of the knowledge asset, the dissemination engine will target the

knowledge assets to specified user groups through different channels (including social media).

(vii) **Interactive user engagement module:** The clearinghouse will be an active platform by engaging with the users and enabling them to interact and engage with each other based on their interests, availability, and requirement.

(viii) **Tracking of the technology adoption and scaling:** one of the critical successes for the clearinghouse can be measured in terms of how many technologies, solutions, and roadmaps had been adapted and implemented by different stakeholders. This requires key tracking of the implementation and upscale. The system will entail a mechanism to capture the technology use and upscale.

Functioning mechanism of clearinghouse

447. The clearinghouse to function efficiently fulfilling its objective requires a well-established workflow and Standard Operating Procedures that will guide the identification, acquisition, validation, and dissemination of knowledge assets and technologies for upscale and roll-out. One of the crucial elements of the clearinghouse is the peer-review mechanism. The peer-review for any knowledge asset/technology will involve review by a committee of stakeholders and experts, both from internal and external sources. The committee's modus operandi, its functions, the stakeholder membership, and the assessment/review process will be developed through an inclusive design workshop at the beginning of the project.

Development and implementation

448. The clearinghouse system will explore adopting existing base platforms for the clearinghouse. The development and implementation of the clearinghouse will revolve around the following four pillars.

Operationalizaiton and SOP	Development of the Clearning	Dissemination	Socialisationa and Capacity Development
•Development of Strategic workflow and SoP •constituting the peer-review group •Engaging key stakeholders	•Development of system architechture •Development of knowledge based taxanomy •Pilot and system roll-out	•Connec and egnage witih diffrent sociail media channels •Develop Applciation Program Interfaces to automate contetn disserminateion in existing mobile apps	•Engage with stakeholders for promotion •Promote the clearninghouse platform for wider adoption and use

449. The ownership of all the data collected through the platform belongs to the project, and the high-level privacy standards will be followed to ensure that the sensitive data is valued and safeguarded appropriately. If required, the system can be deployed in a separate cloud service as agreed by co-EEs (i.e., MAFF and MoE), IPs, and the Government of Cambodia.

8.6. Suggest Actions under Output 2.3

450. The tables above show the crop-specific adaptive measures. Under this output, the PEARL project will promote these measures in conjunction with the improved agrometeorological advisory services and risk awareness among the beneficiaries under Output 1.1. Many of these measures demonstrated under this output will be fully operationalized as part of business plans under Output 2.1 and financed by the FARM under Output 2.2.

451. The analysis also recommends an effort to improve existing knowledge management systems that currently exist at an individual initiative level by harmonizing and streamlining their availability and accessibility for the project beneficiaries to promote relevant best practices and lessons learned through a variety of mediums, including social media platforms and mobile apps.

Activities, Descriptions and Sub-Activities
Activity 2.3.1: Develop a clearinghouse system, consolidating existing knowledge systems, for harmonized knowledge management and systematic dissemination of lessons learned and best practices in climate-resilient, inclusive, gender-responsive, and high-value agriculture for supporting the implementation of the roadmaps and action plans under Activity 2.1.1, and for raising awareness of the practices and technologies under Activity 2.3.2 and associated economic and social benefits. **Description:** A consolidated and improved clearinghouse will systematically collect and disseminate relevant lessons learned and best practices from all past and ongoing pertinent initiatives for promoting climate-resilient, high-value, and sustainable agriculture practices and technologies. The centralized system will assure the quality control and harmonization of information through various mediums, including FFS curricula, Facebook, YouTube channels, and mobile apps (e.g., Tonle Sap App, Chamkar and EcoKasksekor) so that farmers and other local value chain actors have reliable sources of consistent technical guidance and interactively provide feedback and information. The information is also used to promote buyers' informed purchasing and sourcing of agricultural products. • Sub-activity 2.3.1.1: Consolidate and improve existing knowledge systems to established a semi-automated clearinghouse system to collect, process, and disseminate relevant lessons learned and best practices in climate-resilient, inclusive, gender-responsive, and high-value production and processing practices and technologies. • Sub-activity 2.3.1.2: Promote through FFS curricula, Facebook, YouTube channels, and mobile apps (e.g., Tonle Sap App, Chamkar and EcoKasksekor) for on-demand information access among smallholder farmers, other local value chain actors and buyers, particularly women farmers and value chain actors. • Sub-activity 2.3.1.3: Conduct annual training seminars for retailers, hoteliers, restauranteurs, and traders/exporters to increase their awareness of the benefits of climate-resilient, inclusive, gender-responsive, and high-value agriculture to promote informed purchasing and sourcing.
Activity 2.3.2: Provide horizontally and vertically harmonized and targeted extension services, linking the provincial, district, commune, and village levels and public and private extension providers, to promote the adoption of climate-resilient, inclusive, gender-responsive, and high-value practices and technologies relevant for the implementation of roadmaps and action plans developed under Activity 2.1.1 and financed under Activity 2.2.1. **Description:** For successful implementation of the provincial-level value chain roadmaps and crop-specific action/business plans prepared by ACs, FAs, PGs, CPAs, CFs, and agricultural unions and financed through FARM under Activity 2.2.1 must be coupled with consistent and coordinated extension services to promote highly relevant production and processing practices and technologies that are climate-resilient, inclusive, gender-responsive, and high-value. Such practices and technologies will include the application of stress-tolerant varieties, small-scale irrigation systems, horticultural techniques (net house, raised bed production, drip irrigation), on-farm and homestead multi-use ponds, composting and organic fertilizer production, elements of the system of rice intensification, solar water pumps and storage tanks, integrated livestock waste management, IPM[28], climate-resilient post-harvest storage, value-addition facilities, and traceability and labeling.

[28] The project will scale up the efforts of the National Integrated Pest Management (IPM) Program, supported by FAO and the International Rice Research Institute, developed over the past decades.

- Sub-activity 2.3.2.1: Design inclusive and gender-responsive training curricula for four target groups - 1) public extension officers at the provincial, district and commune and village levels, 2) private extension providers, including NGOs, 3) trainer/model farmers and local value chain actors, and 4) female farmers and value chain actors - to promote the adoption of climate-resilient and high-value practices and technologies in line with the roadmaps and action/business plans (Output 2.1)
- Sub-activity 2.3.2.2: Conduct biannual training of public extension officers for identifying, demonstrating, and promoting climate-resilient and high-value practices and technologies relevant for the action/business plans.
- Sub-activity 2.3.2.3: Conduct annual training of private extension providers, including NGOs to mainstream climate-resilient and sustainable practices and technologies and clearinghouse knowledge into their services.
- Sub-activity 2.3.2.4: Conduct biannual TOT training of representative farmers and other local value chain actors, particularly women farmers and value chain actors from ACs, FAs, PGs, CFs, and unions on demonstrating and promoting climate-resilient and high-value practices and technologies relevant for their action plans implementation (flexible time arrangements to meet women specific needs).
- Sub-activity 2.3.2.5: Conduct biannual TOT training of representative farmers and other local value chain actors, particularly women farmers and value chain actors from CPAs on demonstrating and promoting climate-resilient and high-value practices and technologies relevant for their action plans implementation (flexible time arrangements to meet women specific needs).
- Sub-activity 2.3.2.6: Establish model farmer and processor demonstration sites to promote the adoption of climate-resilient, inclusive, gender-responsive, and high-value best practices and technologies.

8.7. Upper-Watershed Areas Restored And Protected To Increase Agroecological Functions (Output 2.4)

8.6.1. Background

452. The PEARL project will also promote an integrated watershed management (IWM) approach to improve agroecological conditions at the site-specific and landscape levels. IWM activities will support community protected areas (CPAs) and community forests (CFs) in critical catchment areas linked to cashew, mango, organic rice, and vegetable production to strengthen catchment restoration and protection efforts and improve their livelihoods. The activities will promote alternative livelihood options (e.g., apiculture, agroforestry fruits tourism, organic rice production, and value addition to non-timber forest products (NTFPs)). As part of the project preparation process, a study was conducted to identify where the project should implement IWM activities building on the existing knowledge of catchment restoration potential in the NTSB.

453. A 2018 study produced by IUCN (2018), *Application of Restoration Opportunities Assessment Methodology (ROAM) in Asia*, presents the case for investing in forest landscape restoration to restore and enhance forested areas ecosystem services. The study highlights Cambodia's ambitious goal of maintaining 60% forest cover in 2030, as stated in its Intended Nationally Determined Contribution (INDC), and posits that this goal is obtainable if landscape-level approaches to forest landscape restoration and improved land management are implemented.

454. The IUCN study targeted three of the four target provinces under PEARL (Kampong Thom, Preah Vihear, and Siem Reap). The report identified restoration interventions in the provinces intended to increase forest cover, reduce soil erosion, increase the availability of non-timber forest products (NTFPs), and improve local livelihoods (ibid.).

455. The report further highlights that a significant barrier to improved landscape restoration in the provinces is the uncertainty of land tenure rights (ibid.). The PEARL project thus focuses activities under Output 2.4 (Upper watershed areas restored and protected to increase agroecological functions for downstream farming activities in the target areas) on Community Protected Areas (CPAs) and Community Forests (CFs). A study was conducted during project formulation to identify target CPAs and CFs for PEARL restoration interventions.

456. In addition, Cambodia's National Biodiversity Strategy and Action Plan (NBSAP) (2016) underscores the uniquely important role of agriculture in the maintenance and restoration of ecosystem services and biological diversity. The NBSAP identifies its objectives, among others, to enhance the public awareness of the importance of biodiversity and ecosystem services for ensuring sustainable development and to address factors that lead to biodiversity loss and ecosystem degradation while enhancing factors that support their conservation (ibid.).

8.6.2. Study Approach

457. The PEARL under Output 2.4 aims to restore 7,600 hectares (ha) of critical catchment forests and other ecologically sensitive zones in the upper watersheds through IWM and agroforestry interventions by CPAs and CFs. Key guidelines of the Restoration Opportunities Assessment Methodology (ROAM) (Bernacki *et al.*, 2018) under FAO and IUCN were adopted to analyze and identify potential CPAs and CFs to engage in Forestland Restoration (FLR) interventions under the PEARL project based on this methodology.

458. The resulting report identified and recommended 20 CPAs and CFs to engage under PEARL. Among the 20 identified, 14 are CPAs, and 6 are CFs. A large group of these communities is located within the catchment areas of Stung Sen River, where their catchment restoration and protection activities have a significant bearing on downstream rice-growing regions in Kampong Thom and Preah Vihear provinces. Other CPAs and CFs are located near the Kulen National Park in Siem Reap and Sang Rokha Vorn Wildlife Sanctuary in Oddar Meanchey. The report recommends the PEARL project to support these CPAs and CFs in designing and implementing restoration and protection activities to improve their livelihood options to achieve the restoration target.

8.6.3. Suitable CPAs and CFs for Forest Land Restoration Initiatives

459. The study conducted resulted in a long list of 43 CPAs and CFs through consultations with the designated government officials, NGO staff, local authorities, and representatives of CPAs and CFs in the NTSB. From the long list, 20 suitable CPAs and CFs were identified for Output 2.4. The shortlist consists of 14 CPAs and 6 CFs. Detailed information on each CPA /CF is presented in Appendix 7 of the full study. The shortlisted CPAs and CFs are briefly described below.

Kampong Thom

460. There are four CPAs selected for the PEARL project in Kampong Thom, largely based on the recommendations from the government officials. Kampong Thom has more CPAs than the other three provinces because the Stung Sen River, the main artery of organic rice production in the region, cuts through the province. These CPAs are located close to each other and all four CPAs share their boundaries which have big positive impacts for conservation and protection of biodiversity, livelihood improvement of local communities as CPA members and project implementation. These CPAs include:

1) Kaki Brahoang is in Sraeveal Khang Lech and Sampour Touch villages, Dang Kambet commune, Sandan District;
2) Skor Krouch is situated in Dang Het, Prasat Andet, Krasaing, Pro Kaki, and Khmer villages, Sandan commune, and District;
3) Chhoam Thlork is in Vieng, Dang Totoeng, Kraing Deum, Svay, Ngan, Veal Brinh Leu, and Sralao villages; Ngan commune; Sandan district. The first three CPAs are located in Boeng Per Wildlife Sanctuary; and,
4) Kbal Daun Krei is in Boeng village, Mean Rith commune, Sandan district, located in Prey Lang Biodiversity Conservation Corridor.

461. Three CFs have been proposed for the PEARL project, because they meet the PEARL project criteria, proximity, and recommendations given by the government officials and NGO staff. In addition, the CPAs and CFs mentioned above will play important roles to provide the ecological services for downstream organic rice and horticulture producers. These CFs includes:
1) Prey Tatei is located in Kanthy village, Mean Rith commune, Sandan district;
2) Prey O'Kranhoung is in Chhoam Svay village, Mean Rith commune, Sandan district. The first two CFs borders one another and are in the same commune, suitable for project implementation; and,
3) O'Soam is in O'Soam village, Sala Visey commune, Prasat Balangk district, close to Boeng Per wildlife sanctuary.

Siem Reap

462. Three CPAs have been selected in areas in the Kulen National Park, in Khnang Phnom commune, Svay Leu district. They are villages located in the Kulen mountain and are adjacent to one another, separated by forests borders. Their catchment areas are critical for ensuring ecosystems services, particularly the provisioning of water and agroecological conditions, not just for themselves but also downstream areas where the project targets vegetable producers. These CPAs have also been highly recommended by MOE, and supported by various projects of development partners through MOE, thus possessing the relevant capacity to implement restoration and protection activities. These include:
1) Chup Tasok situated in Khla Khmum village, Khnang Phnom commune, Svay Leu district);
2) Prey Thom Anlung Thom located in Anlung Thom village, Khnang Phnom Commune, Svay Leu District); and,
3) Prey Thom Popel located in Popel village, Khnang Phnom Commune, Svay Leu District).

Oddar Meanchey

463. Four CPAs have been selected in the province. These CPAs were initially established as CFs when their forest areas were under the FA's management, and later they were transformed into CPAs when they were declared protected areas under the jurisdiction of MoE around 2016. Two CPAs are located in Sang Rokha Vorn Wildlife Sanctuary, and the other two CPAs are situated in the Northern Biodiversity Conservation Corridor. These CPAs have been strongly recommended by MoE to be included in the PEARL project, as they are critical for mainlining and restoring ecosystem services for local farming activities and contend with limited resources and livelihood opportunities due to their remoteness. These four CPAs/CFs include:
1) Sang Sahakum Rokha Vorn comprises five villages of Srah Keo, Sambou, Tumnup Thmey, Char Chas and Char Thmey, Trapeang Tav Commune, Anlong Veng district;

2) Ratanak Rokha consists of seventeen villages of Kaun Damrei, Bak Nim, Chha'Eup, Kouk Chress, O'Russey, O'Kanseng, Daun Keo, Chhouk, Polr, Trapeang Veng, Khtum, Taman, Champa Sok, Chheu Krom, Kiri Vorn, Boss, and Banteay, in Samrong and Koun Kriel communes, Samrong municipality [district];
3) Samaki composes of one village O'Samrong, Trapeang Tav Commune, Anlong Veng district; and,
4) Thmorda O'Toek Khiev is located in Thnal Keaeng, O'Beng, Chroak, O'Chik, and Preah Chambok villages, Ph'av commune, Trapeang Prasat district.

Preah Vihear

464. Three CPAs have been selected for the PEARL project in this province. They are located in Kulen Promtep Wildlife Sanctuary with high conservation value and a significant livelihood source for local people. Given their adjacent locations, their connectivity and proximity to the organic rice-growing areas downstream provide significant impact potential through the project interventions. These CPAs include:
    1) Akphivoat Prey Veng is located in Prey Veng village, Srayang commune, Kulen district;
    2) Sambo Akphivoat is in Sambou village, Srayang commune, Kulen district; and,
    3) Pourieng is located in Pourieng village, Kulen Chheung commune, Kulen district.

465. Additionally, three CFs have been selected in the same district of Kulen. These CFs were strongly recommended by the Provincial Forestry Cantonment of Preah Vihear, given their active management and protection efforts to prevent encroachment and destruction. Together with the CPAs described above, the PEARL project's support for these CFs will significantly enhance its impact potential through achieving greater catchment connectivity and concerted efforts at the landscape level. These CFs include:
    1) Prey Mloung is situated in Srayang Tboung village, Srayang commune, Kulen district;
    2) Koh Ker Rik Chamroeun is in Koh Ker village, Srayang commune, Kulen district; and,
    3) Prey Pou Mek Boun is located in Pyou Chhrouk village, Kulen Chheung commune, Kulen district.

466. Table 30below summarizes the 14 CPAs and 6 CFs selected through this study, based on the shortlisting criteria, including having a CPA/CF management plan, robust governance structure, proximity to the project' target areas (impact), crops and cropping systems, and livelihood improvement potential through, for example, ecotourism development. Furthermore, it is critical to note here that CPAs and CFs are not allowed to expand their crop production areas beyond their original cropland areas before becoming CPAs and CFs.

Figure 89 (map) shows locations of selected CPAs and CFs.

Table 30 Summaries of 20 Selected CPAs and CFs for the PEARL project

#	CPA/ CF Name	Location (Province/PA)	Management Plan	Governance	Impacts (proximity)	Cropping (target crops: mango, cashew, organic rice, horticulture)
1	CPA-Kaki Brahoang (Boeng Per Wildlife Sanctuary)	Dang Kambet commune, Sandan District, Kampong Thom	Management plan is under development. The CPA covers a forest area of 1,524 ha, and registered with MOE in 2010 with support from the Adaptation Fund project of MOE.	By-law prepared since 2010 and updated in 2019, with support from USAID funded Prey Lang project. Committee members are so active, CPA patrolling.	This CPA borders with Skor Krouch and Kbal Daun Krei CPAs.	Mix orchard plantations, producing mango, cashew, and cassava, covering more than 28% (427 ha). Rice and horticultural crops are also grown outside the CPA area.
2	CPA-Skor Krouch (Boeng Per Wildlife Sanctuary)	Sandan commune and District, Kampong Thom	5 years management plan (2016-2020) over 3,449 ha was prepared in 2015 with support from the Adaptation Fund project of MOE. It was approved in 2016	By-law with clear committee member structure approved by MOE in 2010, and then updated in 2020 with support USAID funded Prey Lang project. Committee members are so active	This CPA borders Kaki Brahoang and Chhoam Thlork CPAs.	Mix orchard plantations producing mango, cashew, casava, and rice and horticulture cover more than 3,000 ha. Other rice and horticultural crops are also grown outside the CPA area.
3	CPA-Chhoam Thlork (Boeng Per Wildlife Sanctuary)	Ngan commune, Sandan district, Kampong Thom	5 years management plan (2016-2020) was prepared in 2015, and it covers 5,204 ha (approved by MOE in 2010 as with by-law), with support from the Adaptation Fund project of MOE. The Management plan was approved in early 2016.	By-law prepared in 2010 and registered with MOE the same year with support from MOE's adaptation fund project. It was updated in 2020 with support from the USAID-funded Prey Lang project. Committee members are so active.	This CPA borders to Skor Kroch CPA.	Mix orchard plantations with key crops like cashew and cassava, covering an area of 4,076 ha. Upland rice and fruit trees are also grown inside the CPA area.
4	CPA-Kbal Daun Krei (Prey Lang Biodiversity Conservation Corridor)	Mean Rith commune, Sandan district, Kampong Thom	Management plan was approved in 2021. It covers 1,803 ha, and the Management Plan was prepared since 2019 with support from the Adaptation Fund project of MOE. It was approved in 2019.	By-law approved by MOE in 2021, with support from USAID funded Prey Lang project since 2020 and FA cantonment funded in 2019.	This CPA borders Prey Tatei and Prey O'Kranhoung CFs.	Mix orchard plantations, producing rubber, cashew, and cassava, covering over 540 ha (20%). Other crops like rice and horticultural crops are grown in a few places in the CPA area.

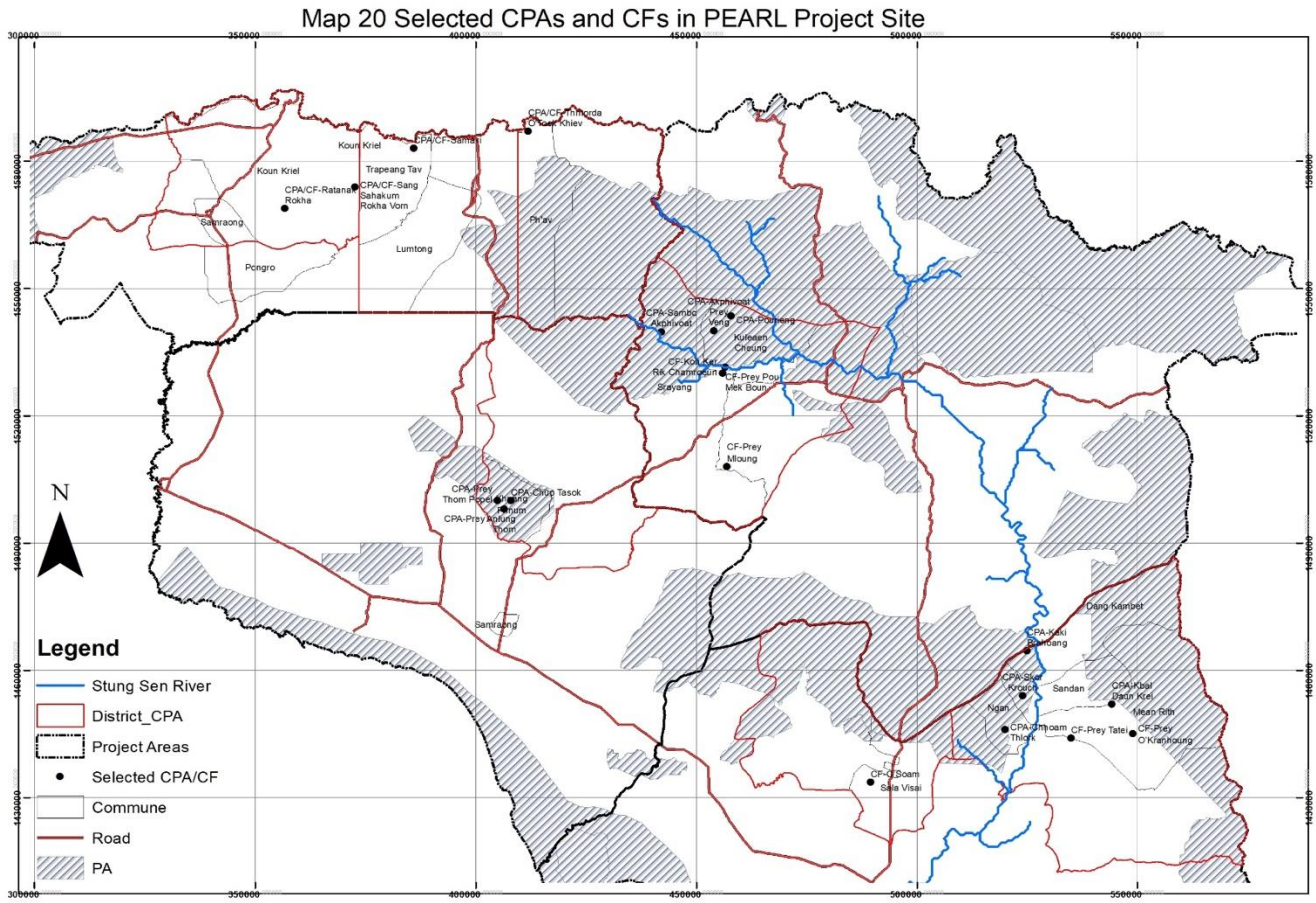
5	CF-Prey Tatei	Mean Rith commune, Sandan district, Kampong Thom	15-year management plan (2015-2029) was approved in 2015. It covers 1,395.44 ha, which was registered with MAFF in 2008. An agreement was made in 2009	By-law prepared since 2002 and approved by MAFF in 2008 with support by RECOFTC through Mlup Baitong, a local NGO. Committee members are so active.	This CF is close to Prey O'Kranhoung CF and Chhoam Thlork CPA.	Mix orchard plantations, producing cashew and cassava, cover more than 119 ha. No other crops like rice and organic rice are grown in the CF area.
6	CF-Prey O'Kranhoung	Mean Rith commune, Sandan district, Kampong Thom	15-year management plan (2015-2029) was prepared in 2015 and approved in 2016 with support from MAFF line departments and NGO partners. It covers 1,131 ha and was registered in 2010 with MAFF.	By-law prepared since 2002 with support from local NGO RPFD (Rural Partnership for Development) and MAFF line departments, registered with MAFF 2010. By-law and committee members were updated and reviewed in 2014 with support from Mlup Baitong, and the MAFF line departments. CF is still supported by the USAID Greening Prey Lang project.	This CF is close to Prey Tatei CF and Kbal Daun Krei CPA.	Mix orchard plantations, producing cashew and cassava, cover more than 150 ha inside the CF area. Some other crops like rice grown over 5 ha and no organic rice are grown in the CF area.
7	CF-O'Soam	Sala Visai commune, Prasat Balangk district, Kampong Thom	15 years management plan (2016-2030) was prepared and approved in 2016 over 307.69 ha, registered in 2004 with MAFF. An agreement was made in 2015	By-law prepared in 2004 with support from MAFF line departments and local NGO BFDK (Buddhism for Development Kampong Thom). Registered with MAFF in 2014. By-law and committee members were updated and renewed in 2013. Current support of COW (Cows for Cambodia), a local NGO since 2021 for forest protection patrolling and another saving group.	This CF is close to Boeng Per wildlife sanctuary.	Mix orchard plantations, producing cashew, cover more than 18 ha inside CF. No other crops like rice and organic rice are grown in the CF area.
8	CPA-Chup Tasok (Kulen National Park)	Khnang Phnom commune, SvayLeu district, Siem Reap	Management plan was developed in 2008. CPA covers 259 ha. It was created in 2003 with support from the UNDP's BESD project (Building an Enabling Environment for Sustainable Development in Cambodia) implemented	By-law approved by MOE in 2008 with support from LLP from 2017-2020 for CPA patrolling and CPA committee monthly meeting. The Committee members are very active.	This CPA borders Prey Anglong Thom and Prey Thom Porpel CPAs	There are two cash crops - cashew and mango – grown on approximately 25 ha. 24 ha is for ecotourism site. There are no other crops like regular rice and

			by MOE for supporting reforestation on approximately 13 ha.			organic rice grown in the CPA area.
9	CPA-Prey Thom Anlung Thom (Kulen National Park)	Khnang Phnom Commune, Svay Leu District, Siem Reap	5-year management plan (2021-2025) was prepared in 2020, over 365 ha, which was registered in 2001 with MOE, with support from the of UNDP's BESD project (Building an Enabling Environment for Sustainable Development in Cambodia) implemented by MOE.	By-law prepared in 2001 with technical support from FAO and MOE line departments. Registered under MOE in 2003. By-law was updated in 2008 and 2020 with support from FAO and numerous local NGOs since 2016 for forest protection, patrolling, and livelihood support.	This CPA borders with Prey Thom Popel CPA and Chup Tasok CPA.	No plantation or rice production in this CPA area. But it was delineated into production zone -to use forest resources within in regulations (27 ha), Ecotourism (24 ha), and restoration (77 ha that used to be the Chamkar like mixed orchard).
10	CPA-Prey Thom Popel (Kulen National Park)	Khnang Phnom Commune, Svay Leu District, Siem Reap	5-year management plan (2021-2025) was prepared in 2020 over 798 ha, registered with MOE in 2003 with support from the of UNDP's BESD project (Building an Enabling Environment for Sustainable Development in Cambodia), implemented by MOE.	By-law was prepared in 2003 with support from FAO and MOE line departments and registered with MOE the same year. By-law was updated in 2008 and 2020 with a clear governance structure of committee members with support from UNDP and various local NGOs since 2016 for forest protection, patrolling, and livelihood support.	This CPA borders Chup Tasok and Prey Thom Anlung Thom CPAs.	There are 50 cashew orchard plantations, covering an area of approximately 100 ha in this CPA. The ecotourism (128 ha), use and development (58 ha), and restoration zone (46 ha).
11	CPA/CF-Sang Sahakum Rokha Vorn (Sang Rokha Vorn Wildlife Sanctuary)	Trapeang Tav and Koun Kriel Communes, Anlong Veng district, Oddar Meanchey	5-year management plan (2018-2022) was established in 2018 under MAFF over 18,261 ha and then integrated under MOE jurisdiction in 2020 with support from the Adaptation Fund project of MOE. It was approved in 2020.	By-law approved in 2018 and agreement in 2019 by MAFF with support from Dan Mission (international NGO) since 2020 for helping such as committee meeting, by-law awareness, fire break road, ecotourism area, and CPA patrolling. It is so active.	This CF/CPA borders with CPA/CF Ratanak Rokha.	Mix orchard plantations, producing mango, cashew, and cassava, covering more than 913 ha (5%). About 1,800 ha (10%) for ecotourism development. There are no other crops like regular rice grown in the CPA area
12	CPA/CF-Ratanak Rokha (Sang Rokha Vorn Wildlife Sanctuary)	Samrong and Koun Kriel communes, Samrong municipality [district], Oddar Meanchey	Management plan has not yet been prepared, and it is being legalized into CPA. The CF was initially registered under MAFF in 2005 with support from the REDD+ project through the Adaptation Fund project of	By-law and an agreement were established in 2009 with support from CDA (Children Development Association, a local NGO). Members are very active.	This CF borders with CPA/CF-Sang Sahakum Rokha Vorn.	About 1,500 ha are allocated for ecotourism activities, including agroforestry and mixed orchard, and organic rice farming

			MAFF over a forest area of 12,872 ha.			
13	CPA/CF-Samaki (Northern Biodiversity Conservation Corridor)	Trapeang Tav Commune, Anlong Veng district, Oddar Meanchey	Management plan is under development with support from the REDD+ project through Adaptation Fund project of MAFF. CF covers an area of 1,079 ha, and it was created in 2005 under MAFF.	It is still a draft by-law with support from Sovanna Phumi (local NGO) and UNDP since 2017 on registration.	This CF/CPA borders Ratanak Rokha CPA/CF.	There are no orchard plantations or rice production in the CF area, and it is located in mountainous, forested areas. 11 ha allocated for ecotourism site with beautiful waterfall.
14	CPA/CF-Thmorda O'Toek Khiev (Northern Biodiversity Conservation Corridor)	Ph'av commune, Trapeang Prasat district, Oddar Meanchey	Management plan was established in 2014 with support from the REDD+ project through Adaptation Fund project of MAFF. It covers 2,025 ha, and it was created in 2004 by MAFF.	By-law was established in 2004 by MAFF, and it is being updated with support from WCS and USAID-Greening Prey Lang on CF patrolling and ecotourism site management.	This CF borders with Samaki CPA/CF.	There are no mixed orchard plantations or rice production in the CF area, and it is located in mountainous, forested areas. About 500 ha allocated for ecotourism site.
15	CPA-Akphivoat Prey Veng (Kulen Promtep Wildlife Sanctuary)	Srayang commune, Kulen district, Preah Vihear	Management plan is under development with support from WCS and MOE. CPA covers 1,048 ha.	By-law was established in 2014. Committee members are active. CPA is currently supported by WCS and USAID-Greening Prey Lang on CPA patrolling and saving group in 2021.	This CPA borders Sambo Akpivoat and Pourieng CPAs	There are no mixed orchard plantations, but rice/organic rice production on more than 50 ha in the CPA area including ecotourism site. These crops are allowed outside the CPA area.
16	CPA-Sambo Akphivoat (Kulen Promtep Wildlife Sanctuary)	Srayang commune, Kulen district, Preah Vihear	Management plan is under development with support from WCS and MOE line departments. CPA covers an area of 1,071ha.	By-law was prepared in 2013 with support from WCS and MOE line departments. Committee members are active and supported by WCS, and USAID-Greening Prey Lang on CPA patrolling, check dam repairing, and organic rice production since 2021.	This CPA borders with Akphivoat Prey Veng CPA	There is only a cashew plantation, approximately 4 ha inside the CPA. While normal rice field or organic rice field outside of the CPA area. 15% proposed for replantation including agro-forestry and organic farming of rice. 5% for promoting ecotourism sites
17	CPA-Pourieng (Kulen Promtep Wildlife Sanctuary)	Kulen Chheung commune, Kulen district, Preah Vihear	Management plan has been under development with support from the Adaptation Fund project of MOE. CPA covers an area of 567.22 ha.	By-law was established in 2019 with support from FAO's Life and Nature project, MOE line departments.	This CPA borders Akphivoat Prey Veng CPA and close to Sambo Akphivoat CPA	There is no mixed orchard plantation. Organic rice (Ibis rice) is produced outside the CPA area. 15% for replantation with human assisted approaches (including

						agro-forestry and organic farming of rice), and 5% for promoting ecotourism sites.
18	CF-Prey Mloung	Srayang commune, Kulen district, Preah Vihear	The management plan is under development, and an agreement was made in 2018. This CF covers a forest area of 1,740 ha.	By-law was established in 2008 with support from the MAFF line departments. It registered with MAFF in 2020. The committee members are active	This CF does not border other CF nor CPA, but it is close to Prey Pou Mek Boun and Koh Ker Rik Chamroeun CF in the same commune.	There are some plantations (35 ha) producing cashew and mango: no rice or organic rice production in the CF.
19	CF-Koh Ker Rik Chamroeun	Srayang commune, Kulen district, Preah Vihear	The 15 years management Plan (2017-2031) was prepared in 2016 and approved in 2017. The agreement was made in 2017 with Preah Vihear Forestry Cantonment. This CF covers a forest area of 1,864 ha.	By-law was created in 2017 and registered with MAFF the same year. The committee members are active.	This CF borders Prey Pou Mek Boun CF.	There are some plantations (8 ha) producing cashew and cassava. There is no rice or organic rice (Ibis rice) production in the CF.
20	CF-Prey Pou Mek Boun	(Kulen Chheung commune, Kulen district), Preah Vihear	Management plan (2017-2031) prepared in 2016 and approved in 2017. The agreement was also made in 2017 with Preah Vihear Forestry Cantonment. CF covers 582 ha	By-law was established in 2017 and registered with MAFF the same year. The committee members are active.	This CF borders with Koh Ker Rik Chamroeun CF.	There are some plantations (10 ha) producing cashew, coconut, mango, and cassava. There is also conventional rice production in the CF.

