GCF RLLP Proposal Annex A.3.

Feasibility Study

Climate-Smart Agriculture Manual

This document provides - (i) Technical strategy and technical information kits of CSA practices for incorporation in SLM (ii) Operational procedures for planning, implementation and categorization of practices - among other information relevant to SLMP-2 and RLLP.

Ministry of Agriculture and Natural Resources

Sustainable Land Management Program

Climate Smart Agriculture

A Field Manual for Practitioners

December 2016

Addis Ababa

List of Acronyms

ARP .... Adaptive Research Plan
BoO ....Basket Of Options
CA ....Conservation Agriculture
CBPWMG ....Community Based Participatory Watershed Management Guideline
CRGE ....Climate Resilient Green Economy
CSA ....Climate Smart Agriculture
DA .... Development Agent
ESMF ....Environmental and Social Management Framework
FAO ....Food and Agriculture Organization
FTC .... Farmer Training Centres
GCCA...Global Climate Change Alliance
GDP ....Gross Domestic Product
GHG .... Green House Gases
IGA ....income generation activities
ISFM .... Integrated Soil Fertility Management
MoANR... Ministry of Agriculture and Natural Resources
SLMP ....Sustainable Land Management Programme
SWC ....soil and water conservation
SWM ....Soil Water Management

Contents

1. Background on Climate change and Agriculture

Climate change is experienced all over the world and has become a global phenomenon. It expresses itself by global warming, rising sea levels, changing weather patterns and increasing frequency of natural hazards among others. Most people are affected by climate change worldwide in one way or another while at the same time also contributing to climate change. It is often overlooked that much of the climate change is man-made, caused by the way the natural resources are managed, in particular land, water and air which are the basis for all life on our planet. Addressing climate change is generally associated with reduction of GHG emissions. Therefore, the international climate change discussion centred around the industrial, energy and transport sectors, which are strong contributors to GHG emissions. However, within the international discussion on climate change the role of the agriculture sector has recently received greater attention, as a contributor of climate change as well as with regard to its mitigation potential. In the context of agriculture there is meanwhile a much stronger focus on adaptation, which is the urgent need of farmers, especially smallholder farmers to adapt their agriculture practices to the increasing effects of climatic variations. Accordingly, with a stronger orientation on adaptation, the focus goes towards the agriculture sector and smallholder farmers in developing countries. Agricultural production, including livestock farming, is attributed to contribute significantly to GHG emissions. At the same time, agricultural production, especially on smallholder level suffers drastically from the effects associated with climate change.

In Africa, agriculture is the backbone of most national economies. While the continent accounts for only 6.5% of global greenhouse gas emissions it is considered particularly vulnerable to the consequences of climate change (WRI, 2016). Developing synergies between mitigation and adaptation are the core of climate sensitive agriculture. The "International Assessment of Agriculture, Science and Technology for Development "concluded, that "continuing the business as usual" in utilizing Green Revolution technologies and practices of food production "were not an option for the future" (IAASTD, 2009). This has emerged the need for a climate-sensitive or climate-smart agriculture. Both terms are used synonymously under the CSA abbreviation in this document.

2. Climate Smart Agriculture

The term "climate-smart agriculture" (CSA) emerged in the course of the international debate on climate change as it soon became obvious that "business-as-usual" cannot be an option for tackling climate change impacts on, and by agriculture. Nevertheless, it remains a challenge to identify the "business-as-unusual" or what is the additional benefit compared to agriculture development as in the past? Being both a significant contributor to GHG emissions and at the same time strongly affected by climate change, requires a substantial revision of methods and techniques of agricultural production. Climate smart agriculture (CSA) may be defined as an approach for transforming and reorienting agricultural development under the new realities of climate change (Lipper et al. 2014). The most commonly used definition is provided by FAO which defines CSA as "agriculture that sustainably increases **productivity**, enhances resilience **(adaptation)**, reduces/removes GHGs **(mitigation)** where possible and thereby enhancing achievements of national food security and development goals" (s. Fig. 3).In short, CSA aims to promote the adoption of technically, financially and environmentally sound production practices, while incorporating resilience to climate effects and contributing to reduced GHG emissions.In addition to conventional agricultural development with the only focus on income generation (IGA) and food security, CSA systematically integrates climate change in terms of adaptation and/or mitigation objectives

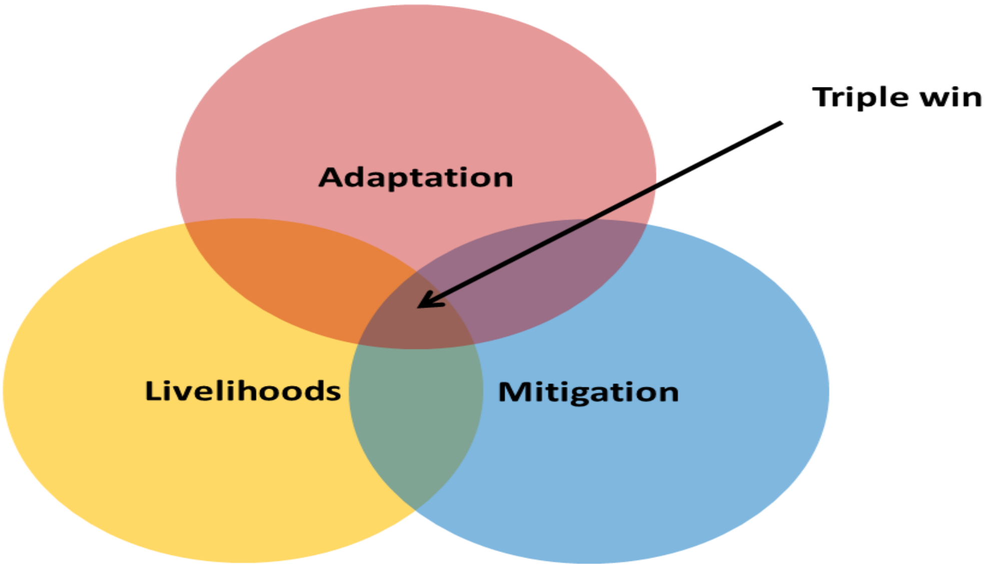


Fig.1: The three pillars of Climate-Smart Agriculture

The three pillars of CSA can be defined as follows:

Productivity: CSA aims to sustainably increase agricultural productivity and incomes from crops, livestock and fish, without having a negative impact on the environment.

Adaptation: CSA aims to reduce exposure of farmers to short-term climatic variability, while also strengthening their resilience by building capacity to adapt to climate-related shocks and longer term impacts. Therefore, adaptation also refers to resilience, vulnerability and risks. Particular attention is given to protecting the environmental services (e. g. clean water, fertile soils, etc.) which ecosystems provide to farmers and society. These services are essential for maintaining productivity and the ability to adapt to climate change.

Mitigation: Wherever and whenever possible, CSA should help to reduce and/or remove greenhouse gas (GHG) emissions. This implies that production systems generatefewer emissions, avoid deforestation and manage soils and vegetation (crops, pastures and trees) in ways that maximize their potential to act as carbon sinks and absorb CO_2 from the atmosphere.

Box 1: From mitigation to adaptation with mitigation as co-benefit (synergy)

From the very beginning the debate on tackling climate change focussed on mitigating greenhouse gas (GHG) emissions. This also led to an emerging Carbon market, whereby emission reduction or carbon sequestration would be paid for according to the market price of the ton of CO_2. Carbon credit payments would be made based on the MRV (Monitoring, Reporting and Verification) procedure, which had to be in place at the national level. Although many projects were launched internationally to create access for smallholder farmers to Carbon financing, not many have been successful. This is due to the complexity of installing a MRV system for smallholder farmers, as well to the virtual collapse of the carbon market when the price went down from more than 20 $US/ton of CO_2 to about 1 $US/ton of CO_2This has contributed to a shift in focus of the climate change discussion to the adaptation aspect especially for the smallholder farming context. Nevertheless, all three aspects of climate-smartness are addressed by CSA.

- **CSA integrates multiple goals and manages trade-offs.** Ideally CSA produces triple-win outcomes of increased productivity, enhanced resilience and reduced emissions. But often it is not possible to achieve all three simultaneously. As such, trade-offs must be acknowledged when implementing CSA activities, while managing these trade-offs requires identification of synergies, costs and benefits of the different options.
- **CSA maintains eco-system services.** It is imperative that CSA interventions do not contribute to the degradation of ecosystem services such as clean air, water and healthy soil. Thus, CSA adopts a landscape approach that builds upon the principles of sustainable agriculture.
- **CSA is context-specific.** No interventions are climate smart everywhere or every time. Interventions must take into account how different elements interact at the landscape level and within or among ecosystems.
- **CSA has many different entry points.** CSA interventions can go beyond single technologies at farm level and may include the integration of multiple interventions at the food system, landscape, value chain or policy level.

In conclusion, what is new about CSA is, on the one hand, that the approach invites to consider these three objectives together at different scales - from farm to landscape – at different levels - from local to global - and over short and long time horizons, taking into account national and local specificities and priorities. On the other hand, CSA makes an explicit consideration of climate risks that require changes in agricultural technologies and approaches. Figure 4 figure depicts the different dimensions of CSA:

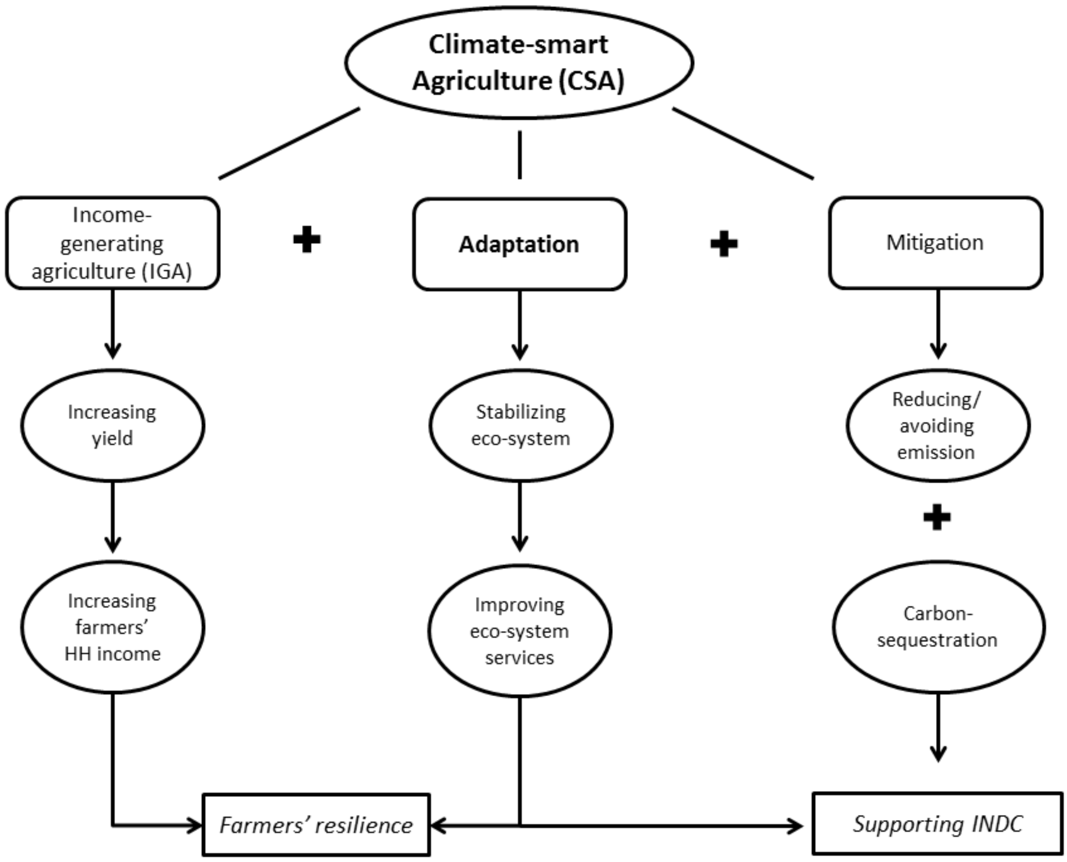


Fig.2: Conceptual dimensions of Climate-smart Agriculture

2.1. How to identify climate-smartness

When identifying climate-smart interventions one has to be aware that climate-smartness is not a "yes" or "no" matter, but rather a continuum where some interventions are more climate smart than others. For example, an intervention with a strong impact on reducing emissions might not necessarily generate much income for a farmer. Furthermore climate-smartness can be achieved by **doing different things** and very often also by **doing things differently**.

"Climate smartness" depends largely on the way how agricultural activities are being implemented rather than what is being produced. It requires ecological and social resilience factors (i.e. natural, human and social capital) to be developed (Adger 2000) instead of simply focusing on income generation.

In most cases, agricultural activities cannot be categorized as "climate smart" or "not climate smart". Climate smartness of agricultural activities is a quality that can best be measured on a continuous spectrum ranging from "less climate smart" to "more climate smart".

The degree of climate smartness of an intervention depends also on the quality and method by which it is implemented. For example, the effect of mulching on farm depends on the amount of crop residue or other organic material that is used to cover the soil. Or the effect of reduced tillage will depend on the actual number and depth of ploughings. One example of systematic classification of climate-smartness of individual practices is the "basket-of options" (BoO) developed and applied on a pilot basis by GIZ-SLM in Ethiopia through the GCCA Project. In GCCA,a large number of agriculture interventions have been rated for their climate-smartness. Although the climate smartness of individual practices has been used to select the practices included in the infotechs of this Manual, the BoO methodology can be applied as an orientation for practitioners using this Manual, especially for the selection of packages of practices. The detailed classification of CSA practices is included in Annex xx.

3. Ethiopian Context of Climate Change and Sustainable Land Management

In Ethiopia, like most of the development countries with low level industrialization, the agriculture related sub-sectors have the greatest share of GDP and a relative large share of GHG emissions. Figure3 shows the breakdown of calculated emissions in Ethiopia by sector or sub-sector in 2010, where the agriculture sector represents an estimated 63% of total emissions.

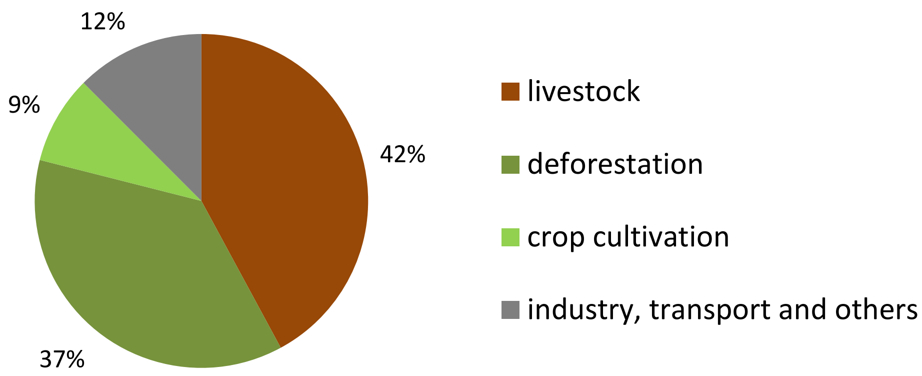


Fig.3: Economic sub-sectors emitting a total 150 Mt CO_2e in Ethiopia 2010 (Ethiopia INDC)

Out of the total GHG emissions of Ethiopia of 150 Mt CO_2e in 2010, the livestock subsector had the highest share with 65 Mt CO2e (42%) followed by deforestation and forest degradation due to cutting and burning fuel wood and logging with 55 Mt CO2e (37%) and crop cultivation with 12 Mt CO2e (9%).

For several years, the Ethiopian government and its line Ministries have been addressing climate change through the development of a number of strategies and plans, including:

- National Adaptation Program of Action (NAPA, 2007)
- Ethiopian Program of Adaptation to Climate Change (EPAAC, 2011)
- Climate Resilient Green Economy Strategy (CRGE, 2011)
- Agriculture Sector Adaptation Strategy
- Nine Regional State and two City adaptation plans

The CRGE is Ethiopia's strategy for addressing both climate change adaptation and mitigation objectives. The CRGE defines that Ethiopia intends to limit its net greenhouse gas (GHG) emissions in 2030 by 64% as compared to a projected "business-as-usual" scenario. At the same time, Ethiopia also intends to undertake adaptation initiatives to reduce the vulnerability of its population, environment and economy to the adverse effects of climate change. The long-term goal is **to ensure that adaptation to climate change is fully mainstreamed into development activities**. Considering that agriculture is a major contributor to GHG emissions and smallholder farming systems produce the majority of Ethiopian agricultural output, the focus on adaptation is fully justified. The main effort in the near-term is to build the capacity needed to mainstream adaptation to climate change into all public and private development activities.

For several years, the Ministry of Agriculture and Natural Resources (MoANR) has been addressing climate change impacts also within the Sustainable Land Management Programme (SLMP) in the Ethiopian highlands. The SLMP-2 project design comprises the following components:

Component 1: Integrated Watershed and Landscape Management
- **Sub Component 1.1:** Sustainable natural resource management in public and communal lands
- **Sub Component 1.2:** Component Homestead and farmland development, livelihood improvements and **climate smart agriculture (CSA)**

Component 2: Institutional Strengthening, Capacity Development and Knowledge Management
Component 3: Rural Land Administration, Certification and Land Use
Component 4: Project Management

In SLMP, currently in its second phase, the entry point for the SLM approach is the micro-watershed. The prime focus lies in the rehabilitation of degraded areas (slopes, gullies, etc.) through soil and water conservation (SWC) measures. SLMP addresses the challenges in the Ethiopian highlands through a three-stage approach (Fig. 2). After (1) community mobilization is achieved (2) soil and water resource rehabilitation in the micro-watershed is tackled with communities to (3) put the rehabilitated land into productive use through agriculture and livestock production.

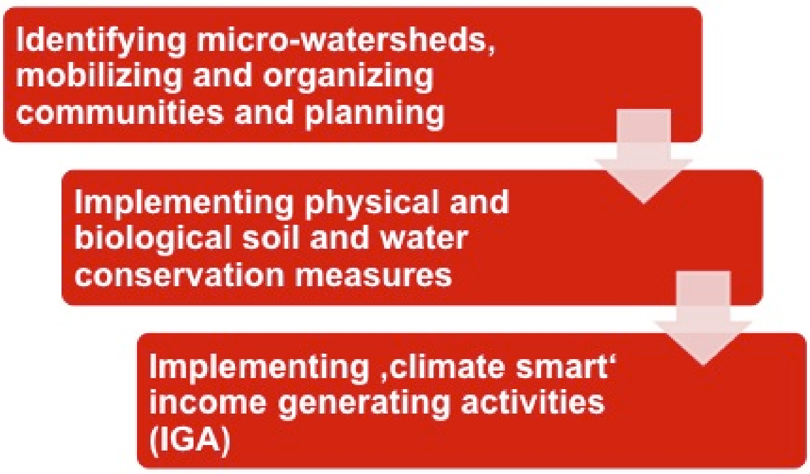


Fig.4: Three phases of SLM implementation

While phases 1 and 2 of SLMP aim to conserve soil and water at the landscape level and primarily take place on communal land, the third phase of SLM is implemented on farmers' private land. SLMP is guided by an ecosystem-based approach to food security, where SWC measures implemented at the landscape level decrease soil erosion rates and rehabilitate degraded land. These measures represent a pre-condition to sustainably intensifying crop and livestock production on private farmland as they rehabilitate vital ecological functions (e.g. water availability, nutrient cycling, natural pollination services, etc.) within the micro-watershed.

For the implementation of SLMP, MoANR developed and documented comprehensive "Community Based Participatory Watershed Management Guidelines" (CBPWMG). The document includes detailed actions with regard to the implementation of phases 1 and 2. In particular the guidelines describe the steps for identifying the critical watersheds, establishing various watershed development teams, and developing watershed investment and management plans with the community.

4. Rationale and Scope of the CSA Field Manual

As the CBPWMG guidelines refer predominantly to SWC measures on communal land, and IGA activities are currently selected primarily based on productivity criteria, it is necessary to develop guidelines and procedures for implementation of specific CSA interventions, i.e., sustainable and resilient crop and livestock practices on farm land. In the context of SLMP, the CSA Field Manual is operationally complementary to the CBPWMG, as the interventions and practices to be promoted should be closely linked to SWC measures, would help farmers to generate income and would be climate sensitive.

CSA interventions should build upon SWC measures already implemented in target watersheds. For example, climate-smart crop and livestock interventions would need a well-functioning area closure as a precondition. This connection to SWC intervention is important to assure that unsustainable agricultural practices do not revert the benefits of prior physical and biological rehabilitation measures. As SWC measures focus on rehabilitation of degraded and mainly community land, CSA activities address agricultural production as a next step towards sustainable watershed management with a landscape approach. In this way, the farmland-based activities become fully integrated with in the above-described watershed/landscape approach and contribute towards the goal of climate resilient watersheds. Although sustainable CSA may require actions on building policy framework, strengthening of institutions and development of financing options, this CSA Field Manual is intended to assist practitioners to guide farmers in the adoption of CSA, and therefore focuses only on field level interventions on SLMP beneficiaries.

The CSA Manual focuses on component 1.2 of SLMP. Nevertheless, the content can be applied easily to a wider scope by supplements the CBPWM Guidelines which primarily give instructions for implementing soil and water conservation (SWC) activities on communal land (component 1.1). This CSA manual, therefore, focuses although not exclusively on agriculture and livestock activities on private farmlands.

The CSA manual provides guidance to MoANR and project staff at all levels in the implementation of climate sensitive crop and livestock development activities. It describes the operational approach of integrating climate sensitive agriculture and livestock activities into the watershed development under the SLMP. More specifically the manual provides tools and methodologies on how to plan, identify, operationalize and monitor climate sensitive agriculture activities.

4.1. CSA Field Manual Structure

The Manual is divided in two distinct sections: Section 1 describes the operational criteria and procedures to be applied for all CSA interventions, while Section 2presents a detailed description of practices through individual “infotechs” for each type of recommended intervention.

The “infotechs” contain all necessary technical information (including specific norms for implementation) as a stand-alone fact sheet, and form the core element for field practitioners to advice farmers on CSA practices selected for the eight types of priority CSA interventions. As such they represent the basis for the planning and selection of practices as well as for budget calculations.

A number of interventions have already been identified as key for the development of CSA in the context of Ethiopia’s SLMP. For each intervention, a specific Infotech has been developed based on current local and international knowledge. The infotech contains a list of recommended CSA practices. The infotechs are considered “living” documents, and as such are expected to be modified, updated and/or refined by the results and practical experience generated during the pilot phase of CSA implementation in selected SLMP watersheds. The initial infotechs developed cover the following intervention areas:

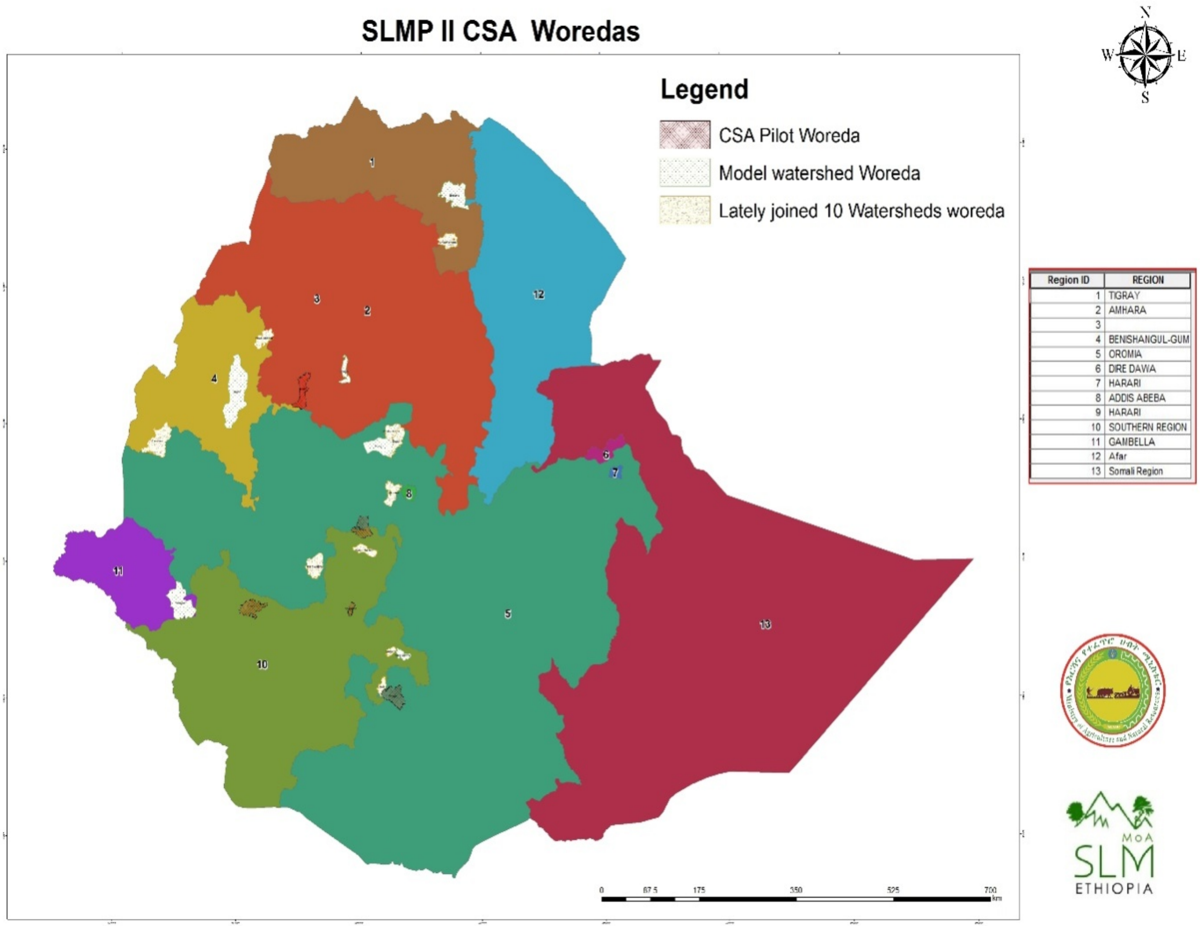
- **Agroforestry**(defined as trees, including bamboo, planted in association with farmland crops)
- **Conservation agriculture** (defined as minimum tillage with mulching and crop rotation)
- **Agro-biodiversity** and **Crop production (**includes a wide range of crop management practices as well as adoption of improved native varieties)
- **Integrated Soil Fertility Management (ISFM)**(includes the range of interventions directly improving soil fertility and indirectly crop management)
- **Livestock management and forage development**(all sustainable animal husbandry and animal breeding measures except animal breeding and health services)
- **Manure management (**including biogas production and utilization**)**
- **Agricultural water management**
- **Climate Information and weather forecast**

5. Operational Approach for CSA Implementation

5.1. Scope and Target Areas

The ultimate goal is to implement CSA activities in all 135 watersheds comprising the SLMP project areas. However, given the need to test operational procedures, adjust institutional arrangements and verify the technical recommendations contained in the infotechs, a validation phase of 12-18 months will be conducted. This validation phase will be implemented in a total of 30watersheds selected on the basis of their representativeness and compliance with the eligibility criteria (see below), in particular regarding the level of adoption of SWM practices. The names, locations and main features of the selected watersheds are described in the following table and map.

