RESEARCH AND IMPACT REPORT

Tajikistan

Livestock and Pasture Development Project Phase II (LPDP II)

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IFAD

Investing in rural people

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Acronyms

ATET	Average Treatment Effect on the Treated
CAPI	Computer Assisted Personal Interview
EG	Economic Goal
FIES	Food Insecurity Experience Score
HDDS	Household Dietary Diversity Score
IA	Impact Assessment
IFAD	International Fund for Agricultural Development
IPW	Inverse Probability Weight
IPWRA	Inverse Probability Weighted Regression Adjustment
LPDP I	Livestock and Pasture Development Project Phase I
LPDP II	Livestock and Pasture Development Project Phase II
MoA	Ministry of Agriculture of the Republic of Tajikistan
MT	Mainstreaming Theme
PCR	Programme Completion Report
PSM	Propensity Score Matching
RIA	Research and Impact Assessment Division
SO	Strategic Objective
ToC	Theory of Change

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Executive Summary

With a population of 8.35 million people and an area of 143,100 km2, Tajikistan's landscape is dominated by mountains which occupy about 93 per cent of its territory. Poverty and low standards of living remain a pressing problem for the country, and particularly for the Khatlon region which is the poorest region of the country. About half of the country's population lives below the poverty line, which increases to 78 per cent in the Kathlon region. The region's land is degraded, the availability of inputs and credit is limited, irrigation facilities are lacking, and access to improved technologies and markets is poor.

In the past decades, several factors have hampered environmentally sustainable agricultural development, including excessive pasture use and degradation, input intensive agricultural growth and climate-change induced dynamics (soil erosion and degradation and drought situation). Cultivating the land and raising livestock means survival for people living in rural areas of Tajikistan and particularly in the Kathlon region. About 50 per cent of the population depends on agriculture for livelihood, and most farmers lack access to adequate inputs, resources, technology and markets. Livestock is a key part of the agricultural sector and it is of critical importance in the livelihood strategy of poor rural households in Tajikistan.

It is in the context of this that the Livestock and Pasture Development Project (LPDP) was implemented to raise awareness and increase households' capacity towards integrated natural resource management and lower ecological footprint while raising livestock productivity. LPDP was implemented by the Ministry of Agriculture over two phases from 2011 to 2021. The first phase of LPDP (LPDP I) was implemented from 2011 – 2018 in selected districts of the Khatlon region in South-western Tajikistan. LPDP II built on the achievements of LPDP I with expanded geographical coverage in the same region and was implemented between 2016 and 2021. The LPDP II aimed to increase incomes and food and nutrition security of livestock farmers by boosting livestock production, productivity, and restoration of degraded pastures in the Khatlon region of Tajikistan. The project was funded by IFAD (86 per cent), the Government of Tajikistan (9 per cent), and beneficiaries (5.1 per cent) for a total cost of US$26.16 million. This impact assessment (IA) report focuses on LPDP II.

This IA study was conducted as part of IFAD11 IA agenda using end-line data commissioned by the PMU that cover 1,500 households (both beneficiaries and non-beneficiaries) collected in August-October 2021. We analysed LPDP II impacts on IFAD's goal, strategic objectives and some of the IFAD's mainstreaming themes, using non-experimental impact analysis methods that allow us to attribute impacts to the interventions.

Concerning economic mobility, we find that LPDP II had a positive impact on livestock income while it had negative impacts on incomes from transfers and livestock assets. Although it did not have an attributable impact on total income, livestock income makes up the largest share of beneficiary incomes and is the income source targeted by the project. We find no attributable impact on agricultural assets, household durables, housing quality, income from crop production, and agricultural and non-agricultural wages.

Regarding the objective of increasing livestock production, LPDP II had a positive impact on beneficiaries' cattle productivity as evidenced by their higher average weight, annual milk production and productivity. We find no attributable impact on average weight of sheep or total value of livestock by-products excluding milk.

The channels through which the aforementioned livestock production impacts have been realized include increased adoption of project promoted livestock rearing and pasture management activities. Beneficiary households were more likely to use preventive treatment (especially vaccinations) and spend lower per cattle for this treatment. LPDP II households are also more likely to feed their livestock from protected rangeland, use stalls to house their livestock, and source from safer and healthier water points than the control group. On pasture management, beneficiary farmers are more likely to use rotational plans, rely more on land authorities and owners to set the pasture usage parameters, and count on visual validation of restoration of pastures compared to the control villages. Treatment villages are also more likely to work to restore degraded pastures compared to non-beneficiaries. We did not find attributable impacts of the project on GIS-measured village-level vegetation index as a result of the pasture restoration activities.