Figure 90 Map of 20 selected CPAs and CFs in PEARL Targeted Areas



Challenges in the CPA and CF Selection Process

467. Two types of challenges were observed during the assignment. The first type is technical, and the second type is physical.

468. The technical challenges were mainly associated with:

- Limited data accessibility and availability on CPAs and CFs, especially the official lists and data sources: Information regarding by-laws, registration status and dates, agreements of CPA and CF with the MOE and MAFF line departments, and management plans are not centralized.
- Data discrepancy and resultant deviation: Different sources of data and information with data discrepancies made the analysis and selection of suitable CPAs and CFs challenging.
- Selection criteria proposed by FAO: Officials from the Provincial Departments of Environment and Forestry Cantonments and representatives of the NGOs and communities were not supportive of the selection criteria, as they did not match their choices of CPAs and CFs. For instance, the government officials wanted the PEARL project to include communities they have worked for a long time, and those communities are more easily accessible. While the NGOs preferred the communities supported by their projects, as they had invested in their conservation activities. The community people claimed that their communities had little support from the government and NGOs. Therefore, this opportunity should be given to their communities.

469. The physical challenges were due to:

- COVID-19 pandemic: Travel and social gathering restrictions make it difficult for the National Expert to face-to-face meetings with the government officials, NGOs, and other relevant stakeholders. Completing the assignment required face-to-face meetings, but due to the official ban on physical gatherings, some major delays were experienced.
- Poor road access, coupled with the rainy season road conditions: These conditions hindered the field visits to some of the CPAs and CFs recommended by the government officials and the NGO field staff. The National Expert instead conducted interviews with the CPAs and CFs over the phone and other possible online mediums.
- Insufficient time allowed for the fieldwork: More time was required for meaningful interactive discussions and extensive visits to the 20 recommended CPA and CF sites spread across the four large provinces with difficult rural road conditions. Applying the ROAM approach fully was impossible within the given time frame, as traveling from one community to another was highly time-consuming and often took a whole day.

470. The 20 CPAs and CFs selected for the PEARL project have been carefully considered through the National Expert's thorough analysis based on the PEARL criteria and recommendations by the government officials and NGO staff, and interactive discussions with the local community representatives. Each selected CPA/CF has many strengths. These include clear demarcation of boundaries, by-laws with active committee members and active participation of community members, the agreement signed with relevant government ministries, a management plan, and support from national and international development partners. These strengths are present in all 14 CPAs and 6 CFs selected by this study, although to varying degrees, and these strengths will be solid factors contributing to the successful implementation of the PEARL project.

8.8. Suggested Actions under Output 2.4

Activities, Descriptions and Sub-Activities
Activity 2.4.1: Restore and protect critical forest catchments in upper watershed areas where the target crops are produced (this activity will build directly on and extend the existing conservation and catchment protection efforts by MoE, WCS[29] and others). **Description:** Establishing an inter-district integrated watershed management (IWM) program with relevant district councils in upper catchment areas of where the target crops are produced will enable both the restoration and protection of critical catchment forests and other sensitive ecological zones and improvement of agroecological conditions, including water availability and quality, while also reducing hazards, for downstream targeted farmers. Such restoration efforts will also increase the livelihood quality of upstream communities through improved ecosystem services and alternative livelihoods development (e.g., apiculture, agroforestry-based (fruits) tourism, NTFP value addition). • Sub-activity 2.4.1.1: Establish an inter-district IWM framework to identify priority areas and interventions for restoring and protecting critical catchment forests and other sensitive ecological zones in upper watershed areas where the target crops are produced. IWM activities will build on and enhance CPAs' and CFs' management plans. • Sub-activity 2.4.1.2: Design restoration and protection plans and provide capacity development in an inclusive and gender-responsive manner for the identified CPAs and CFs through agroforestry, other revenue-generating conservation activities, and contract work. • Sub-activity 2.4.1.3: Support CFs to implement and monitor their restoration and protection plans. • Sub-activity 2.4.1.4: Support CPAs to implement and monitor their restoration and protection plans. • Sub-activity 2.4.1.5: Establish a methodological approach and mechanism to identify baselines, monitor the impacts of catchment protection and restoration, and identify issues for improvement under the inter-district IWM framework.

[29] WCS successfully established a conservation-focused organic rice brand, Ibis Rice, incentivizing local conservation efforts to improve local agroecology and habitat connectivity.

9. OUTCOME THREE: ENABLING CONDITIONS FOR CLIMATE-RESILIENT AGRICULTURE ARE ENSURED

9.1. Regulatory and institutional arrangements and capacity relevant to developing certification-based value chains strengthened to provide enabling conditions for adopting climate-resilient, high-value and sustainable agriculture and food security (Output 3.1)

471. Institutional support and coordination efforts and mechanisms for supporting the market-based transition of smallholder farmers and other local value chain actors to climate-resilient and high-value agriculture are currently limited. Enabling regulatory and institutional conditions are required to ensure that the certification standards targeted by the project are effective and climate resilient to achieve its goal. A systematic approach to promoting inclusive and gender-responsive financial access for smallholder farmers and other local value chain actors without collateral or guarantor is necessary to complement FARM under Output 2.2 to accelerate their transition. The PEARL project will also improve public-private partnerships, which are currently limited, and intersectoral coordination mechanisms to support the transition to climate-resilient agriculture.

9.1.1. Regulatory and institutional framework for the climate-proofed certification programs

472. An intersectoral technical working group (TWG) is needed to ensure a policy and regulatory review and sector engagement system to improve institutional coordination and ensure the coherence of policy and regulatory framework to support Output 2.1 on the ground. Clear policy and consistency in implementing regulations and ensuring compliance sit above the specifics of individual value chains and are foundational in enabling improvement throughout the agriculture sector.

473. Mitigating certain climate risks through certification schemes and value chains involves systems and structural assessments at the national level to formulate policy and measures around agroecological and climate-informed prioritization of certain national key products. Another fundamental enabling factor that cuts across value-chains is law enforcement for a range of sectors: not only environmental regulations but also tax and fees.

474. The proposed intervention will provide a transparent regulatory and compliance space that supports the timely change and embeds a platform for continual industry consultation. The TWG will ensure national-level enabling conditions for local-level development actions and sector capacity-building activities. In this context, the TWG, comprising members from sectoral institutions and the private sector, will identify areas of improvement and recommend actions for ensuring an enabling policy, regulatory and institutional environment (e.g., developing online certification/traceability tools) for promoting climate-resilient, inclusive, and gender-responsive agricultural certification programs.

475. The intersectoral TWG will facilitate a national-level forum that ensures industry needs and concerns can be raised and policy recommendations tuned to specific sectoral issues and concerns. Climate risks and mitigation and adaptation measures should be streamlined into various value chain stages and certification programs from the policy, regulatory and institutional perspectives. This is well illustrated in the checklist by IFAD (2015) with value chain interventions and outcomes, climate risk issues, and climate risk management opportunities.

476. Furthermore, increasing pest and disease incursions associated with increased temperatures and drought conditions are viewed as a significant influence on the increased application of pesticides. The implication for food safety and security as a result of increased pest and diseases warrants policy and

institutional-level responses, including sectoral integration and improved enforcement and monitoring. Streamlining policy and agency interaction also has essential for ensuring the necessary legal and policy frameworks are in place to facilitate the adoption of certification and quality assurance.

477. However, policy inconsistency and lack of industry consultation are prominent and pervasive problems in all sectors, and this is a significant impediment that permeates all sector issues. The successful implementation of specific interventions depends upon fundamental basic national-level enabling conditions. Furthermore, the benefits of collected actions stretch beyond the specific value-chains, and these enabling conditions relate specifically to institutional and policy support in a range of sectors.

478. For instance, formulating policy and regulatory measures intersectorally around agroecological restoration, climate-informed prioritization of certain national key products, water use regulations, and climate-proofing of crucial market tools such as GI, organic certification, and CamGap, is essential.

479. For example, in the definition of the GI specifications, it is vital to ensure effective inter-value-chain stakeholder participation. This means that all relevant stakeholders are consulted in ways that would enable them to contribute to the process of decision-making. This is particularly important when it comes to the registration of rice as a GI product and ensuring that it has a specific mechanism in place to contribute to building the project beneficiaries' climate resilience. Unlike the organic and GAP standards, GI requirements are pre-determined by a standardized set of guidelines, thus requiring active stakeholder participation in defining them. Each product, therefore, has a unique and specific code of practice and book of specifications that are tailored to its distinct and most crucial characteristics. Depending on the number of aspects captured by these control plans, the cost of verification for the GI certification process varies greatly. This is another critical consideration that necessitates an effective regulatory and institutional environment to guide the design process with clear guidance on climate resilience and sustainability to ensure certification's overall feasibility and effectiveness under the project objective.

480. Law enforcement on illegal import and export and the sales and use of agrochemicals are also needed. Not having producer identity is a gamble with food safety standards, and undercut prices deteriorate market opportunities for producers with safe production standards. Import competition is seen as a problem, and action identified in the e-survey (ICEM, 2020) includes increasing regulation of imported (competing) products and enforcing stricter controls on imports. Developing better and more reliable export markets is also presented as a solution to constraints in this industry. Subsidies and/or regulation of prices of farm inputs were also proposed.

9.1.2. Finance Sector Coordination

481. Ensuring the financial independence of stakeholders and supporting organizations through the actions is at the heart of the project intervention through FARM (Output 2.2.). However, such support would not be successful or sustainable without a systemic effort across the agricultural finance sector to make finance more accessible for smallholders and other local value chain actors to accelerate their adoption of climate-resilient and high-value agriculture. The absence of such sectoral action poses a significant risk to the country's sustainable development and food security prospects.

482. A common lending practice among agricultural finance lenders is thus needed to promote loan products that favor climate-resilient loan applications and provide required transitional financial support to smallholder farmers, ACs, FAs, PGs, unions, and SMEs with limited capacity to provide collateral.

483. The project will partner with the Agricultural and Rural Development Bank of Cambodia (ARDB) and private financial institutions to develop a lending scorecard system to consider climate resilience, inclusivity,

and sustainability as crucial eligibility criteria in screening loan applications. This system would promote not only an overall shift towards climate-resilient agriculture within the sector but also a just transition by increasing smallholder farmers' and other local value chain actors' ability to access finance through climate change adaptation.

484. As part of this effort, the PEARL project will directly assist with the GCF accreditation of ARDB. Upon being accredited by the GCF, the ARDB is expected to build on the scorecard system to develop a complementary GCF project for scaling up low-cost agricultural finance to support Cambodia's accelerated transition to climate-resilient agriculture.

9.1.3. Forums for Inter-sectoral Coordination and Private Sector Engagement

485. Increased efforts are needed to promote effective PSPPs through the existing national and provincial stakeholder coordination mechanisms, namely the National Council for Sustainable Development (NCSD), National Committee for Sub-National Democratic Development (NCDD), and public forums at the provincial level. The project will support these mechanisms at the national and provincial levels to increase cross-sectoral coordination and private sector engagement in climate-resilient and inclusive value chain development by promoting forums that bring together public and private actors, engaged in different stages of the target value chains and local communities to discuss issues and seek solutions jointly.

486. Activities under Output 3.1 will be implemented under the joint leadership of MAFF and MOE with technical support from FAO Cambodia. Concerning agricultural finance, the ARDB will play a coordinating role.

9.2. Suggested Actions under Output 3.1.

Activities, Descriptions and Sub-Activities
Activity 3.1.1: Upgrade/establish an enabling regulatory and institutional framework for the climate-proofed certification programs under Activity 2.1.2. to operate effectively. **Description:** The updated guidelines, training manuals, and tools for the target certification programs under Activity 2.1.2. must be fully underpinned by appropriate regulatory conditions and institutional arrangements to operate effectively and ensure long-lasting impacts. • Sub-activity 3.1.1.1: Mobilize the TWG, established under Sub-activity 2.1.2.1, to identify areas of improvement and recommend actions for ensuring an enabling regulatory and institutional environment for promoting climate-resilient, inclusive, and gender-responsive agricultural certification programs. • Sub-activity: 3.1.1.2: Organize a stakeholder validation meeting(s) for the recommendations and submit stakeholder validated recommendations for amendments in the regulatory and institutional framework to the policymakers for their consideration.
Activity 3.1.2: Demonstrate a harmonized sectoral approach to climate-resilient, inclusive, and gender-responsive finance to complement Activity 2.2.1 for rolling out the FARM. **Description:** This approach will promote and demonstrate harmonized practices across the agricultural finance to mainstream climate and sustainability considerations as critical de-risking measures by developing and adopting a scorecard system to increase financial access for smallholder farmers and other local value chain actors, particularly women farmers and value chain actors, with limited to no collateral assets. • Sub-activity 3.1.2.1: Establish a working group with members from public and private financial institutions servicing the agriculture sector to design a lending scorecard system together with a user manual to consider climate-resilience and sustainability as main eligibility criteria for screening loan applications from smallholder farmers and other local value chain actors with limited to no collateral.

- Sub-activity 3.1.2.2: Facilitate agreements with at least three public and private financial institutions to operationalize the scorecard system on a pilot basis.

Activity 3.1.3: Increase private sector engagement in sub-national planning for improved PSPPs.

Description: Effective PSPPs for the development of climate-resilient, high-value, and sustainable value chains for smallholder farmers and other local value chain actors and ensuring food security depend on enabling conditions that forge coordination and collaboration across relevant sectors (i.e., agriculture, finance, food, retail, hospitality, and trade) and between national and sub-national governments. Another such condition is to respond to citizens' voices to create and achieve shared social visions, and this activity will ensure these enabling conditions.

- Sub-activity 3.1.3.1: Strengthen the provincial public forum mechanisms by increasing private sector engagement to facilitate open dialogues between governments, the private sector, and smallholder farmers and local value chain actors to forge effective PSPPs.
- Sub-activity 3.1.3.2: Establish a sub-committee to serve NCSD and NCDD to strengthen cross-sectoral and vertical coordination and institutional arrangements by improving a feedback mechanism between national policy processes and sub-national forums on PSPPs for climate-resilient, inclusive, gender-responsive, and high-value agriculture and improved food security.

9.3. Gender-responsive landscape-level agroecology monitoring system (LAMS) developed to crowd in public and private investments in climate-resilient, high-value and sustainable agriculture (Output 3.2)

487. A systematic approach and process to enable strategic investment by the public and private sectors into climate-resilient and high-value agriculture in a strategic and structured manner are currently absent. This hinders a clear understanding and monitoring of capacity gaps and climate finance investment needs, thus limiting the country's ability to direct public spending and private sector investment into creating bankable projects to ensure incremental outcomes. The PEARL project will establish an integrated decision-support tool for systematically monitoring climate risks and suitability shifts, linking to Output 1.1 and identifying investment gaps and opportunities, and monitoring progress to increase public and private investment. This tool will also support the country's effort towards developing and operationalizing an Enhanced Transparency Framework (ETF) under the Paris Agreement.

488. The project will also establish a gender-responsive, landscape-level agroecology monitoring system (LAMS) to crowd in public and private investments in climate-resilient, higher-value and sustainable agriculture. This is a climate-informed investment decision support system for public and private investors to funnel investment into a climate-resilient and just transition of the sector. The LAMS will also be linked with other climate data systems such as the national greenhouse gas inventory (NGHGI) and National Forest Monitoring System (NFMS) under REDD+ to support Cambodia's reporting to the UNFCCC through the Enhanced Transparency Framework (ETF) under the Paris Agreement.

9.3.1. Design Description of LAMS

489. The primary objectives of LAMS are to:

- Curate and integrate diverse sources of data related to landscapes, agriculture, watersheds, climate change, markets in one single platform;
- Identify gaps in climate-resilient investments based on scenario-based analysis (i.e., climate, biophysical, social, and economic) and provide appropriate opportunities for policymakers and investors to take investment decisions, supported by data analytics;
- Assist policymakers and investors without data expertise to identify gaps and investment opportunities in climate-resilient technologies and solutions through an interactive, user-friendly web-based interface;

- Track, monitor, and report on investment progress towards climate-resilient agriculture over a period.

490. The LAM system is systematically designed to address the gaps in limited data-driven, evidence-based capacities at the policy level to support investment decisions. The LAMS collects and compiles data from multiple sources, including the primary data generated through the project (i.e., agrometeorological advisory information, agricultural finance, the clearinghouse of lessons learned and best practices) and other sources (e.g., REDD+ NFMS, NGHGI). The data harvest process from these sources will be automated to provide (near) real-time updates. The collected data through pre-determined algorithms will generate automated dashboards that support scenario-based decision-making.

491. The system contributes to building evidence of climate investment scenarios and effective mechanisms to climate change mitigation in agriculture. The platform also envisages creating an investment roadmap plan for longer duration/multi-year investments and also creates suitable scenarios for different investors based on their investment patterns and trends.

492. Apart from being a data-driven support system guiding the investments, the platform will also help in tracking and monitoring the investments, investor decision trends, and comparing the investment decisions. This provides a solid foundation for developing an ETF for the agriculture sector.

493. The design and development of the LAMS will be a step-by-step approach in consultation with all stakeholders and different data sources (i.e., requiring data sharing agreements and harmonization arrangements). The system will be based on a digital M&E system and the clearinghouse for closer integration to enhance usability, data sharing, and efficient implementation. The overall implantation will be based upon an initial consultation workshop that will lead to developing systems specifications. Specific design steps will include:

(i) Identification of data sources, a meta-analysis of data for ingestion;
(ii) Developing data harvesting/sharing frameworks;
(iii) Design and development of the high-level technical architecture of the system in consultation with the key stakeholders (other data sources, PEARL project, national government, user groups) through user engagement workshops;
(iv) Development of wireframes, design prototypes for consultation and approval;
(v) The actual development of the system;
(vi) Pilot test of the system with select user groups; and
(vii) Deployment and continuous improvement through feedback mechanisms.

494. Activities under Output 3.2 will be implemented under the joint leadership of MAFF and MOE with technical support from FAO Cambodia.

9.4. Suggested Action under Output 3.2.

Activities, Descriptions and Sub-Activities
Activity 3.2.1: Establish a gender-responsive landscape-level agroecology monitoring system (LAMS) with an interactive web platform. **Description:** LAMS will offer a one-stop-shop platform for public and private investors in agriculture to make informed investment decisions. LAMS will guide investors by identifying investment gaps and opportunities in making agriculture resilient to climate change, high-value, inclusive, and gender-responsive to maximize their investment returns and track investment progress in terms of emissions, climate resilience, and social and environmental impacts over time. LAMS will be operationally linked to other climate-related monitoring systems (e.g., REDD+ NFMS, NDC ETF).

- Sub-activity 3.2.1.1: Establish an expert working group with technical members from institutions managing relevant databases concerning climate change, agricultural production, and related socio-economic development and investment activities to identify the scope of LAMS's function parameters, data needs, and sources, and data sharing and harmonization needs, roles and responsibilities of parties involved, and an annual operating budget.
- Sub-activity 3.2.1.2: Facilitate data sharing and harmonization agreements between MAFF (a host of LAMS) and relevant data-holding institutions (NIS, MAFF, MoE, MoC, MWoRAM, and others).
- Sub-activity 3.2.1.3: Design a gender-responsive LAMS operating framework with a web interface and an SOP for operating LAMS, including operational guidelines, roles and responsibilities, and training manuals.
- Sub-activity 3.2.1.4: Train system analysts and administrators on the SOP to operationalize LAMS.
- Sub-activity 3.2.1.5: Refine the predictive models of climate impacts on the target crops and other key crops in AquaCrop and through AEZ methodology based on ground data to aid the identification and selection of climate-resilient investment options under LAMS.

Activity 3.2.2: Promote the use of LAMS in public and private investment decision-making, monitoring, and reporting.

Description: To ensure wide application of LAMS among policymakers, public institutions, and private investors, promotional material development (e.g., leaflets, sample analysis reports shared through social media and email listserv), and awareness-raising and end-user training events, including virtual resources, will be carried out.

- Sub-activity 3.2.2.1: Develop awareness materials (e.g., leaflets, sample analysis performed on LAMS web platform, virtual end-user support materials on YouTube) and an end-user training program.
- Sub-activity 3.2.2.2: Conduct bi-annual end-user training events to promote the broad application of LAMS and collect user feedback to improve LAMS's scope and analytical functions.

10. PROJECT COSTS AND FINANCING

495. The total project costs are estimated at USD 42.85 million (see Table 31). More detailed information is included in the supporting documents for this project (see Annex 3 – Detailed Budget).

496. Planned financing would take the form of a grant to be provided by the GCF for an amount of USD 36.23 million, while USD 6.2 million in co-financing will be provided by project partners and FAO. Co-financing from the two Executing Entities (MAFF and MOE) will be contributed in-kind through the provision of government resources specifically allocated to PEARL project activities. Further co-finance will be provided from the FAO-GEF/LDCF projects.

Table 31: Project Costs and Financing

Outcome	Output	Indicative cost	GCF financing		Co-financing		
		Amount million USD ($)	Amount million USD ($)	Financial Instrument	Amount million USD ($)	Financial Instrument	Name of Institutions
1. Farmers' capacities are enhanced to manage climate impacts and related risks	1.1. Availability and access to agro-meteorological advisory services tailored to target value chains improved.	3,504,366	3,084,366	Grants	0.3	In-kind	MAFF
					0.12	In-kind	FAO
2. Adaptive capacity of smallholder farmers and other local value chain actors, particularly vulnerable women farmers, is increased.	2.1 Premium market access opportunities for cashew, mango, organic rice, and vegetable producers and processors increased.	17,074,115	13,909,11	Grants	2.01	In-kind	MAFF
					1.155	In-kind	MoE
	2.2. Access to technologies for climate-resilient agriculture and value chain development improved.	8,965,495	8,785,495	Grants	0.18	In-kind	MAFF
	2.3. Awareness and knowledge of climate-resilient and sustainable, high-value agriculture increased.	3,151,330	1,970,850	Grants	0.73048	In-kind	MAFF
					0.25	In-kind	MoE
					0.2	In-kind	FAO
	2.4. Improved agro-ecological conditions and connectivity.	4,592,220	3,822,220	Grants	0.42	In-kind	MoE
					0.35	In-kind	FAO

3. Regulatory and institutional frameworks and capacities for climate-resilient agricultural certification, cross-sectoral coordination for increased PSPPs and smallholder financing, and climate-informed investment support are strengthened.	3.1. Regulatory and institutional arrangements and capacity relevant to developing certification-based value chains strengthened.	1,509,525	1,160,795	Grants	0.215	In-kind	MAFF
					0.133730	In-kind	MoE
	3.2. Gender-responsive landscape-level agroecology monitoring system (LAMS) developed.	2,012,690	1,787,690	Grants	0.225	In-kind	MoE
PMC		2,040,490	1,711,450	Grants	0.25452	In-kind	MAFF
					0.07452	In-kind	MoE
Total cost (USD)		42,850,231		36,231,981			6,618. 250

11. IMPLEMENTATION ARRANGEMENTS

497. The PEARL project's proposed management and implementation arrangements are a direct result of ongoing discussions between FAO and relevant national authorities, including MAFF and MOE among others, and further feedback has been provided by provincial and local stakeholders in project consultations.

498. FAO will act as the GCF Accredited Entity (AE) to lead project preparation and appraisal, and oversee implementation, ensuring appropriate fiduciary, operational, and technical standards are adhered to, and monitoring and evaluation responsibilities are fulfilled. Building on its global leadership, country-specific expertise and long track record of supporting the RGC in agriculture, forestry, fisheries, and addressing climate change, FAO is best placed and has comparative advantage to play the AE role in designing and implementing the proposed project, as demonstrated by the NDA no-objection letter.

499. To perform the AE functions, FAO will set up a dedicated FAO-GCF project supervision team comprising relevant staff from the FAO Country Office in Cambodia, the FAO Regional Office for Asia and the Pacific, and FAO Headquarters. The members of this project supervision team will perform the necessary supervision and oversight functions, including supervision and backstopping missions during the entire implementation period, as required. The project supervision team will remain independent of the Executing Entity functions also performed by FAO (see below). In line with the GCF policy on fees adopted through GCF Board Decision B.19/09, the above-mentioned segregation of responsibilities within FAO will ensure that the Organization can independently and effectively perform the types of AE functions listed in the GCF General principles and indicative list of eligible costs covered under GCF fees and project management costs.

Executing Entities (EEs)

500. As the government co-EE with the largest share of the grant finance and the most activities to implement in the PEARL project, MAFF will also host the Project Management Unit (PMU), and will ensure support is delivered in close collaboration with key federal, provincial, and local entities. Because the PEARL project aims to work in rural areas these local level relationships are key to the effective delivery and sustainability of this project. All government ministries that are partners in the PEARL project have provincial offices, for instance the Provincial Department of Agriculture, Forests, and Fisheries (PDAFF). These provincial entities have both the local knowledge and the last-mile outreach capacity to effectively implement the relevant aspects of the PEARL project. Each project activity is "owned" by one of the project partners.

501. Seamless EE arrangements between FAO, MAFF and MOE are necessary not only for ensuring the effective delivery of the intended outcomes and outputs as the project crosscuts several technical and market-focused areas, but also for ensuring effective and sector-wide capacity transfer and country ownership of transferred capacity to ensure the sustainability of the project outcomes beyond its life (see Table 32).

Table 32: Assignment of EEs (see Annex 4 for sub-activity level assignments)

Output	Activity	EEs

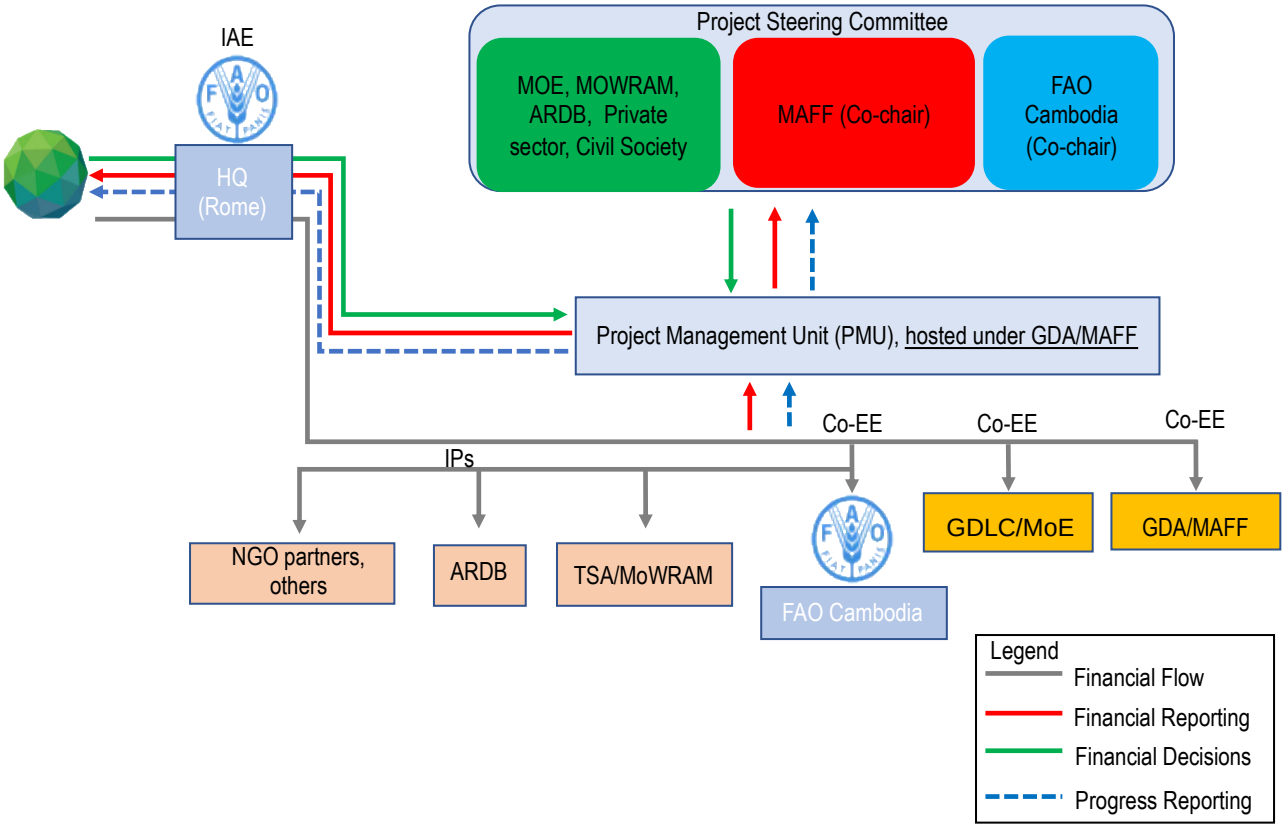
Output 1.1	Activity 1.1.1	FAO
	Activity 1.1.2	FAO, MAFF
	Activity 1.1.3	FAO, MAFF
Output 2.1	Activity 2.1.1	FAO, MAFF, MoE
	Activity 2.1.2	FAO, MAFF
Output 2.2	Activity 2.2.1	FAO
	Activity 2.2.2	MAFF, MOE
	Activity 2.2.3	FAO, MAFF
Output 2.3	Activity 2.3.1	FAO, MAFF
	Activity 2.3.2	FAO, MAFF, MoE
Output 2.4	Activity 2.4.1	FAO, MAFF, MoE
Output 3.1	Activity 3.1.1	MAFF
	Activity 3.1.2	FAO
	Activity 3.1.3	FAO, MAFF, MOE
Output 3.2	Activity 3.2.1	FAO, MAFF, MOE
	Activity 3.2.2	MoE

12.1. Implementing Partners (IPs)

502. The project will also draw on the Implementation Partners (IPs) (i.e., MoWRAM, MoC, ARDB, NGO partners such as GRET, IRAM, WCS and others). Such partners typically possess specialized expertise, knowledge, and mandates and can offer insights and services essential to achieving project results. In some cases, project-financed staff will consult and coordinate with the IPs to prepare and inform specific activities to be delivered under the project. In other instances, the IPs will be involved in the project through Letters of Agreement (LoAs) or contracts to provide specific services to the project and intended beneficiaries. Their roles and responsibilities are detailed in the budget plan (Annex 4).

503. Figure 90 summarizes the project implementation arrangements.

Figure 91: Project Implementation Arrangements



12.2. Project Steering Committee

504. MAFF, as the main and largest national beneficiary entity of this project, will establish and and co-chair a Project Steering Committee (PSC) with FAO. This committee will be comprised of representative members from relevant ministries, other implementation partners. The PSC will also invite representatives from relevant CSOs, the private sector, and academia as necessary to discuss thematic issues as well as partnership opportunities. The PSC´s main responsibility will be to provide strategic guidance and support coordination among government institutions, and will provide general oversight for the implementation of the project. The PSC will further be responsible for reviewing and approving annual work plans, budgets and progress reports, and providing strategic guidance for addressing risks and issues that could not be handled by the PMU alone. They will approve the Project Implementation Manual (PIM) and Project Reporting Guidelines (PRG), prepared by the PMU during the inception phase. PSC meetings will be held twice a year: prior to annual budget planning and after the closure of fiscal year.