SLMP II CSA Woredas



Region ID	REGION
1	TIGRAY
2	AMHARA
3	
4	BENISHANGUL-GUM
5	OROMIA
6	DIRE DAWA
7	HARARI
8	ADDIS ABEBA
9	HARARI
10	SOUTHERN REGION
11	GAMBELLA
12	Afar
13	Somali Region

Table 1. Location and Main Features of CSA watersheds (pilot phase)

No	Region	Woreda	Critical Watershed	Selected micro watershed	Area (ha)	Farm land area (ha)	Households (No)	Cattle (No)	SSI Activities
1	Oromia	Tiro afeta	Nedhi	gariwayu	1284	758	220	399	
		H/Abote	Aleltu	Wiiji	792	596	435	1740	
		Degem	Lagaworke	cheraki anode	848	411	348	2128	Yes (Traditional)
		Wolmera	Wechcecha	Damare	561	396	107	321	-
		Woliso	Rebu	Warabo	260	130	821	3610	-
		Uraga	Bangasa	Hashufe	503	316	297(3)	394	Yes (Traditional)
		Kuyu	Chirecha	fincha	801	596	211	921	Yes (Traditional)
2	SNNPR	Bule	Baricha adado	Wachlacha	364.4	273.3	942	678	
		Mihurna aklil	Begez	Begez 7	800	115	625	950	
		Wensho	Orisha geo	First Fero Dea	303	295	664	1631	
		Arbegona	Geramba gorante	Bebeko	820	750	1196	3471	Stream diversion, 15 ha
		Angacha	Azga supa	Shuba	720	462.3	820	3969	92 Hand dug wall (25 ha)
		Gimbo	Geshy	Geri	312.17	300	91	98	8Rope&washer (19 beneficiaries)
3	Tigray	Endamehoni	UpperBurka abagabir	KollaEmbahsti	1124.3	442.7	273	1658	Above ground reservoir, Diversion canal, Community Ponds
		Raya azebo	Lower burka abagabir	Hirika	830.8	160	488	6556	Small earthen sediment storage dam
		Medebay zana	Adi chegora	Tsilke	557	284	91	1114	Hand dug well, diversion canal construction
		Kolla tembien	Selam	Sheka	695.4	423.1	237	1049	Diversion weir, Diversion canal, Hand dug well
		Kilte awlalo	Abrha-we-Atsbha	Mentebteb	1036	236	440	831	Check dam pond, Diversion weir
		Enderta	Gereb momona	Adikelkel	1204.4	185.5	302	2072	Spring development
4	Benishangule Gumuze	Yapaya	Hipapa	Gichige	808.47	224.77	400	2272	4ha
		Bullen	Shar	Chichil & mahalishari	1469.5	199	58	1046	1ha
		Bambassi	Sonka	Abamendan	698	330	330	1245	3ha

5	Amhara	Bure	Yesir	1. Chenetali	304	202		276	
		Bubign	Arefa	1. Lay Yifuach	460	419	214	416	-
		Guagusa shekudada	Yesir	Chenetali	484	420	210	272	-
		Gonji kolella	Yezat	Tindwat	430	145.25	250	603	-
		Antsokia gemza	Sal	Woshim#2	472.8	274.8	254	879	Crossing pipe
		Shoa-robit	Robi	SarAmba	777	351	175	380	6 ponds
6	Gambella	Mengesh	Fejeje	Upper Geboye	2967	1964	1058	170	No SSI scheme developed
		Godere	Zeiy	Lower Geji	1010	646	1019	2324	One SSI scheme developed (non-functional -canal lining and gate maintenance required)

5.2. Technical Strategy

The incorporation of CSA practices into the SLM program is based on ten strategic elements, some of which are unique to SLM:

- Within each critical watershed, CSA interventions would be designed and implemented in individual micro-watersheds

- CSA interventions would be linked to relevant SWM practices, allowing bothto createCSA/SWM synergies (such as forage utilization from zero grazing on hillsides and from increased soil moisture and water availability) and to enhance the climate smartness of individual CSA practices

- Consistent with the above, the primary eligibility criteria for selection of areas (micro-watersheds) for CSA interventions should be the completion of biophysical measures for soil and water management in communal areas (achievement of "territorial resilience" status)

- Although most practices would be implemented on individual farms, delivery of project support within each micro-watershed would be provided to organized groups of farmers, in line with the overall methodology followed by the project

- The process for adoption of CSA practices will assumes that each practice presents different barriers for successful and sustainable implementation. As a result, the individual practices included in the infotechs will be categorized as:
    - Practices ready for farmer adoption through technical and financial support
    - Practices requiring field testing/demonstration prior to adoption by farmers
    - Practices where significant barriers exist, either due to limited availability of inputs or equipment, or to the need to conduct adaptive research to validate the practice within local conditions

- In response to this, the SLMP CSA strategy will support not only the adoption process by farmers, but also the establishment of demonstration plots (ideally in Farmer Training Centres (FTC) located in the watersheds)

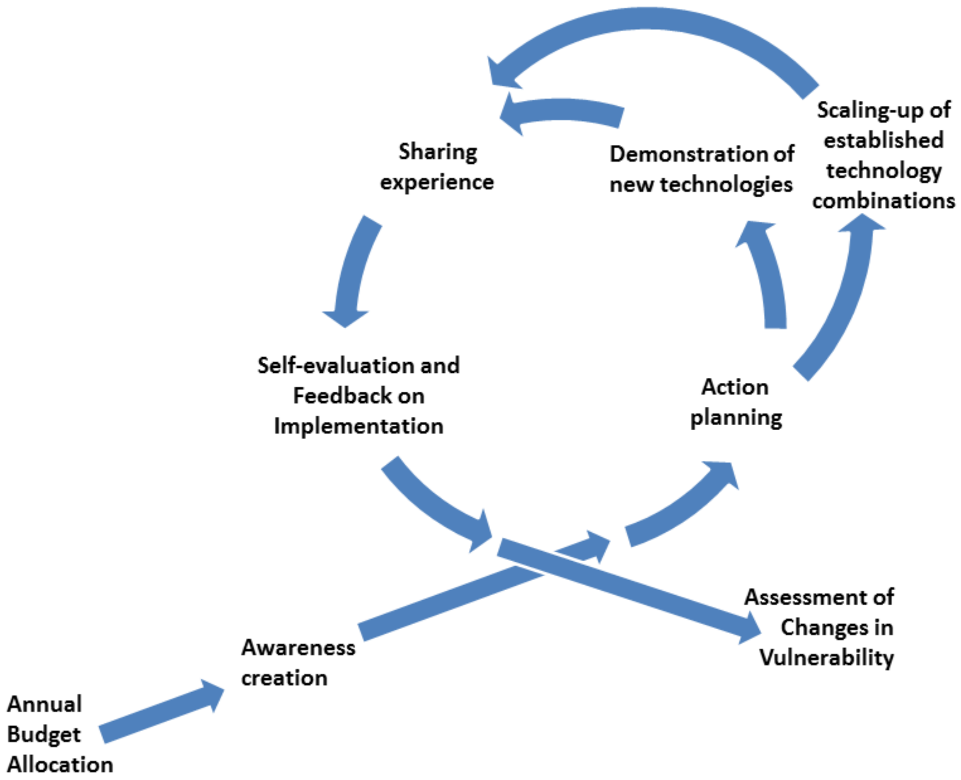
- Given the knowledge-based nature of CSA, beneficiaries will require additional support through training and extension provided by SLMP practitioners

- To address the adoption barriers, the project (through separate design and implementation mechanisms that exceed the mandate of field practitioners) will support specific adaptive research initiatives to be conducted by relevant local research institutions(as well as supporting the import of inputs/equipment currently unavailable in the country and the local development/manufacturing of machinery)

- By combining SWM and CSA practices, and gradually expanding the number of groups supported in each micro-watershed, SLMP would achieve the goal of developing each micro-watershed (and eventually each watershed) into a "Climate Smart Landscape" encompassing different production systems and farms, diverse land ownership regimes, and diverse types of conservation areas".

- Implementation and adoption of CSA will be done primarily through packages of practices, linked to a relevant SWC practice (zero grazing, erosion control, water management, etc.) and ideally comprised of a set of specific CSA practices in which one or two require investments (with SLMP financial support) and the remainder involve associated behavioural changes adopted through training and technical assistance (mulching, reduced tillage, crop/livestock management, etc.)

By applying these principles, promotion and adoption of CSA practices is a dynamic process, which involves not only financial support but also intensive knowledge transfer to beneficiaries through technical assistance, training, demonstration and exchanges, and participatory validation. The diagram below summarizes the main steps of CSA adoption. The specific guidelines and actions to implement each of the steps in the CSA cycle are described in the following sections of the Manual.



5.3. Training for SLMP Staff and Field Technicians

Given that operationalization of CSA practices presents substantial differences with the process currently used to implement SLM and IGA activities, prior to launching CSA activities in the field, all staff involved in the process will undergo an intensive training program to become familiarized with the content of the Manual and get acquainted with the technical and operational aspects of CSA implementation as part of SLMP. The training will be organized for relevant National PSU staff, regional coordinators and advisors, and initially to staff and DAs of the woredas and CWS selected for the pilot phase. Training sessions will include a specific module on the strategic, technical and operational aspects of CSA implementation described in the Manual, and a series of interactive modules on the different practices recommended in the individual infotechs.

Once this initial training is completed and CSA implementation is underway in the 30selected CWS, a similar training program will be organized in each region for the woreda staff and DAs of the remaining watersheds. This training will be field based and conducted in the designated model watersheds in each region.

6. Operational Procedures

6.1. Planning Phase

(i) Integration of CSA interventions into overall Watershed Plans

CSA interventions under SLMP-2 will be implemented primarily in micro-watersheds that have already been supported with SWC measures. CSA interventions on farm land and for livestock development must build upon the soil and water conservation measures which have previously been implemented in the microwatershed. For example, the increase in biomass production resulting from area closures on degraded hillsides or rehabilitation of gullies provides the basis for adoption of zero-grazing on farmland and the consequent improved animal productivity practices.

Differing from SWC, which are mostly one-time measures such as physical and biological rehabilitation of degraded areas, CSA interventions will be implemented on a seasonal or annual basis depending on the number and type of practices to be adopted. As such, a multiyear planning methodology will be adopted, in which the number of annual interventions will depend on the allocated budget and the absorptive capacity of beneficiary groups and availability of local technical staff.

In new critical watersheds, to effectively ensure that CSA interventions are fully complementary to SWC measures, the planning of CSA interventions will be integrated and aligned with the SWC watershed management plans, as described in the CBPWMG (see process flow adapted to CSA). In watersheds where the SWC investments have been completed, the planning and implementation of CSA interventions will be conducted as an individual process, but taking into full consideration the overall results of the SWC interventions, both in terms of the enabling environment created, as well as the contributions made by these interventions with regards to the three CSA pillars, including mitigation where appropriate).

A key aspect of the CSA operational approach is the regional and local assessment of infotechs. For this, prior to engaging the individual communities at the microwatershed level, the regional coordinators and advisors will conduct a review of the infotechs with the objective of adjusting, if needed, the specific recommendations for each practice to the local agro-ecological conditions.

In both cases (planning of new watersheds, or integration of CSA into watersheds with prior SWC interventions), the achievement of a sustainable CSA in the entire landscape will require that IGA interventions are compatible with CSA objectives by not contributing negatively to the objective of improved and adapted production systems which do not increase carbon emissions.

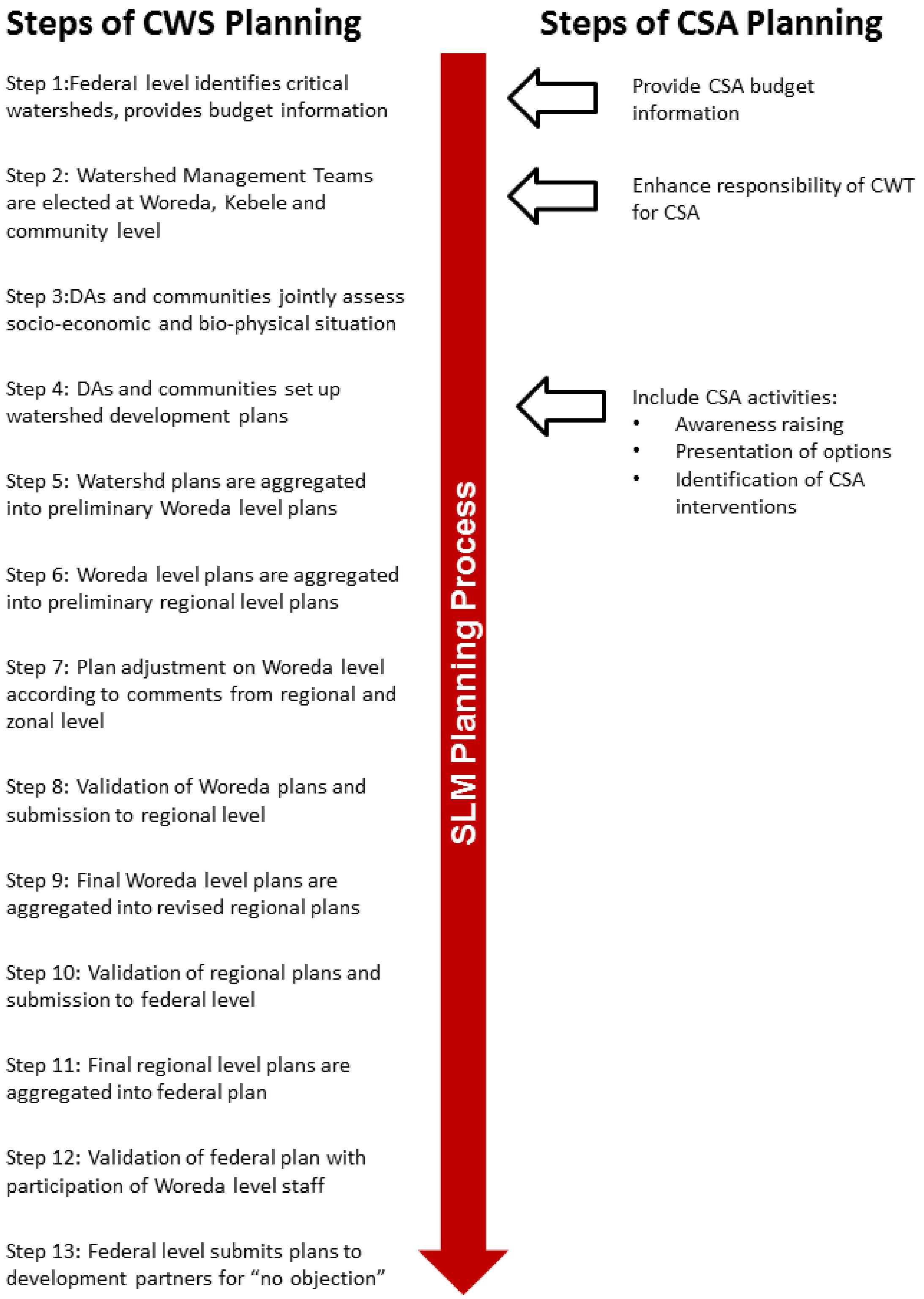


Fig 5: Integrating CSA into the SLM Planning Process

The planning phase starts with the allocation of a separate CSA budget allocation for the woreda. Budgeting for CSA interventions is best done following an envelope approach. Budgeting also frames the type and number of agricultural activities which can be implemented. Therefore, a lumpsum annual budget will be allocated to the Woreda for CSA interventions. Prior to engaging the beneficiaries, based on this information and the availability of human resources, the woreda experts and DAs estimate the number of eligible microwatersheds (and/or groups) that can be effectively assisted during the budget period. Further to the budget allocation, the responsibilities of the CWT should be enhanced in order to assure that CSA interventions are being integrated into the watershed management plans (Step 2).

(ii) Selection of Microwatersheds to receive CSA support (Eligibility Criteria)

Within the selected watersheds, the micro-watersheds where groups of farmers will be supported in adopting CSA practices should meet the following eligibility criteria:

- SWM interventions completed, or well advanced with over 75% of the planned activities finalized, and the remainder scheduled for completion simultaneously with the initiation of CSA support)

- Zero grazing bylaw adopted and enforced (a CSA practice in itself and precondition for implementation of additional climate smart practices related to both crops and livestock)

- Team of woreda experts and DAs fully staffed and with CSA training completed

- Allocation of adequate time of regional advisers to support CSA planning and implementation

6.2. Implementation phase

(i) Group eligibility and formation

The ultimate goal of CSA adoption in SLMP watersheds is to achieve a CSA landscape, where all land and all farmers have adopted practices conducive to increased climate-resilient productivity, while contributing to reduced overall GHG emissions.

Due to technical, financial and operational limitations, this ambitious goal can only be achieved gradually, most likely over a number of years. Consistent with the existing limitations, the operational unit for CSA interventions in eligible microwatersheds will be a group of organized farmers. The number of groups will be determined during the planning phase based on the budget allocated to the woreda for CSA.

CSA groups would be organized by the DAs assisted by woreda experts. In each group, the number of members should ideally range between 20 and 30 farmers. The actual number of farmers in the group (and the number of groups to be organizedwithin each MW, will be decided by DAs and woreda specialists, based on the available budget, the number and complexity of practices to be implemented, the number of households in the village, and the capacity of DAs to provide regular technical support during the entire adoption process.

Groups and individual farmers eligible to participate in CSA adoption groups will be required to meet the following criteria:

- At least one member with recognized leadership
- Farming in contiguous plots or located in the same area (slope, village)
- All member comply with zero grazing
- Group members participated actively in SWM activities
- Satisfactory utilization of IGA support awarded previously by SLMP
- At least one member willing to participate in field days and/or demonstration events
- All members agree to contribute the necessary labor to implement the selected practices, as a form of counterpart financing

(ii) Development of the CSA Plan (planning, selection and budgeting of practices)

Once the CSA group has been established, the CSA Plan for the group is prepared in a participatory manner. For this, DAs and Woreda experts organize a CSA group meeting (or groups within a village, if appropriate) ideally in the context of the SLM annual planning exercise. In the meeting, the DA will make the community aware about CSA; will explain to the community the concept of climate-smartness and especially what is understood as adaptation. In the same meeting the DA also presents the range of interventions available for adoption according to the infotechs, and emphasizes that the anticipated CSA interventions need to have a clear linkage to the previously implemented SWC measures. Consequently, the meeting will also review the previous SWC measures and build upon them towards creating a climate-smart landscape.

(iii) Selection of Interventions and Practice*s*

Based on all the information provided, the DA and group members prepare the CSAPlan by agreeing on the main priority for CSA implementation (crop or livestock production), and subsequently assessing and selecting –from the eight infotechs-- the intervention(s) from which the practices will be selected. Finally, from the selected infotechs, the group decides the specific practices that would comprise the CSA package to be adopted. Once the package has been selected, the CSA Plan is completed with the calculation of physical (i.e. inputs) and financial requirements, including not only the investments at the farm level, but also the training and technical assistance needs. In addition, the DA and the group conduct a similar process to select the practice (or package of practices) to be established by the group and used for demonstration purposes. The resources required are also included in the CSA Plan, under a separate category.

Basic guidelines to be followed for developing packages of climate smart interventions and/or practices are as follows:

- A package should have no more than 5 individual practices from not more than 2 interventions (infotechs)
- Packages are basically land use based, but can combine measures from different land use types and livestock.
- Packages will be developed selecting 1 or 2 key practices (generally those requiring additional investments in equipment or inputs) and 1-3 complementary practices (generally involving improved management, through management practices of zero or low additional cost).
- Farmland-based interventions must include at least one practice with direct positive effects on soil fertility.

The CSA Plan should include following items: (template to be designed)

- Identification of the CSA group, including total and individual area (land size) and herd of livestock of households on which the package of farmland, livestock or homestead CSA activities will be implemented
- List of interventions and practices to be implemented
- No. of male and female headed households participating in the CSA group
- Type and location of demonstration plot to be established
- Type and quantification of equipment and inputs needed
- Expected commitment and contributions (labour, inputs in kind or cash) from the beneficiaries
- Parameters to be recorded and reported in order to monitor the successful implementation and performance of the CSA package
- Training and technical assistance needs for field activities

- Training and dissemination plan for demonstration activities

The scope of intended CSA interventions and the number of groups to be included will have to be based on the available budget allocation. This will most likely make it necessary to conduct a prioritisation of interventions. The DA will facilitate this process considering the needs of the beneficiaries.

The subsequent process of aggregating the group CSA plans will be the same as for the community watershed plans.

6.3. Agreement and categorization of CSA practice(s)

For the purposes of this Field Manual, implementation of CSA interventions at field level (i.e., watersheds) will follow two modalities: (i) direct field adoption and (ii) pre-adoption testing and demonstration. In both cases, the selection of practices to be included under each modality will be decided jointly by DAs and beneficiaries, based on the technical specifications and recommendations included in the infotechs. A third complementary modality (CSA Adaptive Research) will be implemented following a different set of operational and institutional arrangements, described below.

(i) Direct Field Adoption

The practices selected for direct adoption will be implemented by all members of the CSA groups in the form of packages. As part of the development of the CSA Plan, the DAs and the members of the CSA group must jointly agree on the priority intervention to be implemented, and the set of CSA practices to be included in the implementation package. This will be achieved through a participatory process, in which the DA explains (i) the basic principles of CSA, (ii) the specific SLMP objectives, criteria and mechanisms to promote the improvement of production systems through the adoption of CSA practices, and (iii) the different practices recommended in the infotechs for implementation in the microwatershed. Based on this information, the group and the DA discuss and agree on the specific CSA practice, or set of practices, to be implemented by the group. This will include the on-farm practice(s) and the practice(s) proposed for testing and demonstration.

Utilizing a similar process to that applied for the SWC and IGA activities supported by SLMP, the DA prepares the detailed physical and financial CSA Plan, specifying the quantities of inputs and supplies required and the estimated budget. In those cases, where more than one CSA group is established in the microwatershed, the individual CSA plans are consolidated prior to submission for review and approval by the woreda.

(ii) Pre-Adoption Demonstration

Farmers are not expected to make informed decisions on innovations that they have not seen or applied before. To address this, in each microwatershed, beneficiaries will also select one or two CSA practices for pre-adoption testing and demonstration. These practices will be established either in Farmer Training Centres (FTC) or in smaller plots owned by beneficiaries willing to make land available for demonstration purposes. The FTCs should demonstrate a number of technologies that have been screened by the region and woreda as potential for implementation. Farmers can see them in the field and make an informed decision. The required budget for implementation of demonstration practices would be developed by DAs and included in the annual microwatershed CSA Plan. In those cases, where CSA practices are implemented in more than one group in the microwatershed, or more than one microwatershed within a critical watershed, the individual plans will be adjusted to avoid duplication of efforts and promote synergies.

The individual demonstration plots (or ideally the network of demos within a watershed) will be used to conduct CSA formal field days or informal farmer exchanges in appropriate periods of the year, while results related to the three dimensions of CSA will be monitored and evaluated (using a methodology to be developed in accordance to the type of practice) to generate appropriate information for planning, training, and extension purposes.

(iii) CSA Adaptive Research

Complementing this CSA adoption strategy, a third modality will be applied for those potential CS practices which are identified in the infotechs as requiring additional technical, operational or financial validation prior to demonstration or farmer adoption. These practices, or combination of practices, will be included in a parallel CSA Adaptive Research Plan (ARP). This plan will be designed and implemented with SLMP financing, with strong inputs from technical staff and beneficiaries, by appropriate national and regional institutions, with international support when required. The content of the CSA ARP will be defined by the PSU based on the recommendations from the infotechs and with inputs from national, regional and local technical specialists from MoANR and SLMP.

7. Technical Assistance and Support Services

CSA is knowledge intensive and entails moving toward more agro-ecology rather than conventional intensification. It therefore requires building farmers' capacity and reducing existing knowledge gaps and findingan appropriate balance between input distribution (i.e. hardware support) and. knowledge transfer (software provision). Consequently, in addition to financial support, for most climate smart interventions to be adopted and implemented successfully by farmers, technical assistance will be required. This represents a significant difference with respect to the support provided by SLMP to IGA. For CSA interventions to be sustainable, project practitioners will therefore need to extend their support to beneficiaries beyond the planning phase, and provide technical assistance throughout the entire adoption cycle. This will not only ensure that CSA practices and recommendations are adequately implemented by the farmers, but also to promote the expansion of CSA to other groups and eventually the entire landscape, and to support the data collection process needed to validate the new technologies.

For this, the workload of the local technical structure should include additional time (and/or resources) to (i) conduct periodic visits to the plots of farmers implementing CSA practices, (ii) establish the demonstration plots, and (iii) organize and conduct dissemination activities such as field days and farmer exchange visits. Equally important, the regional structure should be capable of providing technical backstopping to DAs, through periodic joint field visits, on-farm refresher training, as well as assistance in planning and conducting demonstration activities.

8. Fiduciary procedures

Procurement, financial management and safeguard procedures for CSA interventions and practices will follow the same rules and procedures currently utilized by SLMP-2 for IGA investments, as outlined in the Project Implementation Manual (PIM) and the Environmental and Social Management Framework (ESMF). Additional CSA-specific procedures would be the need to determine the counterpart financing to be contributed by beneficiaries, and the mechanisms for distribution of equipment, inputs and supplies provided by the project for joint use by the members of a CSA group, in which a representative, designated by group members, would assume the formal responsibility for the reception, distribution and utilization of the items provided by the project.

9. Monitoring and Evaluation

All CSA interventions and/or combinations need monitoring with regards to the inputs provided, their performance and results (outputs). Monitoring parameters will need to be defined for all three elements of climate-smartness of productivity (livelihood), adaptation and mitigation. Planning and monitoring of CSA interventions will be streamlined into the regular SLMP 2 tools used for all project interventions. However, given the pilot nature of the CSA component, a detailed M&E protocol will be developed to ensure adequate quantification and assessment of results related to adaptation and livelihood improvement or income generation. These results will be assessed through annual case studies based on surveys collecting physical information, beneficiary perceptions, and financial results, including gross margins where possible. The methodology and resources required to conduct CSA M&E will be developed prior to initiating the on-farm interventions in 2017.

Measuring mitigation in agriculture and livestock production is a difficult and costly process. Therefore, mitigation effects will be estimated using internationally accepted reference formulas. The EX-ACT tool developed by FAO has proven to be very useful in this regard and will therefore be applied. As the formula requires a number of input data, these will be identified for the respective interventions and will need to be recorded accordingly.