Looking at the specific objectives of the project and at its theory of change, which is meant to increase livestock production and productivity while preserving the environment and adapting to climate change, the project has successfully achieved its results: livestock production and productivity have indeed increased while reducing livestock herd and respecting rotational pasture, thus reducing the ecological footprint.

The impact on market access is limited with no attributable impacts found for livestock sold alive or for livestock by-products such as milk and eggs and even lower access to livestock meat markets than the control group. As a result, the total value of livestock sales is not different between LPDP II beneficiaries and the comparison group. However, LPDP II households are more likely to sell crops than the comparison group. The overall results on market access underscore the fact that the project has not promoted market-oriented livestock production.

The attributable impact on increasing the resilience of LPDP II beneficiaries in the face of climate and non-climate shocks appears weak. The self-reported ability to recover from shocks (climate and non-climate combined) is similar between beneficiaries and the comparison group but beneficiaries are less likely to recover from climatic shocks such as droughts, frost, and flooding. However, beneficiaries are half as likely to report experiencing climatic shocks suggesting that the project may have prevented noticeable climatic shocks from affecting treated households in the first place compared to the control group. The perception of households that suffer climate related shocks to be less able to recover than the comparison group may also indicate a different level of awareness triggered by training and technical support.

Regarding IFAD's mainstreaming themes; we find that the LPDP II had no impact on household food security or dietary diversity. However, the project significantly increased women headed households' livestock income, crop income, annual milk production and productivity, and total annual value of livestock sale. When considering all households, however, we found that female members in the treatment group have less agency or decision power over household owned assets compared to the control group. Regarding social capital, we found that PUUs in LPDP II villages are more vibrant with increased frequency of meetings and stronger membership participation. This will likely promote increased social capital and better channeling of livestock and pasture management training and other services through the local institutions. Based on these IA results we draw lessons for future similar projects and relevant policies.

1. Introduction

With a population of 8.35 million people and an area of 143,100 km2, Tajikistan's landscape is dominated by mountains which occupy about 93 per cent of its territory. Poverty and low standards of living remain a pressing problem for the country, and particularly for the Khatlon region which is the poorest region of the country. About half of the country's population lives below the poverty line, which increases to 78 per cent in the Kathlon region. The region's land is degraded, the availability of inputs and credit is limited, irrigation facilities are lacking, and access to improved technologies and markets is poor (World Bank, 2015).

In the past decades, several factors have hampered environmentally sustainable agricultural development, including excessive pasture use and degradation, input intensive agricultural growth and climate-change induced dynamics (soil erosion and degradation and drought situation). Cultivating the land and raising livestock means survival for people living in rural areas of Tajikistan and particularly in the Kathlon region. About 50 per cent of the population depends on agriculture for livelihood, and most farmers lack access to adequate inputs, resources, technology and markets. Livestock is a key part of the agricultural sector and it is of critical importance in the livelihood strategy of poor rural households in Tajikistan.

Prior to the fall of the socialist system, livestock production was based on an elaborate system aiming at securing animal feed in the winter using (i) intensively–cultivated crops in large-scale state and collective farms, (ii) sizeable imports of concentrates and (iii) a centralized structure of pasture management and utilization. After 1991, the deterioration of these three pillars transformed the livestock husbandry system in Tajikistan from one based on intensive livestock farming to one based on extensive livestock husbandry. At present, the pasture management system in Tajikistan remains largely unchanged since Soviet times with the exception that the lowest rung in the management system (corporate farms) no longer has adequate resources for pasture upkeep nor an adequate management system. As a matter of fact, there exist a mere contradiction between the common use of pastureland without proper management and the private household livestock farms whereby livestock husbandry relies primarily on grazing supplemented by limited cultivated feed crops and minimal concentrates. The inadequacy of such a centralized management system is reflected in the overexploitation of pasture, free-riding behaviours and conflicts between villages over the use of the surrounding land. This extensive livestock production system has led to a vicious cycle of ever-lower animal yields and rural income which is triggered by the legitimate interest of farmers to increase their livestock production by increasing their livestock inventories which in turn has created a greater demand for limited feed, leading to a decrease in the feed per animal ratio, to a deterioration of the grazing land and to a further fall in animal yields. As a result, the rise in livestock assets coupled with the fall in feed supplies has meant the dramatic fall of livestock productivity, low milk and meat yields and land degradation in the country further worsening poverty among households.