12.3. Project Management Unit (PMU)

505. A PMU will be established at the GDA/MAFF. It will be managed by the National Technical Advisor (Project Coordinator), who will be responsible for project implementation and coordination with all stakeholders. The PMU will be responsible for ensuring the implementation and monitoring of day-to-day activities through coordination with the EEs, the technical quality of the project outputs, effective stakeholder engagement, and safeguarding the project and its beneficiaries. The government counterpart to the National Technical Advisor (Project Coordinator) will be the Project Director, appointed by the GDA/MAFF (see Table 8).

506. As a high volume of procurement is anticipated in the PEARL project, in particular concerning the proposed FARM mechanism set-up under Output 2.2, the PMU will be assisted by additional personnel in addition to the core PMU staff members to support its responsibility for initiating and completing all procurement cases in a timely fashion and providing assistance to the beneficiary groups with financial and operational matters. Furthermore, there will also be National Safeguard and Gender Specialists to lead the project's effort in mitigating negative social and environmental impacts while enhancing positive ones, including those on gender.

507. The PMU will prepare an annual work plan and budget, including a procurement plan, which the PSC will review and approve. The PMU is also responsible for preparing an inception report, quarterly progress reports, annual performance reports, and expenditure reports.

508. Project-recruited staff and staff seconded by the government will collectively comprise a project delivery team that will ensure sound and effective project implementation. The specific roles of critical members of this project delivery team are described in Table 33.

Table 33: Key Positions

No.	Position	Duration	Responsible Areas	Responsibility
1	Project Director (co-financed position)	Part-time	PMU and All Outcomes	• Provide overall directions and guidance and operational leadership for all activities. • Provide high-level coordination support between all EEs and implementation partners.
2	National Technical Advisor (Project Coordinator)	72 months	PMU and All Outcomes	• Ensure day-to-day project operations and coordination with all stakeholders involved in project implementation. • Oversee all planning activities, including annual work planning and budgeting, and coordinate PMU-led recruitment, procurement, and monitoring and reporting activities. • Ensure timely mobilization of all necessary resources, including co-finance.
3	International Senior Project Officer (Chief Technical Advisor)	66 months	PMU and All Outcomes	• Oversee technical activities in all outcome areas. • In close coordination with the Project Director, National Technical Advisor, and national counterparts, supervise and coordinate the work of all international and national experts to ensure timely deliverables that meet FAO/GCF quality standards and reflect international best practices. • Ensure strategic and technical linkages and coherence between the outcomes and outputs.
4	Head of Operations (international)	17 months	PMU and All Outcomes	• Provide overall guidance on all operational matters based on FAO rules and regulations and international best practices. • Ensure quality assurance of all technical, operational, and financial activities.
5	International Operations Officer	30 months	PMU and Outcome 2	• Liaise with various units of the FAO Country Office to ensure all operational activities are planned and carried out in a timely manner and in compliance with the necessary rules and regulations. • Support the development of operational and procurement specifications under the FARM mechanism.
6	National Operations Officer	72 months	PMU	• Oversee all operational matters under PMU. • Provide capacity development support to the co-EEs to establish the necessary quality control mechanisms that match FAO/GCF quality control standards for operational issues.
7	National Procurement/Grant Specialist	72 months	PMU	• Manage all procurement activities under PMU. • Support the procurement of goods and services under Component 2 as required.
8	National Finance Specialist	72 months	PMU	• Prepare financial plans and expenditure reports. • Make payments and track expenditures and process payments.

				• Provide capacity development support to the co-EEs to establish the necessary quality control mechanisms that match FAO/GCF quality control standards for financial matters.
9	National Finance Associate	72 months	PMU	• Assist the National Finance Specialist in financial management and quality control.
10	National Human Resources Specialist	72 months	PMU	• Coordinate all human resources recruitment and related activities to ensure timely implementation of project activities.
11	National Administration Assistant	72 months	PMU	• Assist project staff in ensuring day-to-day project operations and coordination, and carry out any other secretarial tasks.
12	International Technical Advisor for MEAL	500 days	All Outcomes	• Lead the development of a Monitoring, Evaluation, Accountability, and Learning (MEAL) strategy and MEAL system. • Develop the project staff's capacity for implementing the MEAL strategy/system.
13	National MEAL Specialist	72 months	All Outcomes	• Coordinate the implementation of the MEAL strategy/system. • Prepare MEAL reports based on the MEAL Plan (Annex 11).
14	National MEAL Assistant	72 months	All Outcomes	• Assist the International Technical Advisor and National Specialist for MEAL in providing staff capacity development support and implementing the MEAL Plan.
15	National Communications Specialist	72 months	All Outcomes	• Develop and implement a communications strategy. • Support all communication-related activities under the project, including knowledge sharing and management.
16	National Safeguard Specialist	72 months	All Outcomes	• Prepare and implement specific social and environmental management plans based on the ESMF (Annex 6) and Stakeholder Engagement Plan (Annex 7). • Monitor and report progress and newly arising risks.
17	National Gender Specialist	72 months	All Outcomes	• Coordinate the implementation of the Gender Action Plan (Annex 8) and Stakeholder Engagement Plan (Annex 7). • Support the project staff's and co-EE's capacity in gender mainstreaming and women's empowerment.
18	International Technical Advisor on Agrometeorology	36 months	Outcome 1	• Oversee the planning and implementation of all activities under Component 1 to ensure effective and timely sequencing of all key deliverables while meeting FAO/GCF quality standards. • Provide technical guidance on agrometeorological information production and dissemination and related capacity development activities.
19	National Agriculture Extension Advisor	72 months	Outcomes 1 and 2	• Support the beneficiary groups and public and private extension services in identifying and demonstrating appropriate climate-resilient, high-value and sustainable techniques, and technologies through various outreach and extension activities in coordination with relevant experts and government counterparts. • Coordinate Behavior Change Communication (BCC) activities under Outcomes 1 and 2 together with the National Communications Specialist.
20	National Operations Officers (Two positions - Supporting Government co-EEs)	72 months	Outcomes 1 and 2	• Support the co-EEs' (i.e., MAFF and MoE) operational activities under Outcomes 1 and 2 • Ensure all activities, including reporting, comply with PMU/FAO/GCF standards, processes, and procedures.
21	International Technical Advisor for Value Chain Development	72 months	Outcome 2	• Oversee the planning and implementation of all activities under Component 2 to ensure effective and timely sequencing of all key deliverables while meeting FAO/GCF quality standards. • Lead all value chain development activities, including PSPP establishment and marketing.
22	International Technical Advisors for Target Crops (4 positions)	221 days per position	Outcome 2	• Provide technical agronomic advisory services and crop-specific production strategies in coordination with the International Technical Advisors for Value Chain Development and Agrometeorology.
23	National Agricultural Advisor	462 days	Outcome 2	• Support the implementation of crop-specific production strategies. • Provide related capacity development support to the beneficiary groups and extension providers.
24	International Agricultural Finance Advisor	462 days	Outcome 2	• Provide strategic and technical guidance to the establishment of the FARM mechanism.
27	National Procurement/Grant Associate	72 months	Outcome 2	• Manage FARM-related procurement cases. • Handle other procurement activities under Outcomes 1 and 3, as needed.

25	Provincial Value Chain Specialists (4 positions)	72 months	Outcome 2	• Coordinate the implementation of value-chain development activities in the respective provinces.
26	Provincial Value Chain Assistants (4 positions)	72 months	Outcome 2	• Assist the Provincial Value Chain Specialists by executing administrative and operational tasks.
28	National Watershed Management Specialist	72 months	Outcome 2	• In coordination with MoE, design and implement catchment restoration and protection plans and activities with the identified CPAs and CFs.
29	National Policy Analysis Advisor	72 months	Outcome 3	• Oversee the planning and implementation of all activities under Component 3 to ensure effective and timely sequencing of all key deliverables while meeting FAO/GCF quality standards.
30	International Investment Planning Advisor	462 days	Outcome 3	• Provide strategic and technical guidance and support in developing a lending scorecard system and LAMS in coordination with other experts and government counterparts.
31	National Geographical Information System (GIS) Advisor	72 Months	Outcome 3	• Develop a geospatial information portal and data management system linking to LAMS and supporting activities under Outcomes. • Assist project activities with GIS support. • Support the co-EEs in strengthening their GIS capabilities.
32	National GIS Associate	36 months	Outcome 3	• Assist the National GIS Advisor in providing various GIS support activities.

12.4. Institutional overview

509. In its role as the AE, FAO (specifically the FAO-GCF project supervision team) will oversee and supervise the implementation of this project per the Accreditation Master Agreement (AMA) signed between FAO and the GCF. As per the GCF Monitoring and Accountability Framework and the AMA, FAO will provide the GCF with an Inception Report, Annual Performance Reports, an independent Mid-term Evaluation report, a Project Closure Report, and an independent Final Evaluation report. FAO will also provide semi-annual and annual Financial Reports throughout project implementation.

510. At the technical level, responsibility for monitoring will rest with the PMU. The PMU will monitor its progress and impacts via: (i) georeferencing of field activities, allowing clear and transparent identification of results and beneficiaries; and (ii) field data collection by the project's dedicated monitoring and evaluation (M&E) team, led by an M&E Specialist. The M&E team will deploy a combination of direct observation, participatory assessment, and pre and post-intervention survey methods at the individual, household, community, and institutional levels. There will also be independent impact evaluations, as described below.

511. These M&E mechanisms, described in Annex 11, will enable the PSC, PMU, and EEs to demonstrate the adaptive management of the project. Such practices will also be informed by its environmental and social management framework (ESMF) (Annex 6) to take anticipatory action to address risks that may negatively impact the expected results. The PMU will also track the implementation of other related plans, the gender action plan (Annex 8) and stakeholder engagement plan (Annex 7).

512. There will be a grievance redress mechanism established. The PMU will ensure that the mechanism is easily accessible for the project's stakeholders and beneficiaries. The system will follow FAO's Guidelines for Compliance Reviews, which lay out specific procedures for handling and addressing complaints related to its Environmental and Social Standards (FAO ESS, 2015), and establish a designated Safeguards Specialist as a focal person for the grievance redress system. The Safeguards Specialist will work closely with the M&E Specialist to ensure the results-based and adaptive management of the project.

513. The PMU will coordinate with the co-EEs to prepare and submit the following reports accordingly to the PSC, NDA and GCF.

- Inception report to ensure any necessary adjustments to bring the project up to date;
- Quarterly progress reports;
- Annual project performance reports; and

- Annual financial reports on GCF grant and co-finance expenditures.

514. Independent Evaluations: Following the AMA between FAO and GCF, the FAO Office of Evaluation will be responsible for the independent interim and final evaluations. The evaluations will be conducted using a question-driven approach and may include assessments against relevance, effectiveness, and sustainability criteria, among others. The interim evaluation will be instrumental in contributing – through operational and strategic recommendations – to improve implementation, setting out any necessary corrective measures for the remaining period of the project. The final evaluation will assess the relevance of the intervention, its overall performance, sustainability and scalability of results, differential impacts, and lessons learned. The evaluation should also assess the extent to which the intervention has contributed to the GCF's higher-level goal of achieving a paradigm shift in adaptation to climate change in the target value chains in the target provinces in Cambodia. Careful attention will be paid to the disaggregation of data, results, and outcomes by gender.

12. ECONOMIC AND FINANCIAL ANALYSIS

13.1. Macro-finance Analysis

515. The Social Accounting Matrix, including Environmental Accounts (SAMEA) for Cambodia (Mazzoli and Branca, 2022) was built upon several sources. The Cambodia Input-Output table of 2018, sourced from the OECD statistical database, provided the primary base for the estimation. Later, the I/O table was updated with most recent available data to ensure reliability of estimated impacts. In order to update the SAM values to most recent data using the World Bank Country Economy Data, Cambodia National Statistics Office and Asian Development Banks Statistics (ADB). Additional data were also collected from the main international organization databases the international labor organization (ILO) and the International Monetary Fund (IMF). In particular, economic data from the World Bank database on GDP and value added by economic sector and from the ADB for a disaggregation of the economic sector were used. Historical data from households' consumption and population collected by the national institute of statistics (NIS) were also used.

516. The Cambodia SAMEA for 2020 includes 94 accounts divided into:

- 10 agriculture activity sectors, including 8 sub-sectors by type of commodity produced (i.e., grains-legumes, rice, fruits, mangoes, tubers, cassava, sugarcane, other agriculture)
- 22 industry sectors
- 19 service sectors
- 1 Value added sector grouping productive factors (i.e., labor and capital)
- 11 institutional accounts represented by 10 categories of representative households differentiated as rural vs urban households and further disaggregated by per capita consumption quintiles, and the Government account
- 17 polluting substances
- 5 natural resources
- 5 environmental themes
- 4 additional accounts concerning taxes, capital formation (i.e. savings and investments), rest of the world and totals.

Sectors economic linkages and multiplier analysis in Cambodia's economy

517. Once the characteristics of Cambodia's economy are identified, we carry out a sectoral static analysis based on the multipliers' analysis of the economy (see

518. Figure 92). The latter describes how an exogenous expenditure (change) in one sector will be transmitted to the interconnected sectors on the economic system. In other words, this step of the analysis reveals which are the most reactive sectors able to either absorb or transmit further economic stimulus, thus generating higher multiplying effects in the economy.

519. The analysis also makes a distinction between the forward and backward multipliers. Forward multipliers measure the importance of a sector as a supplier of goods and services to upstream sectors. Sectors possessing low forward multipliers indicate that they sell their output mostly to final demand. Vice versa, sectors possessing high forward multipliers provide intermediate inputs to upstream industries.

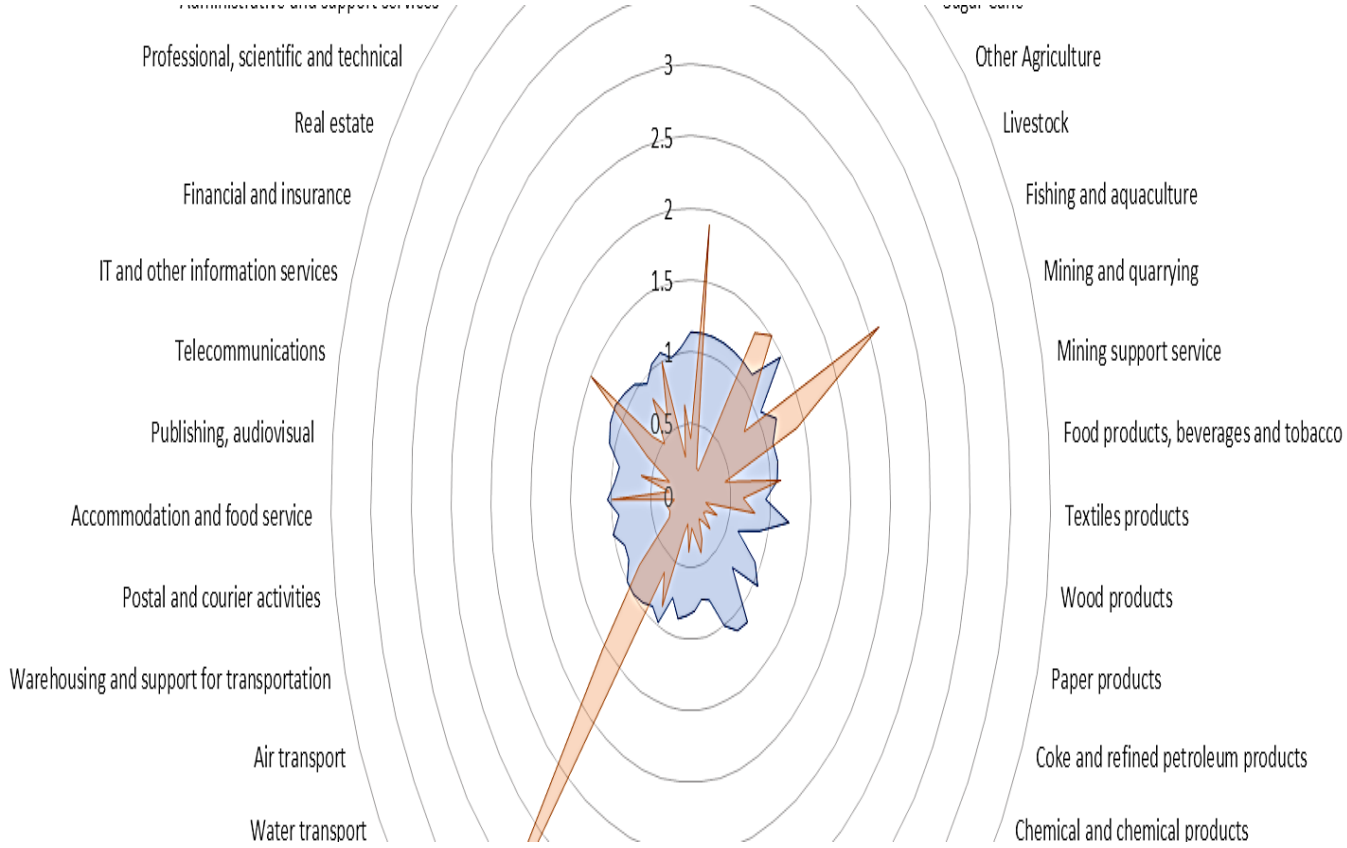
520. Backward multipliers reveal the importance of a sector as a center of demand for the rest of the economy to downstream sectors. Low backward multipliers indicate that a sector dependence on other sectors' inputs is comparatively very low (i.e. inputs are sourced mainly from imports). On the contrary, sectors with high

backward multipliers shows a stronger bond to local industries downstream, which are responsible for the supply of intermediate goods.

521.

522. Figure 92 indicates forward (in orange) and backward (in blue) multipliers with respect to all sectors included in the Cambodia SAMEA. The results show that the highest forward multipliers are in construction and in fishing and aquaculture that are relevant input suppliers to all other industries and sectors upstream. Agricultural sectors tend to show lower forward multipliers, which means they mostly sell their produce to final demand rather than agro-processing industries, exception made for rice, sugarcane and cassava. The backward multipliers in Cambodia present a more homogenous set of results.

Figure 92: Backward and forward multipliers for Cambodia



Source: Mazzoli and Branca, 2022

Quantitative results and simulations

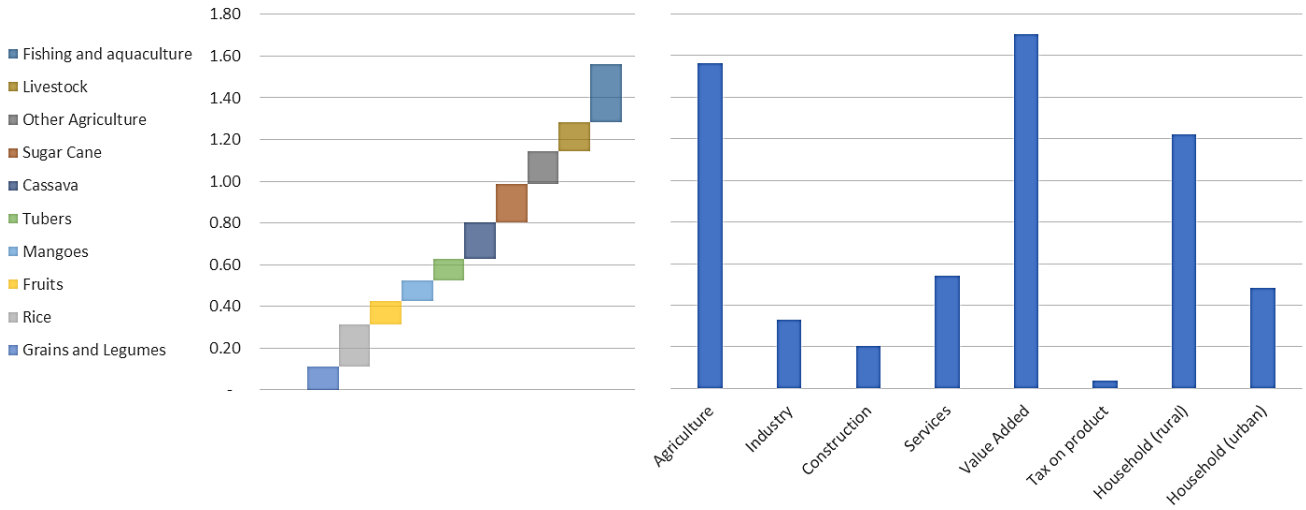
523. This section shows the effect of investments and policy reforms through two sets of simulations. The first focuses on the expected impact that a generic investment in the agricultural sector would have on the upstream and downstream markets and sectors, as subdivided in the SAM. The second simulation analyses the economic impact of implementing the set of interventions foreseen in the PEARL GCF project.

Analysis of the economic and environmental effects of agriculture expenditures

524. The first simulation aims at measuring how independent incremental expenditure in specific agricultural sectors may affect other sectors. In particular, this analysis allows to compare sector performance - in terms of multiplier effect – and to define the leverage capacity each sector expresses as a driver for growth in other sectors.

525. Figure 93 shows how a yearly expenditure in the indicated agricultural sectors (see vertical axis) of one US dollar will contribute to activate downstream-upstream related economic sectors. One primary evidence is that rural households and services are more sensitive to the initial spending in agriculture. These results can be justified observing that these two sectors are more closely connected to the agricultural sector; hence, they are those with the highest capacity to absorb the initial shock. In addition, it is worth noticing that the multiplier for the value added is equal to 1.74, meaning that for each dollar spent, an additional 0.74 dollar is generated in economy.

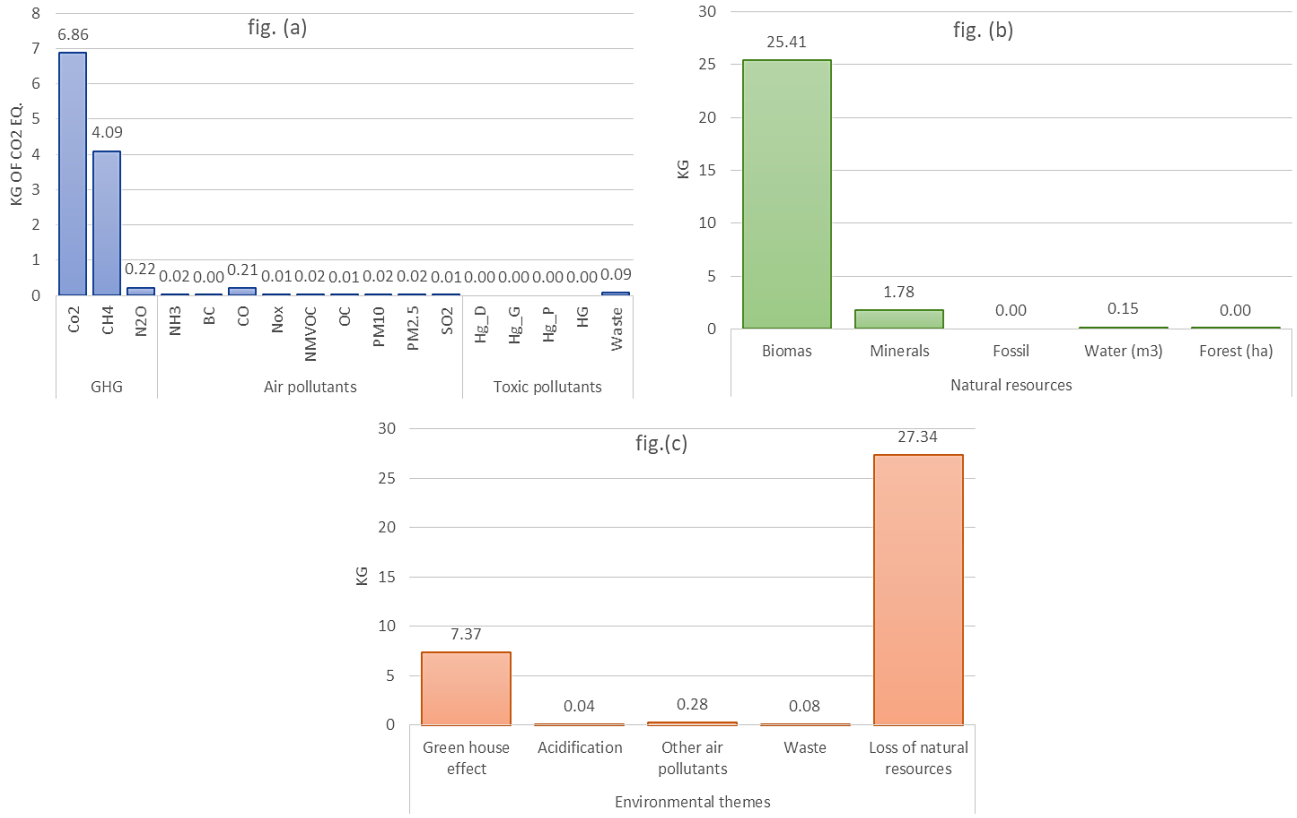
Figure 93: Economic impact of spending in agriculture (dollars)



Source: Mazzoli and Branca, 2022

526. Another interesting simulation concerns the impact and the pressure on natural resources due to the increased economic activity, within and beyond agricultural sectors. As shown in the Figure 94, a surge in spending contributes to an increase in emissions, particularly for carbon dioxide and methane (figure 93a). At the same time, an increase in spending does also increase pressure on natural resources, as shown in figure 93b. Finally, effects on the environment can be grouped based on their contribution to some of the environmental issues monitored through the environmental sub-matrices (figure 93c

Figure 94: Emissions (fig. a), natural resources usage (fig. b) and environmental themes (fig. c) linked to increase in spending



Source: Mazzoli and Branca, 2022

Short-term economic and environmental effects of the GCF Investment in Cambodia

PEARL GCF investment in Cambodia

527. To assess the macroeconomic effects of the strategic plan and policies on migration as detailed in the project documentation of the Public-Social-Private Partnerships for Ecologically-Sound Agriculture and Resilient Livelihood in Northern Tonle Sap Basin (PEARL). We considered the budget allocated and the sector of interest for each budget line. Based on the latter, we simulated the contribution to economic growth (direct and indirect impacts) that a proper implementation of the GCF project would bring about.

528. Currently, the PEARL project will be implemented over 6 years, with a total budget of USD 42.8 million. The project budget is allocated to four components as summarized in Table 34.

Table 34: Project cost by component (USD)

Project components	Allocated budget (USD)
Component 1: Farmers' capacities are enhanced to manage climate impacts and related risks	3,572,226
Component 2: Adaptive capacity of smallholder farmers and other local value chain actors, particularly women farmers and value chain actors, is increased through climate-resilient, high-value, and sustainable agriculture	33,723,180

Component 3: Enabling conditions for climate-resilient agriculture are ensured through a coherent and robust policy, legal, and institutional framework.		3,414,585
Component 4: Project management costs		2,140,240
	Total budget	**42,850,231**

Source: Mazzoli and Branca, 2022

529. This budget constitutes the economic stimulus that is required in the short run to bring returns in terms of productivity increase and sectors development. In order to simulate the economic and environmental impact of the project, the detailed PEARL budget has been re-classified according to the standards used to compile the SAMEA.

530. The harmonization procedure allows us to construct an investment matrix, which considers the expenditures occurring over the six years of implementation. It is worth noticing that the amount of resources included in the investment matrix will not match the total budget of the project. This is because the analysis accounts only for those financial resources that are invested on the national territory. Therefore, those resources spent on the international markets (e.g. international consultancy) are not included in the investment package presented in Table 35.

Table 35: PEARL GCF investment matrix - Annual expenditure (USD)

SAMEA Sectors	Y1	Y2	Y3	Y4	Y5	Y6
Grains and Legumes	56,356	35,261	33,186	32,722	32,523	32,545
Rice	93,926	58,769	55,311	54,537	54,205	54,242
Fruits	37,571	23,508	22,124	21,815	21,682	21,697
Mangoes	93,926	58,769	55,311	54,537	54,205	54,242
Tubers	37,571	23,508	22,124	21,815	21,682	21,697
Other Agriculture	56,356	35,261	33,186	32,722	32,523	32,545
Accommodation and food service activities	418,090	743,674	564,007	500,918	506,766	457,978
Air transport	41,223	36,408	27,621	33,479	28,250	29,921
Chemical and chemical products	18,215	72,861	72,861	72,861	72,861	72,861
Coke and refined petroleum products	317,129	395,756	395,756	395,756	346,614	317,129
Computer, electronic and optical equipment	68,962	145,624	4,587	4,587	4,587	4,587
Electricity, gas, steam and air conditioning supply	28,502	43,245	43,245	43,245	43,245	43,245
IT and other information services	216,961	181,333	109,095	109,095	109,095	109,095
Land transport and transport via pipelines	52,868	33,089	30,755	29,895	29,649	24,735
Machinery and equipment	2,146,515	3,577,525	1,100,777	-	-	-
Manufacturing; repair and installation of machinery and equipment	6,552	26,209	26,209	26,209	26,209	26,209
Motor vehicles, trailers and semi-trailers	50,780	6,552	6,552	6,552	6,552	6,552
Professional, scientific and technical activities	3,381,350	2,115,688	1,991,187	1,963,324	1,951,382	1,952,709
Public administration and defence; compulsory social security	1,194,209	1,276,914	1,250,378	1,241,532	1,241,532	1,241,532
Publishing, audio visual and broadcasting activities	124,853	147,163	137,728	137,728	137,728	137,728
Telecommunications	77,185	126,327	125,344	126,327	126,327	126,327
Wholesale and retail trade; repair of motor vehicles	18,870	2,457	2,457	2,457	2,457	2,457
Administrative and support services	360,373	419,344	419,344	419,344	419,344	419,344
Water supply; sewerage, waste management and remediation activities	119,578	242,433	242,433	242,433	242,433	242,433
Postal and courier activities	6,552	26,209	26,209	26,209	26,209	26,209
Other service activities	39,313	39,313	39,313	39,313	39,313	39,313
Total	**9,063,790**	**9,893,200**	**6,837,100**	**5,639,410**	**5,577,373**	**5,497,331**

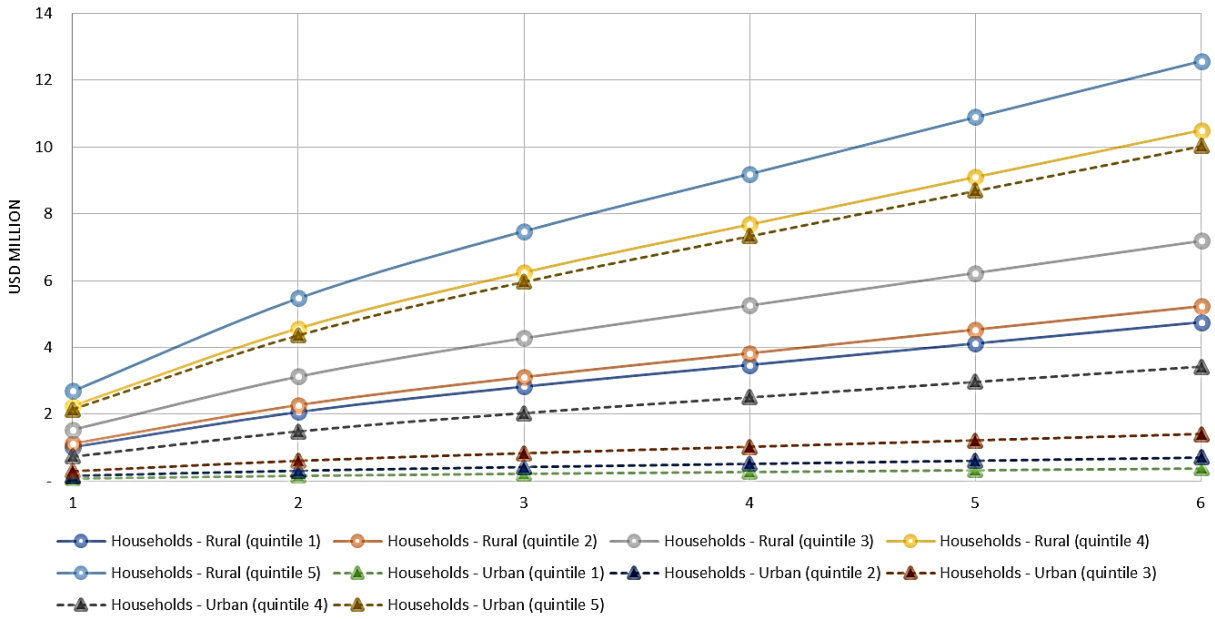
Source: Mazzoli and Branca, 2022

Analysis of the economic impact of the PEARL GCF investment

531. Economic impacts in the short run are related to the implementation of the project and of the investment plan. Over the expected enactment period, the budgetary expenditure will have an impact on national GDP, household and government incomes, per capita consumption and value added.[30] Given the structure of the SAMEA, we can also analyze economic impact on household income distribution, differentiated by wealth levels (i.e., per capita consumption quintiles) and living settings (i.e. rural or urban).