10. Main CSA Challenges

One challenge in the context of CSA can be summarised as the trade-offs that arise when trying to achieve productivity gains, while at the same time aiming to achieve climate mitigation or specific adaptation goals (Corner-Dolloff 2015). Single agricultural activities are rarely capable of satisfying all of these dimensions at once. It is therefore necessary to define climate smart combinations of activities that are prioritised according to desired aspects. Thus, the challenge for SLMP arises of how to design income-generating activities (IGAs) that do not only aim to enhance productivity, but that are actually climate smart.

Another challenge faced by CSA adoption concerns the question how to contribute meaningfully to mitigation goals in the livestock sector. Livestock is an economically important sector in Ethiopia. Changes in livestock management practices, such as the shift from extensive grazing to zero grazing or the introduction of rotational grazing practices are among the most promising options to achieve climate benefits (IAASTD 2009; IPCC 2014). Again, these practices require behavioural change by the farmer. They require intensive knowledge transfer as they involve changing traditional practices. Simply substituting breeds of livestock with a goal to attain higher feed efficiencies is unlikely to have a meaningful effect. Farmers may be unwilling to reduce their livestock stocking rates due to livelihood considerations.

11. The InfoTechs

- **Title of Infotech**
- **Brief description of CSA intervention.**
  The description should include "what" the intervention is about, based on which land use type, and its linkage to the SWC measure.
- **Assessment of climate-relevant potential (adaptation, mitigation and income generation) of theCSA intervention.**
  This describes the expected effects on climate relevance, that is the expected adaptation and mitigation effects. These effects are described as single measures and with possible combinations with other measures. The description should be based on the rating and justification as in the "basket-of-options". This chapter should also provide an estimate of the economic benefits for the individual farmer as well as eco-system benefits for the community at large. Here also it is described whether the intervention needs further testing/demonstrating or whether it can be implemented in upscaling mode already.
- **Geographical range and land use type of the CSA intervention**
  This chapter should describe to which agro-ecological zone the CSA intervention is most suitable and why. It should also describe for which land use type the intervention can be most effectively applied for according to degraded hill sides, farm land, grazing land or homestead development.
- **Level of group formation/organization required.** This should refer to the different degree of group formation required, e.g. an area closure might need a different group than a soil fertility management intervention. This chapter should also describe what which part of the intervention should be performed as a group, and which could be done as individuals. For example, the beekeeping could be done as individuals, but the marketing of honey and other products could be done as a group.
- **Envisaged target group of this CSA intervention.**
  This describes which should be the preferred target group considering poor, vulnerable, women headed households, landless, youth, any farmer or a combination of this groups. The chapter should also describe to what extent the CSA intervention is gender specific.
- **Inputs and skills required for this CSA intervention.**
  This chapter should list the necessary inputs and skills required for implementing the CSA intervention. All inputs should be tight up with at least one accompanying management or implementation practices, e.g. drought resistant seed provision should be combined with intercropping, row planting, reduced tillage or crop residue management. This chapter also outlines the necessary knowledge and skills that are required for successful implementation of the CSA intervention. This will form the basis for identifying training needs in a particular situation (see steps of implementation).
- **Outlook on sustainability.**
  This chapter should describe the elements that need to be put into place for the CSA intervention to be sustainably practiced.
- **Possibility of up-scaling the CSA intervention.**
  This chapter should describe possibilities and conditions (institutional, economic, social and environmental) to replicate and up-scale the CSA intervention.
- **Monitoring the performance of the CSA intervention.**
  This chapter should provide measurable parameters that allow evaluating the performance of the CSA intervention preferably with regard to all three aspects of CSA, which are adaptation, mitigation and livelihood (through income generation and measurable eco-system benefits).
- **References and contact details.**
  This chapter should provide references, further technical materials and contact details for deeper understanding of the CSA intervention

Technical information kit	(1) Brief Description of the technology and what makes it important	(2) Main objective/benefit
Conservation Agriculture	Conservation Agriculture (CA) is an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. CA is characterized by **three linked principles**: **1. Principle of continuous Minimum soil disturbance**. i.e. Tillage is reduced to ripping planting lines or making holes for planting with a hoe. or minimum tillage. **2. Principle of permanent organic soil cover/Keep the soil covered as much as possible;**crop residues left on the field, mulch and special covercropsprotectthesoilthe deleterious effects of exposure to rain and sun; to provide the micro and macro organisms in the soil with a constant supply of "food"; and alter the microclimate in the soil for optimal growth and development of soil organisms, including plant roots. **3. Principle of Mixing and Rotating Crops**:planting the right mix of crops in the same field, and rotating crops from season to season.The rotation of crops is not only necessary to offer a diverse "diet" to the soil micro organisms, but as they root at different soil depths, they are capable of exploring different soil layers for nutrients. Hence, improved rotations should be proposed to the land user together with an entire set of additional measures able to improve yields of the main crops so that the rotation becomes acceptable	***Economic benefit:*** result from CA implementation includes time saving and thus reduction in labour requirement, reduction in costs, e.g. fuel, machinery operating costs and maintenance. ***Agronomic benefits:*** include improvement of soil productivity through organic matter increase, in-soil water conservation and improvement of soil structure, and thus rooting zone ***Environmental benefits:*** includes reduction in soil erosion since the residues on the soil surface reduce the splash-effect of the raindrops. Maintaining soil cover will reduce erosion with the consequent loss of soil fertility, soil compaction, and, eventually, landscape change.

(3) Planning and Implementation Modality	(4) Suitability and adaptability to local conditions and knowledge
Unfortunately, short term solutions and immediate benefits always attract farmers and the full technical and economic advantages can be seen only in the medium –long – term run, when its principles (no tillage, permanent cover crop and crop rotation) are well established within the farming system. (i)Revisit the already developed CA technology package and make ready for mass production and distribution of CA technology package for users (CA package, , for Teff, Maize and wheat MoA Nov, 2008, Amharic version)	Farmers in Ethiopia have the experience of rotating pulse crops with cereal and in some areas planting with a single plough. Besides this, erosion and moisture stress in farm land is the main threat to increase crop productivity. So CA is proposed as one of the most promising means of reducing soil erosion, increasing moisture retention and stabilizing crop yields in the rain fed farming systems CA is more suitable in areas where there is a capacity to grow cash crops (in order to purchase inputs), markets for a diverse range of crops (to support crop rotation),. In addition, CA can be easily adaptable and expand in areas where bimodal rain is common i.e. high value crops are grown widely like in Arsi and Bale highlands and

(ii) Develop meetings, trainings, site visits on demo site including farmer's field day for farmers, extension services and decision makers. (iii) Identify priority areas within the watershed and embark on the scaling-up of the technology to a wider segment of the population, while also focusing on areas where the technology has already been adopted by farmers (iv) Ensure that production inputs are readily available for beneficiary farmers on timely basis (v) Provide alternative feed supply sources, in order to reduce free grazing. (vi) Iftherearetterraceson thefarm,planton them livematerialsuch asvetivergrass, napier,vetchgrass,pigeonpea, susbania,andother strong-rootedcrops (vii) Create an agricultural technology information pool/center at EIAR (research information) and MOA&NR (extension information).	mid-areas which is excess amount of crop residues are available for mulching. In some part of west Oromia region especially eastern wellega CA have been started and implemented by many farmers on farm lands. **Integration requirement and opportunities** CA can be integrated with different practices **1.** Cover Crop is the main activities that need to be integrated as part of CA **2.** Conservation Agriculture with trees (CAWT) is one of the possible practice to integrate CA with Agro-forestry

Minimum Technical Standards and steps

Practicing or Adopting CA – First Steps

Conservation agriculture, especially no-tillage and direct planting, is an entirely new cropping system, not just the change from plough to direct planter (direct seed drill). Farmers have to learn from scratch. Main changes apart from direct sowing are:

- Early planting, even dry planting in semi-arid regions
- Diversified crop rotation, wherever possible three to four years rotation including leguminous and forage crops.
- Use of chemical weed control.
- Stubble retention – controlled grazing.

Choose a field

- Start with fields where the straw and chaff from the previous crop was properly spread or use crop residue as mulch or plant cover crops such as lablab

Reduced plough

- Based on the spacing of the crop type open a narrow planting furrow with a ripper without turning the soil or use a hoe (jab planter) to make small planting holes for direct-planting of the crop or planting through the mulch
- Since tillage is being eliminated, know how to use the herbicides that will replace it; to begin don't chose a heavily weed infested field.

Planting

- Sow seed directly in to the ripped lines of planting holes, or drill seed in to undisturbed soil using direct planters. Inter crop with legumes or sow a cover crop a few weeks later in the growing season to protect the soil.

When to plant:

- Deciding when to plant is one of the most important decisions a farmer has to make. The main aim is to make sure the seeds germinate quickly and evenly. Try to finish planting a field in one day
- Plantseedsduringheavyrain,orwithin48hoursafteritstops.

- Plant only if there is enough moisture for the seeds to germinate evenly. Mulching will improve the moisture level in the soil where you put the seed
- Plant at the right depth for your crop. This helps the seeds to germinate and emerge evenly.

Fertilization

- To adapt the CA technologies it needs to follow the integrated soil fertility management approach. Apply manure and compost long before the rain and basal fertilizer (DAP, NPK or Blended fertilizers) during planting time. Urea fertilizer mainly applied after planting in a split manner but some time applied during planting depends on the crop type. In CA soil fertility management mainly relies on organic sources (compost, manure and green manure), supplemented by inorganic fertilizers based on crop type

Leave the soil covered At harvest; leave the residue on the field to cover the soil during the dry season. Leave the cover crop growing, or plant another main crop if you can

Second and following seasons

- There should now be enough cover on the field. If not, carry in extra residues from nearby and spread them on your field. It is much simpler to prepare for planting in the second season.

Check for weeds Hand-pull them, slash them, or kill them with herbicide.

Crop residues Decide if it's possible to produce enough crop residues on the field for the third season. If not, grow some cover crops nearby, then cut them and spread them on the conservation agriculture field in the third season.

Climate Smartness	Challenge and constraints in implementing CA
➢ Carbonstorage in the soil(Mitigation) ➢ Highersustainedyields(30-200%)atlowercosts ➢ Environmentalconservation ➢ Increasessoilorganicmatterandnutrients,thus reducingtheneedforchemical fertilizers ➢ Improvessoilstructureanditsabilitytoabsorbandhold more moistureforcrop growth. ➢ Reducestimeandlabourrequirementbyupto60%allowingeven allowing the elderly farmers to still practise CA.	**Competition for crop residue and biomass:** The competition for crop residues between livestock (fodder) and soil (fertility) is the main challenge for CA to be adopted by farmers in Ethiopia This requires increase of forage availability and control of free grazing. **Knowledge management:** Many farmers are accustomed to thinking of the plough or the hoe as an essential part of agriculture, and may find it difficult to overcome the idea that ploughing is not required for successful planting. **A short term yield effect** is variable because of attitude of farmers, lack of proper site selection and application of the principles of CA (positive, neutral or even negative). Therefore, the benefits in terms of labor requirement, diversification with legumes, and soil fertility should also be explained to farmers. **Limited access to inputs:** Very limited supply of legume forage seeds, which could be used in intercrops systems. Difficulty in keeping permanent cover crop on the field in drier areas as crop residue is a vital resource for animal feed

(5) Selected CA technologies for each AEZ			
Aspect		Agro-ecological zone of Ethiopian highland (>1500 m.a.s.l.)	

	Selected Practices /Technologes	High Potential Perennial zone (warmers and humid with >240 days growing period)		HPC –High Potential Cereal zone (intermediate with > 180 days growing period)		LPC – Low Potential Cereal zone (high rainfall variability with 90-150 days growing period)		Agropastoral and pastoral drylands - rainfall is limited and the growing period is too short for most crops
		<2500	>2500	<2500	>2500	<2500	>2500	<1500 m
Improvement of production efficiency (reduction in labour requirements and costs)	Reduced tillage (row planting, herbicide application initially)			X	X	X	X	X
Improvement of soil productivity and environment (reduction in soil erosion, biodiversity increase and carbon sequestration)	Cover crops (leguminous – pigeon peas, beans)	X	X	X	X	X	X	X
	Crop residue on the farm (30 after cut and carry)	X	X	X	X	X	X	
	Crop rotation	X	X	X	X	X	X	X
	Mulching	X	X	X	X	X	X	
	Intercropping of food crops and legumes	X	X	X	X	X	X	X
Crop-tree-livestock integration (critical to livestock keeping system)	Planting of forage species with food crops	X	X	X	X	X	X	X
	Planting of fodder trees	X	X	X	X	X	X	X

Conservation Tillage practices example in Ethiopia (south Achefer, Amhara region)

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- Conservation Agriculture Manual
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- Introduction of CA&AF for SLMP-II, Final report, 2014

Technical information kit	**(1) Brief description of Agro-forestry**	**Objective/benefit**
Agro forestry	**Agroforestry** is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. This definition implies that: • Agroforestry normally involves two or more species of plants (or plants and animals), at least one of which is a woody perennial; • An agroforestry system always has two or more outputs; • The cycle of an agroforestry system is always more than one year	The major objective of Agroforestry focuses on the wide range of working trees grown on farms and in rural landscapes. Among these are Economicbenefits**:** a source for Constructionandhouseholdtools, Foodandfodderproducts:for nutrition and income generation,improve smallholder livestock production,medicine to combat disease,etc Environmentalprotection: Treeplantingorretentionprotectssoilandamelioratestheenvironment by controlling soil erosion, minimizing land degradation Reclaiming marginl lands: Improve soil structure drainage, control weeds through mulching and upper canopy cover., bring leached nutrient to the surface and Improvefertilitystatusofthesoilthroughnitrogenfixation

(3) Suitability and adaptability to local knowledge	**(4) Attributes of Agro-forestry/ Potential to increase productivity, Adaptation and mitigation**
Local communities are active managers of woody resources within the local land use systems. Very often they practice already a form of agro-forestry. Improved or new agro-forestry technologies can easily be introduced in new areas as they conform to local knowledge and farming practices. More and more agro-forestry is seen as a land use system that is attractive, well understood and easily accepted by small holder farmers.	Productivity**:** Most, if not all, Agroforestry systems aim to maintain or increase production as well as productivity (of the land). Agroforestry can improve productivity in many different ways. These include: increased output of tree products, improved yields of associated crops and reduction of cropping system inputs, Sustainability*:* By conserving the production potential of the resource base, mainly through the beneficial effects of woody perennials on soils, agroforestry can achieve and indefinitely maintain conservation and fertility goals. Mitigation***:*** Integration of Improved Agroforestry in different land use system will tremendously increase the carbon sequestration as both Above and below ground biomass where the practice is promoted

(5) Tree Management in Agro-forstry	***(6) choice of species in Agroforestry***
The major role of tree management in agro-forestry is restoration of healthy co-existence among integrated crops of a given land use system. The following are some major tending operations in Agro-forestry system These are Watering, manuring, weeding, mulching, replacement planting and others including : **Pollarding**: the cutting back of the crown of the tree at a height of 2m or more from the ground. **Lopping**: a practice of cutting one or more branches of a standing tree for fuel or fodder.	The main Characteristics of a tree that are important for agro-forestry are: ➢ Adaptability of the species for the specific environment ➢ Ability to withstand adverse condition ➢ Palatability of the selected fodder, tree growth rate and growth habit specially on its branching and root system

<table>
<tr><td>Pruning: removal of live or dead branches or multiple branches from the standing tree when shade impact is increasing.
Thinning: removal of part of a standing crop when the stocking is more than necessary and to allow the remaining trees to grow at their optimum rate</td><td>➢ Capability to withstand management practices (pruning, lopping etc) and its ability to nutrient cycling and nitrogen fixation.</td></tr>
<tr><td>(7)Inputs and skills required for Agro-forestry</td><td>(8) Constraints and limitation of Agro-forestry</td></tr>
<tr><td>• Input: seed/seedling, provision of tools for tending operation i.e hoe, reck etc
• Skill on How to collect seed from the locality, seed propagation system, seed storage, seed germination and seedling handling are among others.
In addition, the skill on how to select the right species for the right place has also a paramount importance</td><td>• Free grazing problem makes seedlings exposed to browsing animals,
• Problem of provision of high quality seedling,
• Problem on species–site matching
• lack of seed/seedling source,
• poor follow up after planting in the field(weeding and cultivation etc),
• in some cases, trees may compete for light and space with associated plant on the lower strata,
• Scarcity of trained personnel to handle or improve the existing agro-forestry system and demonstrate at FTCs</td></tr>
<tr><td colspan="2">(9) Agroforestry technologies and activities recommended to be integrated into the SLM programme</td></tr>
<tr><td colspan="2">1.<u>Agroforestry for enhancing land productivity:</u> Agroforestry practices that can improve soil fertility, increase crops yield and provide shade based on the local conditions and existing indigenous knowledge. These include trees arranged irregularly or in some kind of systematic manner on croplands as an intercropping of cereals withfertilizer trees, conservation agriculture with trees (CAWT), promotion of different shade trees in the coffee and spice farming system.
2. Boundary Planting, shelterbelt and livefence: these comprise trees and shrubs planted along and around the farm for protective purpose and boundary marking. They are mainly used or boundary markers, live fence soure of fodder or windbreak.
3. <u>Agroforestry for SWC </u>An Agro-forestry practice that stabilizes the physical structure of the bunds, terraces and raisers in the farm and communal lands integrated with or without grass.
. <u>4.Agroforestry for food and income diversification</u><u>:</u> high-value fruit and leafy-tree technologies can be introduced around homestead based on farmer’s preference, the species requirements and land availability. Under this technology, Common fruit trees, under-utilized perennial food crops, improved high value tree crops and Vegetable trees can be promoted
<u>4.Agroforestry for fodder/forage</u>: Agroforestry that enhance availability of fodder for livestock and bees based on local conditions and farmer’s preference. These include establishment of fodder banks around homestead as live fence, boundary planting and parkland systems.
<u>5. Agroforestry for reclaiming degraded sites</u>: it is intended to restore degraded sites to increase the carbon sequestration potential of degraded farm land as a mechanism to mitigate climate change. Enrichment planting and Farmer Managed Natural Regeneration (FMNR) on ex-closures and degraded natural forests using valuable trees/shrubs; rehabilitation of gullies using local and improved grasses, and lowland and highland bamboos to increase the carbon stock of existing land uses to help in the reduction of greenhouse gas (GHG) emission through C-sequestration in above- and Below-ground tree biomass</td></tr>
</table>

(6) **Table 1: Selected AF technologies, Species type and number of trees/Ha for each AEZ**

Aspects	AF technology/ practice	Proposed species	spacing	Trees/ha	Agro-ecological zone of Ethiopian Highlands					
					HPP		HPC		LPC	
					<2500	>2500	<2500	>2500	<2500	>2500
Enhancing land productivity	Scattered trees on farmland	*F. albida, Cordia africana, Croton macrostachys, Ziziphus spina-christi, Balanites aegyptica, A.abyssinica, A.tortlis, A.etbaica etc.*	10 x 10	100				x	xx	
	Planting selected shade trees in coffee and spice farming	Cordia africana,, Millitia feruginea, A.gummifera, A.lebeck +qq` *Polyscias fulva etc*	10 x 10	100	xx		xx		xx	
Shelterbelt andwindbreak	Trees for farm boundary, shelter belt and live fence	C. cajan, Callliandra calostrosis, Tree lucern etc by Combining of tall spps like Gravillea, Cordia, Croton & others	0.5 x 0.5	40,000	x		x		xx	
Agroforestry for Soil and water conservation	Trees on bunds, terraces and raisers with or without grass	C. cajan, Caliandra, Tree lucern, Sesbania sesban, desmodium, gravillea robusta, etc	1 x 10	1,000			x		x	
Food and income diversification	Promotion of improved highland fruits	Apple, Mango, papaya, Bananna, Avocado etc	4 x 4	625		x		x		x
	Domestication of underutilized wild fruits	Ziziphus mauritania, Ficus spp, Tamarindus indica	1 x 10	1,000			x		x	
	Expansion of Leafy trees and other vegetable trees	Moringa stenopylla, Moringa oliefera	4 x 4	625					xx	
Energy securing measures	Woodlot around homestead and	Gravillea robusta,, Acacia senegal, *Acacia polyacantha*,	1 x 1 2 x 2	10,000 2500	X	X	x	X	x	x

	riverbanks (Biomass production	*Acacia melanoxylon* and other Acacia spp								
Promotion of fodder trees and shrubs	Establishment of fodder bank	Tree lucern, Callandria, Acacia spp. *Ficus thonningii, Dobera glabra, Optunia, ficus indica*	1 x 1	10,000	X	X	x	x	x	x
	Establishment of bee-forage	Acacia spps, Shiffelera abyssinica, *Leucas oligocephala*	1 x 1	10,000					x	
5. Trees/ shrubs on degraded land	Biological gully stabilization with bamboo and other woody material	Highalnd and lowland Bamboo, Acacia spp, A.saligna S. susban, improved grasses	1 x 8	1,250	X	X	x	x	x	x
	Reclamation of degraded sites	Fast growing tree/shrub spp, Optunia spp., Ficus-spp, Salt bush, Agave spps, grass spps, Acacia saligna, G. robusta etc	1 x 1	10,000						

Agro-ecological classification is based on Hoekstra et al. (1990)

HPP – High Potential Perennial zone (warmers and humid with >240 days growing period)

HPC – High Potential Cereal zone (intermediate with >180 days growing period)

LPC – Low Potential Cereal zone (high rainfall variability with 90-150 days growing per

References

- Introduction of Conservation Agriculture and Agro-forestry Technologies in to SLMP-II in Ethiopia, Final report, submitted by African Conservation Tillage Network (ACT) submitted to WB, Ethiopia Country Office, December 2013
- Training package for Agroforestry: Technical manual. developed by GIZ, Ministry of Agriculture, Jan, 2014
- Conservation Agriculture with trees: Principles and Practices: A simplified Guide for Extension staffs and farmers, ICRAF, Nairobi, Kenya, 2014, Technical Manual No 21

<table>
<tr><th>Technical information kit</th><th>(1) Description</th><th>(2) period/ phase of implementation</th></tr>
<tr><td>Agro-biodiversity for enhancing crop production and food security</td><td>The recent concern over environmental quality of agricultural production has led to a renewed interest in crop–livestock systems, primarily because they provide opportunities for agro-bio diversification, nutrient cycling and greater energy efficiency. More generally system diversification is considered a viable option to manage climate related risks
While agrobiodiversity encompasses the variety and variability of animals, plants and micro-organisms that are necessary for sustaining key functions of the agro-ecosystemin support of, food production and food security (including cultural and management practices), including its structure and processes for, and (FAO, 1999a), for ease of implementation we will only focus on crop genetic diversity in this chapter. Other components of agrobiodiversity are found in other infotechs, e.g. agroforestry, forage development, soil fertility and conservation agriculture infotechs,</td><td>Sustainable use of agrobiodiversity is a continuous process and varied among the agro-ecological zones and socio-economic settings of the local communities. There is no pre-defined crops/varieties/breeds that can be recommended before those conditions are known. The communities in different agro-ecological zones should be able to define their priorities and therefore set the objectives of which agrobiodiversity should be promoted. In many cases DAs will have already available manuals to manage the selected crops. However, whenever possible, it is advisable to test the crops and the varieties together with soil fertility management practices or conservation agriculture. This will maximize the overall agrobiodiversity in production systems.</td></tr>
<tr><td colspan="2">(4) Suitability and adaptability to local knowledge</td><td>(3) Main objectives</td></tr>
<tr><td colspan="2">The agrobiodiversity created and fostered with human intervention in the evolution of agriculture, holds useful materials that are time-tested well adapted and suit to the tastes and liking of local communities. The maintenance and use of agrobiodiversity relies on extensive indigenous knowledge systems, which address aspects such as cultivation practices, uses and genetic resources management of such plant species. Thus, it is expected that these resources have the necessary adaptive potential to climate change effect and can enhance resilience and reduce vulnerability.</td><td>Main purposes of sustainable use of agrobiodiversity are:
• Enhance productivity and food security in watersheds;
• Enhance resilience of communities vis-à-vis climate change;
• Foster continuing adaptation to climate change</td></tr>
<tr><td colspan="3">Contribution of CSA/Climate Smartness</td></tr>
</table>

The identification and use of well adapted agrobiodiversity in production systems has a very significant role in enhancing resilience of the watersheds. As a matter of fact, a wisely selected portfolio of crops and varieties can provide good yield under different inter-annual climatic conditions, which Ethiopia experienced often in the past years. In addition, productivity can increase as varieties are selected among those with higher productivity. When this approach is used together with CA or other approaches it can also contribute to mitigation.	
(6) Potential to increase/sustain productivity and environmental protection (impacts)	**(5) Main land use and agro-ecology**
Genetic diversity is important for three main reasons: (a) The combination of various crops and animals in agro-ecosystems permits locally available nutrients for human diets or improves household income, allowing the purchase of alternative food items on the market. Different breeds and species make different contributions to livelihoods through provision of food, fibre, fertilizer, cash income, draught power and transportation. (b) It provides insurance against fluctuating weather conditions. For example, resistance to new diseases, or adaptability to changed climatic condition. Generally, the more complex, diverse and risk-prone peasant livelihood systems are, the more they will need animal and crop genetic resources that are flexible, resistant and diverse in order to perform the required functions. (c) It provides opportunities that are potentially valuable, but not yet exploited. The characteristics found in the largely untapped wealth of undomesticated plants or farmers' varieties can provide a basis for enhanced food availability in future by their use in improvement of crop varieties.	Agrobiodiversity is applicable to all agricultural landscapes though the types of crops and varieties may vary, e.g. we expect more options to be available in the middle altitude than the lowland and highland.i
(7) Description of steps	
Sustainable management of agrobiodiversity should follow the next steps: (a) Identification of suitable crops and varieties that matches farmer's needs. This will require participatory work with farmers. The involvement of the national gene bank at EBI will ensure that farmers' are exposed to greater level of diversity and most suitable varieties can be identified. In addition they will provide support in selection of best animal breeds; (b) Test the varieties through trials in farmers' training centres, ask farmers to evaluate the varieties; (c) Distribute the most preferred varieties using a crowdsourcing approach; (d) Enhance availability through community based approaches (community seed bank/seed producing cooperatives); (e) Document the use of diversity in order to be able to monitor trends and fine tune best varieties (f) Sensitize community about the importance of agricultural biodiversity. Steps a to c are essential for implementation of agrobiodiversity infotech while steps d to f are supporting ones and necessary for strengthening and enhance sustainability of the infotech.	