The Livestock Pasture Development Project (LPDP) has focussed on raising awareness and capacitating households towards integrated natural resource management and low livestock carbon emissions while raising productivity. These objectives have been strengthened further in the second phase of the project implementation which is the focus of this impact assessment (IA) report. LPDP has been implemented by the Ministry of Agriculture over two phases from 2011 to 2021. The first phase of LPDP (LPDP I) was implemented from 2011 – 2018 in selected districts of the Khatlon region in South-western Tajikistan. LPDP II built on the achievements of LPDP I with expanded geographical coverage in the same region. LPDP II entered into force in March 2016 with first disbursement made in November 2017 and completion date of June 30th, 2021.

The project was funded by IFAD (86 per cent), including through the Adaptation for Smallholder Agriculture Programme (ASAP) trust fund (19.5 per cent), the Government of Tajikistan (9 per cent), and beneficiaries (5.1 per cent) for a total cost of US$26.16 million. LDPDP II, as its predecessor, targeted small-scale livestock farmers, private veterinary service providers, and small-scale entrepreneurs and women headed households and women belonging to poor households.

The project had the overall goal of reducing poverty and achieve food and nutrition security by improving the productive capacity of pastures, increasing livestock productivity and reducing the ecological footprint. The projects' goals and development objectives are aligned with those of the National Development Strategy (NDS) 2006-2015, which was updated for 2016-2030 to strengthen reduction of malnutrition and food insecurity and strengthen productive employment).

The project entailed three main components: a) the first component focused on *institutional development* through the establishment of Pasture User Unions (PUUs, henceforth) in order to guarantee land rights to the members, to facilitate common management, training and sustainable use of pasture and rehabilitation activities; b) the second component, namely *Productivity enhancement and improved animal health*, comprised a number of activities aiming at improving livestock husbandry practices, providing veterinary services and access to water as well as increasing fodder production and ultimately livestock production; c) finally, the third component *pasture development and diversification for vulnerability reduction* aimed to promote resilient pasture management and investments by helping PUUs address issues of degradation of pasture resources and climate change and advance income diversification by providing finance to encourage and nurture new economic activities beyond livestock. The activities under the last component accounted for 83.4 per cent of the project's funding, which clearly shows the projects' strong focus on sustainable community-led management of natural resources and reducing the ecological footprint of livestock among other related goals (IFAD, 2022).

This impact assessment investigates whether the LPDP II project contributes to well-being of beneficiaries in key outcome indicators of poverty reduction, resilience and environmental benefits to respond to IFAD's strategic objectives and goals as well as mainstreaming themes.

In this report, we provide and discuss the attributable impacts of LPDP II on outcome and impact indicators identified in the Theory of Change. We also assess the potential mechanisms related to the project's activities through which the impacts transpired. We use rigorous quasi-experimental methodologies to estimate the impacts on beneficiary livelihoods attributable to the project interventions.

To do this, we use the end-line survey conducted between July and October 2021. Data are comprised of 1,466 household surveys from beneficiaries of the project and non-beneficiary households that represent the comparison group. The dataset contains information about households' socioeconomic characteristics, livelihood and income-generating activities, food consumption, social capital, women's empowerment, experience with climatic and socioeconomic shocks, and subjective measures of resilience from shocks.

Impact assessments are important for policymakers, donors, researchers since they serve the dual purpose of upholding accountability and informing improvements to programme implementation and/or new designs. With specific regard to IFAD, this assessment constitutes part of a portfolio-wide set of impact assessments that will be used to evaluate the overall impact of IFAD projects completing between 2019 and 2021 (that is by the end of the IFAD's 11th replenishment cycle). Moreover, providing evidence of programme's effectiveness constitutes an invaluable opportunity for IFAD as well as for the Tajikistan Government to learn which mechanisms worked and which did not work at

benefiting households residing in vulnerable rural areas, how the intervention succeeded in obtaining the benefits, which concrete actions could be taken to enhance results in future projects

The remainder of the report is structured as follows. We begin Section 2 by outlining the project's theory of change and elaborating on its key objectives and activities. A description of the target population follows with the main research questions of the assessment. Section 3 provides details on the methodology employed for the assessment, including the construction of the counterfactual, questionnaire design, and impact indicators. Section 4 presents the profile of the project area and sample while Section 5 discusses the results of the impact assessment. We conclude the study in Section 6 by highlighting lessons learned and recommendations for future policy and project design.