532. According to our simulation, the implementation of PEARL is expect to bring about a positive economic impact on the whole population. As shown in Figure 95, the project implementation would benefit primarily rural households and predominately the richest quintiles (fourth and fifth). However, the present value of the income generated by the project appear to be more evenly distributed across rural households, rather than within the urban household cluster (Figure 96)[31]. The present value of the cumulative government income– and composed by direct and indirect taxes on products, profits and capital – is of USD 4 million.

Figure 95: Cumulative economic impact on households' income (mil. USD)

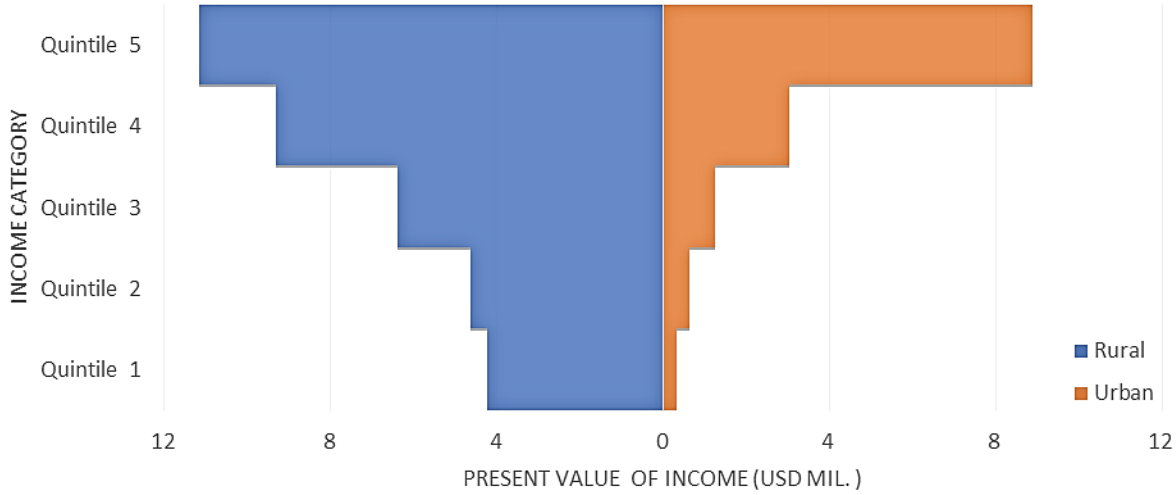


Source: Mazzoli and Branca, 2022

[30] The national GDP is measured as the sum of all value-added in the economy. Increase in the value-added denotes increase in value of production and distribution of goods and services through the introduction of production factors (capital, labour, land and livestock) from intermediate goods (raw materials and non-primary inputs). This can be calculated as the difference between the value of the goods produced and the value of the intermediate inputs used for production or, in an equivalent manner, as the value distributed to productive factors (labour and capital) and government through indirect taxes.

[31] The present value of the income is calculated as the sum of yearly incremental incomes generated during the project implementation phase, discounted at five per cert.

Figure 96: Present value of incremental income by household quintiles (USD Mil.)



Source: Mazzoli and Branca, 2022

533. The project is also expected to play a part to national GDP growth. In particular, over the six years of implementation, our simulation determined a cumulative impact on the Cambodia economy equivalent to USD 53 million, with a multiplier effect of 1.38 per USD dollar spent. Out of the total value created, USD 50.74 million are linked to the direct and indirect sectoral stimulus generated by the project. An additional USD 2.20 million are associated with incremental tax revenues for the government. [32] Therefore, the project will contribute to an annual GDP growth of 0.04 per cent and a cumulative contribution of 0.23 per cent, over the implementation period[33] .

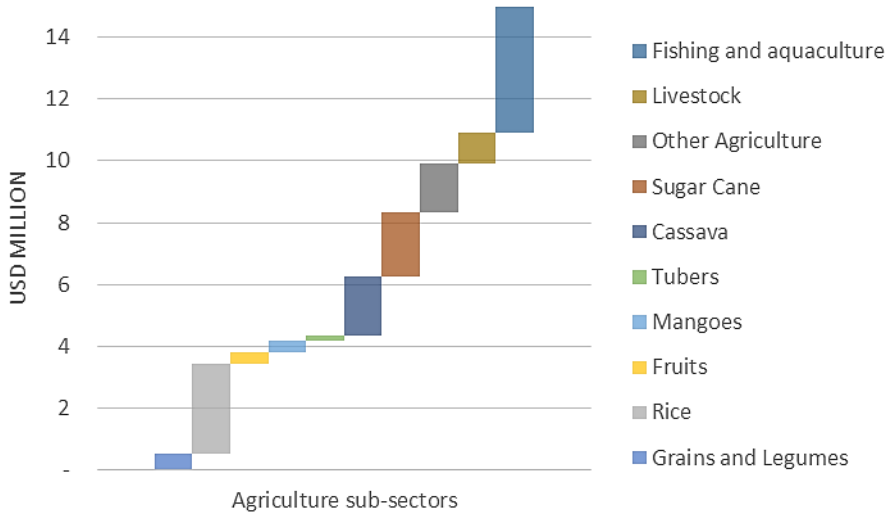
534. Concerning the effects on agriculture, the greatest impacts are registered in those sub-sectors more strongly integrated in the economy, namely: fishing & aquaculture, rice, cassava and sugar cane (Figure 97). The capacity of a sector to absorb and further replicate an economic stimulus relates directly to the forward and backward multipliers involved. As a whole, the PEARL investment will trigger a chain reaction within and beyond the agricultural sub-sectors directly supported by the initial spending. In fact, while the project budget will sustain production of organic rice, cashew, mango and vegetables – as well as investing in other service and industry sectors - the indirect economic stimulus will be strongly perceived in highly interconnected agriculture sub-sectors (e.g. fishing, cassava or sugar cane). On the national economy scale, the greatest stimulus are produced in the service sector (

535. Figure 98). A consolidated summary on the economic impact is provided in Table 36.

[32] Value are expressed in present values equivalences, discounted at five per cent.

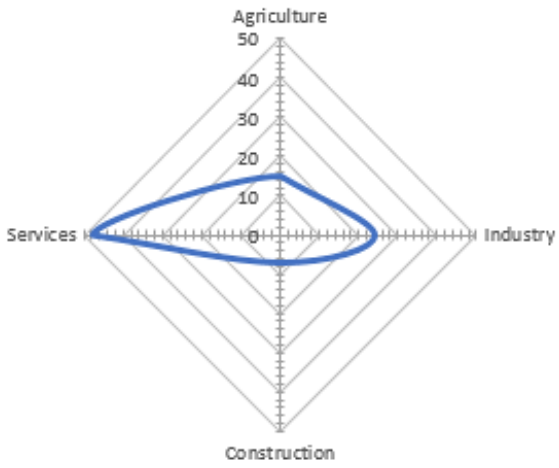
[33] According to the latest available statistics from World Bank, Cambodia GDP in 2020 was equivalent to USD 25.29 billion.

Figure 97: Cumulative economic impact on agriculture sub-sectors (present value - USD million)



Source: Mazzoli and Branca, 2022

Figure 98: Cumulative impact on main economic sectors (present value - USD million)



Source: Mazzoli and Branca, 2022

Table 36: Summary table on PEARL direct and indirect economic impact (USD million)

	Present values		Notes	Present values
Activity sectors		**Institutional sectors**		
Agriculture	14.98	Rural households	quintile 1	4.30
Grains and Legumes	0.54		quintile 2	4.73
Rice	2.88		quintile 3	6.49
Fruits	0.40		quintile 4	9.48
Mangoes	0.36		quintile 5	11.35
Tubers	0.15	Urban households	quintile 1	0.35
Cassava	1.94		quintile 2	0.64
Sugar Cane	2.06		quintile 3	1.27
Other Agriculture	1.59		quintile 4	3.09

Livestock	0.98		quintile 5	9.05
Fishing and aquaculture	4.08	Government		4.14
Industry	23.88	**GDP**		
Construction	7.00	Value added		50.74
Services	46.64	Taxes on products		2.20
		Multiplier effect	USD generated / USD spent	1.38

Source: Mazzoli and Branca, 2022

13.2. Economic and Financial Analysis

536. **Objectives.** The economic analysis objectives are to: (i) determine the economic viability and overall cost effectiveness of the Project, estimated from the perspective of the society rather than the individuals, through the comparison of aggregated economic benefits with the Project economic costs and the assessment of the economic internal rate of return (EIRR); and (ii) perform sensitivity analysis to measure the robustness of the proposed investments and to measure variations in the overall EIRR due to risk and unforeseen factors, including climatic events. Details of the economic analysis can be found in the attached Excel worksheets (Branca and Mazzoli, 2022).

537. **Methodology and assumptions.** The economic analysis is based on the estimation of the benefits gained from the increased economic performance of the households (HHs) targeted by the Project. The main quantifiable economic benefits from the Project are represented by the net incremental benefits as computed in the financial analysis, i.e., the difference between the annual net incomes in the without the project (WOP) and with the project (WP) scenarios. Such income change are the net incremental benefits of single households. They are then aggregated over the total number of household beneficiaries. The economic analysis is conducted over a 20-year period, including the 8-year Project period. Specifically, the HH models discussed in the financial analysis above are used to link the crop activity models with the number of HH beneficiaries (set as target), estimate the overall flow of benefits, and compute the EIRR.

538. Economic benefits are estimated using economic prices (instead of the financial ones). Financial prices of tradable goods are converted into economic ones using a Standard Conversion factor (SCF) computed as shown in

539. Table 37.

Table 37. Computation of the Standard Conversion factor (SCF) for the economic analysis

	M $	Source of data
1) total imports (M)	16,160	WB, 2020
2) total exports (X)	15,793	WB, 2020
3) import taxes (Tm)	2,892.7	WTO, 2022
4) export taxes (Tx)	3,948.31	WTO, 2022
SER	3,931.7	SER=(M+X)/[(M+Tm)+(X-Tx)]*OER
OER	4,066.0	
SCF	0.967	SCF=SER/OER
VAT	0.100	
SCF	0.870	SCF with VAT of 10% also applied to all tradable goods

Source: Branca and Mazzoli, 2022

540. However, for some key traded goods, specific import/export parity prices at farm gate have been computed with reference to international border prices, applying conversion factors for each category of costs, and eliminating taxes and transfers. Specifically, import parity prices are computed for fertilizers (Urea, Phosphate and Potassium Chloride) which are among key imported items, starting from the international Free On Board (FOB)prices at the nearest port and considering tariffs and taxes, marketing charges and transportation costs. Export parity price is computed for aromatic rice , the most exportable commodity among those targeted by the Project and the present analysis. Details are shown in Table 38 and

541. Table 39.

Table 38. Import parity price for key importable inputs

Commodity	Unit	Urea 1/		Phosphate 1/		Potassium Chloride	
		Financial	Economic	Financial	Economic	Financial	Economic
Price F.O.B, Annual average, 2021	$/mt	483	483	123	123	210	210
Plus:							
- Transport, insurance and freight	$/mt	102	102	102	102	102	102
- Marketing Charges (2.5%)	$/mt	12	12	3	3	5	5
Border C.I.F. price	$/mt	597	597	228	228	318	318
Riel equivalent	Riel/mt	2,428,849	2,348,613	928,495	897,823	1,291,081	1,248,430
- VAT (10%)	Riel/mt	242,885	-	120,704		167,841	
- Marketing Charges (2.5%)	Riel/mt	60,721	58,715	23,212	22,446	32,277	31,211
-Import tariff (17.9%)	Riel/mt	434,764	-	166,201		231,104	
Wholesale border price	Riel/mt	2,732,456	2,407,328	1,072,412	920,268	1,491,199	1,279,641
- Transport to regional market 2/	Riel/mt	74,800	74,800	74,800	74,800	74,800	74,800
- Transport to farmgate 3/	Riel/mt	18,700	18,700	18,700	18,700	18,700	18,700
- Marketing charges (2.5%)	Riel/mt	68,311	60,183	26,810	23,007	37,280	31,991
Farm Gate Import Price	Riel/mt	2,894,267	2,561,011	1,192,723	1,036,775	1,621,979	1,405,132
Farm Gate Import Price	Riel/kg	2,894	2,561	1,193	1,037	1,622	1,405
% of nutrient in product	%	0.46	0.46	0.45	0.45	0.60	0.60
Input subsidy (0%)	Riel/kg	-	-	-		-	
Farm gate market price	Riel/kg	6,292	5,567	2,650	2,304	2,703	2,342
Conversion Factor			0.88		0.87		0.87
1/ Urea: E.Europe; Phosphate: rock.							
2/ 400 km @ $ 0.046 $ per-ton/Km = 187 Riel per-ton/Km							
3/ 100 km @ 187 Riel per-ton/Km							

Source: Branca and Mazzoli, 2022

Table 39. Export parity price for exported output

Commodity	Unit	Aromatic rice	
		Financial	Economic
FOB price at port of arrival	$/mt	825	825
Maritime Fret	$/mt	50	50
International Insurance (2% of FOB price)	$/mt	17	17
Exchange rate	Riel/$	4,066.0	3,931.7
CIF price at port of departure	Riel/mt	3,287,361	3,178,764
Export duties (25% of CIF)	Riel	821,840	794,691
Handling (2.5% of CIF)	Riel	82,184	82,184
Storage fee (1% of CIF and duties)	Riel	41,092	39,735
Port fee (50 % of the storage fee and handling fee)	Riel	61,638	60,959
Transportation cost from farm to port	Riel/mt	493,104	493,104
Price at the farm gate	Riel/mt	1,787,503	1,708,091
Price at the farm gate	Riel/Kg	1,788	1,708
Conversion Factor		0.96	

Source: Branca and Mazzoli, 2022

542. The economic analysis links social discount rates to the long-term growth prospects of the country where the project takes place. Historically, sustained real per capita consumption growth rates ranging from 0% to 5% per year have been most observed. This implies discount rates ranging from 0% to 10% per year[34]. The midpoint of this range is chosen as a benchmark value, as also

[34] See 'Technical Note on Discounting Costs and Benefits in Economic Analysis of World Bank Projects', The World Bank, 2010

recommended by the World Bank[35]. This is also in line with the economic growth in Cambodia (GDP has grown on average by 5.06% in the past 5 years (see

543. Table 40). Also, an economic cost of labour of 16,344 Riel/day (computed using the SCF reported above, starting from the financial cost of 21,779 Riel/day) is used as a wage shadow rate.

Table 40. Cambodia: GDP growth rate

Year	%
2016	6.933
2017	6.977
2018	7.469
2019	7.054
2020	-3.148
Average	5.06

Source: Branca and Mazzoli, 2022

544. **Direct project beneficiaries and flow of benefits**. Project activities will directly target 450,000 households located in the project area, according to the implementation phasing hypothesized in Table 41. However, in line with the conservative approach followed in this analysis, it is assumed that not all the target beneficiaries will adopt the proposed climate-resilient management technologies and cropping patterns discussed above. The real adoption rate by year is also shown in Table 41. Overall, it is expected that at least 274,500 HHs will adopt the proposed innovations, corresponding to 60% of the target beneficiaries. To compute the flow of direct benefits of the Project, the net incremental benefits of single households are aggregated over the total number of household beneficiaries according to the phasing reported in Table 41. In this way, benefits are estimated in a very conservative manner.

Table 41. Number of HHs adopters

Targeted households		**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Y6**	**TOTAL**
Project phasing	%	14%	26%	22%	14%	13%	12%	100%
Hypotethical targets (incremental)	Nr. HH	61,511	114,943	99,644	61,730	56,817	55,354	450,000
Adoption rate	%	25%	40%	55%	65%	80%	95%	60.0%
Adopters (incremental)	Nr. HH	15,378	45,977	54,804	40,124	45,454	52,587	254,324

Source: Branca and Mazzoli, 2022

545. **Indirect project beneficiaries and benefits.** There will also be large numbers of smallholders who will benefit indirectly from the Project through diffuse knowledge of improved crop production. Consumers would also benefit from more, better quality agriculture products and better prices, with positive effects in terms of improved nutrition and overall food security. In addition to this, all those living in the rural areas where supported households will be located will benefit from strengthened local economies resulting from inflows of income and strengthened local demand. There will also be increased job opportunities for unemployed and underemployed women and men living in rural areas. The expansion of crop production will also promote development of other complementary economic

[35] See the note prepared by Marianne Fay et al. on Discounting Costs and Benefits in Economic Analysis of World Bank Projects. May 9, 2016. "Where no country-specific growth projections are available, we suggest using 3% as a rough estimate for expected long-term growth rate in developing countries. Given reasonable parameters for the other variables in the standard Ramsey formula linking discount rates to growth rates, this yields a discount rate of 6%. Where there is reason to expect a higher (lower) growth rate, a higher (lower) discount rate should be chosen. The extreme case of a sustained 6% annual per capita growth over the project lifetime would yield a discount rate of 12%."

activities of a wide range of inputs and outputs market agents. Thus, the Project activities will indirectly stimulate the whole rural economy benefiting rural population (including the rural poor) through increased demand for goods and services, additional employment opportunities and possibly reduced rural-urban migration. However, these indirect benefits are not considered in this analysis. In this sense, benefits computed here should be considered an underestimation of total potential benefits of the proposed investments.

546. **Economic Project Costs.** Total project financial costs, invested over 6 years, are derived from the budget of the project proposal. They amount at about USD 42.8 million including co-finance. Such financial costs have been converted into economic cost using the SCF shown above, obtaining about USD 37.92 million. Operating costs (e.g., farmer field schools, input starter packs, knowledge and information material and dissemination activities) are hypothesized equal to 5% and are included from Year 7 to 20, as it is assumed that these costs will have to be incurred if the benefits of the Project are to be sustained in the longer run. To avoid double counting of the costs, only the incremental economic costs of the Project are considered (i.e., the costs of activities funded by the project). Costs already included in the estimation of the net incremental benefits of the crop models (e.g., costs directly borne by farmers engaging in the proposed activities or the Project and accounted for in the models) have been excluded as they are incorporated in the aggregation of the HH/activity models.

547. **Project performance indicators (EIRR and NPV)**. The following profitability indicators of the proposed investments are computed as the *Net Present Value* (NPV) and *Economic Internal rate of Return (EIRR)*. The expected EIRR is computed to illustrate the need for GCF funding and overall cost effectiveness of the project from the social perspective. The overall EIRR of the Project is estimated at 45.8% (base case) which is well above the opportunity cost of capital confirming the economic justification of the Project from the social standpoint. Since the adoption rate is assumed to be only 60% of target farmers, in case of higher adoption rates, the EIRR will increase further. In addition to this, the analysis only considered the economic benefits at farm-gate. The indirect benefits to upstream and downstream actors in the value chain from increased trade volumes, quality and value adding opportunities beyond those mentioned above, have not been considered due to estimation difficulties. The economic NPV is estimated at about USD 84 million over the 20-year period of the analysis, with the benefit stream based on the quantified benefits as specified above. The discount rate adopted in the economic analysis is 5%, as discussed above.

548. **Sensitivity Analysis**. To test the robustness of the above results, a sensitivity analysis has been carried out to incorporate the forecasted impact of climate change on agriculture productivity under the WOP scenario and to measure variations due to unforeseen factors and relevant risks. The climate change impacts modelled into the analysis is aligned with the overall climate change rationale for the Project. Indeed, the extreme complexities of downscaling global climate models and the uncertainty of projecting climate variables in monsoonal geographies are acknowledged here. The sensitivity analysis takes all this into account by simulating the following scenarios: 10 and 20% cost over-run, benefits increment, benefits decrease, and 1 and 2 years of benefits delays. Results are presented in Table 42. It is found that the proposed project is robust from the economic standpoint, since the project is profitable under all simulated changes. The table also shows that the minimum number of adopters required to have a positive NPV (break-even point) amounts to 157,988 HHs, corresponding to an adoption rate of about 31%.

Table 42: Results of the economic and sensitivity analysis

Performance indicators	Base case	Cost increments		Benefits increments		Benefits decrease		Benefits delay	
		+10%	+20%	+10%	+20%	-10%	-20%	1 year	2 year
EIRR	**45.8%**	40.0%	35.4%	52.4%	59.3%	39.5%	33.4%	31.1%	38.1%
NPV @ 5% (000 $)	**84,083**	44,834	41,966	55,338	62,975	40,063	32,426	39,311	45,567

Break-even point (adoption rate)	
Minimum number of beneficiaries to have a positive NPV (HH)	157,988
Corresponding adoption rate (%)	31.3%

Source: Branca and Mazzoli, 2022

549. **Risk analysis.** The bulk of risk to be considered in the sensitivity analysis relates to: a) delays from some of the institutions charged with the responsibilities of implementing and/or overseeing the implementation of some of the Project activities; b) farmers reluctant to fully engage in the Project and adopt the farming practices disseminated; c) worsening of the macroeconomic scenario; d) increased climatic risk affecting temperatures and water availability consequent to climatic changes; and d) discontinuation of practices once the project ends. **Error! Reference source not found.** reports the impact of each of the key risk components on Project economic performance indicators. The probability of occurrence is supposed to affect the entity of cost/benefit increases/decreases reported above, i.e., a low probability translates into a 10% decrease in benefits (or a 1-year delay in benefits), while a medium probability is supposed to determine 20% benefits decrease (or a 2-years benefits delay). It is important to notice that these impacts should be considered as indicative and are based on the information available in the literature and in the feasibility study.

Table 43: Risk Analysis

Risk description	Probability of occurrence	Proxy to compare with sensitivity analysis results	EIRR (%)	NPV (000 $)
INSTITUTIONAL: Limited Institutional capacity	Low	Benefits delay 1 year due to implementation risk	31.1%	39,311
ECONOMIC: Worsening of the macroeconomic scenario	Medium	Increase in costs due to the enhnaced input costs	35.4%	41,966
SOCIAL: Farmers reluctant to fully adopt the farming practices disseminated	Low	Decrease in benefits due to the lower adoption rate	39.5%	40,063
CLIMATIC: increased risk affecting temperatures and water availability	Medium	Increase in benefits due to the worsening of the WOP scenario	59.3%	62,975
POLITICAL: Discontinuation of practices once the project ends	Low	Decrease in benefits due to the suspension of climate-resilience practices and benefits capitalization	39.5%	40,063

Source: Branca and Mazzoli, 2022

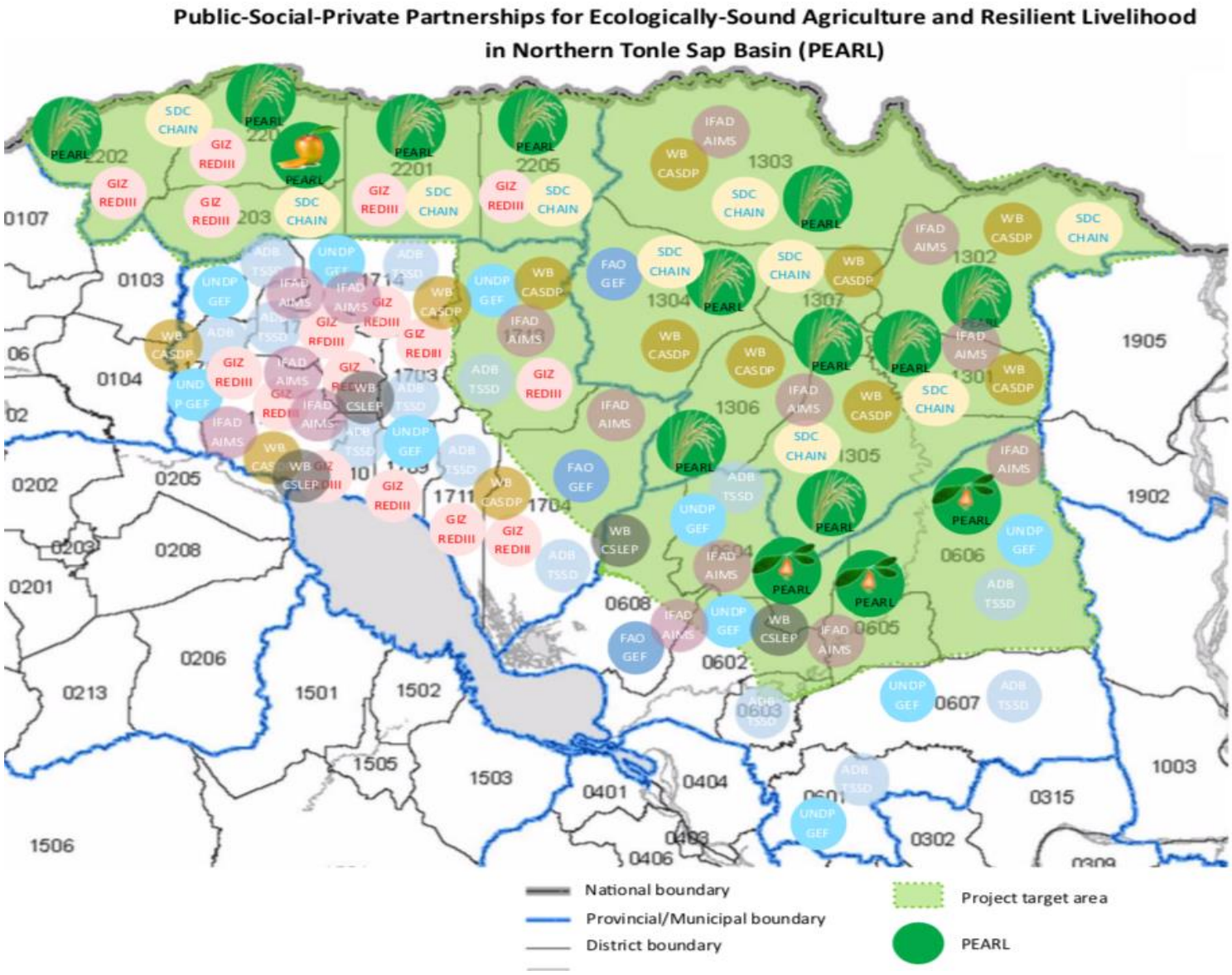
Conclusions

550. Overall, our analysis has shown that a wide adoption of climate-resilient and improved farm management would have important financial and economic benefits in the form of better on-farm returns which can support smallholder farmers becoming more market-oriented, with expected positive results in terms of overall HH's livelihood and reduced poverty. The financial analysis demonstrates that, due to the implementation of project activities, household beneficiaries would increase their financial annual net incomes by 28%. The aggregate Financial Internal Rate of Return (FIRR) is 38.7%, well above the opportunity cost of capital, showing the financial effectiveness of the

planned activities and providing a strong justification for the GCF grant request. Such rate is expected to increase e.g., up to 50% in case of benefits increments by 20% (plausible given the conservative analytical assumptions) confirming the convenience of the proposed investments even with higher opportunity cost of capital. The financial analysis also shows that the aggregate NPV is USD 73.1 million, confirming the attractiveness of the proposed investments.

551. The economic analysis has confirmed the robustness of the investment, from the society's standpoint: overall EIRR of 45.8% even in the case that only 60% of the targeted beneficiaries would adopt the proposed climate-resilient agricultural practices and cropping patterns. The results are strongly positive as shown in the sensitivity and risk analyses for adverse situations as cost over-runs, reduction of prices for their agricultural products, and even reduction in the rate of adoption; as well as for all the risk categories, included the climatic risk. These indicators - while monitoring performance during the implementation of the Project - can provide valuable information for adjusting the strategy and interventions to improve the Project impact.

Annex I: Baseline Investments



Kampong Thom

501	Baray
502	Kampong Svay
503	Stueng Saen
604	Prasat Ballangk
605	Prasat Sambour
606	Sandan
607	Santuk
608	Stoung

Preah Vihear

1301	Chey Saen
1302	Chhaeb
1303	Choam Ksant
1304	Kuleaen
1305	Rovieng
1306	Sangkum Thmei
1307	Tbaeng Mean Chey
1308	Preah Vihear

Siem Reap

1701	Angkor Chum
1702	Angkor Thum
1703	Banteay Srei
1704	Chi Kraeng
1706	Kralanh
1707	Puok
1709	Prasat Bakong
1710	Siem Reap
1711	Soutr Nikom
1712	Srei Snam
1713	Svay Leu
1714	Varin

Oddar Meanchey

2201	Anlong Veaeng
2202	Banteay Ampil
2203	Chong Kal
2204	Samraong
2205	Trapeang Prasat

Table 44: Key Baseline Investments in relation to the barriers and interventions

Barrier	Relevant Existing Initiative/Support Network	Geographical Area within NTSB	Thematic Area of Intervention	Proposed Project Intervention/Coordination
Lack of reliable and accessible agro-hydrometeorological forecasts and related advisory services to address the anticipated decline in agricultural productivity. Lack of awareness and climate-resilient options.	1. Agricultural Sector Diversification Project, WB (loan): US$ 91.67 mil with US$ 10 million in counterpart financing; Duration: 2019 - 2025	12 provinces: Battambang, Mondulkiri, Stung Treng, Ratanakiri, **Preah Vihear**, Kampong Cham, Tboung Khmum, Kratie, **Siem Reap,** Kandal, Kampong Speu, and Kampong Chhnang.	Development of diversified agricultural value chains through: 1) Enabling agricultural diversification; 2) Supporting public infrastructure; and 3) **Improving agriculture information system and quality management** (including early warning systems, standards and market advisory).	- Development of end-to-end early warning systems that are geared towards the agriculture sector to provide site and crop-specific hydrometeorological forecasts and related warnings (i.e., for pest and disease) and advisories for farmers and other value-chain actors (i.e., farm management and market information), as the current early warning efforts are mainly for general disaster prevention purposes; and - Scaling-up of vulnerability and risk assessment tools (i.e., Vulnerability Reduction Assessment (VRA) and Hazard, Vulnerability and Capacity Assessment (HVCA) tools) developed by existing initiatives to support local disaster planning and preparedness efforts
	2. Strengthening **climate information and early warning systems** in Cambodia to support climate resilient development and adaptation to climate change, UNDP (LDCF-GEF), US$ 4.9 million; Duration: 2015 – 2019	**Preah Vihear, Kampong Thom**, Kampong Speu, Kandal, Phnom Penh, Takeo, Kampot, Kep, Preah Sihanouk Ville and Koh Kong.	Supporting MOWRAM in re-installing / re-functioning a total of 24 **Automatic Weather and Agrometeorological Stations** (AWS) and 55 **Automatic Hydrological Stations**/ AHS (covering Surface and Ground Water). The project is also implemented with the MAFF and National Committee for Disaster Management (NCDM).	
	3. "Building disaster-resilient communities" Action Aid, Oxfam, Save the Children, People in Need & DanChurchAid (ECHO-EC), EUR 1.2 million for 2012-2014 and additional EUR 1 million for 2017-2018; Duration: 2012 -2018	Including **Kampong Thom**	Voice-based **early warning system**, reaching about 65,000 people	
	4. Tonle Sap Poverty Reduction and Smallholder Development Project (TSSD), NCDD & MAFF (ADB, IFAD, Finland), US$ 55 million; Phase 1 Duration: 2010 – 2017,	**Siem Reap**: 9 districts out of 12 districts, 58 communes out of 100 communes and 362 villages out of 909 villages **Kampong Thom**: 6 districts out of 8 districts and 45 communes out of	Block grants for the development and upgrading of small-scale rural infrastructure to support higher agricultural productivity with the investments identified in the CIPs. **Supporting small-scale rural infrastructure development, including tertiary distribution system**s as **well as flood control and drainage**	