NOTE: Detailed information on implementation of each of the above steps is provided in separate infotechs.
(8) Integration opportunities/requirements
Adoption of agrobiodiversity can be an added option to be tested alongside integrated soil fertility management, conservation agriculture, agroforestry and forage development. All of the above are clearly linked to improving crop production and system diversification and are therefore sharing the same objectives of this module. Testing farmers' varieties and crops alongside with integrated soil fertility management or in the crop rotation element of conservation agriculture can create an additional benefit for the infotechs. Elements of this infotech can also be used to identify best options for fodder development as well as for prioritization of agroforestry species. Finally, it also recognize the value and will strongly build on existing traditional knowledge.
(9) Challenges
This infotech may face a couple of challenges: 1. There may be a tendency to promote mono-culture in agricultural systems rather than a diversified approach. It may require demonstration to convince farmers, DAs and other relevant stakeholders about the potential benefits of this approach. 2. Farmers may be risk advert and may be reluctant to test the approach on their own fields.
(10) References

<table>
<tr><th>Technical information kit</th><th>(1) Components and phases for implementation</th><th>(2) Main purpose/ core deliverables</th></tr>
<tr><td>Agro-biodiversity for enhancing crop production and food security – step 1</td><td>Identify suitable crops and their varieties for any given production system in watersheds using a participatory approach.</td><td rowspan="5">The assessment has double objective of:
• identifying varieties within target crops that enhance productivity and resilience
• Give attention to neglected diversity with potential to enhance nutrition and generate income.
The target crops for testing will be major staple crops or legumes within the watershed as only few crops can be tested using the approach.

General information around diversity, including products harvested from the wild (fruits, vegetables, mushrooms), minor cultivated crops, including fruit trees, vegetables, oil crops, will also be collected as it may have a potential for income generation activities (IGA).</td></tr>
<tr><td colspan="2">(3) Suitability and adaptability to local knowledge</td></tr>
<tr><td colspan="2">Genetic diversity in agriculture enables crops to adapt to different environments and growing conditions. The ability of a particular variety to withstand drought or inundation, grow in poor or rich soil, resist insect pests or diseases, give higher protein yields or produce a better-tasting food are traits passed on naturally. Without this diversity we would lose the ability to adapt to ever-changing needs and weather conditions. The immense genetic diversity of traditional farming systems is the product of human innovation and experimentation-both historic indigenous knowledge and on-going change in biodiversity. Using superior farmers' varieties and traditional crops is therefore very suitable to local knowledge. When farmers, extension and development agents and scientists join forces they can maximize the benefits deriving from this diversity and they can co-learn the importance of it. Farmers have their knowledge about crops and varieties that may have been under-researched. Development agent can help popularizing those crops and varieties and scientists can gain knowledge on crops which were not fully researched before.</td></tr>
<tr><td colspan="2">(4) Main land use and agro ecology</td></tr>
<tr><td colspan="2">Each watershed and each agro-ecology has its own set of crops and varieties with potential to be used to enhance productivity and resilience as well as provide new livelihood options.</td><td></td></tr>
<tr><td colspan="3">(5) Potential to increase/sustain productivity and environmental protection (impacts)</td></tr>
</table>

This assessment will allow to put the basis for two possible impact: 1. Identification of best varieties for major crops to boost productivity and resilience and 2. To identify crops and species with potential to enhance nutrition and health and to generate new livelihood opportunities. For example if a traditional fruit or vegetable is found with good nutritional qualities it could be turned into a new income generation activity (in addition to provide important nutrients to the community). Same could be say for oil crops with high potential to add value. These aspects will not be treated in this series of infotechs and it is just to highlight the potential of this activity to generate relevant information.
(6) Description of the technology and steps
This technology aims at identifying crops and varieties with high potential to contribute to food security and livelihood. The technology also aims at providing development agents and extension workers with greater insights about diversity and its potential contribution to livelihood The technology is very simple to apply but it requires some skills to allow the implementing team to properly interact with the farmers and representative of the communities. It is important to understand that in this exercise the scope is to learn from the community which resources they have that may enhance food security and create additional opportunities for income generation. This implies that the facilitator needs to have a disposition to be self-reflective, question his/her own assumptions, 'unlearn' and embrace local knowledge and listen to local voices rather than trying to push a predetermined agenda. Hence, it is crucial that the facilitator establishes a relationship of trust and creates a space, which is inclusive and where people feel at ease to express their opinions. Here are some key principles for participatory approaches. **Seeking and valuing local knowledge** Local people have their own expert knowledge. Within the community there will be differing perspectives and "realities" – every person has their own experiences and interpretations which add richness and value to a process. **Using a mixture of visual and verbal techniques** A mix of methods aims to make processes as inclusive as possible. Through diagrams, drawings and sharing experiences, the aim is to involve as many people as possible. The process aims to be on an equal basis, regardless of age, race, gender, culture, literacy level, social or economic status. Methods should be used in ways that make people comfortable, and encourages them to voice their opinions and be heard. **Actively seeking unheard voices** Participatory approaches involve trying to ensure that people who are normally silent are granted safe spaces to be heard. Facilitating participatory approaches means actively trying to find out who wants to participate but is currently excluded, and then trying to include them. The approach also respects that some people may not want to take part! Care needs to be taken about how power relations will affect those who are often suppressed or silent when the project and outsiders have left.

Handing over the stick (or pen, or chalk)
This phrase came from early participatory work and is essentially about letting others “do it”. It involves those considered expert or powerful or of higher status sitting back, keeping quiet and letting the community get on with it. The terms “uppers” and “lowers” are often used in the context of participatory approaches: thinking about the relationships between them and their implications in terms of power, willingness to speak etc. is an important consideration.
Based on these principles, we are ready to start with the exercise.
In order to understand the diversity it is necessary to engage with a group of 6 to 8 male farmers and 6 to 8 female farmers separated (preferably) or together but with equal representation of gender.
NOTE: The facilitators need to come with big piece of paper, pens, post-its, board, flipchart.
When farmers are coming together, the facilitator will:

1. Introducing the exercise

The facilitator introduces him/herself and explains the objective of the exercise. If there are two facilitators available, the group of people is divided into a group of men and a group of women, who will ideally be in separate rooms. The following steps are the same for the two groups.

2. Brainstorming about different components of agricultural biodiversity

The facilitator lists in a flipchart the crops (including fruit trees and vegetables as they are mentioned by the farmers, cultivated and in the wild) and asks participants for what reason they are used locally. It is important to also use the local names of crops when listing them. The participants are asked to rank the species/crop based on the importance for food security/nutrition/livelihood and to add positive as well as negative feature for each crop. The facilitators also asks whether the crops are common or not and whether they are cultivated or found from the wild.

3. Identify varieties for major staple crops (max for 2 crops)

On a separate flipchart the facilitators the 2/3 most important crops in the area and ask participants to indicate the varieties for each crop and whether they are improved or traditional. The facilitator will generate a table as the one below.

Crop: Wheat	
Name of Variety	Type of variety
A	Improved
B	Traditional
C	Improved

D	Traditional

Technical information kit	(1) Components and phases forimplementation	(2) Main purpose/ core deliverables
Diversified Agriculture for food and nutrition security (2)	Test the identified varieties with farmers using diversity blocks. Following the identification of suitable crops and varieties, a field is prepared with a maximum of 30 varieties for field evaluation by farmers and scientists. It is advised that this activity is conducted in collaboration with the closest research centre to benefit from the skills of researchers and technicians.	Diversity block is an experimental block of varieties managed by local institution for research and development purposes (e.g. farmers' training centres). The block is not only used for measuring and analysing agro-morphological characteristics but also used to allow farmers to evaluate the varieties and assess their preferences. Diversity block has the additional advantage of raising public awareness. Planting materials can be multiplied for further distribution to farmers who may request some specific varieties. In case material from other areas or from the national genebank is also tested in diversity blocks, than the diversity block is also a way to expose farmers to this new set of diverse material with traits for potential adaptation to climate change. Finally, the diversity blocks can serve to sensitise local community on the value of community managed biodiversity and create ownership of diversity.
(3) Suitability and adaptability to local knowledge		
This step is required in order identify superior varieties of identified crop(s) for further use in the watersheds. Choice of crop(s) to be tested using this approach will depend on the previous exercise.		
(4) Main land use and agro ecology		
Diversified agriculture can be implemented in all agro-ecologies where there are agricultural practices and is one key climate smart activity. Selection and promotion of superior varieties of any given crop can be enabled under any climatic or soil conditions. In addition, it can be fully integrated with any other climate smart practices related to soil fertility management and most likely it will enhance productivity under those management practices compared to conventional varieties. Evidences from Ethiopia show that productivity can be enhanced twofold under marginal conditions in Tigray and Amhara when using superior and well adapted varieties to local environmental and soil conditions. In addition, these superior varieties tend to have greater resistance to major diseases and therefore contribute to minimize losses from pests and diseases. When grown in mixtures this effect can be further emphasized. The identification of such superior varieties, however, requires at the initial stage a strong collaboration between research and the extension systems. It is therefore essential, unless superior varieties are already identified, to engage with zonal research centers.		
(5) Potential to increase/sustain productivity and environmental protection (impacts)		
The diversity blocks are an essential part of the biodiversity based approach as they are the way through which new varieties with better performance can be delivered to the farmers. It is therefore through diversity blocks that the performance of varieties can be assessed and farmers can become familiar with them. In addition, they will allow testing adaptation of different varieties to different environmental and climatic conditions.		

(6) Description of the steps
The following steps and processes are required to establish a functional Diversity Block. Step 1 Collect seed samples (50-200g seed per variety depending upon crop) during a community meeting. The collected varieties will be based upon the diversity assessment and should include passport data, including the name of the variety, farmers' descriptor, names of farmers who provided the seeds, altitude, name of locality. The seeds shall include both modern and farmers' varieties. Additional varieties shall be collected from other sources such as the National Gene Bank in order to enhance the diversity available to the farmers. Step 2 Complement the information acquired with additional number of varieties from the national gene bank. Ideally a total number of 20-30 varieties should compose a diversity block and therefore the number of additional varieties depend on the number of locally available varieties, Step 3 Reiterate objectives and potential benefits from the diversity block and discuss in the community to identify interested local institutions to grow and maintain a diversity block at a strategic public place and representative domain. Ideally farmers' training centers are to be selected or, in alternative, the nearest research centre. Step 4 Orient community members for simple field layout, planting and labelling and identify a focal person for management of the block. It is essential to provide conceptual and practical training to ensure proper management of the field. Collaboration with nearest research centre may be of great value. Step 5 Grow available diversity of the crop under standard recommended management system for the crops. Make sure each variety is properly labeled to avoid confusion and mixing up of varieties. Ensure that standard agro-morphological traits (depending on the crop) are measured following standard procedure . Step 6 Conduct a field day with interested and knowledgeable farmers, researchers and development agents in order to: • promote proper farmers evaluation of the varieties displayed in the diversity block; • collect demand for seed for future planting • Make sure farmers' preferences are properly captured amd reasons for choice are properly noted, ideally male and female farmers' should evaluate varieties in separate groups. • Reseachers may identify varieties useful for inclusion in breeding programs and can better understand farmers' preferences, Step 7 Harvest seed and store seed in safe and proper environment, avoid seed contamination (harvest 1 block at a time) and prevent seeds attack by insects. Step 8

Update the database of the community biodiversity register to encourage participants for on-farm conservation and to support landrace enhancement. Make sure all information are available to the community

4. Identify traits that are relevant for each crop

On the same flipchart the facilitators ask which traits are important for the crops. This can include agronomic traits, yield, biomass, resistance to pests and diseases etc, quality traits, such as taste,cookabilityetc and ask the farmers to score each trait against each variety from 1 to 5 way so that 5 is very good performance for that trait and 1 is very poor. Finally the enumerator will add an overall column for a general scoring of each variety. At the end of this step the enumerators will have a table like this.

Wheat						
Name of Variety	Type of variety	Trait 1	Trait 2	Trait 3	Trait 4	Overall
A	Improved	3	2	4	4	3
B	Traditional	2	4	3	5	4
C	Improved	1	5	4	2	4
D	Traditional	4	4	5	4	5

5. Identifying lost varieties

Finally the enumerators ask the farmers if they know other varieties that are no longer cultivated in the watershed. If Yes, what are the names of these to be added at the bottom of the previous table and why they are no longer grown.

The final table will look like this:

Wheat						
Name of Variety	Type of variety	Trait 1	Trait 2	Trait 3	Trait 4	Overall
A	Improved	3	2	4	4	3
B	Traditional	2	4	3	5	4
C	Improved	1	5	4	2	4
D	Traditional	4	4	5	4	5
Lost Varieties						Reasons for loosing
X	Traditional					Notes
Y	Traditional					Notes

This activity should be integrated as part of the watershed assessment. It will require a short training for the team and it may be necessary to select a small core number of watersheds representative of different agro-ecological zones in order to use the acquired information for proper planning on maximizing the potential of diversity for the benefit of the farmers.

<table>
<tr><th>Technical information kit</th><th>(1) Components and phases forimplementation</th><th>(2) Main purpose/ core deliverables</th></tr>
<tr><td>Diversified Agriculture for food and nutrition security (3)</td><td>Validate varieties and enhance availability by distributing them through crowd sourcing approaches</td><td rowspan="4">❖ Climate change affects agricultural productivity, making farmers unsecured and vulnerable. One feature of climate change is its unpredictability. Therefore diversifying agriculture at species/variety level will secure farmers from the total loss of harvest.
❖ Crowdsourcing approach uses multiple superior varieties that are tested by the community themselves after selection from diversity block as best in bad season and others best in good season. Then since the climate is unpredictable, when the season is bad the farmer will harvest genotype that suits bad condition and if the season is good he/she will have a chance to get premium production from all genotypes. This tool will enable to reach large farmers in few resources in short period of time.
❖ Using diversified genotypes and/or species is also help farmers to be resilient from sporadic outbreak of diseases and pests. Since the genetic makeup of different genotypes and species is different, they will not be attacked all at the same time.</td></tr>
<tr><td colspan="2">(3) Suitability and adaptability to local knowledge</td></tr>
<tr><td colspan="2">The use of crowdsourcing approach is strongly linked to traditional knowledge. Farmers preferred varieties identified through previous steps are distributed to farmers in small quantities for them to test under their own management practices as well as soil conditions. The big advantage of this approach is that farmers can test the varieties throughout the growing season and they are not limited to a field day. They can therefore really appreciate the potential of the seeds for any use important to them. Quality traits, agronomic traits, fodder quality, nutritional properties are all important to farmers and with the crowdsourcing approach they are in better position to really appreciate them.

The approach allows to engage with a large number of farmers compared to conventional approaches and to have them fully involved in the evaluation. As the extension or research systems do not have to manage the trials by themselves the cost / farmer is much cheaper.</td></tr>
<tr><td colspan="2">(4) Main land use and agro ecology</td></tr>
</table>

<table>
<tr><td>Each watershed and each agro-ecology has its own set of crops and varieties with potential to be used to enhance productivity and resilience as well as provide new livelihood options. All agroecologies and soil types are suitable for the crowdsourcing approach, although using different crops.</td><td>❖ Crowdsourcing can also be used to test combined technologies</td></tr>
<tr><td colspan="2">(5) Potential to increase/sustain productivity and environmental protection (impacts)</td></tr>
<tr><td colspan="2">Varieties distributed to farmers using a crowdsourcing approach have been pre-selected from diversity blocks and are therefore those with high productivity. As in the diversity blocks all varieties are included it is assumed that the one passing that stage are superior to the existing ones.</td></tr>
<tr><td colspan="2">(6) Description of the technology and steps</td></tr>
<tr><td colspan="2">Diversity agriculture can be integrally used with other technologies. As a way of demonstration and scaling up a crowdsourcing approach can be used to rich uncountable number of farmers in short period. The approach can be used also for dissemination of improved seeds or other technologies or a combination of technologies. The idea is that farmers should receive superior varieties and if farmers’ varieties are superior they need to be made available to farmers.

Steps in implementation of crowd sourcing

3. Component Identification
Select varieties from diversity blocks.
Select varieties/genotypes which are being produced by farmers and/or genotypes being produced in other localities that might be believed or identified to suite to such similar areas and farming system.
The genotype components should have different genotypic makeup to react differently for the environment they will face within the watershed.
4. Identify farmers who are receiving different composition of varieties.
5. Seed preparation
Seeds of three varieties or species can be prepared separately if the farmer plan to saw it in a separate plot of land.
Case: from Bioversity international crowd sourcing experiment, farmers were provided three different random varieties from the total of 21 varieties distributed all over in the community.</td></tr>
</table>

6. Site selection and planting
   Crop rotation should be considered whenever a farmer need to select sites.
   It can be planted separately in the farmer field but it is preferred that they are planted together with the same crop for the farmer to appreciate the difference between the new and old varieties
7. Cultivation
   Apply cultural practice and local management practices of cultivation, fertilization (manure and compost) and weeding as recommended for that specific crop species in that specific locality.
8. Measurements
   Let farmers to take their own measurement and deep understanding about the varieties and the climate condition of that specific season, it will help farmers to select varieties for future.
9. Harvesting
   Harvesting can be done by hand using equipment. And let farmers to provide the seed at least for five other farmers in the next season to insure the availability of these varieties within the community and to change the diversity of varieties in that locality.

It is important that development agents follow the farmers throughout the process and advise them as part of their regular activities. In this way they can co-learn with farmers how varieties perform in different soils and micro-ecologies.

<table>
<tr><th>Technical information kit</th><th>(1) Components and phases forimplementation</th><th>(2) Main purpose/ core deliverables</th></tr>
<tr><td>Diversified Agriculture for food and nutrition security (4)</td><td>Enhance social capital by establishing community seed bank.

.</td><td rowspan="5">Once farmers' preferred varieties are identified through diversity assessment and tested in diversity blocks as well as in crowdsourcing, it is important to make them available to the farmers alongside other crops and varieties that are important for that specific locality. Generally farmers varieties are not in the market, they are rarely registered and therefore they are difficult to multiply and make available through seed companies. While registering is considered an important step, it takes time and resources under current regulations. Community seed banks (CSB) are collections of seeds of local farmers' varieties that are maintained and administered by the communities.</td></tr>
<tr><td colspan="2">(3) Suitability and adaptability to local knowledge</td></tr>
<tr><td colspan="2">Community seed banks is a form of community based management and therefore relies on local knowledge to a significant extent. Farmers have knowledge about diversity of different crops and varieties and how to grow them. This body of knowledge is very important to establish the community seed bank.</td></tr>
<tr><td colspan="2">(4) Main use and objectives</td></tr>
<tr><td colspan="2">The main objective of establishing a community seed bank is to ensure that:</td></tr>
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1. Farmers varieties will be conserved under a dynamic evolutionary system (on-farm) and extinction of local seed varieties prevented
2. Farmers livelihood enhanced through diversification of local varieties
3. Immediate and secure source of seeds for the farmers in the target areas will be established (informal seed system will be strengthened)
4. Farmers resilience enhanced
5. Productivity in watersheds is enhanced
6. Farmers are less vulnerable to natural disasters

Clearly a community seed bank can be established in all sites as they build and depend on local resources.

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By establishing a seed bank in a community, it is possible to:

- Minimize loss of crop genetic diversity and local seed varieties
- Generate locally adapted seeds that perform well in the local condition
- Educate the community on how to produce quality seeds
- Create linkage between farmers and national genebanks
- Strengthen local seed system which contributes to sustainable agricultural production and food security.

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<tr>
<td colspan="2">(5) Potential to increase/sustain productivity and environmental protection (impacts)</td>
</tr>
<tr>
<td colspan="2">Community seed banks provide the seeds of farmers' preferred varieties with higher productivity.</td>
</tr>
<tr>
<td colspan="2">(6) Description of the technology and steps</td>
</tr>
<tr>
<td colspan="2">

While these are key principles for good management of community seed banks there are steps and procedures to be followed for their establishment as follows (Adopted from Malik et al, 2013).

1. Selection of suitable site which is convenient and safe for storage of seeds. Location of seed bank should be accessible to most of the farmers of the target area and have the consent of most of the farmers of the watershed.
2. Development of infrastructure such as clean, dry and elevated space, storage bins of different sizes, weighing balance, documentation registers, display containers, metal/wooden shelves, cloth bags/sacks for supply of seeds
3. Formation of farmer groups having knowledge of local seed varieties and willingness to participate in conservation of local seed varieties and definition of by-laws
4. Nominating committee members to follow up the overall operation of the CSB.
5. Indentifying the responsible person (CSB manager) to look after the seed bank, day-to-day operation and maintenance, and motivate the farmers to associate with this system to derive maximum advantage of the seed bank.
6. Conduct awareness programs regularly and motivate the community for participatory seed management process and conservation of their heritage for future generations.
7. Design seed loan system (quantity, quality)
8. Periodical interaction and training of associated farmer families and farmer members of Seed Bank Committee members to make them aware of latest innovations in informal seed system and to get their input to improve on going system.

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9. Assess potential demand and value of such varieties in the local market and promote these varieties to improve their price.
10. Link the seed banks with market to extend financial support to the farmers and seed banks.

NB: This activity should be implemented by Ethiopian Biodiversity Institute. Standards for constructing and managing CSB are available at EBI.

<table>
<tr><th>Technical information kit</th><th>(1) Components and phases forimplementation</th><th>(2) Main purpose/ core deliverables</th></tr>
<tr><td>Diversified Agriculture for food and nutrition security (5)</td><td>Document community based management of diversity through community biodiversity registry. It can be applied to both animals and crops as a way to maintain the information about them.</td><td rowspan="3">Traditional knowledge and skills of farmers and indigenous people can make a significant contribution to sustainable development. Empowering community and local institutions to document and use information of their traditional knowledge and biodiversity helps to foster bioprospecting and check biopiracy. Community Biodiversity Registries can be used by diverse types of institutions for different purposes and, consequently, methodologies for CBR have different variants. In our case the main goal is to strengthening the capacity of local</td></tr>
<tr><td colspan="2">(3) Suitability and adaptability to local knowledge</td></tr>
<tr><td colspan="2">CBR is a participatory method developed by the project team to address a range of objectives, such as protection of traditional knowledge and genetic materials from biopiracy, promoting bioprospecting, monitoring genetic erosion, developing local ownership for development and conservation actions. Basically, through the CBR process, the on farm conservation project aims to empower local communities and institutions to develop better understanding for their own biodiversity assets and their value so that they play an important role in research, development and conservation strategies at the local level.</td></tr>
</table>

<table>
<tr><td>It is, therefore, a very powerful way to document traditional knowledge and to share broadly with relevant stakeholders.</td><td rowspan="3">communities to document important genetic resources and traditional knowledge for developing conservation as well as development plans. However, the information collected and documented through the CBR is very useful also for the research system, for conservation purposes and for the extension agents.</td></tr>
<tr><td>(4) Main land use and agro ecology</td></tr>
<tr><td>CBR can be implemented in each watershed although they require building social capital in the form of managing the registry and collect information from other farmers. Ideally, the can be linked to community seed banks as the committee are knowledgeable about diversity and can therefore provide quality documentation.</td></tr>
<tr><td colspan="2">(5) Potential to increase/sustain productivity and environmental protection (impacts)</td></tr>
<tr><td colspan="2">Having community biodiversity in place is important as it will generate iterative knowledge whereby the potential of different crop varieties can be fully recorded year after year, thus contributing to fine tuning agronomic practices for each variety, their performance in different years and different climatic conditions as well as other benefits provided by the varieties such as resistance to pests and diseases, cooking qualities, nutritional properties, biomass and fodder quality when relevant, market value and potential for commercialization or value addition. Overall, that incremental knowledge will boost productivity by allowing farmers to select the most appropriate varieties for their conditions.</td></tr>
<tr><td colspan="2">(6) Description of the technology and steps</td></tr>
<tr><td colspan="2">Community Biodiversity registries are database with information collected by extension agents. The capacity needed is therefore linked to the identification of the information that the community (together with development agents and researchers) need to deliver to extension agents. Example of information can include the following:
1. Local, scientific and ethnic names of varieties/breed
2. Existence history at a given location (year of introduction, address of locality)
3. Where the variety came from (original place, source of knowledge and materials)
4. Nature of the species (e.g. annual, perennial, ever green, deciduous, herb, shrub, tree, etc.)
5. Mode of reproduction (e.g. means of propagation are described: seed, clones, sapling, stem, leaf)
6. Natural habitats (as defined by farmers)
7. Extent and distribution of genetic diversity ((R) rare, (M) medium, (W) widely grown)
8. Local techniques/traditional knowledge (practices that describe processing of products linked to specific variety and its management)
9. Uses (good and services of cultivar direct use, option and exploration values)</td></tr>
</table>

10. Useful parts, stages and times In addition, if the community seed bank manages the registry it would be very important to ask questions to members about their preferences and options each year. At the point a community registry has been established farmers are already quite familiar with the concept of diversity. The only requirement is therefore a community meeting to discuss the type of information that needs to go into the registry and a specific training for the managers of the registry on how to handle the information. NB: this activity should engage EBI because the information collected in the CBR is relevant to the mandate of the Institute.