2. Theory of change and main research questions

2.1 LPDP II theory of change

The reasons for households to raise livestock are several and tend to vary in accordance to their level of income, context and endowment. From cash income to food, from manure to draft power in agriculture, livestock provides a number of benefits to millions of agrarian households in developing countries, contributing to households livelihoods through direct and indirect pathways. In particular, livestock can contribute to wealth providing cash and in-kind income through the sale of animals and/or the sale and consumption of animal derived products such as milk, meat, eggs and others (Bebe et al. 2003). Moreover, livestock is a safety net in the form of liquid assets, thus it is usually considered as a source of savings and insurance given the fact that the sale of animals provides immediate cash flow to deal with unexpected economic shocks (Moll, 2005, Randolph et al. 2007). In addition to that, the ownership of herds can ease the access to formal and informal credit thanks to the possibility of being used as collateral (Upton, 2004).

When analysing the linkages to nutrition, livestock shows even more interesting and beneficial aspects, albeit controversial if consumed in large amounts as well as with relation to livestock's contribution to GhG emissions. From a nutritional point of view, animal-source foods are nutritionally dense sources of energy, protein, and various essential micronutrients. They match well with the nutrients needed by people to support growth, regular development, physiological functioning, and overall good health. Even in small amounts, foods of animal origin can play an important role in improving the nutritional status of low-income households by addressing micro- and macronutrient deficiencies, particularly those of children and pregnant and lactating women (IFAD, 2021). In Tajikistan, stunting in children under the age of five, which is an important indicator of both micro- and macronutrient deficiency, was at 27 per cent in 2012 (Robinson, 2020). For this reason, anthropometric measures of children were among the key indicators of impact for the first phase of LPDP (Cavatassi and Mallia, 2018).

Inadequate quantity and quality of animal water and feed resources are major factors constraining the productivity of livestock farming in developing countries. The shortage of water and feed for animal has detrimental consequences for household's food supply and income particularly for poor people who rely on agriculture and livestock as a source of food and spend considerable time in collecting these resources (Mekonnen et al. 2015; Yilma et al. 2011). The environmental depletion of resources on which poor rural household operate trap them into a downward spiral (Ostrom et al. 1991). This is especially true in Tajikistan, where the topography is less favourable for agricultural production with 93 per cent of the country occupied by mountains and where livestock raising is more appropriate.

Unemployment in the off-farm sector is widespread and smallholders have few opportunities to diversify into non-livestock income-enhancing activities. As a result, increasing livestock productivity is a promising channel to alleviate poverty and reduce the ecological footprint.

In Tajikistan, rapid individualization of livestock herds in the last few decades led to rapid growth in livestock inventories managed by household farms. By 2016, the total number of livestock in the country was around 60% higher than the total number in 1992 (Robinson, 2020). The rapid expansion of livestock stocks despite the fall in feed availability has kept feed availability per animal extremely low, leading to an overexploitation of the common pasture land. Thus, a major constraint to improvement of livestock productivity is the lack of a proper system of pasture management with the necessary resources to perform pasture management and rehabilitation (Sedik, 2009).

Sustainable livestock management with appropriate pasture use and animal feeding are crucial to avoid a downward spiral into natural resource depletion which can be triggered by overgrazing and land erosion and which, coupled with methane emissions, lead the livestock sector to emerge as among the top contributors to GhG and environmental degradations (Henning et al, 2006). The livestock sector is indeed the largest anthropogenic user of land worldwide, the land area occupied by grazing is equivalent to 26 percent of the usable land surface. Moreover, feed crop production amounts to 33 percent of total land area. Likewise, livestock production is a key factor in deforestation and the pressure on land and overgrazing leads to local and global environmental costs of land erosion linked to GhG emissions. Yet, at the same time, livestock can also tremendously contribute to the GhG emission reduction if sustainably managed. As a matter of fact, the livestock sector contributes to 18 percent of GhG emission measured in CO2 equivalent which offers large possibilities to mitigate climate change through appropriate management of livestock feed and management, which is one of the main purposes of the LPDP project especially in its second phase or LPDP II.