	US$ 60 million; Phase 2 Duration: 2018- 2022	81 communes, and 276 villages out of 765 villages	**works**, structures to protect and conserve natural resources, and construction/rehabilitation of farm-to-market roads, DRR related works. Also, the Good Agricultural Practices (GAP) are being promoted through the farmer field school, and marketing support for GAP producer groups.	through commune development and investment plans (CDPs and CIPs), as they offer great potential for institutionalizing a harmonized approach to disaster risk management to reduce climate-related disaster risks, loss and damage, particularly in the context of agriculture. **Coordination with Co-financing/Baseline investments:** - Establishment of data and hardware/software sharing agreements with co-financing and baseline investments to improve compatibility and extended coverage and application of early warning and forecasting systems particularly in Siem Reap and Kampong Thom where several initiatives provide support that aims to increase early warning and forecasting capacities. - Coordination among these initiatives should move towards the
	5. "Community Based Adaptation Programme (CCBAP)", UNDP (Sweden, Australia), US$ 4.5 million, Duration: 2010 – 2015	National	**Vulnerability Reduction Assessment (**VRA) process was developed. VRA information and recommendations made are to be integrated into Commune Development Plans (CDPs) and Commune Investment Programmes (CIPs)	
	6. "Strengthening Coordination for Management of Disasters", ADB (including ECHO-EC), US$ 2.35 million; Duration 2014 - 2016	National	Guideline for mainstreaming DRR into sub-national development plans was developed, including a risk assessment tool, called (**Hazard, Vulnerability and Capacity Assessment** (HVCA)	
	7. "Community-Based Disaster Risk Reduction", ADB (Japan), US$ 2.5 million; Duration: 2014 - 2017	**Siem Reap** (Puok, Krolanh and Chikreng districts, total 9 communes, 3 communes for each district) **Kampong Thom** (Kampong Svay, Prasat Sambou and Sandan districts, total 9 communes, 3 communes for each district),	Disaster management capacity building of local government units (6 provinces, 18 districts and 54 communes) and mainstream disaster preparedness, disaster **risk reduction and climate change adaptation into the local development planning process** – including community-based DRR and CC adaptation.	
	8. Promoting Climate-Resilient Livelihoods in Rice-Based Communities in the Tonle Sap Region, FAO(LDCF-GEF), US$ 8.9 million; Duration: 60 months (under planning)	Five provinces: Pursat, Battambang, Banteay Meanchey, **Siem Reap and Kampong Thom** (southern rice production areas of the two provinces along the Tonle Sap Lake)	Support to increase climate resilience of vulnerable smallholders in **rice-based** communities faced by increasing climate impacts by: 1) improving the enabling environment (including the availability of water for irrigation, **weather forecasting and agro-met services**); 2) promoting climate-resilient on-farm practices (commercialization and value-addition); and 3) improving the resilience, efficiency and profitability of the	

			rice value chain (participatory guarantee systems, fair trade, IBIS Rice, etc.).	establishment of a national system.
Lack of options for climate-adapted, sustainable, higher-value and diversified agriculture and access to technical and financial support/ resources by farmers and local communities	9. Sustainable Landscape and Ecotourism Project, WB (loan): US$ 50.66 million with US$ 2.5 million in counterpart financing; Duration: 2019 - 2025	Parts of seven provinces located in the Cardamom Mountains-Tonle Sap Landscape in Cambodia—Pursat, Koh Kong, Battambang, Kampong Speu, **Kampong Thom, Siem Reap,** and Kampong Chhnang, with project activities, focused in Tonle Sap Biosphere Multiple Use Area; Phnom Sankos, Phnom Aural, and Tatai Wildlife Sanctuaries; Central Cardamom Mountains and Southern Cardamom Mountains National Parks; and the Cardamom BCC.	Support to protected areas management, and promotion of eco-tourism opportunities and non-timber forest product value chains in the Cardamom Mountains-Tonle Sap landscape through: 1) Strengthening of the capacity for Protected Areas (PAs) landscape planning and management (sustainable financing through PES and REDD+); 2) **Strengthening of opportunities for eco-tourism and NTFP value chains**; and 3) improving access and connectivity to and within the target areas.	- Promotion of agricultural certification programs in the NTSB through integrated landscape and value-chain approaches to incentivize climate-resilient, sustainable, higher-value and diversified production and processing. **Coordination with Co-financing/Baseline investments:** - Partnership agreements with co-financing/baseline investments to ensure coherence and additionality of the project interventions.
	10. Agricultural Value Chain Infrastructure Improvement Project, ADB (loan): US$ 67.83 million; Duration: TBD	Kampong Cham, **Kampong Thom, Otar Meanchey, Preah Vihear, Siem Reap**, Tboung Khmum	Addressing the core sector problem of low productivity, low value addition, and low resource efficiency of Cambodia's agriculture with the following outputs: (i) post-harvest and logistic facilities strengthened; (ii) agricultural production and service infrastructure improved; (iii) rural connectivity and disaster risk management capacity improved; and (iv) **business partnership among value chain stakeholders enhanced** (see detailed description of the outputs in the concept paper).	
	11. "Farmer and Nature Net (FNN)": A nationwide network established in	945 FOs members from 16 provinces including **Kampong Thom and Siem Reap** with a total of	Support to smallholder farmer groups through ecological agriculture development, **self-help savings and credit, dissemination of new**	

	2003 with support of CEDAC	57,666 household members (38,041 women).	**technologies and market information**, value chain development and market linkages. Total savings worth US$ 26,599,306.	
	12. Family Agriculture Enterprise in Cambodia (FAEC), Federation of Farmer' Organizations (FO), support from ADG.	34 Agriculture Cooperatives and 26 Farmer Associations as members, with total 3,865 household members (2,226 women) from 9 provinces, including **Kampong Thom.**	Development and implementation of FOs' strategic, business plans, **accounting systems and internal control systems, capacity building of FOs in ecologically sound farming, market links** and lobbying for enabling policy	
	13. Federation of Cambodian Farmer Organizations for Development (FCFD), support from AVSF	70 FOs members (5,000 households) from 5 provinces, including **Kampong Thom, Siem Reap**	Support to FOs through strengthening capacity, building technical skills, communication capacity and partnerships for **agro-processing and market linkage** as well as contributing. Lobbying for enabling policy.	
	14. Preah Vihear Meanchey Union of Agricultural Cooperative (PMUAC), support from AVSF	**Preah Vihear**	Facilitation of organic certification and organic rice trading between its agricultural cooperative members and rice millers for t**he export of certified organic rice** to the EU and US markets.	
	15. Cambodia Rice Federation (CRF)	National	213 members representing the rice exporter federations, farmer federations, rice miller associations, rice exporter companies, logistics companies, etc.	
	16. Accelerating Inclusive Markets for Smallholders (AIMS), IFAD, US$ 6.1 million; Duration: 2017 - 2022	National - There are expected to be 75,000 direct household beneficiaries from the project within increased household assets of at least 25%	Support to smallholder farmers **to increase returns from farming**, including poorer farmers and youth, through efficient public sector investment. Target value chains: i) quality assured rice; ii) vegetables; iii) backyard chicken; iv) cassava; and v) raw silk.	
	17. Regional Economic Development (RED III), GIZ (BMZ & Swiss Federal Department of Foreign Affairs), US$ … Duration: 2014- 2018, Phase II: 2018-2022	**Siem Reap, Oddar Meanchey and Preah Vihear** to be added from 2018.	Support to the rural poor - especially women – increasing sustainable business and employment opportunities for poverty reduction. It employs a value-chain approach (rice, vegetables, cassava, chicken) as well as pro-poor tourism (handicrafts and bamboo), and improve the capacity of local governments for economic development and inclusive development.	

	18. Empowerment of Civil Society in Oddar Meanchey (CISOM II), ADDA (Denmark), DKK 5 million; Duration: 2016 -2019	**Oddar Meanchey**	**Development of agricultural cooperatives (ACs) and self-help groups** (SHGs) into strong civil society organisations; improvement of business activities and income of poor people in SHGs and ACs. Lobbying for enabling policy.	
	19. Cambodia Agricultural Value Chain Program (CAVAC) Phase II, CARDNO, (Australia), AU$ 89 million	National	Support to small farmers and trade in milled rice and other crops by strengthening market systems and investing in irrigation infrastructure for: (1) **Increased income for smallholder farmers**; and (2) Increased trade in milled rice and other crops.	
	20. Agriculture Services Programme for Innovation, Resilience and Extension (ASPIRE), IFAD, US$ 82 million; Duration: 2014 - 2021	National with 5 target provinces including Preah Vihear, and will expand into the five provinces under the Project for Agricultural Development and Economic Empowerment (PADEE) in 2018, but no NTSB provinces	**Improvement of extension services** available to smallholder farmers, especially those poor and vulnerable smallholder farmers to increase their income.	
	21. Small-Scale Farmer Inclusion in Organic Agriculture Development through Participatory Guarantee Systems, FAO (TCP)	Countries in the region including Cambodia	Support to **organic agriculture through promotion of Participatory Guarantee Systems** (PGS)	
	22. Cambodia Horticulture Advancing Income and Nutrition Project (CHAIN), SNV, Swisscontact & AVRDC (SDC), CHF 3.6 million; Duration: 2014 - 2017, Phase II: 2018-2022	Including **Oddar Meanchey, Preah Vihear**	Support to smallholder farmers to increase their income and food security - **increase income of 15,000 homestead farmers**, 3,000 commercial farmers, 1,200 processors and improved household food security and nutrition for 72,000 households.	
	23. Forest Investment Program - Project 2: Reforestation and Production Forests through Public Private Partnerships, ADB (WB), US$ 24 million, Duration: 2019 - 2023	**Siem Reap and Preah Vihear**	Support to meeting future demands for wood products, including fuelwood, and reduce pressure on natural forests by increasing investments in wood products from production forestry. It aims to: 1. Increase community engagement in production forestry; and 2. Provide technical and financial support to	

			develop new livelihood opportunities, and to adopt sustainable farming practices.	
	24. Feed the Future Cambodia Harvest II, Abt Associates iDE, Emerging Markets Consultants, and InSTEDD, US$ 17 million; Duration: 2017-2022	Including **Kampong Thom and Siem Reap**	Acceleration of growth in the **horticulture sector using a targeted, buyer-led approach** through encouraging and supporting commercial development and healthy competition among value-chain actors to expand into the domestic and international markets.	
Poor farming and natural resources management practices	25. "Life and Nature", FAO (GEF), US$ 5.2; Duration: 2015 - 2019	Including **Kampong Thom, Siem Reap, Preah Vihear**	Adaptation and mitigation of climate change and associated risks through the **development of watershed management plans, assistance to replant vegetation and trees** along streams, rivers, and forested areas, as well as building small scale water retention and irrigation structures. Through the Farmer Field School. a Climate Smart Agriculture Curriculum is being developed and tested.	- Promotion of integrated environmental management approaches (e.g., rice-fish system, integrated production, pest and pollution management and monitoring, landscape restoration) to restore and maintain ecological functions that are vital to climate-resilient farming practices and agricultural certification processes at the landscape level. **Coordination with Co-financing/Baseline investments:** - Partnership agreements with co-financing/baseline investments to ensure coherence and
	26. "Reducing the vulnerability of Cambodian rural livelihoods through enhanced sub-national climate change planning and execution of priority actions", UNDP (GEF), US$ 4.5 million; Duration: 2015 onwards	**Kampong Thom and Siem Reap** (specific district/communes/villages TBD).	Reduction of climate vulnerability of rural communities, especially land-poor, landless and/or women-headed households through investments **in small-scale water management infrastructure, technical assistance to resilient agricultural practices**, and capacity building support.	
	27. Tonle Sap Poverty Reduction and Smallholder Development Project (TSSD), NCDD & MAFF (ADB, IFAD, Finland), US$ 55 million; Phase 1 Duration: 2010 – 2017, US$ 60 million; Phase 2 Duration: 2017- 2020	• **Siem Reap:** (see above for more details) • **Kampong Thom:** (see above for more details)	Support to more than 630,000 households through (i) improved rural infrastructures to support agricultural productivity, market access, and the quality of life in rural communities; (ii) **improved capacity of smallholder farmers to increase agricultural productivity;** (iii) improved agricultural policy environment, (iv) improved availability and access to quality seeds; (v) increased access to agricultural information and market data.	

	28. Enhancing Climate Change Resilience of Rural Communities Living in Protected Areas, UNEP (GEF), US$ 4.9 million; Duration: 2013- 2019	Including **Siem Reap**	Ecosystem-based adaptation through restoring a variety of plant species of degraded forests**; enrichment planting of rice paddy boundaries and other cultivated areas with multi-use tree species to enhance productivity**. Piloting of drought-tolerant hybrid rice varieties and diversification through home gardens systems.	additionality of the project interventions.
	29. Boosting Food Production (BFP), GDA (Cambodia), US$ 20 million, 2016-2018	Including **Kampong Thom and Siem Reap**	Support to quality improvement of fragrance rice and make selected domestic vegetable commodities more competitive and cheaper.	
	30. Integrated Pest Management - Innovation Lab (IPM-IL), IDE & CADF (USAID), US$ 500,000; Duration: 2016-2019	Regional countries including Cambodia (including **Siem Reap**)	Promotion of ecologically based participatory IPM with a focus on **insect pests, pathogens, and weeds of tomato, eggplant, cabbage, cauliflower, beans.**	
	31. Feed the Future Cambodia - Rice Field Fisheries Phase II, WorldFish (USAID); US$ 7 million, Duration: 2016 – 2021	134 sites in the Tonle Sap region including **Kampong Thom and Siem Reap.**	Improvement of **food and nutrition security of poor and vulnerable rural households** through enhancing the productivity of rice field fisheries systems and promoting more efficient and equitable use of water in CFRs to increase productivity and availability of food.	
	32. Commercial Development and Strengthening of Horticulture (CODES), IDE (NZAD)	Including **Oddar Meanchey**	Value chain **development of vegetables and other high value commodities** such as melon.	
	33. Pilot program to improve the resilience of communities to hunger, ACF(Google)	**Preah Vihear**	Promotion of sustainable solutions driven by communities, equipping them with vital skills, partnerships, and tools to fight undernutrition through **sustainable agro-ecological practices** that are climate resilient.	
	34. ASEAN Sustainable Agrifood Systems (SAS), GIZ (BMZ); Duration: 2013 - 2017	National	Implementation of the 'ASEAN Guidelines on the Regulation, Use, and Trade of Biological Control Agents (BCA)' to **harmonize of regulations of BCA, and thus stimulate the availability and usage of BCA as alternative to chemical pesticides**.	

	35. Developing Sustainable Agriculture for Smallholder Farmers in Siem Reap Province Cambodia, APICI Project-GRET, Duration: 2014-2017, extended to 2021	2000 smallholder farmers in 50 villages, 7 communes, located in two districts Sotr Nikum and Prasat Bakong **in Siem Reap**	Improvement of the livelihood of smallholder farmers through intensification and diversification of agricultural production and the strengthening of producers' groups. Specific strategies include: 1. **Promoting System of Rice Intensification (SRI)** principles; 2. Intensifying and diversifying vegetable production; 3. Scaling up chicken production; 4. Improving peri-urban market linkages; 5. Developing village-level saving groups; 6. Improving access to water and effective use.	
	36. Water and Agriculture Sector Project Phase II, MoWRAM (AFD)	Rehabilitation and upgrading of the existing irrigation and drainage systems covering 8,000 ha in 9 selected provinces including **Siem Reap, Kampong Thom and Preah Vihear**	Improvement of local livelihoods with improved water and natural resources management through sustainable irrigation systems. Strategies include **upgrading of irrigated systems and benefits, efficient use and innovative farming practices** (e.g., paddy drying, storage and processing) and diversification through value chains.	
	37. Forest Investment Program - Project 2: Reforestation and Production Forests through Public Private Partnerships, ADB (WB), US$ 24 million, Duration: 2019 - 2023	**Siem Reap and Preah Vihear**	Support to meeting future demands for wood products, including fuelwood, and **reduce pressure on natural forests by increasing investments in wood products from production forestry**. It aims to increase private sector investment in production forestry and restoration with increase community engagement in the management of production forests.	
	38. Forest Carbon Partnership Facility, UNDP (WB), US$ 3.8 million (plus top-up finance); Duration: 2013 - 2018	National (specific demonstration sites to be selected)	Development and strengthening of the Cambodian government's capacities to **address deforestation and forest degradation and to monitor, measure and report on forest changes and emissions**. Specific activities include: demarcation of community forests, protection forests and sustainable management forests including forest certification and implementation of measures to integrate REDD+ into community forestry	

			regulations and management of conservation forests.	
Limited policy and institutional coordination and capacities to ensure enabling conditions	39. Sustainable Assets for Agriculture Markets Business and Trade (SAAMBAT), IFAD (IFAD loan, IFAD Grant, European Investment Bank loan); US$ 53.2 mil., US$ 1.2 mil, EUR 15 mil.; Duration: 2020 - 2025	National with strong focus to build on IFAD's AIMS and ASPIRE projects that have covered some areas proposed under the PEARL project.	Establishment of enabling conditions for agricultural development through ensuring physical infrastructure, energy access, and skills and enterprise development. The project will deliver 650 km of paved rural roads, 150 km of laterite rural roads, and improve 50 rural market area infrastructure and 25 other value chain facilities (e.g., collection points) with renewable energy access.	- Establishment of enabling conditions (regulatory, and market and public engagement) to promote agricultural certification programs that incentivize the adoption of climate-resilient and sustainable technologies and practices, while responding to public needs for food safety. **Coordination with Co-financing/Baseline investments:** - Identification and establishment of an overarching national framework and platform in partnership with relevant co-financing and baseline investments to provide an enabling environment (where possible, utilize and strengthen existing platforms and frameworks).
	40. Climate-friendly Agribusiness Value Chains Sector Project, ADB (ADB-loan, GCF-loan & GCF-grant); US$ 90 mil., US$ 10 mil., US$ 30 mil.; Duration: 2018 - 2024	Not focusing on NTSB - Kampong Cham and Tbong Khmum provinces along the Greater Mekong Subregion (GMS) southern corridor, and Kampot and Takeo provinces	Climate change mitigation and adaptation results: (i) climate smart agribusiness value chain infrastructure, (ii) capacity strengthening in climate friendly agriculture, and (iii) **enabling environment for sound agribusiness policy**	
	41. Platform for Real-Time Information System Management (PRISM), WFP	National	Establishment to a system to provide development activities and emergency response decisions as well as facilitates **implementation of social protection programmes at national level.**	
	42. ASEAN Sustainable Agrifood Systems (SAS), GIZ (BMZ); Duration: 2013 - 2017	National	Implementation of the 'ASEAN Guidelines on the Regulation, Use, and Trade of Biological Control Agents (BCA)' to harmonize of regulations of BCA, and thus stimulate the availability and usage of BCA as alternative to chemical pesticides. This also aims at promoting cross-border value chains in concert with public decision-makers, agricultural enterprises as well as farmers' and private associations through: 1) **Translation and appropriation of the ASEAN Integrated Food Security (AIFS) Framework;** 2) Coordination of high-level policy dialogue to internalise AIFS; and 3) Establishment of the National Expert	

			Group on Soil and Nutrition Management to guide national and regional processes.	
	43. Cambodia Climate Change Alliance Phase II, UNDP (Sweden, EU), US$ 13 million, Duration: 2014-2019	National	**Strengthening of the governance of climate change** (monitoring and evaluation framework, legal framework, institutional arrangements), support to private sector engagement, and development of human and technological capital.	
	44. Cambodia Programme for Sustainable and Inclusive Growth in the Fisheries Sector: Aquaculture component (CaPFish Aquaculture), MAFF (EU); US$ 26 million; Duration: 2017 onwards	National	Support to ensure sustainable, climate-resilient and inclusive growth in the aquaculture sector through: 1) **Scaling-up successful pro-poor aquaculture experiences;** 2) Developing and diffusing more sustainable and efficient practices in the rapidly growing culture of high-input species; and 3) Introducing and pilot-testing improved practices, climate-resilient approaches.	

	45. Forest Investment Program - Project 1: Climate Smart Landscapes through Conservation Corridors; Project 2: Reforestation and Production Forests through Public Private Partnerships; and Project 3: Implement National Forest Monitoring, ADB (WB), US$ 24 million, Duration: 2019 - 2023	National	Project 1: Strengthening of the government's approach to forest conservation and management; promotion of ecosystem connectivity through conservation corridors; improvement of rural livelihoods and reduction of GHG emissions. Project 2: Support to meeting future demands for wood products, including fuelwood, and reduce pressure on natural forests by increasing investments in wood products from production forestry. Project 3: provision of information on the state of forest, estimation and updating of forest carbon stocks in accordance with the UNFCCC decisions on REDD+, and to develop the Timber Legality Assurance System (TLAS).	
	46. Forest Carbon Partnership Facility, UNDP (WB), US$ 3.8 million (plus top-up finance); Duration: 2013 - 2018	National	Development and strengthening of the Cambodian government's capacities to address deforestation and forest degradation and to monitor, measure and report on forest changes and emissions. Specific activities at the national level include: the establishment of a system of safeguards and grievance redress mechanisms, initiation of Forest Law Enforcement, Governance and Trade (FLEGT) process, establishment of a National Forest Monitoring System and support to a REDD+ related GHG reporting.	

Annex II: AquaCrop Analysis

RAINY SEASON RICE

Changes in yield and crop water productivity

Table A: Yield and crop water productivity (CWP) of rainy season rice grown under changing climatic conditions

Factor	Crop response
Climate scenarios *(RCP 4.5 & 8.5)*	● No significant yield and CWP differences are expected when comparing RCPs 4.5 and 8.5
Varieties *(short, medium & long-cycle)*	• Due to a shorter development period, short cycle (95 days) varieties are less exposed to more frequent and intensified weather extremes than medium (125 days) and long (155 days) cycle varieties • The CWP of short cycle varieties rises from 1.09 to 1.55 kg of seed per m^3 of water evapotranspired when the near (2011-2040) and far-future are compared (2071-2099). In contrast to short cycle varieties, the CWP of medium/long cycle varieties decreases from 0.69 to 0.61 kg/m^3 and from 0.32 to 0.21 kg/m^3 when the average of both RCPs in the near (2011-2040) and far-future are compared (2071-2099).
Intra-annual *(sowing date)*	● While 15 June is a more suitable sowing date for medium/long cycle varieties, short cycle varieties outperform when seeding in July. However, up until the mid-century, the yields of short cycle varieties is higher when sowing early in August than early in July
Inter-annual *(21st century)*	● Despite of increasing yield trends when short-cycle varieties are sown in July; until the first half of the century, yields will be higher when sown in early-August compared to early-July ● In most scenarios, the yields of medium and long-cycle varieties will decrease overtime, with few exceptions where yields are expected to increase (e.g., medium- cycle varieties sown on 15 June along location 2 under RCP 8.5)
Spatial *(locations 1-4)*	● The herein simulations confirm that location 2 is the most suitable for growing short cycle varieties, followed by location 1. In locations 1 and 2, the yields of medium/long cycle varieties decrease in 25 out of the 32 simulations (78%); whereas in locations 3 and 4, in 13 out of 32 the simulations (40%). In contrast to medium/long cycle varieties, the yields of short cycle varieties increase in almost every simulation, 25 out of the 32 (78%).
Key findings	● Location 2 (Preah Vihear) is the most suitable zone for growing short-cycle varieties overtime, followed by location 1 (Otdar Meanchey) ● The yields of medium and long-cycle varieties will decrease overtime, with few exceptions depending on the sowing date and location ● Regardless of future climatic conditions (RCPs 4.5 or 8.5), the yields of short-cycle varieties will increase overtime; particularly in locations 1 and 2. Our findings suggests a yield improvement in short cycle varieties from 2.86 ton/ha in the near-term (2017-2040) to 3.30 ton/ha in the medium-term (2041-2070) and up to 3.78 ton/ha in the far-future (2071-2099) when sowing between the 1 and 15 July, equivalent to a 15 to 30% yield enhancement compared to the baseline period (2017-2040). ● The CWP of short-cycle varieties will increase by 42% in the long-term (2071-2099), meaning that the agricultural product (yield) will increase with the same amount of water resources and, therefore, the water use efficiency will increase overtime. On the other hand, the CWP of medium and long-cycle varieties will decrease over time

Figure I: Projected rice yields (ton/ha) during the rainy season under future climate scenarios (RCPs 4.5 and 8.5) over the 2017-2099 period. Blue, red and green circles and triangles correspond to long, medium and short-cycle varieties under RCPs 4.5 and 8.5, respectively; while blue, red and green straight and dotted lines to the yield trends

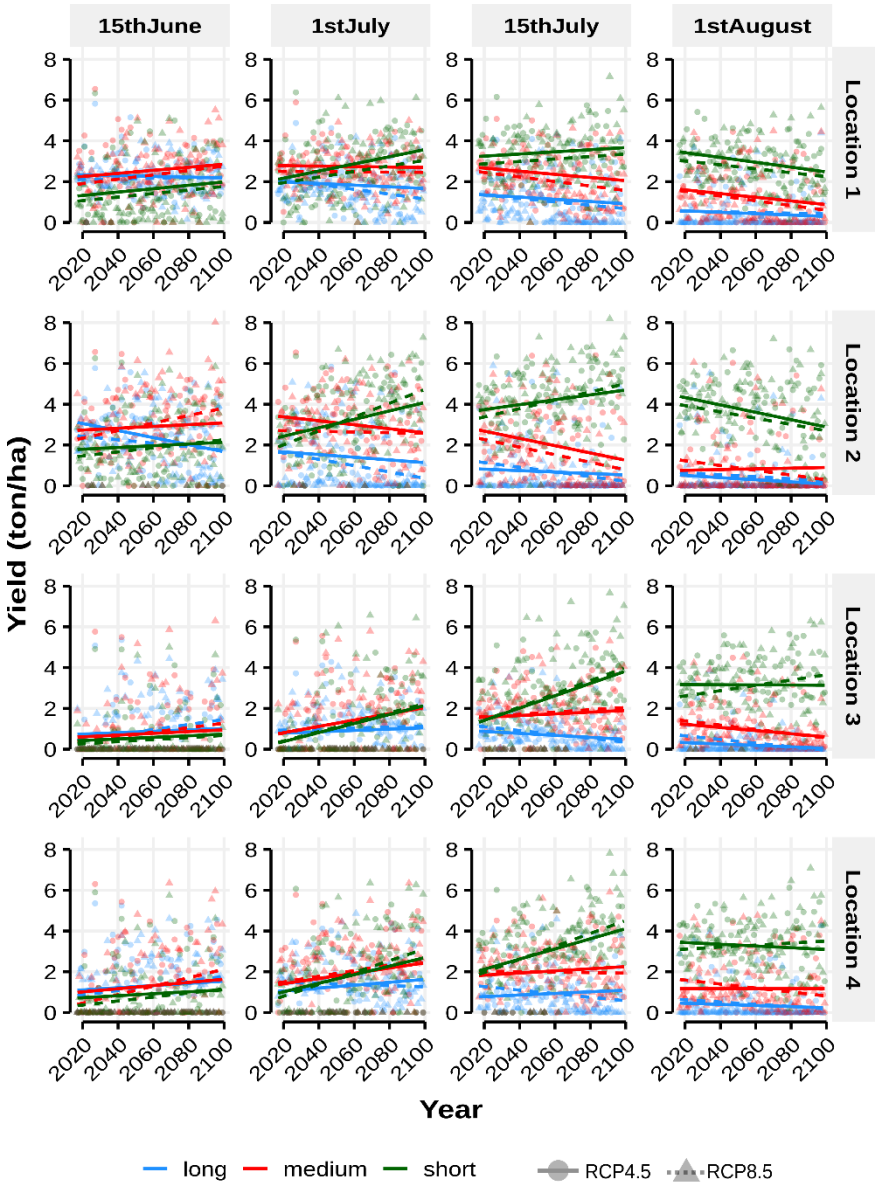
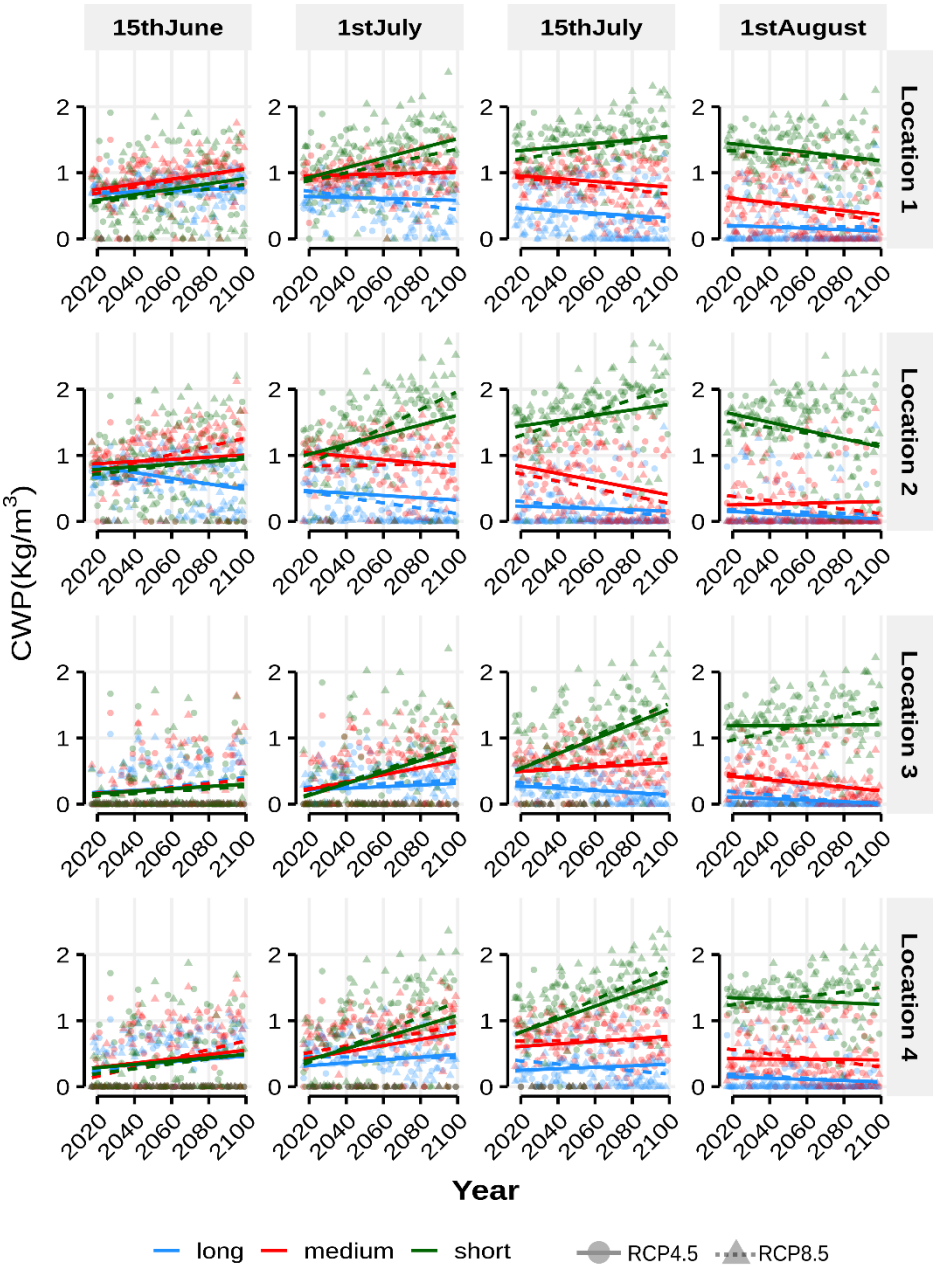


Figure II: Projected crop water productivity - CWP - (kg of yield per m3 of water evapotranspired) of rice grown during the rainy season under future climate scenarios (RCPs 4.5 and 8.5) over the 2017-2099 period. Blue, red and green circles and triangles

correspond to long, medium and short-cycle varieties under RCPs 4.5 and 8.5, respectively; while blue, red and green straight and dotted lines to the CWP trends



Changes in heat-stress conditions

Due to a shorter development period, short cycle (95 days) varieties are less exposed to more frequent and intensified weather extremes than medium (125 days) and long (155 days) cycle varieties. Projections of rainfall show a high inter-annual variability under both RCPs, with a comparable precipitation decreasing trend (19% between 2017-2040 and 2071-2099) despite the location, variety, sowing date and RCP. In a warmer climate, the number of days with heat-stress conditions increases, especially under RCP 8.5. The exposure to heat-stress conditions (Tmax ≥ 35ºC) is substantial among long cycle varieties. For example, when sowing on 15 June, the number of days with heat-stress conditions increases from 74 to 98 days/season and from 86 to 124 days/season, respectively under RCPs 4.5 and 8.5 when the near-future (2017-2040) and far-future (2071-2099) are compared. As a result, long cycle varieties are affected by heat conditions on average 63% (RCP 4.5) and 80% days/season (RCP 8.5). Although short cycle varieties experience fewer days with high

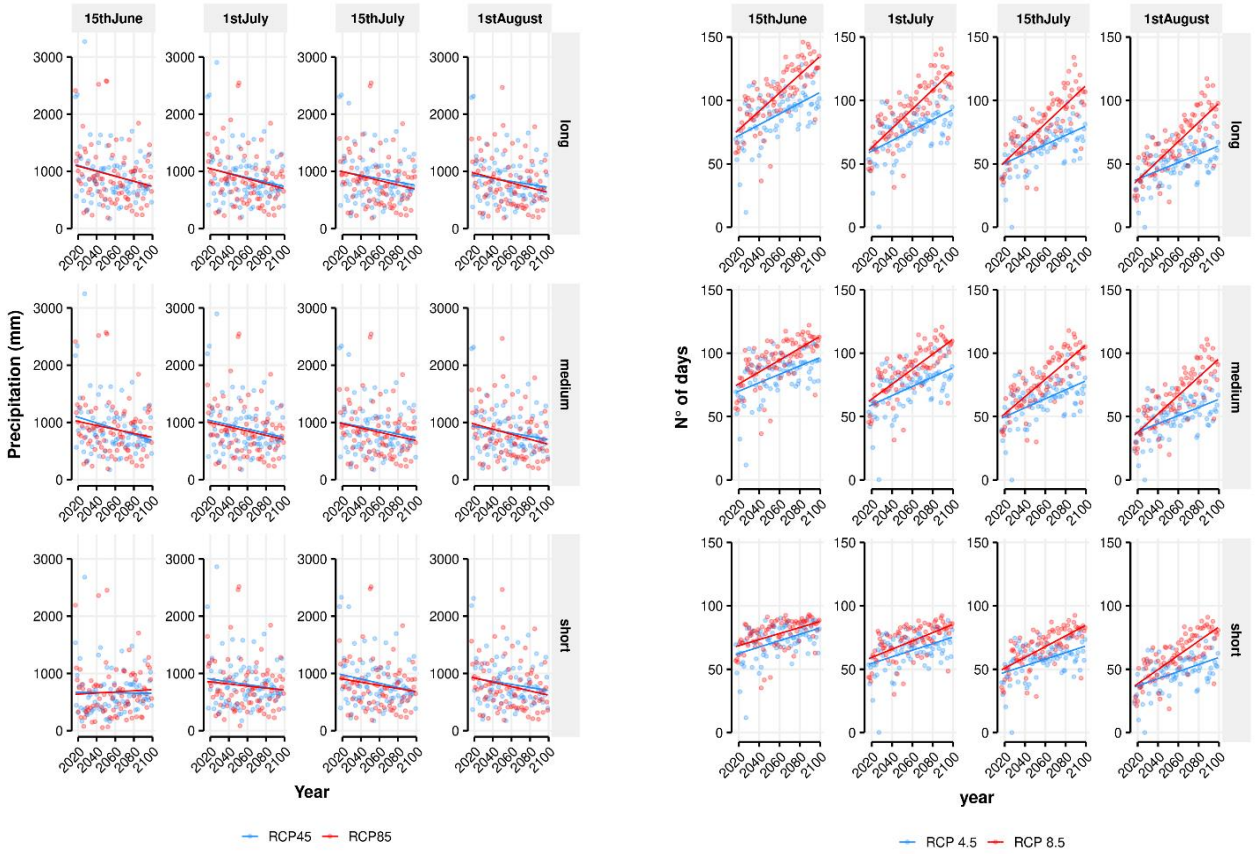
temperatures during the growing season, they are proportionally as exposed as long cycle varieties. For instance, if sowing on 15 June under RCP 8.5, short cycle varieties experience heat around 88% days/season in the far-future (2071-2099). Despite these findings, an increase in exposure to weather hazards does not necessarily imply an increase in plant's susceptibility in terms of development and productivity. In this line, AquaCrop allows the user to find out more about the duration and extent of heat damage to the plant. The results indicate that the percentage of heat-stress affecting crop transpiration is very low (close to 0) for all varieties, location, sowing date and RCPs. This is because the threshold at which stress starts to affect pollination occurs at 35ºC, but full stress at 40ºC and, therefore, the former threshold is barely exceeded during the wet season.