<table>
<tr><th>Technical information kit</th><th>(1) Components and phases forimplementation</th><th>(2) Main purpose/ core deliverables</th></tr>
<tr><td>Diversified Agriculture for food and nutrition security (6)</td><td>Popularize and share diversity within the community through diversity fairs.</td><td rowspan="3">The diversity fair helps to locate the area of high diversity and most productive landraces. It also recognises real custodians of rich genetic diversity and traditional knowledge. The diversity fair provides a good forum that over time and space maintains, enhances and creates crop genetic diversity and ensures its availability to and from farmers and other actors for improved livelihoods on a sustainable basis. Participation in diversity fairs generate self confidence in individual farmers and farmingcommunities as they display their rich crop genetic resources and indigenous knowledge to visitors and fellow farmers. It is one of the best</td></tr>
<tr><td colspan="2">(3) Suitability and adaptability to local knowledge</td></tr>
<tr><td colspan="2">Diversity fair is a participatory tool for raising public awareness on the value of local landraces, bringing the farmers from different part of the watershed together to exhibit the range of diversity, so that traditional systems of seed and knowledge transmission continue to conserve. Traditionally, local seed markets and fairs constituted an important part of the community seed exchange network in the villages of many developing countries.
One of the aims of diversity fairs is to encourage farmers to share information and exchange seeds within the locality, giving them access to a wider choice of varieties and maintaining a higher level of biodiversity. It is often organized as a competitive event so that local communities are encouraged to maintain high crop diversity and bring in rare and unique diversity for display. This is also a good</td></tr>
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<table>
<tr><td>opportunity for researchers and development professionals to identify the custodians and learn more about traditional knowledge. In essence it is where traditional knowledge is shared and discussed with participants of the fair.</td><td rowspan="3">forums to create awareness and interest, amongst diverse stakeholders on the importance and value of local plan genetic resources.</td></tr>
<tr><td>(4) Potential to increase/sustain productivity and environmental protection (impacts)</td></tr>
<tr><td>Diversity fairs is where seeds and knowledge are shared between farmers from different communities within a watershed. It is therefore an opportunity to get seeds of better adapted varieties from fellow farmers from a different village and a chance to test them under different conditions. I addition, extension agent and researcher can attend the fair and can provide additional inputs to farmers on how to better manage individual varieties. All this make the diversity fair an opportunity to further learning how to increase productivity</td></tr>
<tr><td colspan="2">(5) Description of the technology and steps</td></tr>
<tr><td colspan="2">Local institutions (e.g. community seed bank.) organize diversity fairs with technical facilitation from research and development professionals.
The steps to be followed while organizing a diversity fair are as follows:
Step 1: Participatory planning
In order to sensitize farming communities, development workers and researchers to the purpose of the diversity fair, a series of participatory planning meetings with grassroots institutions should be held, in which the detailed steps and procedures, including the options for the prizes, should be followed. In this phase, interaction with local community members, farmers’ groups or CBOs is important to discuss the concept, purpose and financial support for the diversity fair. Identification and agreement with the focal local institution on the organizational modality of the diversity fair should be done. Wider sharing and community level planning of the diversity fair should be visualised. Guiding principles of the diversity fair and criteria for participating community selection should be formulated.
Selection of the venue and appropriate date should be finalised in consultation with local institutions. The organizing committee and sub-committees should be formed and roles and responsibilities for each committee should be defined.
Step 2: Preparation for setting norms and procedure for diversity fair
It is essential that norms and procedures should be made transparent due to the competitive nature of the activity. The information should be widely disseminated at different levels. Agro-ecological zones should be defined to determine the participants of diversity fair at the domain level. Different norms should be used in different sites to suit local conditions. Variety names, distinguishing traits and address of custodians, passport information of materials, specific reasons for cultivation and valuable traits should be provided for each sample. Seed or planting materials originating within the group members should be subjected to in situ verification, if contested/protested. An oral presentation on the value and importance of local varieties should be presented in front of a panel of judges. It is well advised that the dissemination of all the information to farmers about the date, venue and criteria of diversity fair using various means such as rural FM radio, newspapers, or posters in schools, etc. well before time. The potential competitors should understand the criteria for evaluation in different classes and the overall rules for display or competition. It is important to provide orientation training to participating group members</td></tr>
</table>

on materials to be displayed, information to be shared, labelling the materials, number, and type of prizes and rules and regulations for the fair. Logistics information and supplies should be distributed to each farmers' committee with roles and responsibilities and practice sessions to fill out information sheets should be organized. Local communities should be encouraged to use local packaging materials so that the fair has an ethnic-cultural flavour. Press should be invited to visit stalls of the fair, along with local dignitaries, policy makers and district administrators, private entrepreneurs, neighbouring farming communities, pupils. An evaluation committee should be formed and should develop the criteria for evaluation.

Step 3: Implementation

Allocate space to each farmers' group along with the materials to decorate their stall. Field registration and registered materials should be verified, and inauguration of the fair should be instigated by the guest of honour.

Farmers and invitees should be guided to visit the stalls and facilitate in sharing the information and knowledge associated with the exhibited materials. Local institutions should be encouraged to integrate a light cultural show to attract more participants and share knowledge through songs, poems and dramas.

Step 4: Participatory evaluation

Evaluation of displayed materials by each group needs to be completed before the formal event, if possible a day in advance, and the winners should be notified according to the categories of prizes or award. The prize distribution ceremony should be commenced by the guest of honour.

Evaluations of fairs are prepared by experts from outside the community as they are technically sound for improved technologies and new seeds. The compositions of judges should include at least one knowledgeable nodal farmer, PGR specialist, agricultural officer, NGO, merchant, site staff and scientist from the project. The evaluation team should also develop a set of criteria for award assessment. This can vary again according to local expertise and the situation. The major criteria to be considered are:

- Number of local landraces displayed by the group or farmer in the target crops (40%)
- Quality of information (value of PGR) and its authenticity (30%)
- Style of presentation and quality of knowledge (15%)
- Rarity of displayed variety (10%)
- Degree of women participation (5%)

The weight assigned for each criterion can be mutually agreed and the indicators for measurement for each criterion can also be developed by the panel. Prior to the event the information needs be shared with all participating groups at the time of orientation training on the diversity fair.

<table>
<tr><th>Technical information kit</th><th>(1) Components and phases forimplementation</th><th>(2) Main purpose/ core deliverables</th></tr>
<tr><td>Diversified Agriculture for food and nutrition security (7) animal</td><td>Set up within breed genetic improvement using community based animal conservation and breeding (CBACB) approach on selected breeds</td><td rowspan="5">Community-based animal conservation and breeding (CBACB) maintains the genetic diversity along with improvement of livestock productivity. CBACB in developing countries is mainly associated with low input system. To ensure sustainability, CBACB need to be fully participatory (Muller et al., 2002). Farmers will have a chance to manage and observe performances of experimental animals for research and development purpose. Sire selection implemented across diversity flocks, representingseveral groups of animals managed by a farmer. The diversity flock will also allow farmers to evaluate individual candidate animals. Diversity flocks also has the additional advantage of raising public awareness. Best sires need to be maintained within the community. However, the next best sires can be distributed to surrounding farmers showing interest on the animals. Finally, the diversity flocks can serve to sensitise the local community on the value of community managed animal genetic resources and create ownership of diversity.</td></tr>
<tr><td colspan="2">(3) Suitability and adaptability to local knowledge</td></tr>
<tr><td colspan="2">Diversified agriculture is the existing and well known risk management strategy of Ethiopian farmers, and it is believed to be one of the cross cutting component to be incorporated in all system of climate smart agriculture.</td></tr>
<tr><td colspan="2">(4) Main land use and agro ecology</td></tr>
<tr><td colspan="2">Diversified agriculture can be implemented in all agro-ecologies where there are agricultural practices and is one key climate smart activity. Within breed selection and promotion of superior sires of any given animal can be enabled under any climatic conditions. In addition, it can be fully integrated with any other climate smart practices related to less emission of green house gases as improved animals are known to produce less gases per output produced compared to unimproved animals. Community based sheep breeding program has been implemented successfully in 3 sheep breeds in Ethiopia (Menz, Bonga and Horro) (Haile et al, 2011) and other developing countries particularly in Latin American countries (Wurzinger et al., 2011). Participating communities has been benefited from the genetic improvement by raising their income and improve their livelihood. Well adapted indigenous breeds are more productive in marginal areas compared to exotic crossbred animals.</td><td></td></tr>
<tr><td colspan="3">(5) Potential to increase/sustain productivity and environmental protection (impacts)</td></tr>
<tr><td colspan="3">Within animal genetic diversity, heritability of selected traits and selection intensity, generation interval along with proper recording and estimation of genetic potential of animals are essential parts to the realization of genetic gain per generation for community based improvement program. Most of our local breeds are unselected so that they tended to have immense within breed genetic diversity which would serve as raw material for genetic improvement. Genetic improvement through selection is gradual as compared to the use of exotic animals. Use of available breed is also much more sustainable than the use of exotic breeds which are expensive to acquire and high input to manage them.</td></tr>
<tr><td colspan="3">(6) Description of the steps</td></tr>
<tr><td colspan="3">The following steps and processes are required to establish a community based selection.
Step 1
Site, community and farmer selection
Targeted breed for CBACB need to be selected based on the risk status and economic contribution of the breed to the society. Country report and previous characterization work on breeds may help to identify the targeted breed. Once the breed has been defined, appropriate site should be identified. Local development agents and other stakeholders working on the breed should participate in site selection. Relative accessibility of the site to road and market, presence of institutions supporting the community, potential of the area for the conservation and improvement of selected breed need to be considered.</td></tr>
</table>

Interest of the community to conserve the breed through utilization and willingness to work together in implementing the program (interested to use sire and other recourses in common) are prerequisite to select a community. Individual farmers within the community will be identified based on their interest. Flocks in each farmer considered as diversity flock. Sire selection has to be implemented across flocks.

Step 2

Awareness creation

Implementing community-based breeding program, mainly animal identification and performance recording are new for most of Ethiopian livestock keepers. Awareness creation on the importance of such activities is crucial for the success of the breeding program. Experts and researchers working with communities need to have great passion in awareness creation and breeding program implementation.

Step 3

Identifying breeding objectives

Breeding objective and selection criteria should be set based on the interest of participating community considering current and future environmental situations, surrounding community rearing similar breed, current and future market need and national plan. Either or combination of different tools (Interviewing individual farmers, group discussion, workshop, ranking of live animals in reference to other known breeds may be employed to identify selection criteria of farmers.

Step 4

Animal identification, data collection and recording

Animal identification

Ear tags are most commonly used and preferred animal identification method in most areas as they are relatively cheaper and easy to apply. New born animals should be identified from their dam and sire immediately at birth; however, some farmers might resist it. In this case, it is possible to postpone tagging for few days with proper identification and recording of dam tag number, sire tag number and offspring coat colour and unique identifiers. Good numbering system should be devised for decision and analysis purpose. As a general rule unique number should be given for each animal and the identification number given for the offspring should be greater than the number given for its sire and dam.

Data collection

Data to be collected should be decided based on the identified selection criteria. Generally data to be collected should be as simple as possible to be properly implemented under farmer's situation. Birth weight, litter size (in small ruminants) and growth rate might be considered when breeding objective is to increase growth performance of the breed. Mothering ability, reproductive performances and traits related to adaptation may also be considered. Milk yield and lactation length need to be considered to increase milk yield. Pedigree information also crucial for estimation of the genetic worth of the animal and to control level of inbreeding.

Step 5

Select best sires based on records and farmers criteria:

In most cases small holder flocks are too small to make selection within the household flock. Selection of sires would then be implemented at community flock level. Performance records and pedigree information are used to select best animals to be parents of the next generation. The main purpose of selection is to maintain best animals in the flock aiming to disseminate its genetic merit to the next generation. Best animals need to be selected and maintained within the community at early age to avoid prior sell of animals. Designing appropriate time of selection and age of the animal at selection depending on the breed and market situation is crucial. Although offspring produced throughout the year as mating is uncontrolled and non-seasonality of oestrus in the traditional

flocks, there are variation among seasons in number of offspring production. Thus selection should be practiced in batch considering market age of the breed, marketing season associated with annual feasts and frequency of available candidates. Selecting sire immediately before major festivals (New Year, Christmas, Ester, Ed-Al-Adha) are recommended.
Performance records adjust for known environmental variation (like age, management and dam parity etc.) and farmers' criteria would be used to select best sires. Candidate sires should be ranked based on their estimated breeding value and then farmers need to make final selection considering their own phenotypic assessment.
Two step selection; select larger number of candidates at early age (immediately before market age) and then approval, among candidates at breeding age is recommended. Sires failing breeding soundness test need to be rejected automatically. Developing recording format and setting up of data collection and estimation of breeding value of animals need to be assisted by the nearest biodiversity and/or research centers.
Step 6
Ensure use of best sires for the community
includes availing and ensuring functionality of selected sires to serve all flocks of the community fairly. Setting incentive price is important to maintain improved sire and for the sustainability of the breeding program. Thus selected sires having best genetic merit should fetch above average income for the owner. At the beginning the program need to have revolving fund from the project or contribution of members which used for acquiring selected sires and other inputs for the community. After giving proper service, breeding sires will be castrated, fattened and sold at good price. Money obtained from the auction of culled breeding sire used to buy replacement sires for the community.
Step 7
Arrange proper sire use scheme
Selecting and use of as few as possible sires without affecting readily accessibility to all breeding dams is important in order to attain maximum genetic gain. Allocating farmers in to different breeding group based on their neighborhood and communal grazing land helped to create family of flocks and communal ram use arrangement. Group formation and arrangement of communal sire use strategy should be decided with full participation of the community. If breeding sires are needed for more than one generation it is important to rotate sires among groups or family flocks within the community to reduce inbreeding effect.
Step 8
Culling of unselected sires
Unselected sires should be avoided from mating of breeding dams. This might be done using different methods like isolation, tethering, selling, castrating or protect mating using apron or tying of a cord around the neck of the scrotum and looped over the prepuce to prevent extrusion of the penis of the buck or ram as used by Afar pastoralist for sheep. Imposing technologies like conditioning or fattening of unselected sire are valuable to add values on such sires.
Step 9
Conduct a field day with interested and knowledgeable farmers, researchers and development agents in order to:
• Promote proper farmers evaluation of the candidate sires selected from diversity flock;
• arrange proper way of acquiring best sires for the community
• Make sure farmers' preferences are properly captured and reasons for choice are properly noted, ideally male and female farmers' should evaluate candidate sires in separate groups.
• Researchers may identify candidate sires useful for inclusion in breeding programs and can better understand farmers' preferences,

<table>
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<tr><td>Diversified Agriculture for food and nutrition security (8) animal</td><td>Test, validate and promote controlled crossbreeding based on selected breed using communal sire use approach</td><td rowspan="5">Tropical developing countries typically rely on non-specialized multipurpose breeds and extensive production systems and control over breeding animals is often poor. Existing breeds are adapted to the existing environmental situation which is characterized by feed scarcity and disease challenge. However, there is a belief that local breeds are less productive and unlikely to continue sustaining the fast growing demand for food that is created by rapid human population growth, urbanization and income growth. Crossbreeding is considered as one of the options and it is a potentially attractive breed improvement method due to its quick benefits as the result of breed complementarity and heterosis effects (Leymaster, 2002; Hayes et al., 2009). Even though crossbreeding based on improved exotic sires considered as a threat for the locally adapted indigenous breeds, a well designed controlled crossbreeding would help to increase productivity.
Delineating crossbreeding areas and controlling breed introduction should be considered as critical steps to reduce risk of genetic dilution
Participatory evaluation and selection approach used to identify breed of livestock for crossbreeding purpose. Farmers will have a chance to select breeds based on their own criteria considering their environment and capacity to manage improved animals.
Communal sire use scheme or artificial insemination is crucial to enhance sire use efficiency. These tools will enable to reach large farmers minimum resources in short period of time.</td></tr>
<tr><td colspan="2">(3) Suitability and adaptability to local knowledge</td></tr>
<tr><td colspan="2">Breeds for crossbreeding tested under ranch situation or farmer's situation in different area need to be availed for targeted farmers for selection. Then participatory identification of breed for controlled crossbreeding is strongly linked to traditional knowledge. Indigenous knowledge on adaptation, physical appearance, coat colour type and pattern, tail type and size will be used to identify suitable breed and breed composition level. Few individuals of the identified breeds are distributed to farmers for crossing their local breed to test crossbred animals under their own environment and management practices. Existing knowledge on sire sharing is advantageous to minimize inbreeding level. Crossbred animals are tested for their adaptability, performances, quality traits and their physical appearances.
The approach allows engaging with a large number of farmers compared to conventional approaches (eg. selling of breeding stock to individual farmer at a government subsidized price) and to have them fully involved in the evaluation. Working research on farmers flock by their own is advantageous in as it well correspond to the real environment of the breed, more efficient, sustainable and cheaper than working on government confined farms. In most cases managing animals in government farms are less efficient and characterized by high level of mortality suffered from inbreeding due to small numbers of exotic animals and diseases associated with confinement (Ahuya et al., 2005; Getachew et al., 2015).</td></tr>
<tr><td colspan="2">(4) Main land use and agro ecology</td></tr>
<tr><td colspan="2">Each watershed and each agro-ecology has its own set of crossbred level with potential to be used to enhance productivity and resilience as well as provide new livelihood options.</td></tr>
</table>

(5) Potential to increase/sustain productivity and environmental protection (impacts)

Exotic breeds selected for crossbreeding and individual animals distributed to farmers are said to be much better in productivity than the local breeds. Then the crossbred offsprings are expected to be better in productivity, adaptable and higher market value than local breeds.
Better attention and management to livestock associated with improved breed helped to enhance productivity.

(6) Description of the technology and steps

Controlled crossbreeding is a controlled mating and selection of animal breeds to improve certain traits of importance without diluting other local breeds or through avoiding indiscriminate cross breeding:-Steps in implementation:-

1. Identifying site, community and farmers
2. participatory selection of breed, breed proportion

- Highly productive exotic stocks are imported from developed world aiming to improve productivity through crossbreeding of the sire of the exotic animals to the dams of local breeds. Those breeds have been maintained and multiplied in ranches (breeding and multiplication centers) or imported semen has been stored at national artificial insemination center.
- Appropriate breed has to be selected by farmers, development agents and a team of researcher considering the farmers preference, environmental situation and capacity of the community to manage highly productive exotic animals. Then proportion of exotic level need to be determined based on previous performance records and research results. Individual sires have to be displayed to farmers for their approval considering their own selection criteria.

3. Dissemination of selected sires to the community and arrange communal sire use system

- Dissemination of genetic merits attained in multiplication center to large scale farmer’s flock has remained challenging in developing countries. This is mainly because of high cost of improved sires are not affordable by smallholder farmers. In addition, supply from breeding and multiplication center is limited due to high cost of importing and multiplication of exotic animal. Small flock size of smallholder farmers underutilizes the potential of improved sires when an animal is sold to individual farmers. Then improved sire should be disseminated to a group of farmers rather than providing for an individual farmer.

4. Test crossbred animals based on their performances, adaptability and physical appearances

Performances (growth, reproductive, milk yield and other), adaptability and physical appearances will be assessed and evaluated by farmers themselves. Farmers will have a chance to select animals for next generation.

5. Decide optimum level of exotic genotype level

Most studies in developing countries showed that upgrading local breeds to higher exotic level has not been successful due to adaptation problem. The use of larger breeds and or upgrading to higher exotic level in dairy is generally discouraging because of higher nutritional demand, low milk yield, poor adaptability and low production efficiency under small holder situation (e.g. Kahi et al., 2000; Mirkena et al., 2004; Tadesse et al., 2006). Study in sheep also showed that marginal areas like Menz could not support higher level of exotic (Tesfaye, 2016). Thus optimum level of exotic inheritance should be decided considering performances of crossbred animals under farmer’s management and current market and infrastructural situations.

6. Develop mating strategy

Once exotic level is decided, appropriate mating design should be implemented to achieve and sustain targeted level. For example, 50 % exotic and 50 % local decided for specific area, then exotic sire has to be mated with local breed, then the first filial generation will be mated inter se (F1 females are mated with F1 males of the same breed). If 75 % exotic and 25 % local breed decided for the area, the F1 females are mated to the exotic sire to produce 75 % exotic, then the 75% animals are mated inter se.

7. Animal identification, performance recording and record keeping

Animal identification

Ear tags are most commonly used and preferred animal identification method in most areas as they are relatively cheaper and easy to apply. New born animals should be identified from their dam and sire immediately at birth. It is recommended to apply ear tag for immediately at birth; however some farmers might resist it. In this case it is possible to postpone tagging for few days with proper identification and recording of dam tag number, sire tag number and offspring coat colour and unique identifiers. Good numbering system should be devised for decision and analysis purpose. As a general rule unique number should be given for each animal and the number of the offspring should be greater than the number of sire and dams.

Data collection

Data to be collected should be decided based on the identified selection criteria. Generally data to be collected should be as simple as possible to be properly implemented under farmer's situation. Birth weight, litter size (in small ruminants) and growth rate might be considered when breeding objective is to increase growth of the breed. Mothering ability, reproductive performances and traits related to adaptation may also be considered. Milk yield and lactation length need to be considered to increase milk yield. Pedigree information also crucial for estimation of the genetic worth of the animal and to control level of inbreeding.

8. Promote crossbred animal, products and link with market

- Crossbreeding is a fast way of genetic improvement which resulted in higher level of productivity increment in the area. Thus its sustainability highly depends on availability of market. In addition, crossbreeding might result in unusual products and appearance. For example, crossbreeding of Dorper sheep sire with local breed resulted in black colour, thin tail and absence of horn which might not be preferred by most of the highland communities.

9. Dissemination of genetic gain

Dissemination of genetic gain attained in flocks of participating farmers to other flock is crucial to maintain diversity of the gene pool as well as enhance productivity. Depending on the mating strategy used surplus breeding stock might be sold to other farmers.

10. Organizing co-operative

    - is an essential step to facilitate breed testing and genetic improvement program.

Establishing cooperatives will help to:

- Control any breeding interference and genetic dilution from the outside
- Secure input access like ear tag, drug, feed, weighing and other equipments to the community

- Create linkage between the community and other stakeholders
- Facilitate breed registration, certification, promote breed and products
- Control finance of the community
- Facilitate ram use and solve conflicts among members raised during the process of implementation
- Facilitate marketing of breeding and culled animals.

It is very crucial that development agents and researchers follow, assist and advice farmers the process.

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Step 10

Update the database of the community biodiversity register to encourage participants for on-farm conservation and to support farmer's genetic improvement process. Make sure all information are available to the community.

Step 11

Organizing co-operative is an essential step to facilitate breed testing and genetic improvement program.

Establishing cooperatives will help to:

- Control any breeding interference and genetic dilution from the outside
- Secure input access like ear tag, drug, feed, weighing and other equipments to the community
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- Control finance of the community
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It is very crucial that development agents and researchers follow, assist and advice farmers the process.

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Technical information kit	(1) Brief Description	(2) Main objective/ purpose	(3)Period/ phases forimplementation
Climate Smart Forage Development	Forage development is an importpart to respond to current and future milk and meet demand and to improve the environmental footprint of feeding animals. This is because feed is one of the limiting factors in animal production. In order to improve feeding and primary productivity it is important to make better use of existing feed and forage resources and to test new species in potentially suitable environmental conditions. This includes consideration of forages, crop residues and rangelands. Where land is not a limiting factor, forages and rangeland are the best option, however in areas where land is a limiting factor crop residues become prominent. In this infotech we will present a number options that are available to development agents although we are aware that this is not exhaustive and that the whole component of crop residues is missing. Options range from grasses, to annual and perennial legumes and root and tubers.	The main objective of this infotech is to increase and better manage forage crops as an essential element to increase animal productivity in a climate smart manner. It is also important to overcome some of the major obstacles to better forage management, including: Availability of quality seeds, high price of forage seeds, adoption of improved forage management practices and lack Institutional support and coordination This approach will also potentially reduce the emission from animals by providing fodder which is more digestible for the different breeds.	1. **Before Starting:** Understanding of the forage situation in different watersheds in order to identify those that are facing an urgent need to improve forage. During this phase it is also important to understand current practices and potential useful resources already available in the site. 2. **First Season:** Try one of the new options following proper management practices by few model farmers or in farmers training centre. Some of the options using perennial and trees may require two years to observe performance. 3. **Second and Following Seasons:** Further distribute to other farmers or plant in communal land (establishing nursery in case of trees).

(4) Suitability and adaptability to local conditions and knowledge	(5) Main land use and agro ecology
It is important to select different options based suitability and adaptability to local conditions as well as prevalent animal breeds in the different watersheds. A period to test adaptability of these options is required to test productivity, palatability and management options.	Main land uses and agroecology are reported in the infotechs for each different proposed species.

(6)) Contribution of CSA/Climate Smartness
Adaptation and Mitigation Roles While it is difficult to quantify the potential role of this infotech in improving adaptation and reducing GHG emission, there is certainly a positive effect on both, although the magnitude of the effect may be different in different localities and will largely depend on the baseline at each site. One of the ultimate goal of the infotech is to provide better adaptive forage crops and species to local conditions. It is therefore implicit a positive adaptive result. On the other hand increasing biomass and primary productivity if associated with better animal feed will reduce overall GHG emission.
(7) Implementation modality and steps
Details of implementation are specific for each proposed crops GRASS SPECIES:- 1. *Rhodes grass**(chlorisgayanakunth)*** 2. *Elephant, Napier grass**(Pennisetumpurpureum)*** 3. *Oats**(Avena sativa L.)*** 4. *Desho grass* BROWSE TREES:- 1. *Tree Lucerne **(Tagasaste)(Chamaecytisusprolifer)*** 2. *Pigeon pea (Cajanuscajan)* 3. *Sesbania (Sesbaniasesbanscopoli)* 4. *Lucenia (Leucaenaleucocephala)* LEGUMES:- 1. *Vetch (Viciadasycarpa L.)* 2. *Alfa alfa (Medicagosativa)* 3. *Green leaf (Desmodiumintortum)* 4. *White clover (Trifoliumrepens L.)* **ROOT CROPS:–***Fodder beet (Beta Vulgaris)*
References

Technical information kit	**(1) Main objective/purpose and bene**
Rhodes grass (chloris gayana kunth)  	❖ Provide adequate energy for maintenance and moderate level protein. ❖ It is effective in maintaining ground cover and preventing erosion through soil stabilization. ❖ It makes good hay if cut at or just before early flowering.

(2) Description of the Rhodes grass and its potential suitability

Rhodes grass (*Chloris gayana*Kunth) is broadly used grass widespread in tropical and subtropical countries. It is a useful forage for pasture and hay, it is drought-resistant and very productive, of high quality particularly when the grass is harvested during flowering time.Rhodes grass is best adapted to medium –high altitude with moderate amount of rainfall. The species produce a good amount of seeds so it can established from home grown seeds. Its vigorous root system makes it relatively drought tolerant. It is also tolerant to fire and it withstands heavy grazing.

Adaptation:

- ❖ Altitude range: 600-2000 m.a.s.l.
- ❖ Climate requirement: rain fall 650-1200 mm.
- ❖ Soil requirement: Versatile.

Productivity: Normal productivity under farm condition ranges between 5-8t/ha DM, however, with high N application and variable cutting frequency the species has been reported to be able to yield up to 25t/ha DM reported. Crude protein is about 13% in young grass

It is effective for erosion control but should not be used to produce forage on contour since it can become a weed. It tolerates heavy grazing and cutting and so its erosion control attributes are best used for stock exclusion areas.

Cultivation: Well prepared seed bed.

- Propagation is by seed at the rate of 1-4 kg/ha depending on amount of rain fall.
- Seeding depth should not exceed 0.6-2cm.
- Fertilizer requirement: Responds well to increasing levels of N application if in balance with P.
- Companion species: *Sylosanthesguyanensis, Neonotoniawightii, Macroptiliumlathyroids, M. atropurpureum, Medicago sativa, Centrocemapubescens.*

Utilization: Good for grazing and haymaking

Reproduction: Cross-pollinated, isolation distance of 200 m is recommended in seed production. Seed yields 65-650 kg/ha, often it is possible to have two crops per year.

(3) management requirement	**(4) Target groups**

Establishment-can be propagated vegetatively or from seeds surface sown no deeper than 2 cm at seed rate 1 to 4 kg per hectare than rolled. **Fertilizer-** apply well prepared Compost manure during establishment and after every cut **Weeding-** weed twice after planting at monthly intervals during establishment **Harvesting–** cut latest at flowering about 6 months after planting and then every 2 months to maintain quality	Target groups are all communities who have livestock andorganized user groups both men and women on forage production who sell their product to livestock owners,
(5) Limitations	
• Fluffy seed difficult to sow • High levels of soil fertility needed • Not adapted to acid, infertile soils • Not tolerant of high exchangeable aluminium levels • Quality drops rapidly with onset of seeding • Low shade tolerance • Tend to become a weed	

Technical information kit	(1) Main objective/purpose
Elephant or Napier grass *(Pennisetum purpureum*) 	❖ Provide adequate energy for maintenance and moderate level protein. ❖ It is recognized for their effectiveness in maintaining ground cover and preventing erosion through soil stabilization The species has good potential to enhance soil stability and as a wind break. The Napier grasscan be a very tallperennial grass which tends to become coarse as it matures; for this reason it has to be cut often and at early growth stage to ensure good palatability. Its vigorous deep root system makes the species tolerant to limited dry spells and poor drainage. It is useful for cut and carry, hay or silage.