DRY SEASON RICE

Changes in yield and crop water productivity

Table B: Yield, crop water productivity (CWP) and water requirements of rainy season rice grown under changing climatic conditions

Figure III: a) Precipitation changes during the wet season and (b) number of days during the growing season with maximum temperature above 35ºC over the 2017-2099 period. Blue and red circles correspond to RCPs 4.5 and 8.5, respectively. Regressed lines are given for the two RCPs. Because of the small output differences, precipitation and temperature variables for the four locations are averaged



Factor	Response
Climate scenarios *(RCPs 4.5 and 8.5)*	● The interaction between closer to optimal growing temperatures during the boreal winter (December-February) and higher CO_2 concentrations (RCP 8.5) will have a higher

	positive impact on crop yields compared to moderate increases in CO_2 (RCP 4.5). In addition, the differences between RCPs will be more remarkable in the second half of the 21st century compared to the first half.
Irrigation *(fixed and net water supply)*	• Water supply in 7-day intervals (fixed irrigation) will satisfy crop water requirements into the future; mainly because the threshold at which water stresses affect the canopy expansion, cause stomata closure and early senescence of the plant will be uninterruptedly exceeded throughout the growing cycle. • Small CWP differences are projected when the two irrigation schemes (fixed/net) under both RCPs are compared, with a higher water use efficiency under fixed irrigation and in RCP 8.5 • The average irrigation requirements in location 3 under fixed irrigation (±500mm/season) and net irrigation (±1000mm/season) is 30 to 50% higher than that simulated in locations 1, 2 and 4.
Intra-annual *(sowing date)*	● No significant yield differences are projected under different sowing dates (1st Nov to 1st Dec), with identical yield trends overtime
Inter-annual *(21st century)*	● Slight and moderate yield increases are projected both under RCPs 4.5 and 8.5, respectively. From 2060 onwards a divergence in yield trends is also foreseen. While yields stabilize under RCP 4.5 in the mid-century, they continue to increase under RCP 8.5
Spatial	● Similar increasing yield trends are displayed in the four locations, with yields varying between 5.0 to 7.0 ton/ha when the near (2017-2040) and far-future (2071-2099) are compared, except for location 3 under fixed irrigation.
Key findings	● Under RCP 4.5, the yields rise from 5.79 to 6.20 and 6.35 ton/ha when the near-term (2011-2040), medium-term (2041-2070) and far-future (2071-2099) are respectively compared. ● For RCP 8.5, the positive yield changes over time are heightened, increasing from 5.88 to 6.67 and 7.52 ton/ha when the near (2011-2040), medium (2041-2070) and far-future (2071-2099) are compared. The latter changes are equivalent to a 13 and 28% yield increase with regards to the near-term. ● CO_2 concentration increase will benefit rice production by increasing photosynthesis, growth and grain yield while reducing water requirements and, consequently, increasing CWP overtime. However, it is likely (depending on the climate scenario) that future increases in air temperature will rise evapotranspiration rates and will result in slight increases in water requirements overtime - as foreseen when dry season rice is sown on 1 December across the four locations

Figure IV: Projected yields (ton/ha) of short cycle varieties of rice grown during the dry season under future climate scenarios (RCPs 4.5 and 8.5) over the 2017-2098 period. Blue and red circles and triangles correspond to fixed and net water supply under RCPs 4.5 and 8.5, respectively; while blue and red straight and dotted lines to the yield trends

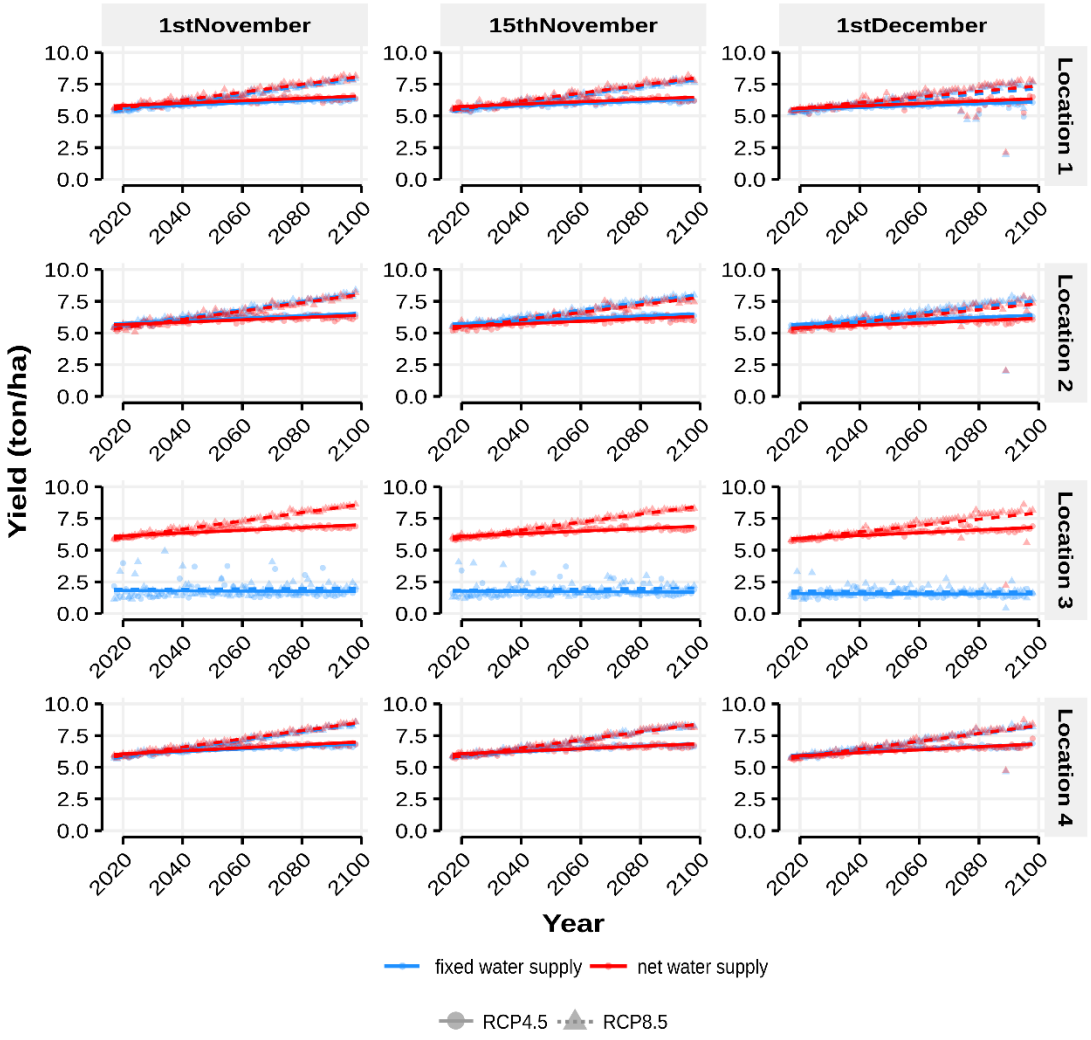


Figure V: Projected crop water productivity - CWP - (kg of yield per m^3 of water evapotranspired) of rice grown during the dry season under future climate scenarios (RCPs 4.5 and 8.5) over the 2017-2098 period. Blue and red circles and triangles

correspond to fixed and net water supply under RCP 4.5 and 8.5, respectively; while blue and red straight and dotted lines to the CWP trends

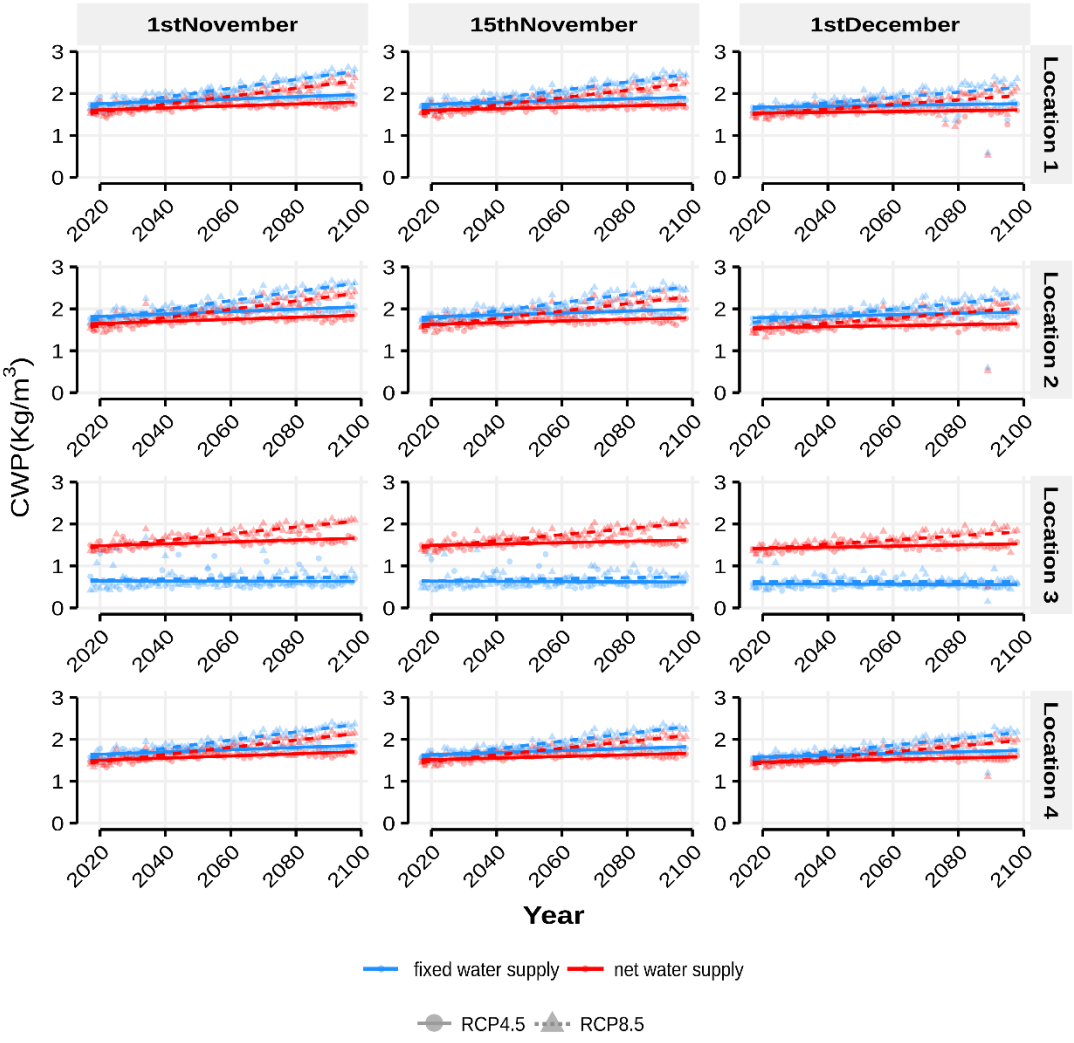
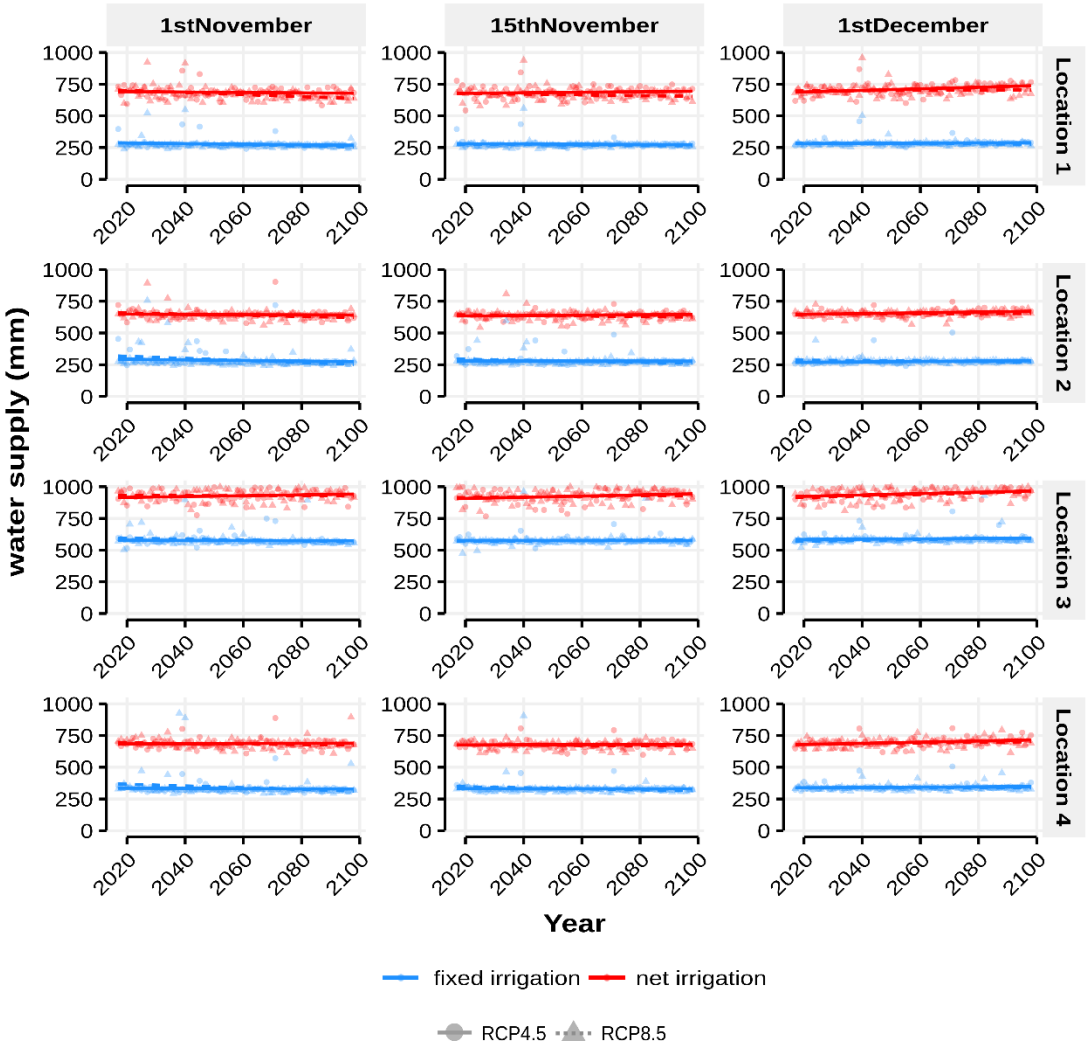


Figure VI: Projected crop water supply (mm) of rice grown during the dry season under future climate scenarios (RCPs 4.5 and 8.5) over the 2017-2098 period. Blue and red circles and triangles correspond to fixed and net water supply under RCPs 4.5 and 8.5, respectively; while blue and red straight and dotted lines to the water supply trends

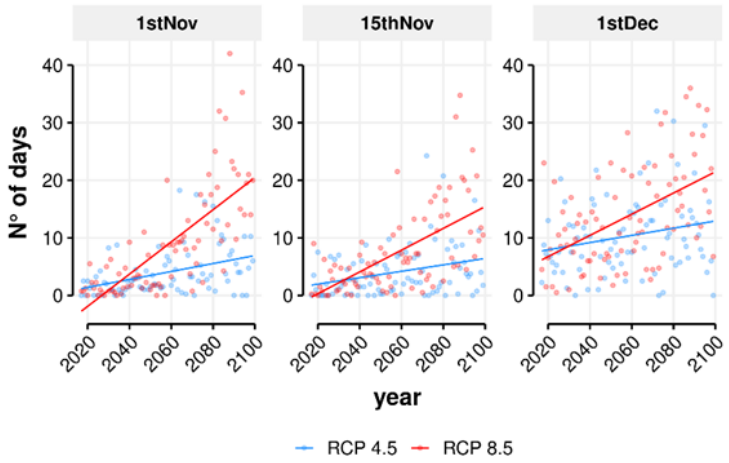


Changes in heat-stress conditions

During the boreal winter, dry season rice is closer to optimal growing conditions than wet season rice. In the near-future (2017-2040), heat-stress conditions (Tmax >35ºC) are infrequent, particularly if seeding early in November (Figure VII). However, the projected temperature rise over the 21st century is also translated into an increase in the number of days with heat-stress conditions over the growing season. For example, the number of days with heat-stress conditions rises from 4 to 8 days/season and from 5 to 17 days/season under RCPs 4.5 and 8.5, respectively when the near (2017-2040) and far-future (2071-2099) are compared (average of sowing dates and locations). These differences are heightened when comparing different sowing dates. For example, when seeding on 1 December, the number of days with heat-stress conditions increases from 8 to 12 days/season and from 9 to 20 days/season under RCPs 4.5 and 8.5, respectively when the near (2017-

2040) and far-future (2071-2099) are compared. However, as for wet season rice, an increase in exposure does not necessarily mean an increase in susceptibility. Overall, in this study, heat-stress conditions are not considered the major limiting factor affecting crop transpiration and pollination and, consequently, the final yield.

Figure VII: Number of days during the growing season (dry-season rice) when temperatures above the critical threshold (>35ºC) will be exceeded under RCPs 4.5 and 8.5 over the 2017-2099 period



TOMATO

Changes in yield and crop water productivity

Tomato irrigation requirements on AquaCrop

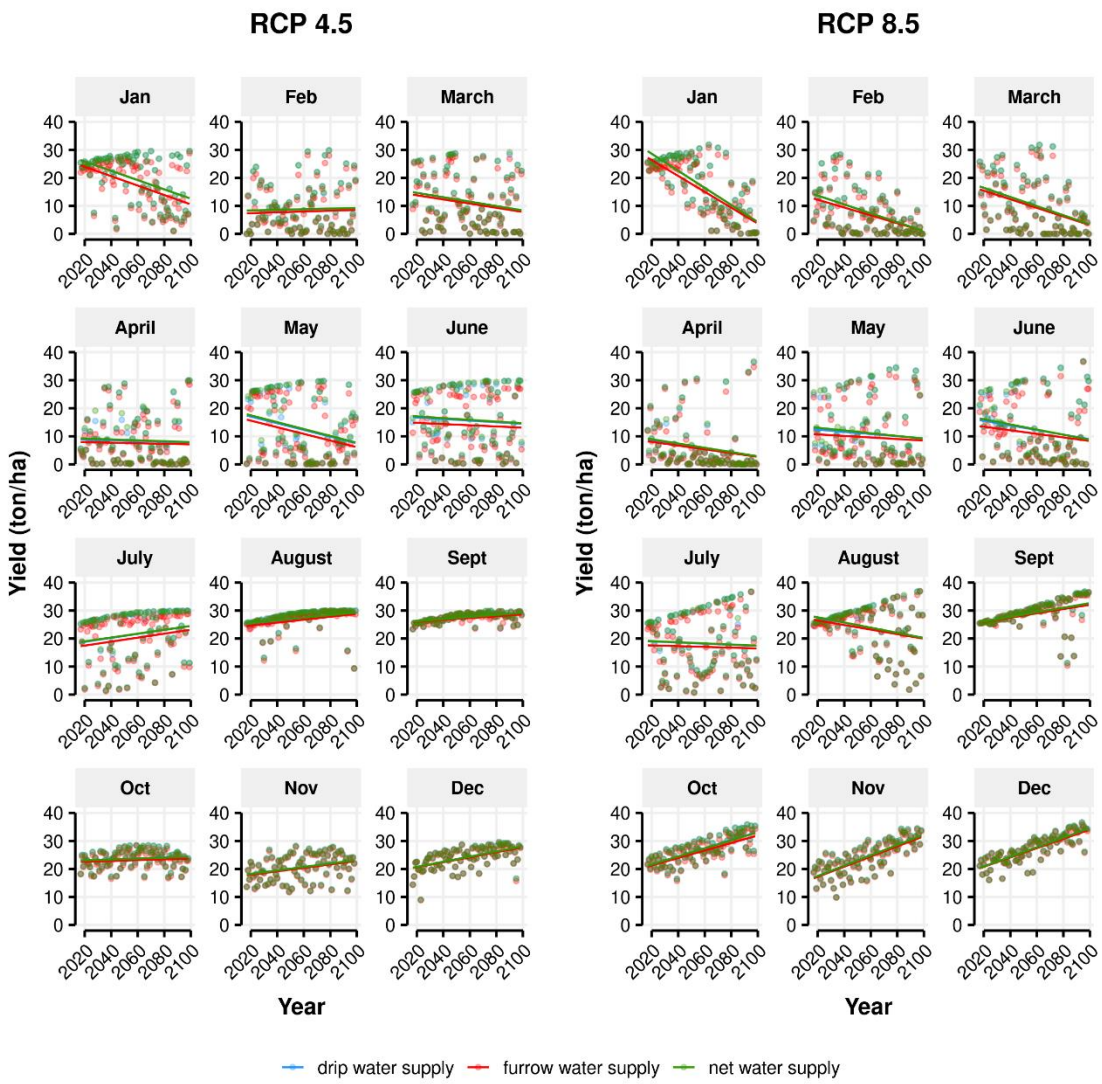
- *Net irrigation:* root zone depletion may not drop below 30% readily available water
- *Furrow irrigation (fixed):* 10 mm of water every 5 days up to 35 days after transplanting (DAT) and then 10 mm every 2 days until harvest. The total amount of water applied was 310 mm/season
- *Drip irrigation (fixed):* 10 mm of water every 5 days up to 40 DAT and then, 10 mm every 2 days until harvest. The total amount of water applied was 290 mm/season

Table C: Yield, crop water productivity (CWP) and water requirements of tomato grown under changing climatic conditions

Factor	Response
Climate scenarios *(RCPs 4.5 and 8.5)*	• Similar yield trends are projected between RCPs, except when transplanted in February, August and October • Alike water requirements are expected between RCPs, but changing depending on the selected transplanting date
Irrigation *(net, furrow and drip water supply)*	• Regardless of the transplanting date, the values of drip and furrow irrigation requirements perfectly match both year-round and into the future • The yields under net water supply are slightly higher than those simulated under drip and furrow irrigation • Due to the combined effect of precipitation and irrigation (exceeding 700mm during the growing period), higher yields (20-35 ton/ha) are projected when tomatoes are transplanted during the rainy season (July-September). However, over the latter months, the water use efficiency is lower compared to the transplanting between October-December • Due to mild temperatures after the rainy season (October-January), the crop water requirements are notably lower (<400mm) compared to the pre-

	monsoon months (March-April), when water requirements range around 500-700mm • Throughout the year, the water supply (rainfed and irrigation) is likely to be higher under net irrigation compared to drip and furrow irrigation conditions; expect during the monsoon and post-monsoon months, where higher water supplies are foreseen under drip and furrow irrigation conditions
Intra-annual *(sowing date)*	• Due to increasing heat stress conditions, tomato yields are likely to be adversely affected; particularly when transplanted between January-August, while positively affected when transplanted between September-December under both RCPs • Between January and June, the interannual yield variability is likely to increase over time, particularly under RCP 8.5. When transplanting over these months, yields are expected to experience a strong decline
Inter-annual *(21st century)*	• The behavior of tomato yields vary considerably depending on the transplanting date and, to a minor extent, to the RCP and irrigation scheme • The interannual yield variability is expected to increase over time, particularly when transplanting outside the wet season
Key findings	● Yield enhancements of +37% (from 20.1 to 27.5 ton/ha) are expected between November and December when comparing the baseline period (2017-2040) to the end-century (2070-2099) (average of both transplanting dates, ensemble of RCPs and three irrigation methods) ● On the contrary, in January, a yield decline of -55% (from 24.2 to 10.9 ton/ha) is simulated when comparing the baseline period (2017-2040) to the far-future (2070-2099) (average of both RCPs and three irrigation schemes). ● While a decrease in crop water productivity (CWP) is foreseen in the first-quarter (January to March), a strong increase is simulated along the fourth (October to December). For these transplanting dates (October to December), the CWP increases by +14% under RCP 4.5 (from 7.9 to 9.0 kg/m3) and by +41% (from 8.1 to 11.4 kg/m3) under RCP 8.5 when comparing the baseline period (2017-2040) to the end-century (2070-2099).

Figure VIII: Projected tomato yields (ton/ha) simulated year-round and under future climate scenarios (RCPs 4.5 and 8.5) over the 2017-2099 period. Blue, red and green circles correspond to the annual projected yields under drip, furrow and net water supply, respectively; while the red, green and blue lines to the yield trends



Note: the yield values under drip and furrow irrigation perfectly match and, consequently, trends overlap

Figure IX: Projected crop water productivity - CWP - (kg of yield per m³ of water evapotranspired) of tomato simulated year-round and under future climate scenarios (RCPs 4.5 and 8.5) over the 2017-2099 period. Blue, red and green circles correspond

to the annual projected yields under drip water supply, furrow water supply and net water supply, respectively; while the red, green and blue lines to the CWP trends.

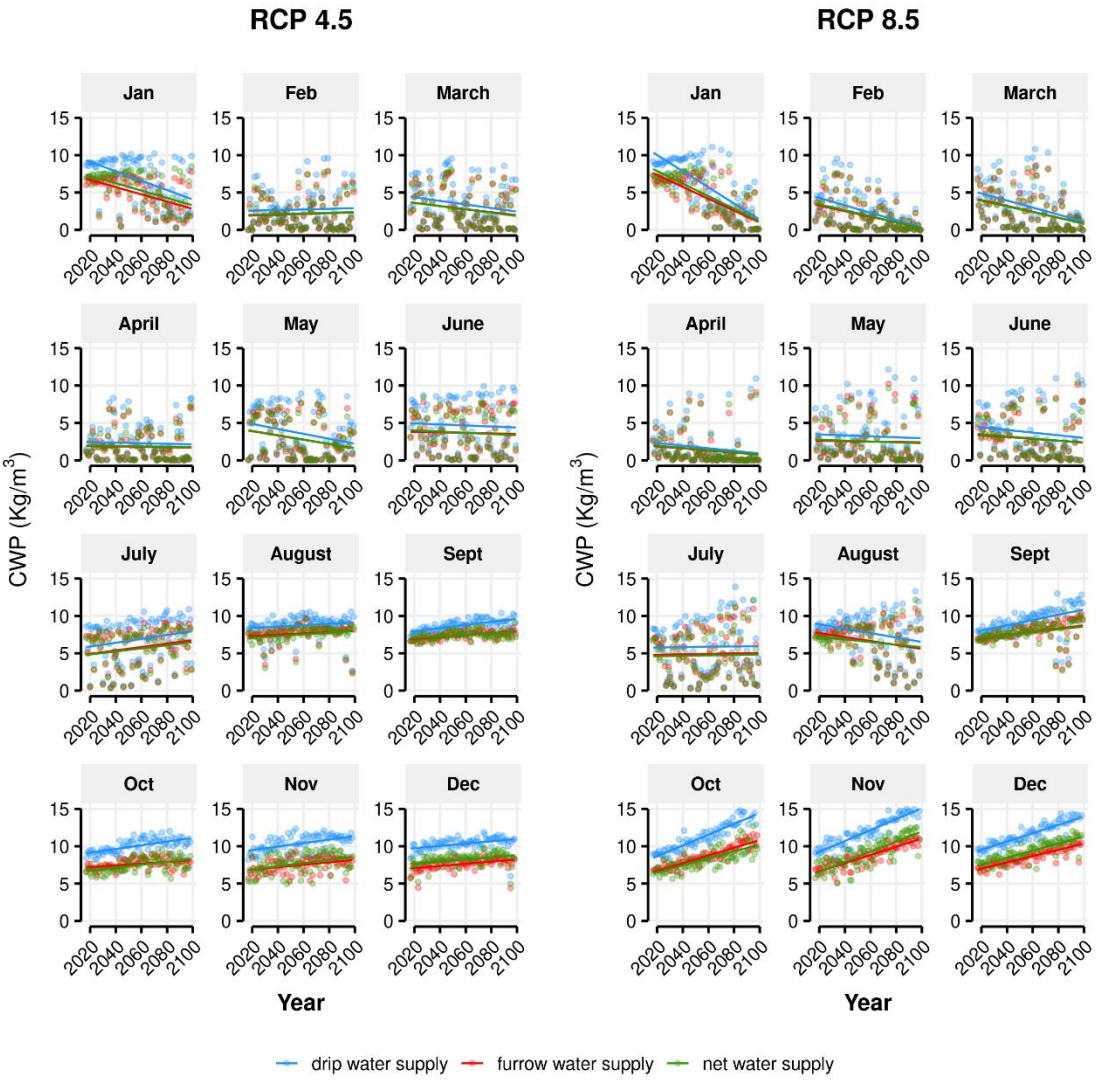
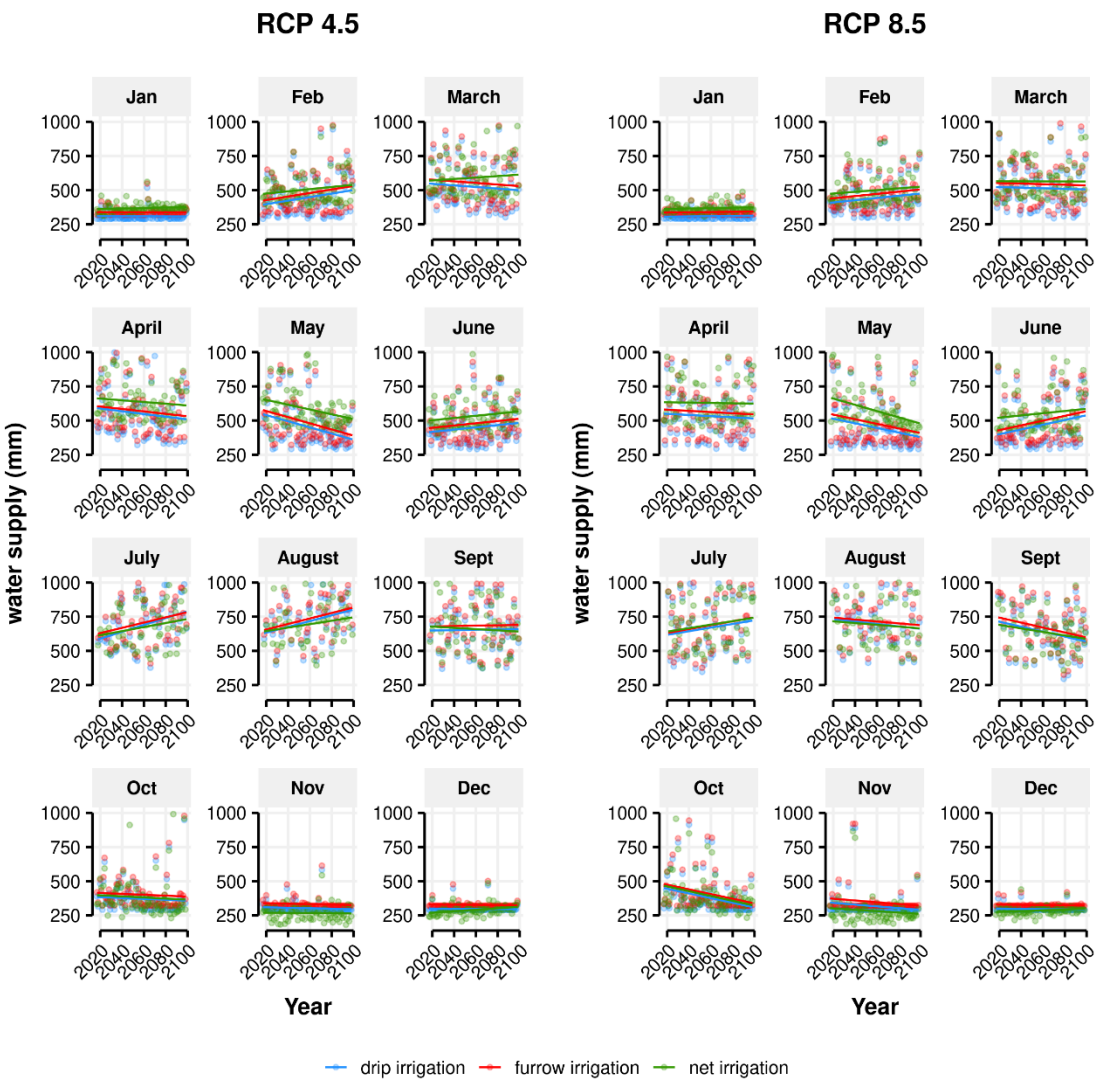


Figure X: Projected crop water supply (mm) of tomato simulated year-round and under future climate scenarios (RCPs 4.5 and 8.5) over the 2017-2099 period. Blue, red and green circles correspond to the annual projected yields under drip water supply, furrow water supply and net water supply, respectively; while the red, green and blue lines to the water supply trends.