(2) Description and characteristics

Adaptation:

- Best-adapted to high-rainfall areas, particularly to establish it.
- Altitude range: from sea level up to 2000 m.a.s.l.
- Climate requirement: Rainfall 1480-1620 mm/y; optimum temperature 25-40°C; resists drought if successfully established. Susceptible to frost.
- Soil requirement: Prefers deep, friable fertile soils.

Cultivation: full land preparation.

- Propagation: The species is usually propagated by stem cuttings buried in 15 cm furrows, 2 nodes, one in soil and one exposed. One ha of grass can provide planting material for 15-20 ha.
- Fertilizer requirement: Responds well to fertilizers applied after every cut.
- Companion species: *C.pubescens, N.wightii, P.phaseoloides.*

Utilization: The best use is in a cut-and-carry system, although it can also made in to silageof high quality without additives. For grazing, it is preferable to be maintained in a lush vegetative form. It is best grazed when the new growth consists of 5 new leaves.

Productivity: Expect about 40 tons per hectare fresh forage for cut and carry. Protein content of the forage is about 9 %.(ILRI)

Reproduction: Cross-pollinated; erratic seeder.

Special merits: High DM yield; deep roots can be efficient for using moisture and N.

(3) Target groups	(4) management requirement
Target groups are all communities who have livestock and user groups organized (both men and women) on forage production who sell their product to livestock owners,	**Field preparation-** ploughed field but grows well with zero tillage **Establishment-**stem cuttings of 2 to 3 nodes planted at 50cm spacing **Fertilizer-**Urea at 100 kg/ha or manure after each cut

	Weeding- after establishment and every cut **Harvesting–** cut at 5cm 3 times per year, or every 3 months if good growth
(5) Limitations	
• Not adapted to areas with frost • Not suited to waterlogged areas • Will not persist without fertilizer, even after good establishment • Coarse, fibrous and sharp leaves if not cut frequently, which makes it not palatable for the animals	

Technical information kit	(1) Main objective/purpose
Oats grass (Avenasp L.) 	❖ a widely adaptable forage or grain crop, ❖ high yielding and fast growing annual fodder crops ❖ becoming increasingly important in Ethiopia

(2) Description of the Oats grass and major chracteristics

It is considered one of the best annual fodder grass for high land areas. Oats grassestolerate acid soilsit is a tall annual cereal up to 1.5 meters high and widely used for fodder. It is very versatile and can be used for grazing, hay, cut and carry and silage. In addition, the grain is very nutritious and suitable for human consumption. In areas with limited land availability this is an important characteristics.

Adaptation: Commonly grown annual crop in cool areas for fodder and grain.

- ❖ Altitude range: 1700-3000 m.a.s.l.
- ❖ Climate requirement: 500-800 mm mean annual rain fall, cold- and frost-tolerant.
- ❖ Soil requirement: Fairly tolerant to water logging.

Cultivation:

- Companion species: *Trifoliumalexandrinum, viciadasycarpa, viciavillosa, Lathyrussativus*.

Utilization: Fodder crop as green feed or conserved as hay.

Productivity: Yields of up 10-52 t/ha of fresh grasses have been reported.

Reproduction: Seed yield up to 10 quintals/ha or more (1 quintal = 100kg).

(3) Target groups	(4) management requirement
Target groups are all communities who have livestock, Organized user groups both men and women on forage production who sell their product to livestock owners. .	**Field preparation-** a clean, well prepared seed bed is required. **Establishment-**seed can be broadcast or row planted at a depth of 4 cm using 70-80 kg per hectare seed rate in pure stand. It can be grown in mixture with vetch (60 kg/ha of oat + 15-20kg/ha of vetch) or peas (60 kg/ha of oat + 20 kg/ha of pea) **Fertilizer-**100 kg/ha DAP at establishment and 50 kg/ha urea or manure during rapid growth **Weeding-** usually hand weeded once during early establishment. **Harvesting –** graze or cut for hay at 50% flowering to ensure quality unless grain harvest is also of interest.

(5) Limitations

- Does not tolerate water-logging
- It is not tolerant to drought or hot, dry weather
- Declines in yield at low soil fertility

Technical information kit	(1) Main objective/purpose
Desho grass	❖ A highly palatable, nutritious and fast growing grass characterized by high leaf/stem ratio ❖ To improve grazing land management, combat declining productivity and carrying capacity of the grazing land, even in degraded soils with lowfertility ❖ To stabilize the physical soil and water conservation structure.

(2) Description of desho grass and its major characteristics

Desho is an indigenous grass of Ethiopia belonging to the family of Pocaceae
- It is a perennial grass with an extensive root system that makes it a good candidate to stabilize soils.
- It has a high biomassproduction capacity ranging from 30–109 t/hadepending on the conditions
- It grows upright with the potential of reaching 90–120 cm based on soil fertility

It can grow anywhere from 1500–2800 masl with optimum elevation over 1700 masl on medium to low soil fertility

(3) Target groups	(4) management requirement
Target groups are all communities who have livestock organized user groups both men and women on forage production who sell their product to livestock owners,	**Planting**: • Recommended to plant at 10 cm by 10 cm intervals along bunds for SWC • Recommended to plant at 50 cm by 50 cm intervals for grazing land management (ILRI forage unit experience) • Remove the leafy part before planting to reduce competition before it establishes well • Open the soil with hoes and place the split in the soil before pressing the basal soil around the seedling **Fertilization:** • Compost/manure of about 4500 kg/ha for establishment and 1000 kg for maintenance **Land preparation**: • Desho needs very good land preparation **Weeding:** • Needs continuous weeding and gap filling **Harvesting:** • Cut and carry system is encouraged to maximize the potential of the species • Should be harvested at 8 cm high from ground level • Highest yield can be obtained if first harvested at 4 months after planting (Gohl 1981)

(5) Limitations

- Shortage of inputs (planting material) and the establishment and maintenance of is labour intensive

Technical information kit	(2) Main objective/purpose
 Treelucern	❖ Often used to overcome feed gaps at times of feed shortage. ❖ provide green forage rich in protein, minerals and vitamins during the dry season or during drought ❖ because of its deep root system it can use moisture very efficiently and continue to grow during droughts ❖ It is a perennial legumes which grow tall ❖ Provide high dry matter yield per year ❖ Can be planted with other forage crops and food crops ❖ It is multipurpose, its uses include: ✓ Provide supplementary feed in drought season ✓ Have high nutritive values ✓ Improve soil fertility ✓ Can be used for fence, wind break, fuel, house construction

(3) Description of the TreeLucerneand its major characteristics

Wide range of adaptation from lowland to 3200 m.a.s.l altitude. It is the only browse legume adapted to higher altitude highlands of Ethiopia. It tolerates infertile and acid soils and droughts once established. Needs good drainage.Useful as multipurpose fodder tree for cut- and- carry fodder, ornamental, wind beak, bee forage, fuel wood and biogas.

Cultivation:

- Propagation is by seed sown directly or by transplanting. Spacing 30-50 cm between plants.
- Seed treatment necessary. Dip in boiling water for 5-10 minutes.
- Inoculate if possible.

Utilization: Establishment is low. Commence cutting in the second year. Cut at 1 meter height every 6-8 weeks. Use as a supplement to crop residues.

Reproduction: Seed yield up to 0.5 kg/tree.

(10) Target groups	(11) management requirement
Target groups are all communities who have livestock organized user groups both men and women on forage production who sell their product to livestock owners,	2. How to prepare your land 1. Secure the perimeter with 20% shade cloth attached to your fences.This will keep rabbits, buck, and other animals from entering your new lands. 2. Ripor double-plough the tree rows about 5 meters apart.Create mound for each row. 3. Place compost and about 50g of super phosphate in the rows where every tree will be planted. 4. Wet your soil. 5. Now you are ready to plant your trees.

	Management of your newly planted trees is vital! • Water regularly for the first 18 months. • Check regularly for snails, insects and other critters who may eat your young trees and take action! • Prune regularly to encourage side branches and denser foliage as well as keeping the trees 1 to 1.5 meters high.
(12) Limitations	
It takes 2 years before it can be harvested, Labour and investment intensive and Lack of basic forage seed.	

Technical information kit	(1) Main objective/purpose

Pigeon pea (Cajanuscajan)

- provide green forage rich in protein, minerals and vitamins during the dry season or in times of drought
- Leaves and beans are also suitable for human consumption and provide significant contribution to nutrition.
- continue to grow in areas and periods of moisture shortage because they can exploit moisture at depth using their deep - root system
- Provide high dry matter yield per year
- Can be planted with other forage and food crops
- Are multipurpose:
  - ✓ Provide supplementary feed in drought season due to their deep roots
  - ✓ Have high nutritive values
- Improve soil fertility
- **Special merits:**Dual purpose crop; tolerant to soil acidity. Can be used as semi-permanent, perennial component in alley cropping systems. Grown as hedgerow for wind beaks, and as ground cover or shade cover for establishing plantation crops, e.g., coffee. Good nitrogen fixation makes it a useful green manure.

(2) Description of the Pigeon pea and its major characteristics

Pigeon pea is adapted to arid and semi- arid environments, it favors warm climate, it is drought – resistant; it can grow at 500-800mm annual rain fall and it is tolerant to acid soils.Good for restoring soil fertility and intercropping with cereals (sorghum, millets) orother legumes (cowpea and groundnut).

Cultivation:

- Propagation: Established from seed sown at the rate of 4-6 kg/ha or 1-20 kg/ha broad casting.
- Spacing: about 1 meter between rows.
- Fertilizer requirement: Responds favorably to P fertilizer but negatively to N.

Utilization: Dual-purpose crop for food and forage. For forage: cut when the first pods begin to ripen at 80 cm height.

Productivity: Up to 12 t/ha DM.

Reproduction: Essentially self- pollinated and self-fertilized, but cross-fertilization by bees can occur.

(3) Target groups	(4) management requirement

Target groups are all communities who have livestock organized user groups both men and women on forage production who sell their product to livestock owners,	**Field preparation-** ploughed field or sown in holes in zero tillage **Establishment-** direct sowing at 3 cm depth or transplant seedling in hedge rows at 1m spacing between plants and 2m spacing between rows **Fertilizer-** DAP at 100 kg/ha or manure **Weeding-** slow weeding establishment phase, weed once 4 weeks after establishment and at regular intervals throughout the first year **Harvesting –** cut at 0.8 m after grain harvest

(5) Limits of use

- Not adapted to areas over 2000m.a.s.l. with frost
- Does not tolerate heavy grazing or low coppicing
- Not suited to waterlogged areas
- Not relished by cattle in the immature stage

Technical information kit	(1) Main objective/purpose

Sesbania (SesbaniasesbanScopoli)


(1) Main objective/purpose

- Often used to overcome feed gaps due to seasonal fluctuations in feed production.
- provide green forage rich in protein, minerals and vitamins during the dry season or in times of drought
- It is a perennial legume which grow tall
- Provide high dry matter yield per year
- Can be planted with other forage crops and food crops
- Are multipurpose:
  - ✓ Provide supplementary feed in drought season due to their deep roots
  - ✓ Have high nutritive values
  - ✓ Improve soil fertility
- Can be used for fence, wind break, back yard forage, alley farming, and forage strips.

(2) Description of the species

Sesbania has a wide range of adaptation, 200 - 2400 m.a.s.l. and it grows mainly under moisture -stress free conditions.Sesbania withstands acidic soils and waterlogging and it tolerates a wide range of soil conditions and salinity.

Cultivation:

- Propagation: by seed; seed must be scarified by putting the seeds in concentrated sulphuric acid for 30 minutes; also mechanically by using drum scarifiers. Plant seedling at the onset of first rains.
- Spacing: variable according to uses:
  - Continuous hedges: 50 seeds/m or 2-3 seeds /hole at 0.5 spacing.
  - Alley cropping: Up to 4 m or more between alleys.

Utilization: Cut at 0.5 - 1 meter height every 6-8 week; Use as a supplement (20-30%) with crop residues. There is no toxicity.

Productivity: Expect up to 20 tons DM/hectare per year. Protein content of the forage is about 25‰.

Reproduction: Cross-pollinated; prolific seeder.

Botanical description: Relatively short-lived (6-7 years) shrub or small tree up 6 m high.

(3) Target groups	(4) management requirement
Target groups are all communities who have livestock organized user groups both men and women on forage production who sell their product to livestock owners,	**Field preparation-** ploughed field or sown in holes in zero tillage **Establishment-** direct sowing by broadcasting at 4 to 5kg per hectare 3cm depth or transplant seedlings in hedge rows at 1 to 2m apart with plants spaced 25 to 5ocm apart with in rows. **Fertilizer-**generally not applied. **Weeding-** resilient and hardly affected by weeds in its establishment phase. **Harvesting –** coppice at 50 to 75cm height 3 to 8 times per year depending on growth.

(5) Limitations
• Not adapted to areas with frost • Easily damaged by grazing or poor cutting management

Technical information kit	(1) Main objective/purpose
Vetch (viciadasycarpa L.) 	❖ Often used to overcome feed gaps due to seasonal fluctuations in feed production. ❖ provide green forage rich in protein, minerals and vitamins during the dry season or in times of drought ❖ Provide higher dry matter yield per year ❖ Can be planted with other forage crops and food crops ❖ Are multi-purpose: ✓ Provide supplementary feed in drought season due to hay making. ✓ Have high nutritive values ✓ Improve soil fertility

(2) Description

The common vetch (*Vicia sativa* L.) is an annual scrambling and climbing legume.

Vicia sativa provides palatable forage (fresh, hay and silage) and grain to livestock. Due to the presence of antinutritional factors, seeds may be used only in small amounts in the diets of monogastric species (including humans). Common vetch also provides a valuable cover crop and green manure (Sattell et al., 1998).

Adaptation: Medium- to high –altitude highlands.

- Altitude range: 1500-3000 m.a.s.l.
- Climatic requirement: Wide rain fall range; can survive at rainfall as low as 400 mm/year.
- Soil requirement: Versatile.

Cultivation: can be established on a rough seedbed.

- Propagation: By seed at the rate of: 20 kg/ha (pure stand); 12 kg/ha (under sown); 5-12 kg/ha (pioneer component of pasture mix); 12-20 kg/ha (sown with oats).
- Fertilizer requirement: Apply 20-40 kg/p/ha at planting
- Companion species: Oats (Avena sativa).

Utilization: As conserved fodder (hay) crop in mixture with oats; good for under sowing maize and sorghum; excellent as pioneer crop.
Productivity: Up to 6 t/ha DM as pure stand.
Reproduction: Cross-pollinated. Seed yield 400-1000kg/ha.
Botanical description: Climbing, sprawling annual legume.

(3) Target groups	(4) management requirement

Target groups are all communities who have livestock organized user groups both men and women on forage production who sell their product to livestock owners,	*Vicia sativa* may be sown in pure stands or mixed with a cereal companion that helps it to climb and thus prevents it from rotting during winter. Common vetch is tolerant of short cutting before flowering and of high cutting at flowering
(5) Limitations	
Lack of basic forage seed.	

<table>
<tr><th>Technical information kit</th><th>(1) Main objective/purpose</th></tr>
<tr><td>Leucaena (Leucaenaleucocephala)

</td><td>❖ Often used to overcome feed gaps due to seasonal fluctuations in feed production.
❖ provide green forage rich in protein, minerals and vitamins during the dry season or in times of drought
❖ continue to grow in areas and periods of moisture shortage
❖ It is a perennial legumes
❖ Provide higher dry matter yield per year
❖ Are multipurpose:
✓ Provide supplementary feed in drought season due to their deep roots
✓ Have high nutritive values
✓ Can be used for fence, wind break, back yard forage, alley farming, and forage strips.
❖ Special merits: vigorous plant of high yield and high quality protein; leaves and thin twigs well-accepted by livestock</td></tr>
<tr><td colspan="2">(2) Description of the species and what makes it important</td></tr>
<tr><td colspan="2">It performs betterin warm climate at altitudes less than 2000 m. It is sensitive to frost, but very drought –tolerant, as it can grow at 400 mm annual mean rainfall. It requires well-drained soils and it is not tolerant to acids soils.Leucaenacan be used to restore soil fertility. It is highly productive and can tolerate heavy cutting/coppicing and grazing. Useful for grazing or cut and carry. It can also provide fuel wood.
Cultivation:Light cultivation for direct sowing; dug holes for transplanting.
- Propagation: by seed sown at 4-7 kg/ha, but different rate or spacing can be used depending on utilization, soil depth: 2-3 cm.
- Spacing: when sown 2-2.5 m between rows to up to 4.0 m between rows/alleys. Usually planted by seedling.
- Treatment: Seed treatment necessary. Hot-water treatment 60-80°C; H2SO4 for 10 minutes.
- Inoculation with appropriate rhizobium strain is helpful.
- Companion species: May be planted to pasture grasses in inter-row spaces.
Utilization: Cut at 80-100 cm height every 6-8 week intervals; Use as a supplement ration 25-30%, beyond this level, animals develop enlarged thyroid gland or goiters because of mimosine (an alkaloid) preventing animals from using iodine efficiently.</td></tr>
</table>

Productivity: Considered the best fodder tree in the world. Multipurpose (for fodder, fuel, pulp, immature shoots and seeds for human consumption, shade and hedge). Yields of 50 t/ha (cut at ground level) and 40 t/ha (at 75cm) have been reported. Despite inconsistent figures 10-20 t/ha DM can be expected.*Protein content of the forage is about 22‰.* **Reproduction:**Self-pollination prevails, although Cross-pollination is possible; prolific seeder. **Special merits:** vigorous plant of high yield and high quality protein; leaves and thin twigs well-accepted by livestock.	
(3) Target groups	**(4) management requirement**
Target groups are all communities who have livestock organized user groups both men and women on forage production who sell their product to livestock owners,	**Field preparation-** ploughed field or sown on holes in zero tillage. **Establishment-** direct sowing at 3cm or transplant seedlings in hedgerows at 1m spacing between plants. **Inoculants-** specific Rhizobia needed. **Fertilizer-** DAP at 100kg per hectare or manure. **Weeding-** slow early growth, weed once 4 weeks after establishment and at regular intervals throughout the first year. **coppicing–** coppice at 75cm height and protect from grazing while young **Harvesting-** cut 3 times per year in Debrezeyt
(5) Limitations	
• Not adapted to areas over 2000m with heavy frost, Not suited to heavy dry areas	

<table>
<tr><th>Technical information kit</th><th>(1) Main objective/purpose</th></tr>
<tr><td>Alfalfa (Medicago sativa)
</td><td>❖ Special merits: Lucerne (alfalfa) is the most widely used fodder in the tropics and has special application in the dairy business. It is ideal for irrigated pasture. Under irrigated conditions at DebreZeit, harvests every 3-4 weeks (12 times a year) have been possible.
❖ Leader in livestock feeding in the world because of its:
✓ high yield
✓ palatability,
✓ richness in protein, and
✓ High content of calcium and vitamins.
❖ provide green forage rich in protein, minerals and vitamins during the dry season or in times of drought
❖ Provide higher dry matter yield per year
❖ Can be planted with other forage crops</td></tr>
<tr><th colspan="2">(2) Description and what makes it important</th></tr>
<tr><td colspan="2">Wide range of adaptation from 500-3000 m.a.s.l altitude and above. It is best adapted to warm, temperate climate. Because of its deep-rooted habit, it can be grown in areas receiving as little as 550 mm annual rain fall. It is quite intolerant to water logging and it requires fertile, well drained soils. It prefers neutral or alkaline (lime-rich) soils and it is susceptible to acid soils.
Utilization: Utilized as grazed mixed pastures, as hay or as green fodder. Cut or graze at 30-40 days interval or at 10% flowering.
Productivity: Variable as according to moisture supply. Yields of 7-9 t/ha/yr. are expected is quite often achieved.
Performance: Expect about 20 tons per hectare dry matter per year from about 6 to 8 cuts in well managed stands. Protein content of the forage is usually from 20-25% with digestibility of about 70%.(ILRI)</td></tr>
</table>

Reproduction: Cross-fertilized; bees necessary for pollination. Seed yields 100-300 kg/ha.	
(3) Target groups	**(4) management requirement**
Target groups are all communities who have livestock organized user groups both men and women on forage production who sell their product to livestock owners,	**Field preparation-** well cultivated uniform and firm seed bed. **Establishment-**seeds broadcast or drilled in rows or on ridges 50 to 70cm apart at 12 to 20kg per hectare under irrigation or 10 to 12kg per hectare under rain fed conditions.(ILRI) **Fertilizer-** DAP at 100kg per hectare may be used. Phosphorus may be required for establishment. **Weeding-** weeding essential in establishment stage and crop requires frequent cultivation. **Harvesting –** harvested for hay by cutting at 5cm height at first flowering.
(5) Limits to use	
• Not tolerant of continuous grazing • Poor drought tolerance and require water for year round production • Not very tolerant of acid soils and water logging • Susceptible to many pests and diseases • Bloat in livestock is the major limitation to grazing Lucerne • Lack of basic forage seed.	

Technical information kit	(1) Main objective/purpose
Green leaf (Desmodium intortum)  	❖ No toxicity recorded and no bloat. ❖ Good early and late season vigour. ❖ Shade tolerant. ❖ Often used to overcome feed gaps due to seasonal fluctuations in feed production. ❖ provide green forage rich in protein, minerals and vitamins during the dry season or in times of drought ❖ Provide high dry matter yield per year ❖ Can be planted with other forage crops ❖ Improve soil fertility

<table>
<tr><th colspan="2">(2) Description and its major characteristics</th></tr>
<tr><td colspan="2">Greenleaf desmodiumis best adapted to high rainfall areas exceeding 900 mm, with altitude range 800-2500 m.a.s.l. Fast growing giving good ground cover in 4 to 5 months and it is adapted to a variety of soils including acid soils. Green leaf is highly specific in its Rhizobium requirement.
Utilization: Utilized as grazed mixed pastures, as hay or as green fodder. Cut or graze at 30-40 days interval or at 10% flowering.
Reproduction:Self-and cross-pollinated. Sensitive to photoperiod; it is a short-day plant. Seed yields 100-120 kg/ha.
Yield potential: Varies widely from 3-20 t/ha DM in pure stands.</td></tr>
<tr><th>(3) Target groups</th><th>(4) management requirement</th></tr>
<tr><td>Target groups are all communities who have livestock organized user groups both men and women on forage production who sell their product to livestock owners,</td><td>Field preparation- well prepared seed bed.
Establishment- by seed sown at the rate of 1-2 kg/ha in rows 45 cm wide. Cuttings root may be used.
Fertilizer-Reported to respond well to P and K application.
Weeding- slow establisher, weed once after 4 weeks and again after 8 weeks, when well established will suppress weed.
Harvesting – first time at flowering after about one year and then every six months.
Herbicide effects
Seedlings show good tolerance to the herbicide 2, 4-D; mature plants are reasonably tolerant of the desiccant diquat.</td></tr>
<tr><th colspan="2">(5) Limits to use</th></tr>
<tr><td colspan="2">• Low seedling vigor, Poor persistence under heavy grazing, Susceptibility to pests, Poor tolerance of drought and No tolerance to salinity and Not adapted to areas with frost</td></tr>
</table>

White clover (Trifoliumrepens L.)

- ❖ It is tolerant to free grazing as it can withstand animal movements.
- ❖ It is an ideal mulching crop
- ❖ Are multi-purpose:
  - ✓ It is a good soil protector
  - ✓ Have high nutritive values
  - ✓ Improve soil fertility

(2) Description

White clover (Trifoliumrepens L.) is a short-lived perennial that can reseed itself under favorable conditions. It grows rapidly and spreads via stolons. White clover has a shallow root system, which makes it intolerant of drought conditions. It grows best during cool, moist weather on well-drained, fertile soils with a pH between 6 and 7. Pure stands of white clover are not usually planted because of their low growth habit and associated low yield. However, they make high-quality pastures in mixture with other grasses and fix nitrogen for use by the grass.
Clovers (Trifolium spp.) constitute one of the major forage legumes widely grown for its rich protein content and capacity to improving soil fertility

Adaptation: Cool tropical highlands.

- Altitude range: 1800-3000 m.a.s.l.
- Climatic requirement: Mean annual rainfall 800-1500 mm.
- Soil requirement: Versatile.

Cultivation: Well-prepared seedbed.

- Propagation: By seed at 3-6 kg/ha.
- Fertilizer requirement: Responds well up to P and S application.

Utilization: Most suited for grazing.

Productivity: About 1.5-2.5 t/ha/DM.

Reproduction: Cross-pollinated.

(3) Target groups	(4) management requirement
Target groups are all communities who have livestock organized user groups both men and	Harvest ManagementHarvesting white clover for hay or silage is generally based on the grass in mixture with the clover, since white clover constitutes a small proportion of the

women on forage production who sell their product to livestock owners,	total forage and is of relatively high quality at maturity. Harvest should be dictated by the harvest schedule that maximizes grass performance.
(5) Limitations	
Lack of basic forage seed.	

Technical information kit	**(1) Main objective/purpose**
Fodder beet (*Beta vulgaris*)  	❖ Often used to overcome feed gaps due to seasonal fluctuations in feed production. ❖ Are annual fodder crops which grow under the soil. ❖ Provide higher dry matter yield per year ❖ Are multipurpose: ✓ Provide supplementary feed in drought season due to their deep roots ❖ Have high nutritive values
(2) Descriptions	
Adaptation: High land crop (1800-3000 m.a.s.l). Needs long growing season, 5-7 months of 750 mm rain or over. • Soil: fertile sandy soil, avoid water logging.	

- Yield potential: Under well-fertilized and irrigated conditions at DebreZeyt Research Center each tuber had a fresh weight of 37.5 kg in about 5-7 months growth period.

Cultivation:

- Propagation:
    - Direct seeding 5 kg/ha; sowing depth, 2 cm; plant in rows 40 cm apart and thin to 20-25 cm between plants when two real leaves have been developed.
    - Transplanting from nurseries planted 1-2 months ahead of planting time gives it a competitive advantage over weeds.
- Seed propagation is stimulated by cold, thus an altitude between 2500-2750 m.a.s.l. is suitable.
- Fertilizer: Fodder beet is a heavy feeder and thus it should be planted near an animal corral for easy application of manure.

Utilization: Used in intensive management systems in dairy or fattening enterprises beets must be chopped before feeding.