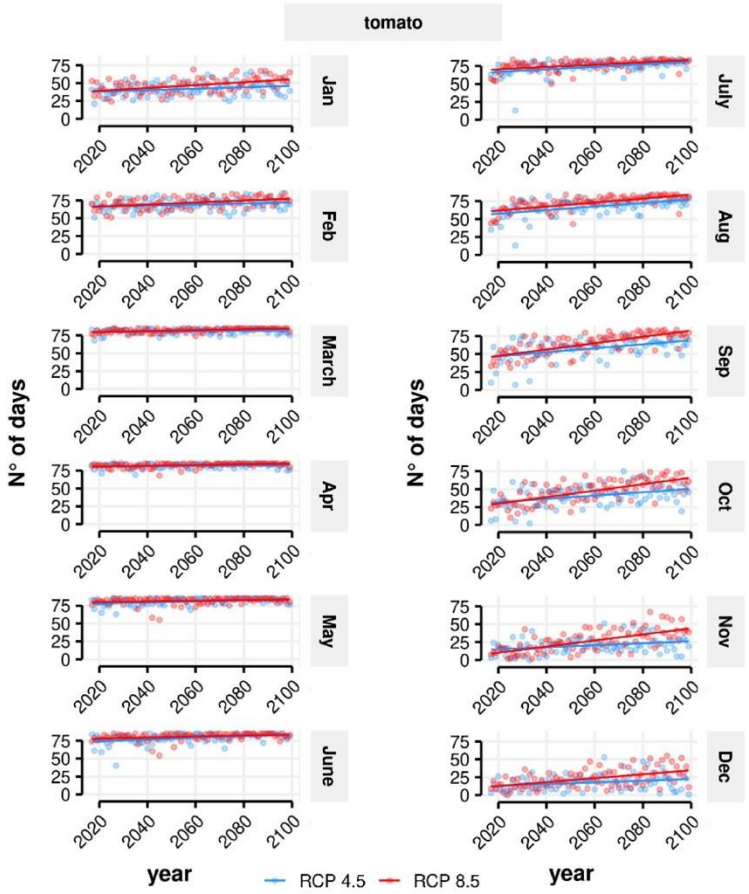


Changes in heat-stress conditions

In the present, tomato is already uninterruptedly affected by heat-stress conditions (Tmax > 33ºC) when transplanted between March and June, and these conditions are expected to extend to February, August and September under both RCPs by the end-century (Figure XI). Hence, high temperatures throughout the year will cause abortion of the gametophytes and lead to the reduction of fruit set overtime (as reported in the yield trends in Figure VIII, particularly under RCP 8.5). Since tomato reaches the flowering stage 55-65 days after transplanting, and it can last up to 15-20 days, it is likely that heat-stress conditions will affect the crop two months after transplanting. In addition, when transplanting in fall, plants generally experience optimal growing conditions compared to the rest of the year. The latter is also reflected in the number of days under heat-stress conditions throughout the growing cycle (maturity is reached 85 days after transplanting). For instance, while the 33ºC heat-stress threshold is exceeded between 0 to 50 days

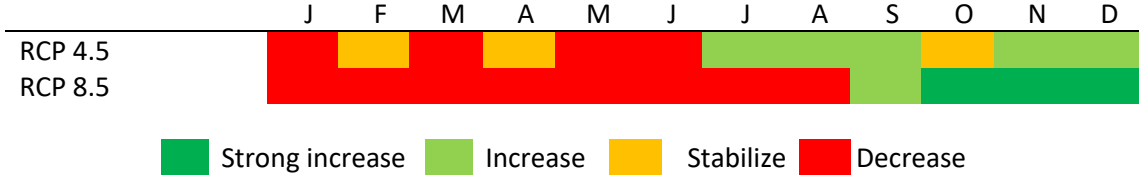
when transplanting between September and January, it is exceeded more than 70 days when transplanting between February and August. However, as for the rest of the year, heat-stress conditions are also projected to increase overtime, rising from 29 to 40 days/season and from 31 to 41 days/season under RCPs 4.5 and 8.5, respectively when the baseline period (2017-2040) and end-century (2070-2099) are compared (avg. of September-January transplanting dates). Over the latter months, the increase will be more abrupt between September and November compared to December and January.

Figure XI: Number of days during the growing season when temperatures will exceed the critical threshold for tomato (33ºC) under RCPs 4.5 and 8.5 over the 2017-2099 period



Based on AquaCrop simulations, tomatoes will be highly exposed to heat-stress conditions throughout. As a result, tomato yields are likely to experience a notable reduction if sown between January and June under RCP 4.5 and between January and August under RCP 8.5. Nevertheless, increasing temperatures during the boreal winter will favor the crop's development and, consequently, of its productivity. Additional information on this regard can be found in the AquaCrop results section.

Figure XII: Projected yields for tomato in Siem Reap based on AquaCrop simulations under RCPs 4.5 and 8.5



PAK CHOI

Changes in yield and crop water productivity

Pak Choi irrigation requirements on AquaCrop

- *Net irrigation:* root zone depletion may not drop below 50% readily available water
- *Furrow irrigation (fixed):* 5 mm of water every 5 days up to 20 days after sowing (DAS) and then, 10 mm every 2 days until harvest. The total amount of water applied was 115 mm/season
- *Drip irrigation (fixed):* 5 mm of water every 5 days up to 20 days after sowing (DAS) and then, 10 mm every 2 days until harvesting. The total amount of water applied was 115 mm/season

Table D: Yield, crop water productivity (CWP) and water requirements of pak choi under changing climatic conditions

Factor	Response
Climate scenarios *(RCPs 4.5 and 8.5)*	● A small yield increase is foreseen under RCP 4.5, while a strong increase under RCP 8.5. Due to pak choi's C3 photosynthetic pathway, the plant will benefit most (in terms of yield) of the fertilization effect of CO_2 under RCP 8.5 compared to RCP 4.5
Irrigation *(net, furrow and drip water supply)*	• Regardless of the sowing date, drip and furrow water supplies will perfectly match year-round and into the future • Similar water supplies (100-150mm) are simulated when drip/furrow and net irrigation are sown between November-December. However, for the rest of the year (January-October), water supplies under net irrigation will double those of drip/ furrow irrigation • Drip, furrow and net irrigation water supplies will range between 100-200mm if sown between October-February and will be much higher (200-400mm) if sown between March-September under both RCPs. The latter differences are explained by a higher water supply, from irrigation and precipitation, during the monsoon months
Intra-annual *(sowing date)*	• Water requirements of pak choi are expected to decrease if sown during the pre-monsoon (April-May) and during the post-monsoon months (October-November). However, a notable increase in water supply, most likely due to an increase in precipitation, is foreseen when sown in August under both RCPs • For example, if pak choi is sown in May under RCP 8.5, the yields increase by +24% (from 10.2 to 12.7 ton/ha) under furrow irrigation, by +30% (from 16.6 to 21.5 ton/ha) under net irrigation, and by +33% (from 12.1 to 16.1 ton/ha) under drip irrigation, respectively when comparing the baseline period (2017-2040) to the end-century (2070-2099).
Inter-annual *(21st century)*	• Very low interannual yield variability is foreseen when pak choi is grown under net irrigation compared to drip/furrow irrigation • Pak choi's water use efficiency is expected to increase overtime; particularly under RCP 8.5, where yields are expected to increase with the same amount of water
Key findings	● The highest yields with lowest water supplies are projected over the dry season (sowing between November-February), when temperatures are milder and, consequently, evapotranspiration rates are lower ● Yields are expected to rise by +25% (from 15.4 to 19.2 ton/ha and from 13.4 to 16.8 ton/ha) under drip and net irrigation and by +24% (from 11.7 to 14.5

ton/ha) under furrow irrigation when comparing the baseline period (2017-2040) to the far-future (2070-2099) for the ensemble of RCPs.

- With regards to the crop water productivity (CWP), pak choi's water use efficiency is expected to increase over time, mostly under RCP 8.5. While the CWP rises by +12% (from 7.6 to 8.5 kg/m^3) under RCP 4.5, it increases by +37% (from 7.6 to 10.4 kg/m^3) under RCP 8.5, respectively when comparing the baseline period (2017-2040) to the far-future (2070-2099) for all sowing dates and irrigation schedules.

Figure XIII: Projected pak choi yields (ton/ha) simulated year-round under future climate scenarios (RCPs 4.5 and 8.5) over the 2017-2099 period. Blue, red and green circles correspond to the annual projected yields under drip water supply, furrow water supply and net water supply, respectively; while the red, green and blue lines to the yield trends.

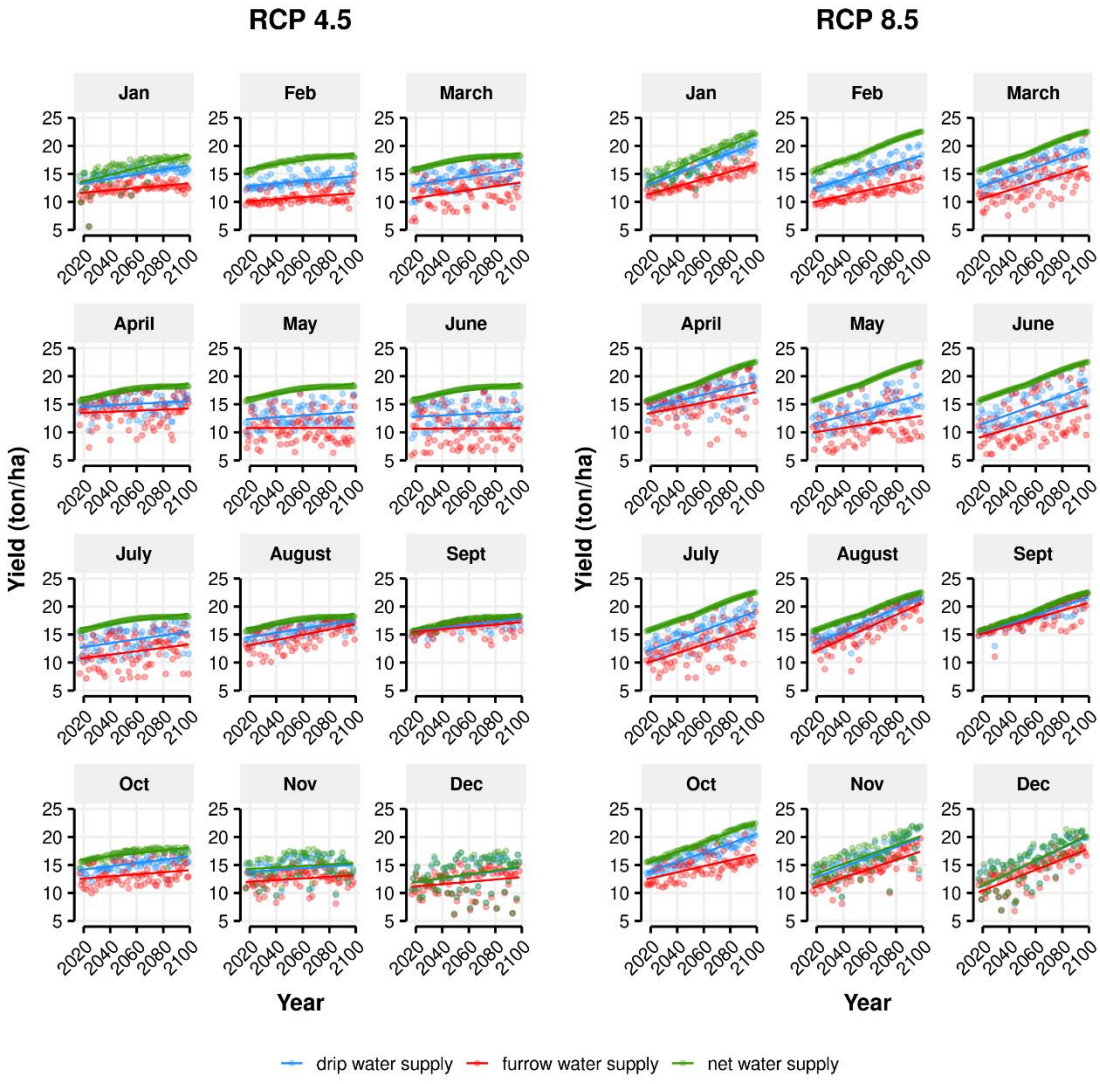


Figure XIV:Projected crop water productivity - CWP - (kg of yield per m^3 of water evapotranspired) of pak choi simulated year-round under future climate scenarios (RCPs 4.5 and 8.5) over the 2017-2099 period. Blue, red and green circles correspond to the

annual projected yields under drip water supply, furrow water supply and net water supply, respectively; while the red, green and blue lines to the CWP trends.

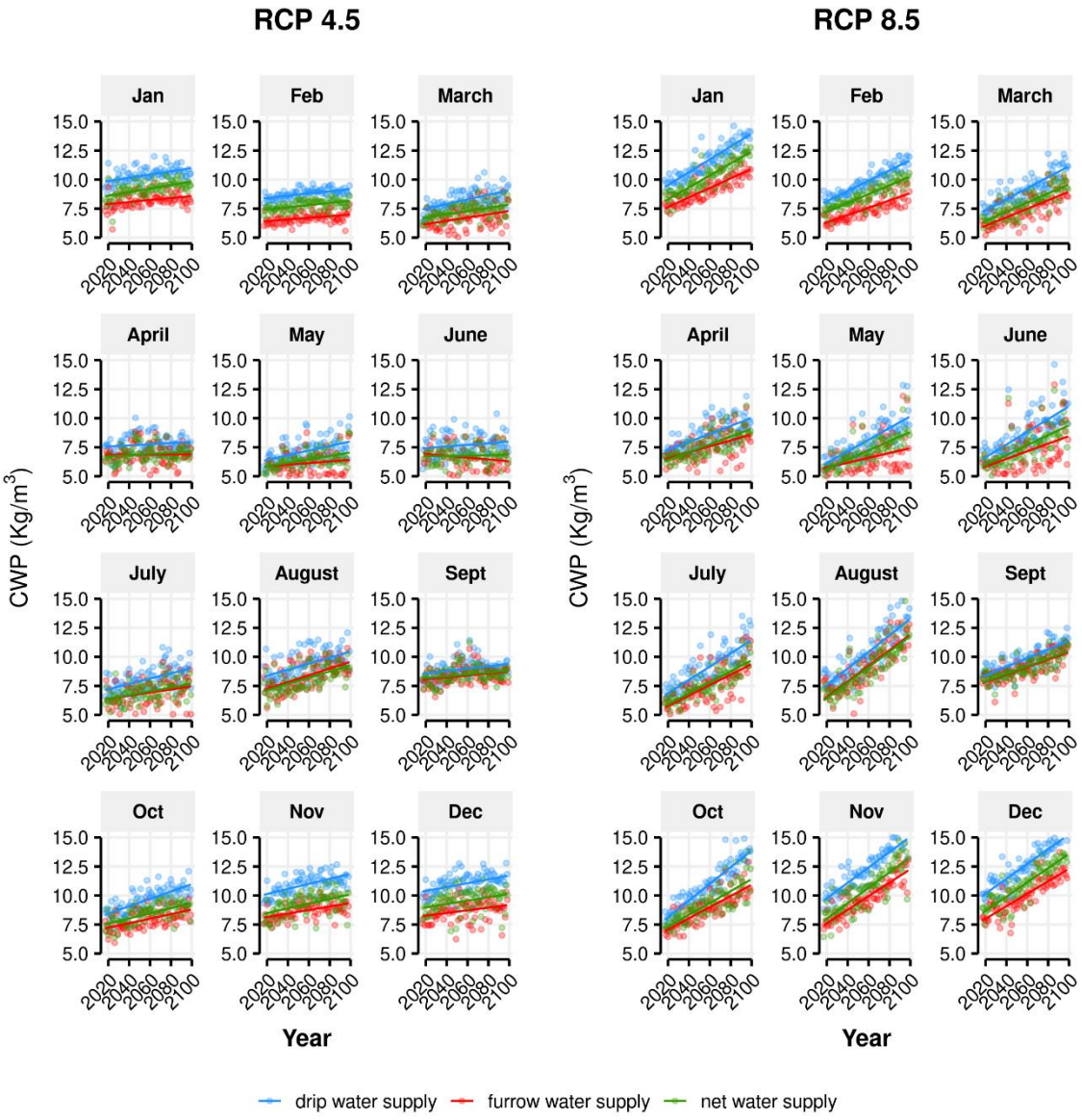
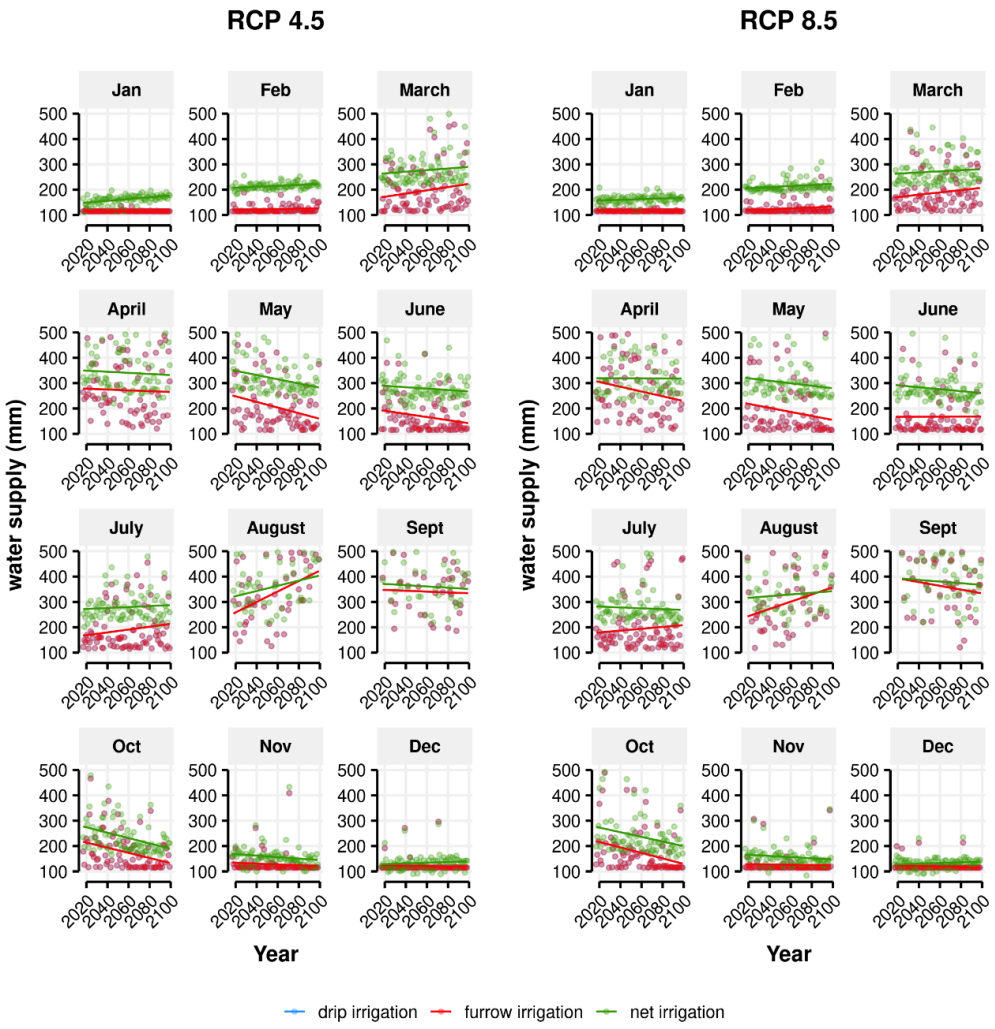


Figure XV:Projected crop water supply (mm) of pak choi simulated year-round under future climate scenarios (RCPs 4.5 and 8.5) over the 2017-2099 period. Blue, red and green circles correspond to the annual projected yields under drip water supply, furrow water supply and net water supply, respectively; while the red, green and blue lines to the water supply trends

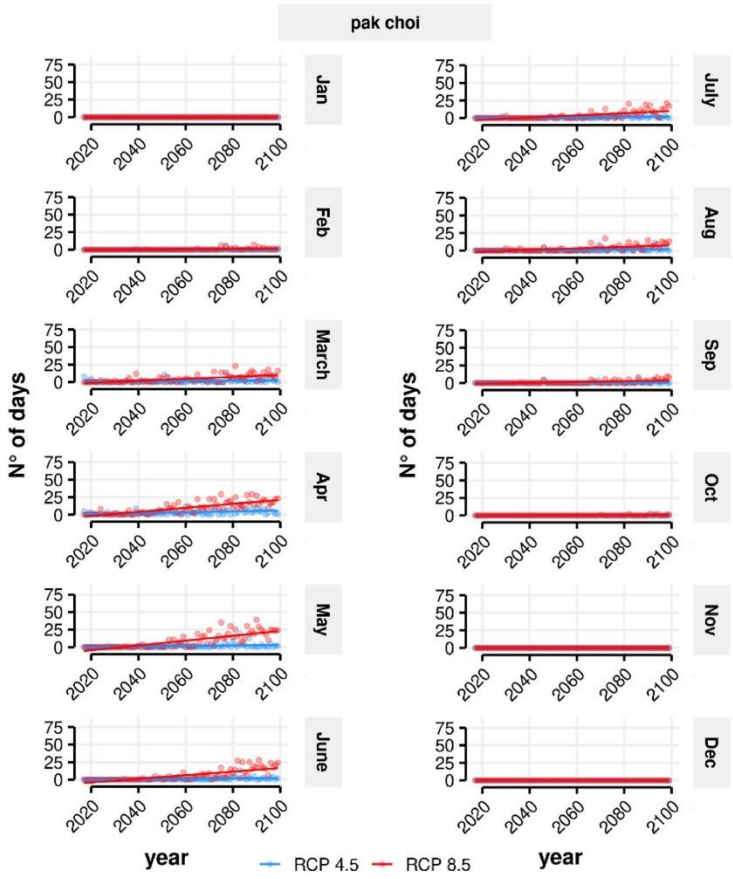


Changes in heat-stress conditions

Pak choi (Chinese cabbage) is a plant that tolerates very well high temperatures. Some studies suggest that the crop can withstand temperatures of up to 38ºC (Ahmed et al., 2019), while others note that the cut-off temperature for cabbage is as high as 40ºC (Wellens et al., 2013). In addition, the crop's exposure to heat-stress conditions is low because the plant is generally harvested 45 days after sowing and, therefore, the likelihood of being adversely affected by heat-stress conditions is limited. Along the study area, the 40ºC threshold will only be exceeded during the pre-monsoon months (when year-round temperatures are highest) and at the beginning of the rainy season, mostly under RCP 8.5 and by the end-century. For instance, when sown between March and June, the number of days with Tmax >40ºC will increase from 1 to 15 days/season when the baseline period (2017-2040) and end-century (2070-2099) are compared, respectively under RCP 8.5. Although the upper threshold will be sporadically exceeded into the future, the likelihood of high temperatures affecting the crop remains low, mostly because the crop is harvested before it reaches

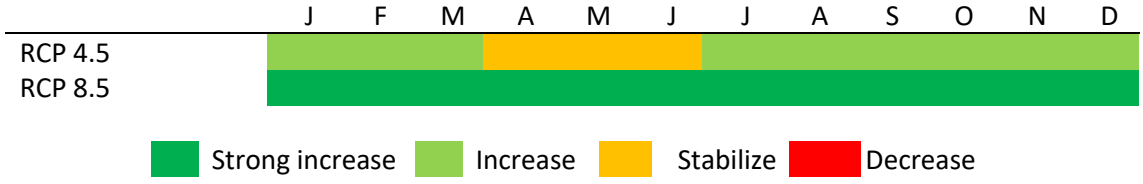
the most sensitive phenological phases such as flowering. Therefore, pak choi's tolerance to heat-stress conditions and its capacity to benefit from increasing CO_2 concentrations will ensure crop's adaptability and, therefore, suitability along the project areas into the future. However, this will vary depending on the selected cultivar. For instance, the 'Chun-gwang' cultivar can produce threefold higher leaf-dry weight under elevated CO_2 concentration, but a threefold lower leaf-dry weight when exposed to both elevated CO_2 and high temperatures for 90 days (Choi et al., 2011).

Figure XVI:Number of days during the growing season when temperatures will exceed the critical threshold for pak choi (40ºC) under RCPs 4.5 and 8.5 over the 2017-2099 period



Based on crop simulations, pak choi yields are likely to increase into the future, mostly under RCP 8.5 with a significant yield increase throughout the year. Thanks to its heat-tolerance and capacity to benefit from the CO_2 fertilization effect, the crop is projected to perform highly under changing climate conditions. Additional information on this regard can be found in the AquaCrop results section.

Figure XVII: Projected yields for pak choi in Siem Reap based on AquaCrop simulations under RCPs 4.5 and 8.5



LONG BEAN

Changes in yield and crop water productivity

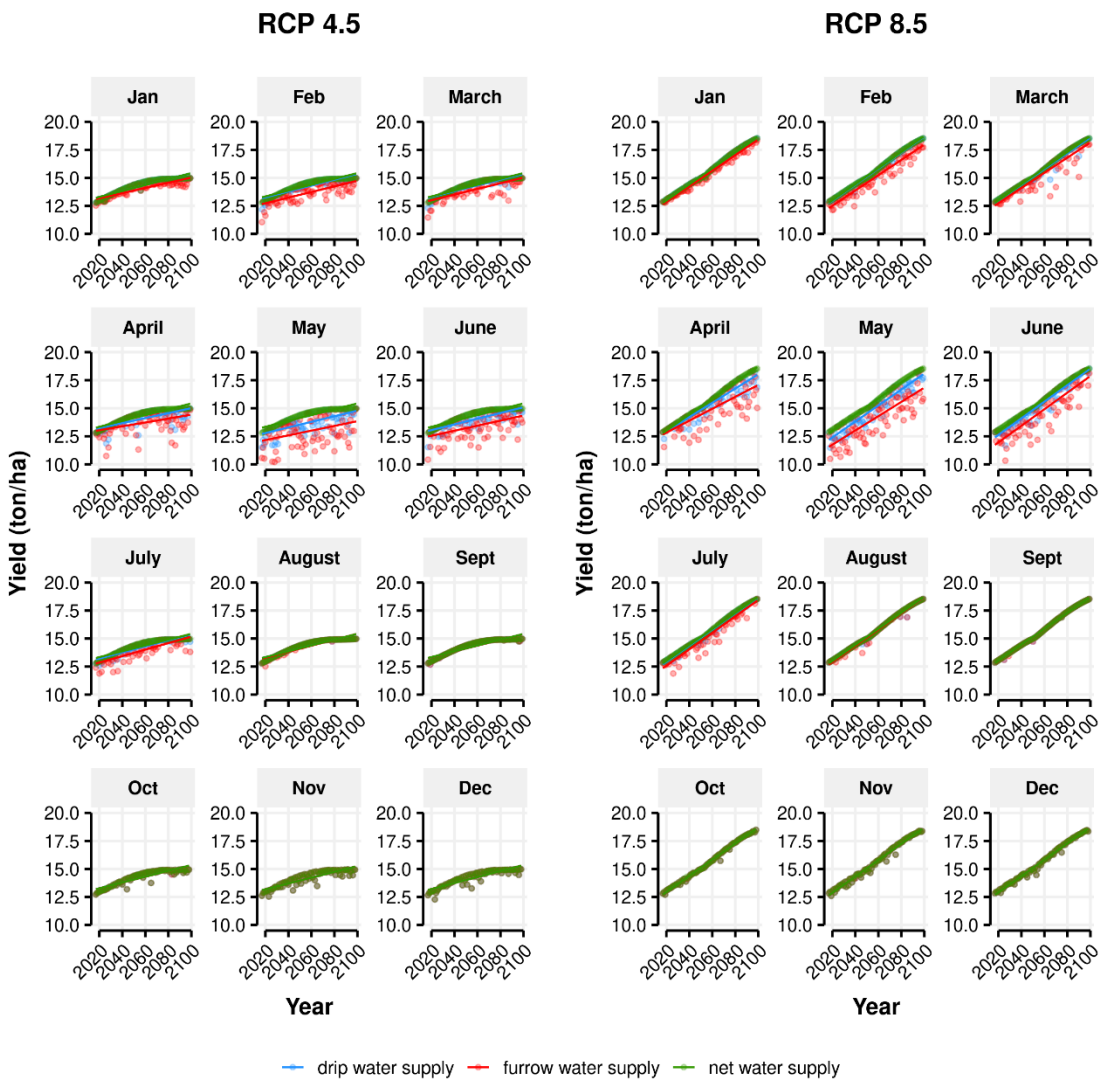
Long-bean irrigation requirements on AquaCrop

- *Net irrigation:* root zone depletion may not drop below 40% readily available water
- *Furrow irrigation (fixed):* 8 mm of water every 5 days up to 35 DAS and then, 10 mm every 2 days until harvest. The total amount of water applied was 314 mm/season
- *Drip irrigation (fixed):* 8 mm of water every 5 days until 35 DAS and then, 10 mm every 2 days until harvesting. The total amount of water applied was 314 mm/season

Table E: Yield, crop water productivity (CWP) and water requirements of long-bean under changing climatic conditions

Factor	Response
Climate scenarios *(RCPs 4.5 and 8.5)*	• Long-bean yields will experience a notable increase under RCP 8.5 throughout the century and a moderate increase in RCP 4.5 up until the mid-century
Irrigation *(net, furrow and drip water supply)*	• No significant yield differences are reported between different irrigation schemes. However, slightly higher yields are expected under net irrigation compared to drip and furrow irrigation during the pre-monsoon months • While the average CWP over the century is of 4.0 and 4.5 kg/m^3 under drip irrigation, that of furrow and net irrigation is of 3.5 and 3.9 kg/m^3, respectively for RCPs 4.5 and 8.5. • The amount of water supply will range between 500-750mm from February to September and between 250-500mm from October to January. The latter differences are explained by higher water inputs (precipitation and irrigation) during the monsoon months and high-water requirements during the pre-monsoon months, when evapotranspiration rates are generally higher. On the opposite side, during the boreal winter, evapotranspiration rates will be lower and, as a result, the crop water requirements and simulated water supplies
Intra-annual *(sowing date)*	• No significant yield differences are expected when different sowing dates are compared, with a similar yield performance year-round and under both RCPs • However, significant differences in water use efficiency are depicted when selecting different sowing dates, with a lower CWP when comparing the pre-monsoon months (April-May) to the rest of the year (June-March). The CWP average values throughout the century are projected to be of 3.2 and 3.8 kg/m^3 under RCP 4.5, and of 3.5 and 4.3 kg/m^3 under RCP 8.5 when the pre-monsoon months (April-May) are compared to the rest of the year (July-March), respectively. The latter differences correspond to a 20% CWP enhancement if the sowing during the pre-monsoon months is avoided
Inter-annual *(21st century)*	• Yields are projected to increase by +11% (from 13.2 to 14.7 ton/ha) under RCP 4.5 and by +29% (from 13.5 to 17.4 ton/ha) under RCP 8.5 when comparing the baseline period (2017-2040) to the end-century (2070-2099). • The CWP is improved by +11% (from 3.5 to 3.9 kg/m^3) under RCP 4.5 and by +34% (from 3.5 to 4.7 kg/m^3) under RCP 8.5 when comparing the baseline period (2017-2040) to the end-century (2070-2099) (average of all sowing dates and three irrigation methods).
Key findings	• Notable water savings (+15%) are expected when using drip irrigation compared to furrow and net water supplies • Regardless of the sowing date and irrigation scheme, long-bean yields are expected to increase by around 30% under RCP 8.5 by the end-century

Figure XVIII: Projected long-bean yields (ton/ha) simulated year-round under future climate scenarios (RCPs 4.5 and 8.5) over the 2017-2099 period. Blue, red and green circles correspond to the annual projected yields under drip water supply, furrow water supply and net water supply, respectively; while the red, green and blue lines to the yield trends



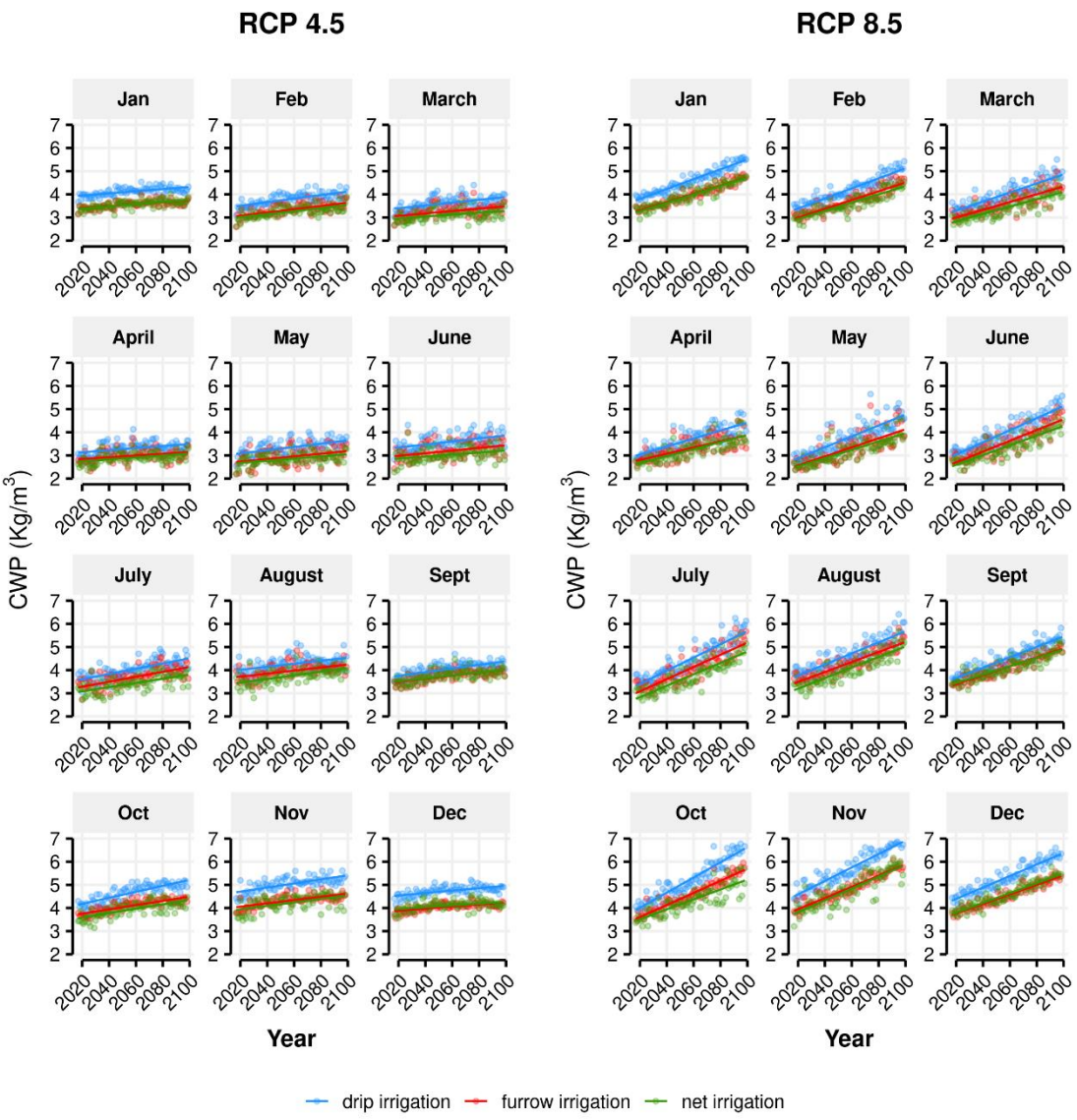
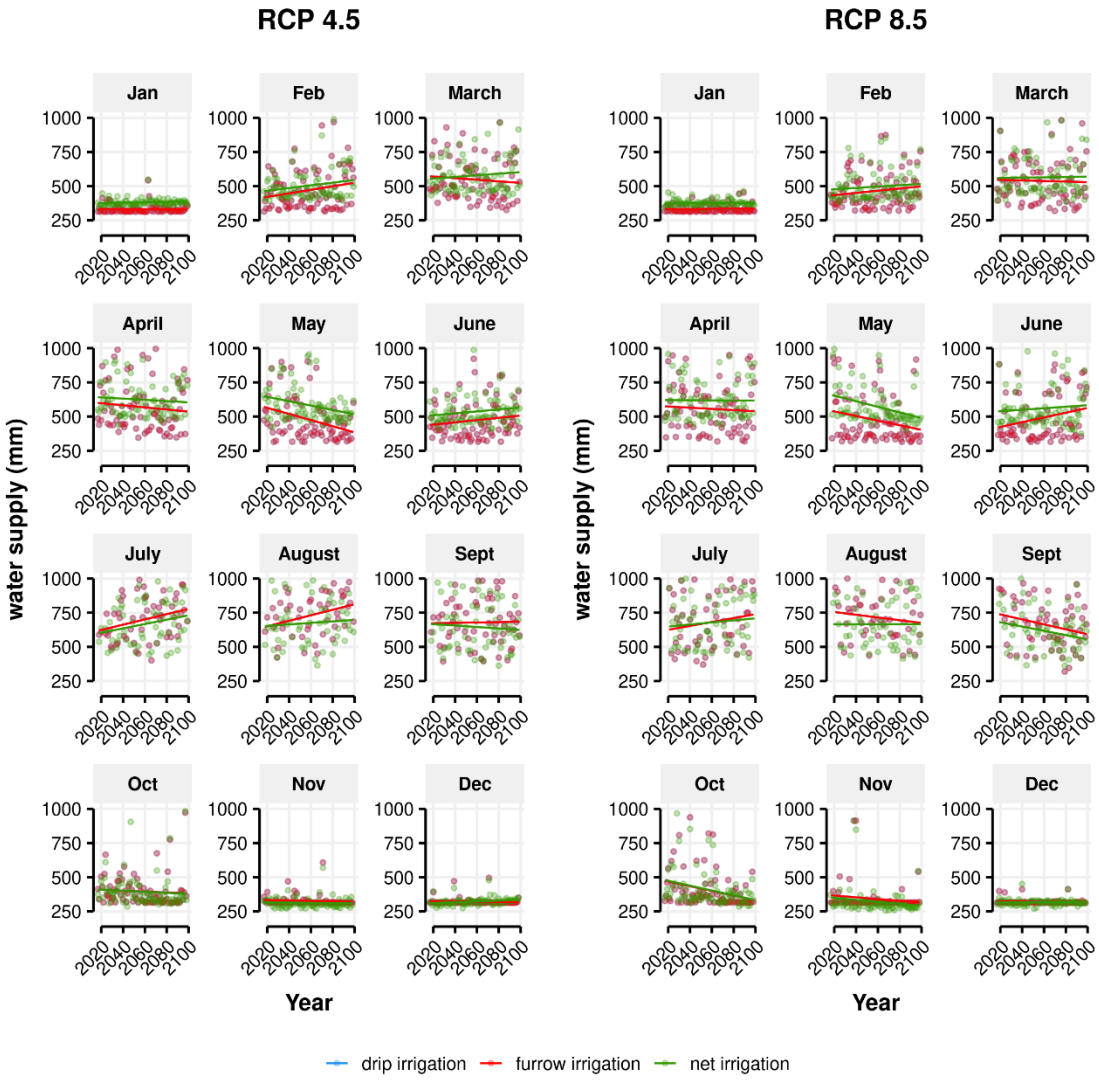


Figure XIX: Projected crop water productivity - CWP - (kg of yield per m³ of water evapotranspired) of long-bean simulated year-round under future climate scenarios (RCPs 4.5 and 8.5) over the 2017-2099 period. Blue, red and green circles correspond to the

annual projected yields under drip water supply, furrow water supply and net water supply, respectively; while the red, green and blue lines to the CWP trends

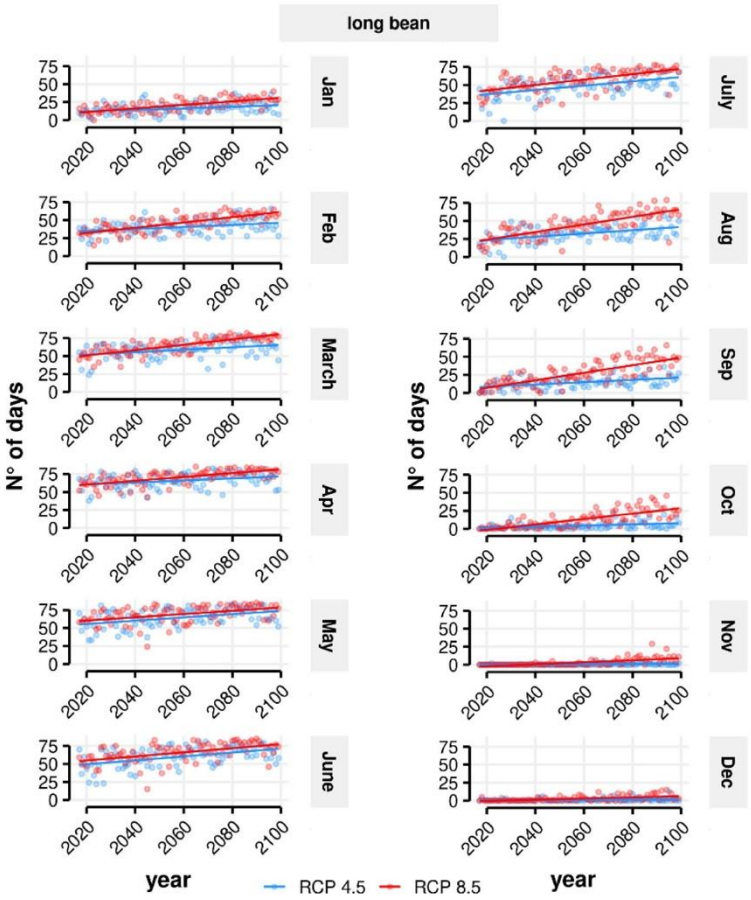


Changes in heat-stress conditions

Long bean's exposure to heat-stress conditions is likely to be higher during the pre-monsoon and early wet-season months (March-June) (Figure XX). Over these months, heat-stress conditions (>36ºC) will exceed more than 50 days during the growing season, lasting approximately 90 days. When sown between March and June, the number of days with heat-stress conditions will increase from 55 to 67 days/season and from 60 to 75 days/season under RCPs 4.5 and 8.5, respectively when the baseline period (2017-2040) and the end-century (2070-2099) are compared. Therefore, heat-stress conditions will be exceeded throughout 79 and 88% of the days, respectively when the crop is grown under RCPs 4.5 and 8.5 and between March and June. On the other hand, when long-bean is sown between November-December, heat-stress conditions will be totally avoided. In addition, most of the differences in heat-stress conditions between RCPs are projected during the monsoon months (August to October). Despite an increase in heat-stress conditions overtime,

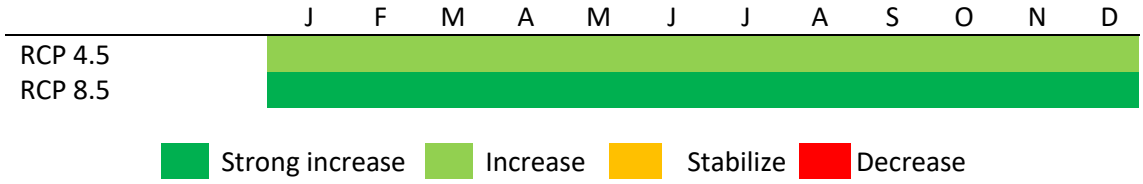
abiotic stress, such as heat-stress, will be off-set by increased CO_2 concentration, which is likely to positively impact crops with a C3 photosynthetic pathway.

Figure XX: Number of days during the growing season when temperatures will exceed the critical threshold for long-bean (36º) under RCPs 4.5 and 8.5 over the 2017-2099 period



The yields of the long bean are projected to significantly increase under RCP 8.5 and moderately increase under RCP 4.5. However, while the yields under RCP 8.5 are likely to increase throughout the 21st century, under RCP 4.5 they are likely to increase mostly in the first half of the century. Regardless of the sowing date, the increasing yield trends are expected to be similar year-round. Additional information on this regard can be found in the AquaCrop results section.

Figure XXI: Projected yields for yard long bean in Siem Reap based on AquaCrop simulations under RCPs 4.5 and 8.5



Annex III: Target Beneficiaries

Based on stakeholder consultations during the project design phase, combined with the projections of climate change impacts and demographic factors underlying particular socioeconomic vulnerabilities, the project will target 24 districts in the northern sections of the NTSB (see the maps in Annex 16) with relatively well-kept agroecological conditions and predominantly small-scale agricultural practices due to its geography and topography. Their remoteness and relatively hilly topography make large-scale commercialization, mechanization, and intensification challenging and costly. Despite these limitations, these districts are also located along national and provincial roads, which offer significant potential to increase smallholder farmers' market access through this approach (see Annex 16 - maps).

In these sections of the NTSB, many smallholder farmers in these areas produce cashew, mango, organic rice, and vegetables in relatively small quantities with minimal to no agrochemical input (Burn et al., 2018; ICEM, 2020). Therefore, premium market segments that value quality over quantity can most effectively harness their growing capacity to produce cashew, mango, organic rice, and leafy vegetables to instigate transformational change towards climate-resilient agriculture.

Table 45: Demographic Profile of 24 Target Districts

Prov.	Admi level	Name (Latin)	Total Population	# Women	% of Women	# HH	# Women-headed HH	# people in agriculture	# men with agriculture	# women with agriculture	# farmers with rice farming as major livelihood activities	# men with rice farming as major livelihood activities	# women with rice farming as major livelihood activities	# farmers with vegetable farming as main livelihood activities	# men with vegetable farming as major livelihood activities	# women with vegetable farming as major livelihood activities	# farmers growing perennial crops as major livelihood activities
KT	District	Kampong Svay	107,593.00	54,736.00	51%	24,452.95	7,936.72	39,343.34	20,286.00	19,627.00	32,978.93	18,954.00	18,517.00	610.20	384.00	445.00	2,229.92
KT	Town	Stueng Saen	59,044.00	30,392.00	51%	13,419.09	4,406.84	21,590.51	7,116.00	5,064.00	18,097.91	6,398.00	4,613.00	334.86	307.00	212.00	1,223.72
KT	District	Prasat Ballangk	61,823.00	30,802.00	50%	14,050.68	4,466.29	22,606.70	11,986.00	11,611.00	18,949.71	11,473.00	11,228.00	350.62	98.00	107.00	1,281.32
KT	District	Prasat Sambour	49,804.00	25,383.00	51%	11,319.09	3,680.54	18,211.74	10,556.00	10,482.00	15,265.70	9,527.00	9,658.00	282.46	111.00	136.00	1,032.22
KT	District	Sandan	63,304.00	32,081.00	51%	14,387.27	4,651.75	23,148.26	12,987.00	14,159.00	19,403.66	10,047.00	11,212.00	359.02	101.00	74.00	1,312.01
KT	District	Santuk	113,649.00	54,222.00	48%	25,829.32	7,862.19	41,557.82	20,525.00	18,867.00	34,835.19	18,102.00	16,680.00	644.54	374.00	246.00	2,355.44
PV	District	Chey Saen	26,387.00	13,651.00	52%	5,863.78	1,801.93	10,658.23	5,482.00	5,365.00	7,834.62	4,913.00	4,791.00	234.10	147.00	145.00	969.47
PV	District	Chhaeb	24,354.00	12,085.00	50%	5,412.00	1,595.22	9,837.06	4,067.00	4,196.00	7,230.99	3,542.00	3,722.00	216.06	83.00	80.00	894.78
PV	District	Choam Ksant	58,500.00	30,171.00	52%	13,000.00	3,982.57	23,629.30	7,242.00	8,155.00	17,369.35	6,293.00	7,373.00	518.99	196.00	132.00	2,149.33
PV	District	Kuleaen	33,990.00	17,026.00	50%	7,553.33	2,247.43	13,729.23	7,008.00	6,390.00	10,092.04	5,457.00	4,980.00	301.55	139.00	158.00	1,248.81
PV	District	Rovieng	47,574.00	24,420.00	51%	10,572.00	3,223.44	19,216.07	9,091.00	8,748.00	14,125.29	7,076.00	6,586.00	422.06	164.00	148.00	1,747.90
PV	District	Sangkum Thmei	21,197.00	10,720.00	51%	4,710.44	1,415.04	8,561.88	5,235.00	4,748.00	6,293.64	4,455.00	4,085.00	188.05	11.00	6.00	778.79
PV	District	Tbaeng Mean Chey	11,418.00	5,904.00	52%	2,537.33	779.33	4,611.95	2,828.00	2,251.00	3,390.14	2,091.00	1,667.00	101.30	60.00	46.00	419.50
PV	Town	Preah Vihear	22,983.00	11,894.00	52%	5,107.33	1,570.01	9,283.28	2,160.00	2,054.00	6,823.93	811.00	793.00	203.90	101.00	91.00	844.41
SR	District	Banteay Srei	44,781.00	22,583.00	50%	9,735.00	2,890.62	14,583.95	8,333.00	8,728.00	12,689.40	6,867.00	7,449.00	318.58	376.00	467.00	221.40
SR	District	Chi Kraeng	151,163.00	76,845.00	51%	32,861.52	9,836.16	49,229.66	27,127.00	23,770.00	42,834.40	25,112.00	21,762.00	1,075.41	638.00	605.00	747.37
SR	District	Prasat Bakong	82,214.00	41,903.00	51%	17,872.61	5,363.58	26,774.85	11,930.00	11,235.00	23,296.62	10,860.00	10,062.00	584.89	498.00	578.00	406.48
SR	Town	Siem Reap	250,798.00	12,890.00	5%	54,521.30	1,649.92	81,678.05	13,256.00	11,463.00	71,067.53	11,471.00	9,763.00	1,784.24	1,030.00	1,139.00	1,239.98
SR	District	Soutr Nikom	117,186.00	59,427.00	51%	25,475.22	7,606.66	38,164.28	21,073.00	21,034.00	33,206.48	20,007.00	200,023.00	833.69	505.00	494.00	579.38
SR	District	Svay Leu	44,092.00	21,802.00	49%	9,585.22	2,790.66	14,359.56	8,675.00	7,069.00	12,494.16	6,813.00	5,754.00	313.68	107.00	87.00	218.00
OM	District	Anlong Veaeng	50,441.00	24,856.00	49%	10,965.43	2,435.89	22,092.29	8,498.00	7,640.00	22,092.29	7,117.00	6,641.00	140.15	104.00	109.00	461.95
OM	District	Banteay Ampil	52,333.00	25,653.00	49%	11,376.74	2,513.99	22,920.95	12,511.00	12,239.00	22,920.95	11,212.00	11,168.00	145.40	63.00	37.00	479.28
OM	Town	Samraong	65,803.00	22,141.00	34%	14,305.00	2,169.82	28,820.58	11,912.00	10,603.00	28,820.58	10,915.00	9,766.00	182.83	149.00	129.00	602.64
OM	District	Trapeang Prasat	59,281.00	29,279.00	49%	12,887.17	2,869.34	25,964.06	13,460.00	14,436.00	25,964.06	12,729.00	13,824.00	164.71	104.00	86.00	542.91
			1,619,712.00	690,866.00	48%	357,799.85	89,745.93	590,573.58	263,344.00	249,934.00	508,077.57	232,242.00	402,117.00	10,311.30	5,850.00	5,757.00	23,987.02

As shown in Table 45, according to the most recent agricultural census (NIS, 2019), approximately 590,000 individuals (48% women) practice farming as their primary livelihood activity in these 24 target districts. About 85% of these farmers are involved in rice production, while the remaining 15% produce perennial and other crops, including vegetables, as their primary crops. Approximately 150 officially registered AC, FAs, PGs, and agricultural unions are currently active in the project's target districts. The project targets roughly 25% of these farmers (135,000) to adopt climate-resilient and high-value agricultural practices through climate-resilient value chain development through Outcome 2. Under Outcome 1, approximately 75% of these farmers (450,000) will benefit from improved access to crop-specific agrometeorological advisory services. Additionally, based on the areas identified for the IWM activities under Output 2.4, derived from the recent restoration potential study (2018), the project targets roughly 8 to 10 % of the immediate downstream farmers (ca. 50,000) as direct beneficiaries of improved agroecological conditions while noting the overall benefit of enhanced ecosystem services to a more significant number of beneficiaries along the waterways. In determining these target figures, the project development team consulted with the past and ongoing agricultural support projects of FAO and other development partners in the country, to identify the project's potential outreach capacity from the operational and financial standpoints.

These target areas and figures, combined with the selection of target crops, were validated through the national stakeholder validation workshop (Annex 7). The sensitivity analysis under the economic and financial analysis (Annex 3) indicates that the project must directly benefit at least 157,988 farmers to maintain its positive investment return, and this confirms the robustness of the project's direct beneficiary targets.

Table 46 Summary of Direct Beneficiaries

Number of Beneficiaries	Direct Beneficiary Type	Benefit Description
450,000	Smallholder farmers in the target districts	Improved access to tailored agrometeorological advisory services to reduce agricultural loss due to climate change;
135,000[36]	Smallholder farmers and other local value chain actors, including local SMEs, in the target districts	Improved market and financial access and accelerated support for adopting climate-resilient and high-value practices and technologies;
50,000[37]	Downstream farmers in the target districts.	Improved ecosystem services, agroecology, and 20 CPAs/CFs with improved livelihood options through restoration and protection of catchment.

In total, 450,000 beneficiaries will directly benefit from improved agrometeorological information, training/extension services, and other last-mile services to increase their resilience to climate change. Within this group of beneficiaries, smaller groups (see Table 46) will receive highly tailored capacity support to improve their crop-specific application of agrometeorological information and advisory services, access premium markets, finance, and climate-resilient, and high-value technologies, and benefit from restored ecosystem services in upper catchment areas, and improved downstream agroecology.

Table 47 Demographic Profile of NTSB

	All	% Women
Total Area (hectares)	2,500,000	
Total Population	3,793,793	44%
% of ID poor population	15%	n/a
# of Households	8 33,029	23%
% of ID poor households	15%	not available
# of people in agriculture	1,355,336	37%
% of rice farmers	87%	45%
% of perennial crop farmers	3%	n/a
% of vegetable farmers	2%	39%
# of registered ACs	3 06.00	n/a

The project also targets roughly 25% of the NTSB's population (1,000,000) who are primarily dependent on agriculture as their primary livelihood activity (Table 13) as its indirect beneficiaries. The project defines them as a beneficiary group that is not directly targeted by the project, and this group is thus not involved in the target value chains in the 24 districts of the NTSB. These indirect beneficiaries will benefit from the project by having general access to improved agrometeorological information and increased exposure and awareness of alternative practices and technologies through peer-to-peer learning, demonstration sites, extension services, social media platforms, and mobile apps. In addition, private sector actors, including agricultural suppliers, collectors, traders/exporters, retailers, hoteliers, and restauranteurs, playing critical roles in providing agricultural extension services, developing market opportunities, and promoting climate-resilient and high-value practices, as well as consumers, will benefit from increased supply and sourcing capacities for climate-resilient and sustainable products and related investment opportunities. For the private sector actors and consumers, the project cannot at this point estimate its target beneficiary figures; however, at the inception stage and during the implementation, the project will conduct several surveys to measure and report its impact on these beneficiary groups.

[36] This is part of the 450,000 total direct beneficiaries.
[37] This is part of the 450,000 total direct beneficiaries.

Annex III: TSSD's Revolving Fund Experience

Revolving Fund Experience - Tonle Sap Poverty Reduction and Smallholder Development (TSSD) Project by ADB/IFAD (Executing national entities: MAFF and MOI), based on the interview with the TSSD team

Target beneficiaries:
ID poor farmers in BTB, BMC, SRP, KPT, KPC, TBK & PVG
Initially designed for rice and vegetable production, however, almost two-thirds of the beneficiaries use the funds for chick/chicken raising (poultry) instead as it offers quick income generation opportunities.

Number of beneficiaries:

- In the first phase (2010-2017), 196 communes and 27 districts were targeted, and 1,241 Livelihood Improvement Groups (LIGs) were established.
- Each LIG consists of 20 to 25 members who are ID poor households[38] from the same village.
- In the second phase (2018-2022), the coverage has extended to 270 communes and established all together approximately 2,000 LIGs.

Initial capital investment:

- US$ 7 million

Operating unit:

- LIGs.

Intermediary for fiduciary control:

- Commune Councils receive funds through NCDD into dedicated accounts and manage fund disbursements to and repayments from LIGs.

Mechanisms:

- Revolving funds are managed by commune councils, which then transfer funds to LIGs for further disbursement to their members.
- An individual member of a LIG is eligible to borrow up to US$ 240 at a time.
- To access funds, a LIG member must develop a business plan as well as a repayment plan.
- LIG leaders regularly update their members on progress in terms of business planning, receiving loans, repayments, etc., to ensure a strong support environment within each group.
- LIGs provide group support to their members through peer-to-peer (P2P) learning and assistance (e.g., literate members support others in preparing and reviewing these plans and keeping track of repayments).
- Each commune council has commune extension workers tasked to provide technical backstopping in business planning and assisting with, for instance, poultry activities.
- TSSD provides capacity development support to LIGs and their members in these areas and establishing individual bank accounts to receive funds.
- TSSD also promotes good agricultural practices (i.e., CamGAP) and sustainability considerations in business planning.

Repayments:

[38] The Identification of Poor Household Program (known as ID Poor) first started in May 2012 under the Ministry of Planning's Proclamation following the RGC's Sub-Decree released in 2011. The Program aims at identifying poor households according to their poverty levels in several areas. The ID Poor households are categorized into two groups – Level 1: Poor, and Level 2: Very poor, depending on how they score in key assessment areas.

- 2 % monthly interest is applied(APR of 24%).
- Repayment durations are determined based on business and repayment plans (e.g., for rice, six months, nine months for handicraft).
- In each LIG, three members form a fguarantee system to prepare plans and deal with default.
- 50% of the interest collected is paid back to LIGs to establish group savings.
- If a borrower runs into difficulty making a repayment, the corresponding 3-member guarantee group, and LIG first intervene to support. The issue could be brought up to the commune council level to find a solution (e.g., the council would summon the borrower, guarantee group members, and LIG leader to resolve the issue through deferral, an amendment to a repayment plan, etc.).

Current status:

- Fully operational.
- Initial investment has grown to US$ 10 million.

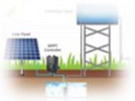
Lessons learned:

- Low default rate among LIGs (so far, only 37 LIGs dissolved) and their members is attributed to a solid supporting environment within each group, sharing common underlying socioeconomic conditions (i.e., ID Poor status).
- P2P efforts (e.g., literate members supporting others through business planning and bookkeeping) within each LIG have created strong social cohesion among members and resulted in an effective group guarantee system.
- Use of ICT is key to successful implementation: All transactions are done through mobile technologies – bank branches are often not nearby.
- LIG group savings were not initially planned, but had it been part of the initial plan, the total available funding size would have been much more significant – highly recommended to set them up at the outset.
- Initially, US$ 240 cap was thought to be too small, but the small amount (i.e., highly manageable) and quick disbursement speed through the Block-grant Mechanism, approved by MoEF, through NCDD directly to commune councils and LIGs, have been proven effective.
- LIGs' decentralized decision-making in leadership appointment, governance, business, and repayment planning has also been proven to increase their members' accountability, and business literacy and acumen.
- Highly decentralized Block-grant Mechanism has enabled the commune councils to play significant roles in administering the revolving fund, which has strengthened the linkages between the revolving fund and decentralized planning tools such as commune development plan (CDP) and service delivery at the sub-national level.

Additional Notes:

- LIGs are not cooperatives, as they are small groups of ID poor farmers, but some members might also belong to some cooperatives.
- TSSD has taken some LIGs to evolve them into "Market Improvement Groups (MIGs)" to extend their focus on market development beyond production.
- TSSD has also helped form the Farmers Livelihood Improvement Association (FLIA) under MoI, which organizes 2,000 LIGs – the country's largest association.
- FLIA supports LIGs in business development and other capacity-related matters.
- FLIA holds an assembly meeting every year with LIG representatives for activity planning.
- FLIA is financially sustainable (i.e., every LIG pays US$ 20 a month membership fee).

Annex IV: Examples of Technologies and Infrastructure Assets under FARM

Example Asset	Basic Asset Specifications	Pricing (USD)	Note
 Solar Water Pump	• 190W x 15 solar panels • Motor 3 HP • 5 kW Water pump inverter • Wires and other accessories • 60-80 m^3 flow capacity	15,000 – 20,000	Multiple unites are required by each beneficiary group
 Drip Irrigation System	• Same system as above • Drip lines (USD 500 per ha) • Automated timer	40,000 -45,000 for 50 hectare cropland	
 Solar Cold Storage Room for mango and vegetables	• 5 kW solar capacity • 1.5- 2.7 refrigerant capacity • Humidity control range 65-95% • Temperature range of 4 - 10˚ C .	15,000 – 25,000	Multiple unites are required by each beneficiary group
 Juice processing machine for reducing postharvest loss and value addition	• 3-5 t/hr. processing capacity • 1- 30 kW power output • High energy efficiency rating	100,000 -120,000	Multiple beneficiary groups may jointly own and share one unit.
 Laser land leveler to improve fertilizer and water use efficiency and increase production capacity.	• Fuel efficient 80 HP tractor • Trimble laser levelling unit • External hydraulic pump and oil cooler	45,000 – 50,000	

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