Reproduction: Seed yield is about 400-500 kg/ha.

Botanical description: Biennial tuberous herb

(3) Target groups	**(5) management requirement**
Target groups are all communities who have livestock organized user groups both men and women on forage production who sell their product to livestock owners,	- Weeding - Manure /fertilizer application - Land preparation

Glossary

Browse: The part of leaf and current twig growth of shrubs, woody vines, and trees available for animal consumption.
Concentrate: All feed low in fiber and high in total digestible nutrients (TDN) that supply primary nutrients (protein, carbohydrate, and fat).
Feed: Any non-injurious, edible material, including forage, having nutritive value for animals when ingested.
Forage: The part of the vegetation that is available and acceptable for animal consumption, whether considered for grazing or mechanical harvesting; includes herbaceous plants in mostly whole plant form, and browse.
Fodder: Any bulky green or dry plant material, which is used for stock feed.
Forage crop: Forage plants harvested before being fed to animals, e.g. hay, silage, green chop.
Green chop: Harvested forage fed to animals while still fresh.

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Technical information Kit1	(1) Brief description ofbasin irrigation	(2) Main objective
Basin Irrigation	Basin irrigation is an irrigation method that involves dividing a field into several relatively small level plots called checks or basins surrounded by low soil bunds. Water is conveyed to checks by a system of supply channel, laterals and field channels. Basin irrigation is the simplest and most widely used surface irrigation method.	To increase crop productivity through the application of irrigation water to basins (level plots) separated by bunds.

(3) Implementation of basin irrigation

Basin irrigation can be implemented in a given areas by considering surface slope, soil and crop types, and water availability.

(3.1.) Suitability

Basin irrigation is most suited on flat lands with soil type shaving moderate to slow infiltration rates. It can also be used on sloping land provided that the soils deep enough to allow levelling without exposing the subsurface soil. Basin irrigation can be used for most crop types and is suitable for most soils. The most suitable crops for basin irrigation include paddy rice, alfalfa, clover, citrus, banana, cereals(maize, wheat, and barley), etc. However, basin irrigation is generally not suitable for crops which cannot stand in wet or waterlogged conditions for a period more than 24 hours. These are usually root and tuber crops such as potatoes, cassava, beet root and carrots which require loose, well-drained soils. Basin irrigation is mostly suitable for flat topographies.

(3.2) Site selection

When you select a site for basin irrigation, you need to consider three major factors: (1) the slope of the land, (2) the soil texture, and (3) the water discharge or water flow rate. Basin irrigation is suitable for flat or gentle slopes. Higher water flow rate is required for clay soils than sandy soils.

(3.3) Basin layout and basin size

The basic structure of a basin irrigation is the **basin** which is formed by fencing an area by constructing bunds. The size of the basins depends on the slope of the area, the soil type and the available water flow to the basins. The relationship between slope and basin width is given in Table 1.

Table 1. Approximate values for the maximum basin width (m) at different surface slopes

Slope%	Width (m)	
	Average	Range
0.2	45	35-55
0.3	37	30-45
0.4	32	25-40
0.5	28	20-35
0.6	25	20-30
0.8	22	15-30

1	20	15-25
1.2	17	10-20
1.5	13	10-20
2	10	5-15
3	7	5-10
4	4	3-8

The relationship between stream size (water flow) and soil texture is given in Table 2 below.

Table 2. Suggested maximum basin areas(m^2) for various soil types and available stream size or flow rate (liter/second)

Stream size (liter/second)	Soil texture			
	Sand	Sandy loam	Clay loam	Clay
5	35	100	200	350
10	65	200	400	650
15	100	300	600	1000
30	200	600	120	2000
60	400	1200	2400	4000
90	600	1800	3600	6000

Basin layout not only refers to the shape (e.g., squares, rectangular or irregular) and size (e.g., 10, 100 or 1000 m^2) of the basin but also to the shape and height ((e.g., 10,50or100cm) of the bunds.

In general, one can determine the size of basins based on the following criteria.

The size of the basin should be small if:

1. the slope of land is steep
2. the soils is sandy
3. streams flow to the basin is small
4. required depth of the irrigation application is small
5. field preparation is done by hand or animal traction

The size of the basin can be large if:

1. the slope of the land is gentle or flat
2. soil type is clay
3. stream size to the basin is large
4. Required depth of the irrigation application is large

5. Field preparation is mechanized

3.4. Size of bunds

Bunds are small earth embankment which contain irrigation water within basins. They are sometimes called dykes or levees. Bunds can have different sizes and shapes (width and height) and they can be either temporary or permanent.

- Temporary bunds can have 60-120cm at the base with a height of 15-30cm above the original ground surface, including a freeboard of 10cm
- Permanent bund can have 130-160cm at the base with a height of 60-90cm above the original ground surface,and asettling height of 40-50cm (see the pictures and diagrams at the end of this document).

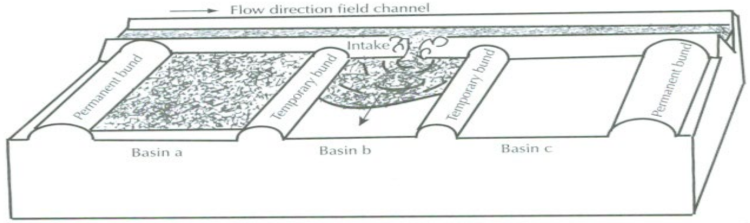
3.5. Steps in basin construction

There are three steps to be followed in the construction of basins:

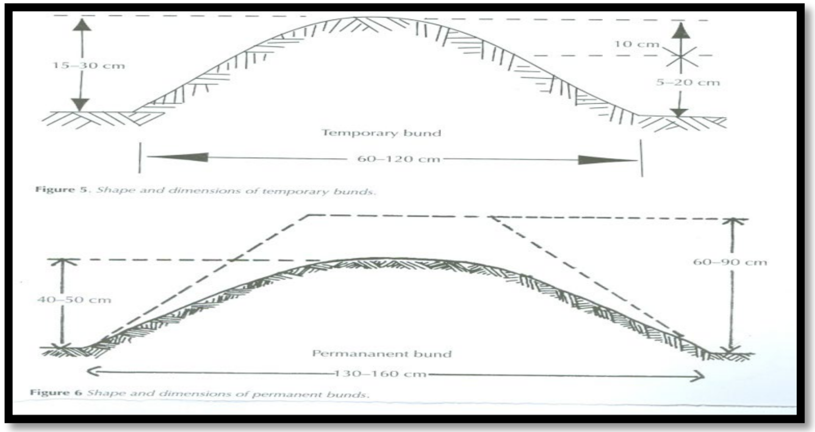
1. **Setting out contours:** Setting out contours is relatively simple and involves only straight lines. A terrace is set out by first locating a suitable contour lines across the land slope. This is the line along which the first bund is constructed. A second line is then set out along a contour further up the slope to mark the location of the next bund.
2. **Building bunds**: - both temporary and permanent bunds can be formed by hand or by animal or tractor-powered equipment. The constructed bund should be properly compacted so the leakage cannot occur.
3. **Land leveling:** Land leveling on flat land involves smoothing out the minor high and low spots so that the difference in leveling is less than 3cm within a basin. Although it could be difficult to check a 3cm high and low spots in a field using an eye, this can easily be checked by apply water across basin.
4. **Contract water supply furrows:** furrows that supply water from a water source to each basin need to be constructed. The width and depth of the water supply furrows depend on the flow rate and depth (amount) of irrigation required.

(4) Challenges and constraints (limitations)

The principal limitations of the method include interference of the ridges with other farm activities, considerable and is wasted to idgesandlateral field channels construction, impedes surface drainage and causes soil crusting, precise land grading and Level
Ingare necessary, labour requirements for land preparation and application of irrigation water are much higher, highinitialcapitalinvestmentascomparedwith othersurfaceirrigation methodsandunsuitability forirrigatedcropssensitivetowetsoil conditions.



Layout of basin irrigation system



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Technical information Kit --	(1) Brief description	(2) Major objective
Furrow Irrigation	Furrow irrigation refers to irrigating land by constructing furrows between two rows of crops or alternately after every two rows of crops, particularly for narrow spaced row crops such as onions, cabbage and pepper. It involves only wetting part of the surface of the soil so that water in the furrow moves laterally by capillaryaction to the un-watered areas below the ridge and also downward to wet the root zone soil.	to apply water through well prepared furrows to reduce evaporation losses and puddling of the soil surface,improve aeration of the root zone, and minimize accumulation of salts near the plant bases in areas where the problem exists.

(3) Implementation

Implementation of furrow irrigation requires preparation of rows with a careful selection of crops, surface slope, and soil type.

(3.1) Suitability

Furrow irrigation is well suited both to small and large farms. It is also suitable for many crops, and especially to row and tree crops, and it is the most widely used method for row crops such as vegetables, maize, groundnut, sugarcane, cotton, potatoes, etc. Fruit crops are also irrigated using furrow irrigation method. Crop type, farm equipment and row spacing are the factors that determine furrow size and shape.

(3.2) Design and layout

Furrow Layout

In furrowirrigation,waterisappliedtosmallchannels,knownasfurrowsthatarebetweentherowsofplants.Furrows are prepared by preparing long shallow trenches on the ground. The most important factor in the layout of furrows is determining the optimum furrow length.

Furrow Length

The most practical and efficient length of furrow is determined by considering the following factors:

- slope,
- soil type,
- stream size,
- irrigation depth,
- cultivation practice ,and
- field length.

Furrowlength can be as long as **500m** dependingonthe factors mentioned abovebutthefieldsizeandshape of fragmented fields, as is the case with smallholder farmers, put practical limits on furrow length. In principle, furrow lengths are shorter in coarse soils and longer in heavy clay soils. In this regard, furrow length is as short as 10 - 20 m long in vegetable gardens and long as 500 m in deep-rooted crops such as cotton in largemechanized irrigation schemes. Efficient furrow irrigation always involves run-off and surface drainage system, which is usually built at the end of the furrow perpendicular to the furrow, so that excess water from the is drained out. The recommended maximum furrow lengths for different soil types and slopes are given in Table 1.

Table 1.Recommendedfurrowlengthsfordifferentslopes,soil typesandnetdepthofwaterapplication (mm)

Furrow Slope (%)	Maximum flow of water per second	Furrowlength(m)							
		Soiltypeandavailablesoilmoistureinmm/mdepthofsoil							
		Clay			Loam		Sand		
		50	75	150	100)	150	50	75	100
0.05	3.0	120	300	400	270	400	60	90	150
0.10	3.0	180	340	440	340	440	90	120	190
0.20	2.5	220	370	470	370	470	120	190	250
0.30	2.0	280	400	500	400	500	150	220	280
0.50	1.2	280	400	500	370	470	120	190	250
1.00	0.6	250	280	400	300	370	90	150	190
1.50	0.5	220	250	340	280	340	80	120	190
2.00	0.3	180	220	270	250	300	60	90	150

Source:IrrigationAgronomyManual (1990),AddisAbaba

It can be understood from the table that furrow length decrease as slope increases or decreases depending on soil type. When the slope increases, run-off also increases, particularly on heavy clay soils with low infiltration rate, and when the slope is decreases, run-off is low increasing infiltration rate on coarse textured soils. Moreover, as the slope increases, the movement of water reaching the ridges will decreases resulting in water loss at the end ofthe furrow. In addition, higher velocities ofwater in the furrowlead to risks ofsoil erosion. Thus, in deciding a furrowsystem, careful consideration of slope length, soil texture and the other factors mentioned above isa must.

In order to control or at least minimize erosion, particularly in areas where there is heavy rainfall, furrow must have a limited slope and followingthe slope guidelines shown in Table 2 below is advisable.

Table2. Slope levels recommended for furrowirrigation on different soil types

Soiltype	Maximumrecommended slope,%
Sand	0.25
Sandyloam	0.40
Finesandyloam	0.50
Clay	2.50
Loam	6.25

In furrow irrigation, water is admitted to the head of each furrow, and the rate of flow is adjusted so that water flows from one end of the furrow to the other without overtopping. As the water reaches the end of the furrow, water infiltrates into the soil along the furrow to satisfy the water requirements of crops. The rate of flow into the furrow depends primarily on the intake rate of the soil and the length of the furrow. Infiltration rates for various soil textures and suitable furrow flow rates per 100 m length of furrow are given in Table3 below.

Table 3. SoilInfiltrationratesandsuitablefurrowinflowsper100moffurrowlength/furrowspacing1m/

Soil	Infiltration rate (mm/h)	Furrow inflow(liters/second/100m)length
Clay	1-5	0.03-0.15
Clayloam	5-10	0.15-0.30
Siltloam	10-20	0.30-0.50
Sandyloam	20-30	0.50-0.80
Sand	30-100	0.80-2.70

Source: Stern (1985).

Determination of the correct flow rateper furrow requires testing under field conditions. This can be done using a simple advance and recession test. If you plan to do this, please follow the following steps:

a) Markthree points along the furrow - a point near the beginning, the midway point, and a meter from the end of the furrow.
b) Directed water into the furrow at the desired operating flow rate
c) Record the time when the water passes the three markers
d) At the end of the irrigation, record the time that it takes the water to infiltrate and regress from the end of the furrow to the beginning.

e) With these two sets of data, plot the advance (c) and recession (d) curvesfor the flow rate in the furrow on x-y axis graph: x-axis is representing the length of furrow and corresponding marks; y-axis is the time on the same graph paper. If the two curves (i.e. advance and recession) are more or less parallel to each other, this indicates that the flow and time for the length of furrow being tested give a good water distribution. If this is not the case, the flow rate and/or time of irrigation should be changed. This test should be done for each alteration until the desired results are achieved.

Furrow Spacing

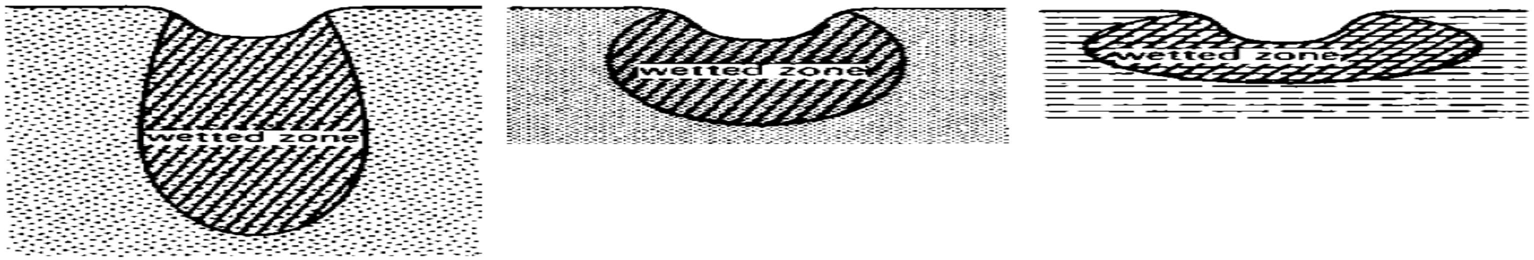
As mentioned above, furrow irrigation adapts better than any other method to crops that are grown in rows with more than 30 cm spacing, such as vegetables, maize, groundnut, sugarcane, cotton, and potatoes. Fruit crops are also irrigated by furrow method. Crop types, farm equipment to be used and planting distances between plants arethe factors that determine furrow size and shape. Furrowsareusually v-shaped in cross section, 25- 30 cm wide at the top, and 15- 20 cm deep, shallower in lightersoils and deeper in heavier soils. Wider, U-shaped furrows with a greater wetted area are sometimes used on soils with slower water intake rates. Usually, the spacing between furrows is narrower in sandy soils and wider in heavy soils. This is to ensure that water spreadslaterallyintothesoil belowridgesanddownwardsintheeffectiverootingdepth uniformly. Furrowspacinginsandy soilsis inarangeof60to80cm,whereasinclaysoils75to150cmandinloamsoilsit is between 60to90cm. Shallowrooted andtransplanted cropsusingseedlingsrequiresmallwidthandshallowdepth, while deeprootedcropshavewideanddeepfurrowdepth. Thereare3differenttypesoffurrow methods: straight level furrow, straight graded furrow and contour furrow (see Figure 1).

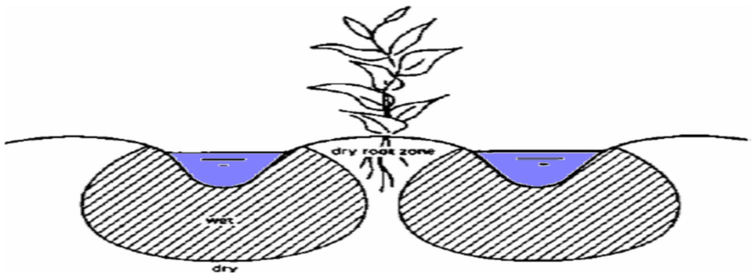
(4) Challenges and constraints (limitations)

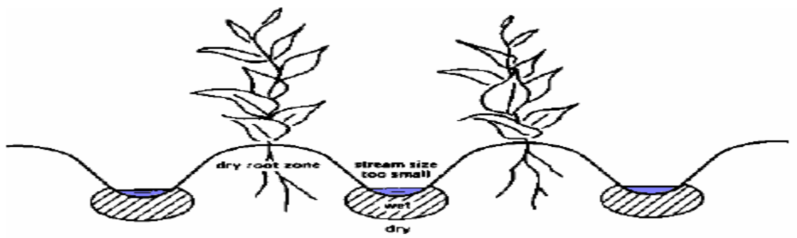
The major problem in furrow irrigation is poor wetting pattern which can be caused by:

- Unfavorable natural condition. For example, compacted soil layers and uneven slope can result in uneven wetting along the furrow. This problem can be overcome by changing the land to a uniform slope.
- Poor layout- if furrow spacing is too wide, the root zone will not be adequately wetted.
- Poor management- a stream size that is too small will result in inadequate wetting of the ridges because of poor water distribution along the length of the furrow. Whilst overtopping of the ridge could also occur under high flow rate, stopping the inflow too soon is also a common management fault.

Figure 1. Spacing and wetting of furrows







a) Too wide furrow spacing **b) Too small flow**

Figure 2. Pictures of furrow irrigation

Technical information Kit--	(1) Brief description	(2) Major objective
Community pond	A community pond is a pond or reservoir constructed by a community during the dry period for the purpose of storing surface runoff from a catchment area.	To store water for use during the dry seasons for domestic and livestock use or for irrigating small gardens.

(3) Implementation

Implementation of border irrigation requires careful selection of surface slope, soils types, and catchment area.

(3.1) Suitability

Suitable in areas where scarcity of water is sever and there are no surface and/or underground water resources that are economical to develop. Therefore, community pods are mostly useful the arid and semiarid areas of Ethiopia. Community pods suitable in locations where there is enough catchment area that supply water to be stored in the ponds. Although pods needs to be constructed in lower catchment areas (farm, grass and communal lands)with a slope of less than 5% for protection or reducing erosion.

(3.2) Design and layout

The most common shapeof pond is a trapezoidal, mostly a frustum of cone with wider and narrower areas on the top and bottom parts of the trapezoid, respectively. The horizontal and vertical lengths ratiosare important in the construction of community ponds. The vertical to horizontal ratios have to be 1:2 (1 to 2) on stable soils and1:3 on unstable soils such as Vertisols (clay soils).

1. Determination of the volume of a trapezoidal community pond

The volume of trapezoidal prism pond can be calculated using the top and bottom areas of the trapezoid as follows:

$$V = \frac{H}{3}\left(A_t + A_b + \sqrt{A_t^2 + A_b^2}\right)$$

where V = storage capacity (m^3)

H = water storage depth or height (m)

A_t = top area of storage = L × W (m^2)

A_b = base area of storage = a × b (m^2)

W = width of top area (m)

L= length of top area (m)

a= width of bottom area (m)

b= length of bottom area (m)

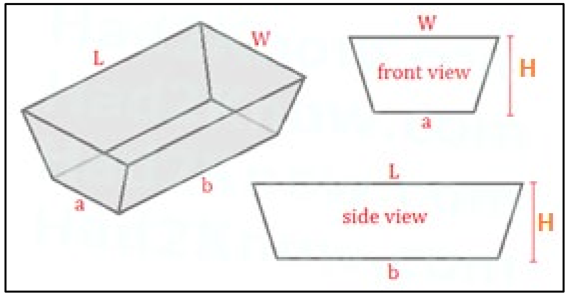
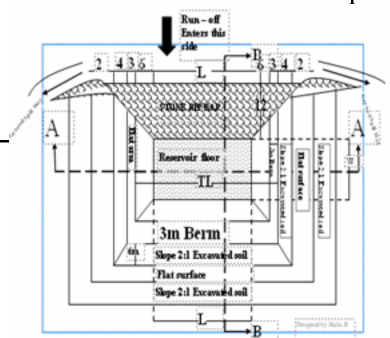


Figure 1. Top and bottom sides of a trapezoid

The volume of trapezoidal pond can also be calculated using the top, middle and bottom areas of the trapezoid as follows:

$$V = H \times \frac{[A + 4B + C]}{6}$$

where,



V = Volume of the pond (m^3)
H = Depth of the pond (m)
C = bottom area of pond (m^2)
A = top area of pond (m^2)
B = mid depth area (0.5*H) (m^2)

Figure 2. Dimension of a rectangular trapezoid community pond

2. Volume of a frustum of cone shape

The volume of a frustum of cone shape can be calculated using the following formula:

- V=1/3IIr3=Cone volume

$$V = \frac{\pi}{3} h(0.5R^2 + 0.5r^2 + (0.5R * 0.5r))$$

whereV is volume of the pond (m^3), Ris top diameter (m), r is bottom diameter (m), and h is the depth of pond (m).

Ponds can be classifies in to three based on their size as follows:

- Type 1: 5504m^3 capacity with a top diameter of 40m , bottom diameter of 28m and depth of 6m
- Type 2: 2487m3 capacity with a top diameter of 30m , bottom diameter of 20m and depth of 5m
- Type 3: 1401 m3 capacity with a top diameter of 25 , bottom diameter of 17 and depth of 4m

You can calculate the volumes given for each type above using the formula provided above.
Example: Type 1: V = π/3*6*($(40/2)^2$+ $(28/2)^2$+ (40/2)*(28/2)) = 6.283*(400+196+280)= 5504m^3

The volume of the frustum of a cone (Vc) in m^3 is calculated as follows:

$$Vc = \frac{\pi}{3}\left(\frac{R}{2}\right)^2 - \frac{\pi}{3}\left(\frac{r}{2}\right)^3$$

(3.3) Construction and maintenance of community pond

The construction of a community pod is a step-wise process. The major steps are shown below.

Method 1:

1. Mark the top area of the pond on the ground with pegs
2. Mark the bottom area of the pond on the surface
3. Start excavating the bottom area to the required depth
4. Reshape the sloping side, triangle
5. Place the excavated soil 3maway from the border of the pond
6. Make stone steps or side steps along the side of the pond to allow people to fetch water

Method 2:

1. Mark the top area of the pond on the ground with pegs
2. Mark an area inside the top area maintaining the side slope
3. Consider point O (see Figure 3) as the center of the pond
4. If the side slopes are considered to be same in both sides, distances of points AC and BD are equal, and similarly, distances of points OA and OB are equal as well
5. Start excavating or digging AMNB first and then shape CAM and DBN
6. Place the excavated soil 3maway from the border of the pond
7. Make stone steps or side steps along the side of the pond to allow people to fetch water

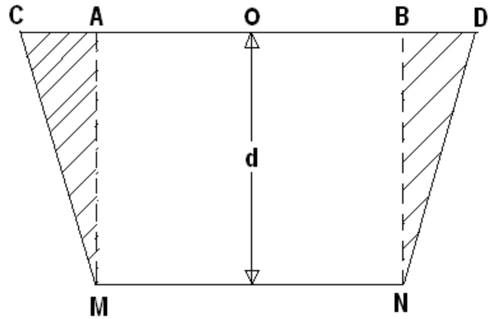


Figure 3. Marks for trapezoid construction

(3.4) Maintenance and management of community ponds
The pond has to be fenced for safety purpose, i.e., to protect animals and children from easily reaching to the water and get drowned. There is also a need to have appropriate water lifting technologies such as treadle pumps, pedal pumps, rope and washer pump etc., to abstract water from the pond.

(4) Challenges and Constraints (limitations)
Excavation is labor intensive, and it requires regular maintenance and management.

Figure 4. Pictures of a community pod. Photo: Hailu Hunde.

Reference

HailuHundie (2012) Soli Conservation Training Manual. KombolchaATVT College, Ethiopia.

Surash R.(2002) Soil and Water conservation Engineering . Bhargave printer,Delhi.

Technical information Kit-	(1) Brief description ofbasin irrigation	(2) Main objective
Climate/Weather information	Agriculture depends on weather/climate conditions that govern the growth and development of crops and animals, water availability to crops and animals, land use and agricultural decisions. Natural resource use and conservation is also highly influenced by climate. The Ethiopian climate is characterized by spatial and temporal variability and it is also influenced by global climate change. Adapting agriculture to both climate change and variability requires farm decisions that are based on pre-season, in-season and post-harvest climate information. This info-tech provides useful guidance in the use of climate information that guide farm level decisions under the changing climate.	The objective of this IFOTEC is to guide practitioners on the use of timely pre-season, in-season and harvest period climate/weather information for managing climate change and variability at farm and watershed levels

(3) Use of climate/weather information for agricultural decisions

1.1. Understanding terminologies

In order to use weather/climate information for practical decision making, first you need to understand the commonly used climate terminologies which are stated below.

Weather/climate information refers to a climate or weather forecast information obtained from climate service providers ahead of

- a season (e.g., Kiremt, Belg, Bega), known as seasonal forecast,
- a dekade (10 days), known as dekadal forecast,
- a month (30days), known as monthly forecast
- a week, known as weekly forecast, and/or
- a day, known as daily forecast

in order to guide seasonal, decadal, weekly and/or daily climate sensitive agricultural decisions.

The rainfall and temperature forecasts, particularly, the seasonal forecasts are provided by the climate providers in three categories as follows:

- **above-normal** when the forecast value is well above the median value of the previous 30 years (normal period) at a given site or region,

- **below-normal** when the forecast value is well below the median value of the previous 30 years (normal period) at a given site or region
- **near normal** when the forecast value is similar or close to the median value of the previous 30 years (normal period) at a given site or region.

1.2. Identify the stage of decision making

In order to use climate forecast information meaningfully, you need to look at the different stages of agricultural and natural resource conservation operations and the associated decisions needed: These include:

a) **Pre-season agricultural and natural resource decisions:** these are decisions to be made before the season starts based on seasonal climate forecast. The seasonal forecast information that you need to get for decision making are the mount of the expected rainfall in the coming season, start of the season and the length of the growing period. For example, if you receive a **below normal rainfall** and short growing season forecast for the *Kiremt* season rainfall, you need to prepare for constructing rain water harvesting structures, buy seeds of drought tolerant and short maturing crops for planting and decide on the type and amount of fertilizers that you need to buy from the market for a drier season. On the other hand, if the forecast is **above normal rainfall** for the *Kiremt* season, you need to consider constructing structures that control runoff and soil erosion on the steep slopes and drainage structures and ways to manage water logging on black clay soils, buy seeds of higher yielding crop varieties and higher fertilizer amounts. If the forecast is near normal rainfall for the *Kiremt* season, you follow the 'normal' or commonly used agricultural and natural resource conservation operations and decisions. Please note that the decisions and options that you need to make could vary based on agro-climatic conditions (*Dega, Woninda Dega or Kola*). For detail information on seasonal forecast and possible decisions, please see Table 1.

b) **In-season agricultural and natural resource decisions:** these are decisions to be made after the season starts (after planting) based on decadal or weekly and sometimes daily climate/weather forecasts. For example, if the forecast information is about dry weeks, you need to adjust your fertilizer application rates, consider water harvesting for supplemental irrigation, reduce your weeding frequency; and if the forecast shows additional dry weeks coming up, you may also consider thinning. If the forecast shows high rainfall in the coming weeks, you may need to apply your fertilizers, and consider soil erosion measures. See Table 2 for more details.

c) End of season agricultural and natural resource decisions: these are decisions to be made towards the end of the season (harvest time) based on weekly and sometimes daily climate/weather forecasts. End of the season is the time when crops mature and become ready for harvest. The forecasts that are given during these period are untimely rains, hail storms, floods, and heavy winds. Based on the forecast information, you are expected to harvest as early as possible or prepare for any protection that damage the crops. For example, if the forecast show heavy rainfall conditions that can cause flood towards the end of the season which can destroy the natural conservation structures that you built throughout the season, you need to make the necessary decisions to protect your conservation structures. For more details on the use of end of season climate/weather forecast, see Table 3.

(3.1) Suitability

Climate and weather information is applicable to all agro-ecologies and farming systems

(4) Implementation of climate information use for agricultural decisions

4.1. Pre-season climate information

- **Why is it needed?** Pre-season climate information is important to make early decisions like land preparation, crop/variety type choice, water management and labor requirement and need for credit services (See Table 1). These decisions are important to minimize risks and exploit opportunities in a given cropping season to enhance crop productivity, contribute to household food security and reduce greenhouse gas emissions by optimizing tillage and other land operations.
- **Where is it needed?** Pre-season climate info is needed across all ago-ecologies.
- **What type of climate information is needed?** Start of rainfall, length of growing season and seasonal rainfall distribution and amount.
- **Sources of information for pre-season climate information includes:**
    - ✓ National Meteorology Agency (NMA) seasonal forecast (http://www.ethiomet.gov.et/bulletins/bulletin_viewer/462/bulletins/Belg_Assessment&Kiremt_2016_Outlook/en)
    - ✓ Online weekly forecast (http://zw.freemeteo.com/weather/?language=englishandcountry=ethiopia
    - ✓ Medias (TV, Radio, bulletins, newspapers),
    - ✓ Interactive voice response , IVR (From Ethio-telecom),
    - ✓ Short message services (SMS) and
    - ✓ Minister of Agriculture (MOA) internal communication

4.2. In-season climate information

- **Why is it needed?** In-season climate information is important to make crop management decisions like proper fertilizer choice, amount and placement, supplementary irrigation requirement, cultivation and crop protection measures and reduce land degradation that may arises from low productivity.
- **Where is it needed?** In-season climate information is needed across all agro-ecologies.
- **What type of climate information is needed?** Dekadal, weekly and daily rainfall forecast.
- **Sources of information for in-season climate information:**
    - ✓ NMA dekadal, weekly and daily rainfall and temperature forecasts (http://www.ethiomet.gov.et/daily_weather; http://www.ethiomet.gov.et/forecasts/three_day_forecast)
    - ✓ Climate bulletins (http://www.ethiomet.gov.et/bulletins/bulletins)

- ✓ Ethiopia Institute of Agricultural Research (EIAR)- 10 days rainfall forecast,
- ✓ Online weekly forecast (http://zw.freemeteo.com/weather/?language=englishandcountry=ethiopia)
- ✓ Medias (TV, Radio, newspapers),
- ✓ Interactive voice response , IVR (Tele),
- ✓ Short message services (SMS),
- ✓ MOA internal communication.

4.3.Harvesting period climate information

- **Why is it needed?** Climate information during harvesting period is important to avoid/reduce damage from unexpected rain, hailstorm, flood, strong wind, and outbreak pests and diseases.
- **Where is it needed?** Harvesting period climate information is needed across all ago-ecologies.
- **What type of climate information is needed?** Special climate warnings on unexpected heavy rain, hailstorm, flood, strong wind, unusual outbreak of pests and diseases.
- **Sources of information harvest period climate information**
  - ✓ NMA dekadal, weekly and daily rainfall and temperature forecasts (http://www.ethiomet.gov.et/daily_weather; http://www.ethiomet.gov.et/forecasts/three_day_forecast)
  - ✓ Ethiopia Institute of Agricultural Research (EIAR)- 10 days rainfall forecast,
  - ✓ Online weekly forecast (http://zw.freemeteo.com/weather/?language=englishandcountry=ethiopia)
  - ✓ Medias (TV, Radio, newspapers),
  - ✓ Interactive voice response (IVR) from Tele
  - ✓ Short message services (SMS),
  - ✓ MOA internal communication.

(4) Challenges and constraints (limitations)

The major limitations are availability of timely and location specific climate information. The users need to be aware of where the climate information can be reached and accessed.

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Table: Possible crop management decisions based on pre-season climate information and Agro-ecology

Rainfall Onset forecast (N, E, L)	LGS* forecast (N, L, S)	Rainfall amount forecast (N, AN, BN)	Decision implications in different agro-ecologies			Remark
			Dega	**Weyena-dega**	**Kola**	
Normal	Normal	Normal	• Follow commonly practices of land preparation, sowing time, crop/variety choice and other water/ soil management practices			These decisions should take into account the soil type and water availability conditions of a given particular site under consideration
Normal	Normal	Above normal	• Use commonly grown crops • Soil erosion could be a major problem- prepare for soil conservation practices ahead of time	• Use commonly grown crops • Soil erosion is likely and prepare for soil conservation practices ahead of time	• Use common grown crops • Soil erosion could be a possibility based on soil type	
Normal	Normal	Below normal	• Consider water harvesting and storage for supplemental irrigation	• Prepare for water harvesting/storage structures for supplemental irrigation	• Practicing water harvesting/storage structures and supplemental irrigation is required for successful crop harvest • possibility of crop failure is likely	
Normal	Long	Normal	• Medium to late maturing crop types/varieties	• Medium to late maturing crop types/varieties	• Medium maturing crop types/varieties	
Normal	Long	Above normal	• Grow late maturing crop types/varieties • Soil erosion could be a major problem- prepare for soil conservation practices ahead of time	• Grow late maturing crop types/varieties • Soil erosion is likely and prepare for soil conservation practices ahead of time	• Grow medium maturing crop types/varieties • Soil erosion could be a possibility based on soil type	

Normal	Long	Below normal	• Grow medium to late maturing crop types/varieties • Consider water harvesting and storage for supplemental irrigation	• Medium maturing crop types/varieties • Prepare for water harvesting/storage structures for supplemental irrigation	• Grow early to medium maturing crop types/varieties • Practicing water harvesting/storage structures and supplemental irrigation is required for successful crop harvest • Possibility of crop failure is likely if not supplemented with irrigation	
Normal	Short	Normal	• Grow early to medium maturing crop types/varieties • Consider water harvesting in drier localities	• Grow early maturing crop types/varieties • Practice water harvesting	• Grow very early maturing crop types/varieties • Water harvesting is necessary for successful crop production	
Normal	Short	Above normal	• Medium maturing crop types/varieties • Soil erosion could be a major problem-prepare for soil conservation practices ahead of time	• Grow early maturing crop types/varieties • Soil erosion is likely and prepare for soil conservation practices ahead of time	• Grow very early maturing crop types/varieties • Soil erosion could be a possibility based on soil type • Water harvesting may help avert rainfall distribution problems	
Normal	Short	Below normal	• Grow early to medium maturing crop types/varieties • Consider water harvesting and storage for supplemental irrigation	• Grow early to very early maturing crop types/varieties • Prepare for water harvesting/storage structures for supplemental irrigation	• Grow extra early maturing crop types/varieties • Practicing water harvesting/storage structures and supplemental irrigation is required for successful crop	

					harvestpossibility of crop failure is likely	
Early	Normal	Normal	• Early land preparation • Early planting is required • Use commonly grown crop types/varieties	• Early land preparation • Early planting is required • Use commonly grown crop types/varieties	• Early land preparation • Early planting is required • Use commonly grown crop types/varieties	
Early	Normal	Above normal	• Early land preparation • Early planting • Use commonly grown crop types/varieties • Soil erosion could be a major problem-prepare for soil conservation practices ahead of time	• Early land preparation • Use commonly grown crop types/varieties • Early planting • Soil erosion is likely and prepare for soil conservation practices ahead of time	• Early land preparation • Use commonly grown crop types/varieties • Early planting • Soil erosion could be a possibility based on soil type • Water harvesting is beneficial	
Early	Normal	Below normal	• Early land preparation • Early planting • Medium maturing crop types/varieties • Consider water harvesting and storage for supplemental irrigation	• Early land preparation • Early planting • Grow early to medium maturing crop types/varieties • Prepare for water harvesting/storage structures for supplemental irrigation	• Early land preparation • Early planting • Grow early maturing crop varieties • Soil erosion could be a possibility based on soil type • Practicing water harvesting/storage structures and supplemental irrigation is required for successful crop harvest • Crop failure is likely if not irrigated	
Early	Long	Normal	• Early land preparation • Early planting • Long maturing crop types/varieties	• Early land preparation • Early planting • Medium to late maturing crop types/varieties	• Early land preparation • Early planting • Medium maturing crop types/varieties • Water harvesting is beneficial	

Early	Long	Above normal	• Early land preparation • Early planting • Late maturing crop types/varieties • Soil erosion could be a major problem-prepare for soil conservation practices ahead of time	• Early land preparation • Early planting • Late maturing crop types/varieties • Soil erosion is likely and prepare for soil conservation practices ahead of time	• Early land preparation • Early planting • Medium maturing crop types/varieties • Soil erosion could be a possibility based on soil type • Water harvesting may be required in some areas where rainfall distribution is poor	
Early	Long	Below normal	• Early land preparation • Early planting • Medium to late maturing crop types/varieties • Consider water harvesting and storage for supplemental irrigation	• Early land preparation • Early planting • Medium maturing crop types/varieties • Prepare for water harvesting/storage structures for supplemental irrigation	• Early land preparation • Early planting • Early maturing crop types/varieties with drought tolerant traits • Practicing water harvesting/storage structures and supplemental irrigation is required for successful crop harvest • Possibility of crop failure is likely	
Early	Short	Normal	• Early land preparation • Medium maturing crop types/varieties Early planting	• Early land preparation • Early maturing crop types/varieties Early planting	• Early land preparation • Very early maturing crop types/varieties Early planting Water harvesting is required	
Early	Short	Above normal	• Early land preparation • Medium maturing crop types/varieties • Early planting • Soil erosion could be a major problem-prepare for soil conservation practices ahead of time	• Early land preparation • Medium maturing crop types/varieties • Early planting • Soil erosion is likely and prepare for soil conservation practices ahead of time	• Early land preparation • Early maturing crop types/varieties • Early planting • Soil erosion could be a possibility based on soil type • Water harvesting may be required in some areas	

					where rainfall distribution is poor	
Early	Short	Below normal	• Early land preparation • Medium maturing crop types/varieties • Early planting • Consider water harvesting and storage for supplemental irrigation	• Early land preparation • Early to medium maturing crop types/varieties • Early planting • Prepare for water harvesting/storage structures for supplemental irrigation	• Early land preparation • Very early maturing crop types/varieties • Early planting • Prepare for water harvesting/storage structures for supplemental irrigation	
Late	Normal	Normal	• Late land preparation • Use commonly grown crop types/varieties •	• Late land preparation • Use commonly grown crop types/varieties	• Late land preparation Early maturing crop types/varieties Water harvesting is beneficial	
Late	Normal	Above normal	• Late land preparation • Use commonly grown crop types/varieties • Soil erosion could be a major problem-prepare for soil conservation practices ahead of time	• Late land preparation • Use commonly grown crop types/varieties • Soil erosion is likely and prepare for soil conservation practices ahead of time	• Late land preparation • Earlyto medium maturing crop types/varieties • Soil erosion could be a possibility based on soil type Water harvesting may be required in some areas where rainfall distribution is poor	
Late	Normal	Below normal	• Late land preparation • Medium maturing crop types/varieties • Consider water harvesting and storage for supplemental irrigation	• Late land preparation • Early to medium maturing crop types/varieties • Prepare for water harvesting/storage structures for supplemental irrigation	• Late land preparation • Early maturing crop types/varieties • Practicing water harvesting/storage structures and supplemental irrigation is required for successful crop harvest • Possibility of crop failure is likely distribution is poor	
Late	Long	Normal	• Late land preparation • Late planting • Use medium maturing crops/varieties	• Late land preparation • Late planting • Use medium maturing crops/varieties	• Late land preparation • Late planting • Grow early to medium maturing crops/varieties	

Late	Long	Above normal	• Late land preparation • Late planting • Use late maturing crops/varieties • Soil erosion could be a major problem-prepare for soil conservation practices ahead of time	• Late land preparation • Late planting • Use late maturing crops/varieties • Soil erosion is likely and prepare for soil conservation practices ahead of time	• Late land preparation • Late planting • Use of medium maturing crops/varieties is a must • Soil erosion could be a possibility based on soil type • Water harvesting may be required in some areas where rainfall distribution is poor	
Late	Long	Below normal	• Late land preparation • Late planting • Use medium to late maturing crops/varieties • Consider water harvesting and storage for supplemental irrigation	• Late land preparation • Late planting • Use medium maturing crops/varieties • Prepare for water harvesting/storage structures for supplemental irrigation	• Late land preparation • Late planting • Use early maturing crops/varieties Prepare for water harvesting/storage structures for supplemental irrigation	
Late	Short	Normal	• Late land preparation • Late planting Use early to medium maturing crops/varieties	• Late land preparation • Late planting Use early maturing crops/varieties	• Late land preparation • Late planting • Use of very early maturing crops/varieties is a must • Water harvesting is beneficial	
Late	Short	Above normal	• Late land preparation • Late planting • Use early to medium short maturing crops/varieties • Soil erosion could be a major problem-prepare for soil conservation practices ahead of time	• Late land preparation • Late planting • Use early maturing crops/varieties • Soil erosion is likely and prepare for soil conservation practices ahead of time •	• Late land preparation • Late planting • Use of very early maturing crops/varieties is a must • Soil erosion could be a possibility based on soil type • Water harvesting may be required in some areas where rainfall distribution is poor	
Late	Short	Below normal	• Late land preparation	• Late land preparation	• Late land preparation	

			• Late planting • Use early maturing crops/varieties • Consider water harvesting and storage for supplemental irrigation	• Late planting Use very early to early maturing crops/varieties • Prepare for water harvesting/storage structures for supplemental irrigation	• Grow very early maturing crop types/varieties • Practicing water harvesting/storage structures and supplemental irrigation is required for successful crop harvest • Possibility of crop failure is likely distribution is poor	

Table 2: Possible crop management decisions based on in-season climate information, Agro-ecology and Soil water holding capacity

Weekly rainfall forecast	Soil water holding capacity	Decision implication based on Agro-ecology			Remark
		Dega	**Weyena-dega**	**Kola**	
No-rain (dry)	Low (Sandy soil)	Normal crop growth expected	Drought sensitive crops may need attention (supplementary irrigation could be consider)	Crops may be affected by water stress ✓ Apply supplementary irrigation ✓ Mulching ✓ Consider thinning	If consecutive weeks are dry crops could be affected by water stress and decisions
	Medium(Loam soil)	Normal crop growth expected	Normal crop growth expected but drought sensitive crops may need attention	Crops may be affected by water stress ✓ Apply supplementary irrigation or consider other evaporation reducing measures	
	High (Clay soil)	Normal crop growth expected	Normal crop growth	Normal crop growth expected but drought sensitive crops may need attention	
	Low (Sandy soil)	Normal crop growth expected ✓ Apply recommended fertilizer rates,	Normal crop growth	Normal crop growth expected but drought sensitive crops may need attention	
	Medium(Loam soil)	Normal crop growth expected ✓ Apply recommended fertilizer rates, ✓ Practice weeding and other cultivation normally	Normal crop growth expected ✓ Apply recommended fertilizer rates,	✓ Drought sensitive crops may need attention (supplementary irrigation could be consider)	
	High (Clay soil)	Normal crop growth expected Water logging problem is likely	Normal crop growth expected ✓ Apply recommended fertilizer rates,	Normal crop growth expected but drought sensitive crops may need attention	

Light rain					should consider cumulative effects of weekly forecasts
Heavy rain	Low (Sandy soil)	Normal crop growth expected ✓ Apply recommended crop management practices ✓ Expect nutrient leaching ✓ Soil erosion is more likely (take conservation measures)	Normal crop growth expected ✓ Apply recommended fertilizer rates ✓ Soil erosion is likely (take conservation measures)	Normal crop growth expected ✓ Apply recommended crop management practices	
	Medium(Loam soil)	Normal crop growth expected ✓ Apply recommended crop management practices ✓ Expect some waterlogged conditions ✓ Soil erosion is likely (take conservation measures)	Normal crop growth expected ✓ Apply recommended fertilizer rates ✓ Soil erosion is more likely (take conservation measures)	Normal crop growth expected ✓ Apply recommended crop management practices	
	High (Clay soil)	Crops may be affected by water logged conditions ✓ Apply soil water drainage practices (e.g., BBM, BBF) ✓ Don't apply fertilizers ✓ Soil erosion is highly likely (take conservation measures)	Normal crop crop growth expected but there could be water logged conditions for sensitive crops ✓ Consider drainage measures	Normal crop growth expected ✓ Apply recommended crop management practices ✓ Soil erosion is likely in some pocket areas	

Table 3: Possible crop harvest decisions based on harvest period climate extreme information

Climate extremes, pest and disease forecasts	Decision implication based on Agro-ecology			Remark
	Dega	Weyena-dega	Kola	
unexpected heavy rain, strong wind, hailstorm and flood	Ready for early harvest, be aware of possibilities of wind and water erosion	Ready for early harvest, be aware of possibilities of wind and water erosion	Ready for early harvest, be aware of possibilities of wind and water erosion	Early harvested crops may develop molds and wastage would be high and hence daily follow up is required to make sure that acceptable drying after harvest
unusual pest and disease outbreak	Early harvest, prepare for crop protection measures	Early harvest, prepare for crop protection measures	Early harvest, prepare for crop protection measures	
No climate extreme problem	Proper time for effective crop harvest			

ANNEX 1 – The Basket of Options Methodology

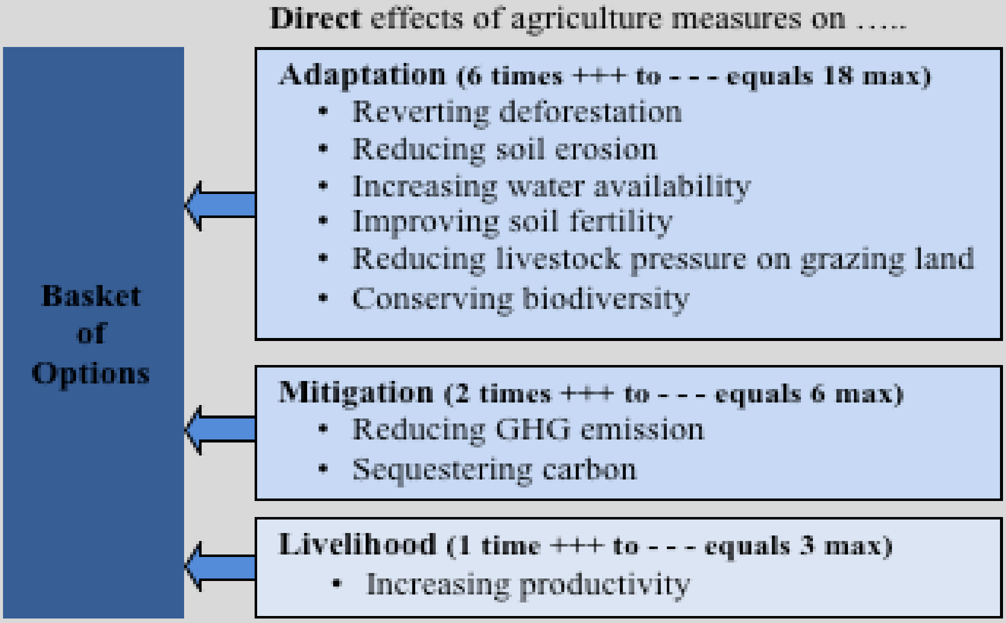
The Basket of Options (BoO) methodology can be used to conduct an assessment of the climate smartness of practices recommended in the infotechs, and subsequently as part of the training to be provided to CSA practitioners and advisors. Secondly, the DA can use the BoO to provide examples of climate-smartness of interventions. In addition, the methodology of scoring points to individual practices can be used as a selection tool to identify suitable CSA interventions or packages

Box: Basket of Options (BoO) for classifying climate-smartness of CSA activities
The BoO classifies agricultural interventions or practices and scores them according to their adaptation, mitigation and livelihood enhancement potentials. The interventions are grouped into 4 major land use types of the typical watershed and one livestock group. The following table gives an overview of the BoO matrix.

Measures by land-use type/livestock	Adaptation	Mitigation	Livelihood	M&E	Remarks
Degraded hillsides	Score and justification		Score and justification		
Farmland		Score and justification			
Homesteads	Score and justification		Score and justification		
Grazing land		Score and justification			

Livestock	Score and justification		Score and justification		

As one score for adaptation and mitigation cannot be easily attributed six and two sub-parameters respectively were introduced to describe the complexity of direct effects. These sub-parameters help to describe the **direct** effects of an intervention on the three components of CSA. The different sub-parameters are as follows.



Each intervention is being scored for each sub-parameter with a score ranging from -3 to +3 (or - - - ….. 0 ….. +++). The scores of the 6 adaptation sub-parameters, 2 mitigation sub-parameters and 1 livelihood sub-parameter together make the total score of climate-smartness. The total CSA rating being the summary of all 9 sub-parameter ratings automatically gives a very strong focus on adaptation because the adaptation component is made up of 6 sub-parameters compared to two and one sub-parameter for mitigation and livelihood respectively.

The different sub-parameters also allow focussing on interventions with maximum effects on mitigation for example by selecting respective activities from the BoO with the highest mitigation rating.

Thereafter the maximum score in the BoO for each intervention for adaptation, mitigation and livelihood is 6x3=18, 2x3=6 and 1x3=3 respectively; totalling to a **maximum climate-smart score of** 18+6+3=**27**

The following table presents the climate-smart scores for some single interventions on farmland. The table also proposes whether the intervention should be implemented in testing/demonstration mode or in the upscaling mode (to be updated).

Table - Selected interventions and their ratings by order of total rating

Direct effects on →	**Adaptation**							**Mitigation**			**Livelihood**		**CSA**
Measures by land use type	**Forest degradation**	**Soil degradation**	**Water availability**	**Soil fertility**	**Livestock pressure**	**Biodiversity**	**Subtotal**	**Reducing emission**	**Storing carbon**	**Subtotal**	**Increasing productivity**	**Subtotal**	**Total rating**
Farm land													
Agroforestry	NDR	++	++	++	+	+	8	++	++	4	++	2	**14**
Applying compost	NDR	++	++	+++	NDR	++	9	--	++	0	++	2	**11**
Mulching	NDR	++	+++	+	NDR	+	7	+	+	2	+	1	**10**
Forage production	NDR	+	+	+	++	+	6	+	+	2	+	1	**9**
Conservation Agriculture	NDR	++	+	++	+	+	7	+	0	1	+	1	**9**
Intercropping	NDR	++	++	+	NDR	+	6	NDR	NDR	0	++	2	**8**
Green manuring	NDR	+	++	++	NDR	+	6	0	+	1	+	1	**8**
Using bio-fertilizer	NDR	NDR	NDR	+++	NDR	+	4	+	NDR	1	++	2	**7**
Applying lime on acidic soils	NDR	+	+	+++	NDR	+	7	-	NDR	-1	+	1	**7**
Crop residue management	NDR	++	+	+	-	+	4	+	+	2	+	1	**7**
Crop rotation	NDR	+	+	+	NDR	+	4	NDR	NDR	0	++	2	**6**
Planting with space/row planting	NDR	+	+	0	NDR	0	2	NDR	NDR	0	++	2	**4**
Changing crop varieties	NDR	0	NDR	+	NDR	-	0	0	0	0	++	2	**2**

Note: (NDR=No Direct Relation)

The scoring of CSA interventions in the BoO has been done on the basis of single interventions. As a single intervention often doesn't include a triple win due to trade-offs between the CSA elements, a high degree of climate-smartness can be achieved by combining different single measures. For example, the rating of conservation agriculture is composed of the three single measures by which it is defined, that are minimum tillage, mulching and crop rotation. Combining single measures meaningfully can increase the degree of climate-smartness of interventions and helps to work towards climate-smart watersheds. Therefore, in order to overcome trade-offs between the three components within a single measure DAs should facilitate the planning to identify combination of measures within a land use type.

Each score in the BoO is underpinned with a justification. These justifications are very important to understand and possibly review the scores. The scores are most meaningful if an intervention is precisely defined, for example row planting compared to ISFM which entails a great number of activities with different degree of climate-smartness. While the scale effect is partially considered in the score, for example planting trees on degraded hill sides is stronger than planting few trees around the homestead, the time effect is normally not considered in the score. For example, the climate effects of planting trees occur usually much later than applying compost on the farm land. The following table is the example for justifications of the scores for applying compost on farmland.

Table 3 - Example of rating climate-smart measures and their justifications

Criteria	Direct effects on	Applying compost	
		Rating	**Justification**
Adaptation	Forest degradation	NDR	No Direct Relation
	Soil degradation	++	the organic matter soil nutrients are better maintained
	Water availability	++	enhances water holding capacity through improved soil structure
	Soil fertility	+++	adds soil organic matter (SOM)
	Livestock pressure	NDR	No Direct Relation
	Biodiversity	++	maintains & improves soil biota
	Subtotal	**9**	
Mitigation	Reducing emission	**- -**	increases GHG emissions if exposed
	Storing carbon	++	the absorption of compost directly increases soil organic matter
	Subtotal	**0**	
Productivity	Increasing productivity	++	directly increases crop yield depending on compost quality and amount applied
	Subtotal	**2**	
CSA	Total rating	**11**	