The primary objectives of the LPDP project are to address the abovementioned development bottlenecks through different interlinked and synergetic activities. The project was implemented by the Ministry of Agriculture over two phases from 2011 to 2021. The first phase of LPDP (LPDP I) was implemented from 2011 – 2018 in selected districts of the Khatlon region in South-western Tajikistan. LPDP II built on the achievements of LPDP I with expanded geographical coverage in the same region. LPDP II entered into force in March 2016 with first disbursement made in November 2017 and completion date of June 30th, 2021. The overall objective of LPDP II was to improve the living conditions and reduce rural poverty in Tajikistan through i) institutional development by enhancing the capacity of targeted public sector and community organizations by improving their effectiveness and efficiency at pro-poor pasture management development. ii) improve livestock productivity and animal health by increased access to livestock and veterinary services, and fodder supply for smallholder producers, resulting in decreased mortality and increased productivity of livestock due to a reduced incidence and prevalence of diseases. iii) promote pasture development and diversification for vulnerability reduction by increased access to more productive and climate resilient pasture areas as well as to diversified income-generating opportunities for livestock communities through a sustainable, community-led management of natural resources. In addition to this, the project has received ASAP funding aiming to mainstream climate change adaptation into the whole investment.

Figure 1 presents the list of activities implemented through the project and the causal mechanisms that are expected to lead to the desired impacts (i.e. theory of change). The theory of change is the result of the work of the RIA team with the crucial contributions gathered from the discussions with the Project Management Unit (henceforth, PMU) and the direct beneficiaries of the projects interviewed.

The set of activities related to the first component entails the establishment of a decentralized management unit for pasture, namely the Pasture Users' Unions (PUUs, henceforth). PUUs are created at the village level with the intent to acquire the formal legal rights for pasture use, which are transferred directly to the members. Once the legal setting of the union has been set up, the board of the members pools together the resources needed for the maintenance of the pasture land, creates a rotational plan and the union becomes the channel through which the need-specific project's activities are implemented. The legal framework created by the PUUs should decrease the disputes and conflict over land use both between members of the community and nearby villages. Moreover, by setting individual responsibilities on each member, the internal organization of the PUUs is expected to decrease free-riding behaviours which usually lead to overexploitation of pastures and consequent land degradation. In addition to this, the implementation of a rotational plan for pasture is expected to increase land available for grazing in a sustainable manner thereby contributing to sequestration of CO2 and therefore to mitigation of climate change (USAID, 2015). At the Jamoat[1] level, this component should translate into greater community cohesion and improved quality of pasture land. By end of 2020, LPDP II established 197 PUUs (IFAD, 2021).

Livestock productivity heavily depends on the quantity and quality of feed and water. The lack of sufficient feed and water availability constraints animal productivity (Bezabih & Berhane, 2014). Providing improved seeds and fertilizers for fodder production and building water points, animal sheds and veterinary services should lead to an increase in livestock production and productivity thanks to higher water availability and to better, more nutritious and sufficient feed. Moreover, the pressure on feedstock should be reduced in the harshest seasons thanks to shelters, which allow for less calories dispersion from livestock in the coldest season when pastures cannot be reached. These actions should lead to comply with the pasture carrying capacity and therefore to a reduction of land erosion from overgrazing and should lead to less emission from pastureland and from methane.

In overgrazed pastures, reducing grazing pressure can lead to soil carbon sequestration. Grass productivity and soil carbon sequestration can also be improved by increasing grazing pressure on pastures where it is too low (Henderson et al., forthcoming). Therefore, improved grazing management by adjusting grazing pressure can contribute to reduced emissions by improving grass productivity and soil carbon sequestration. Optimizing grazing intensity can be achieved by avoiding overgrazing, this can be implemented by increasing mobility, and by making adjustments to grazing and pasture resting period (Mottet et al., 2016; Henderson et al., forthcoming), which is one of the purpose of the LPDP project. Likewise appropriate breeding practices and reproductive management can lead to reduced emissions, also one of the purpose of the project. In other words, if appropriately managed the approach taken in the LPDP project could be twofold: increase livestock productivity and production through better feed and through appropriate breeding and reproductive management and veterinary support while avoiding overgrazing so to ensure reduced erosion and degradation therefore achieving adaptation and mitigation objectives.

As part of the project, the PMU created and/or supported groups of small-scale Gissar sheep breeders providing each group with Gissar rams to improve the quality of local sheep breeds. By the end of 2020, the project provided purebred bulls and Hissar rams through 67 sub-projects (IFAD, 2021). Livestock ownership is expected to increase households' welfare through own-consumption or income generation (Jin et al. 2014). Building veterinary clinics or adequately equipping the already existing ones, should lead to easier access to veterinary services thus decreasing the incidence of animal diseases. The expected deriving outcome from these activities entail benefits at the household level

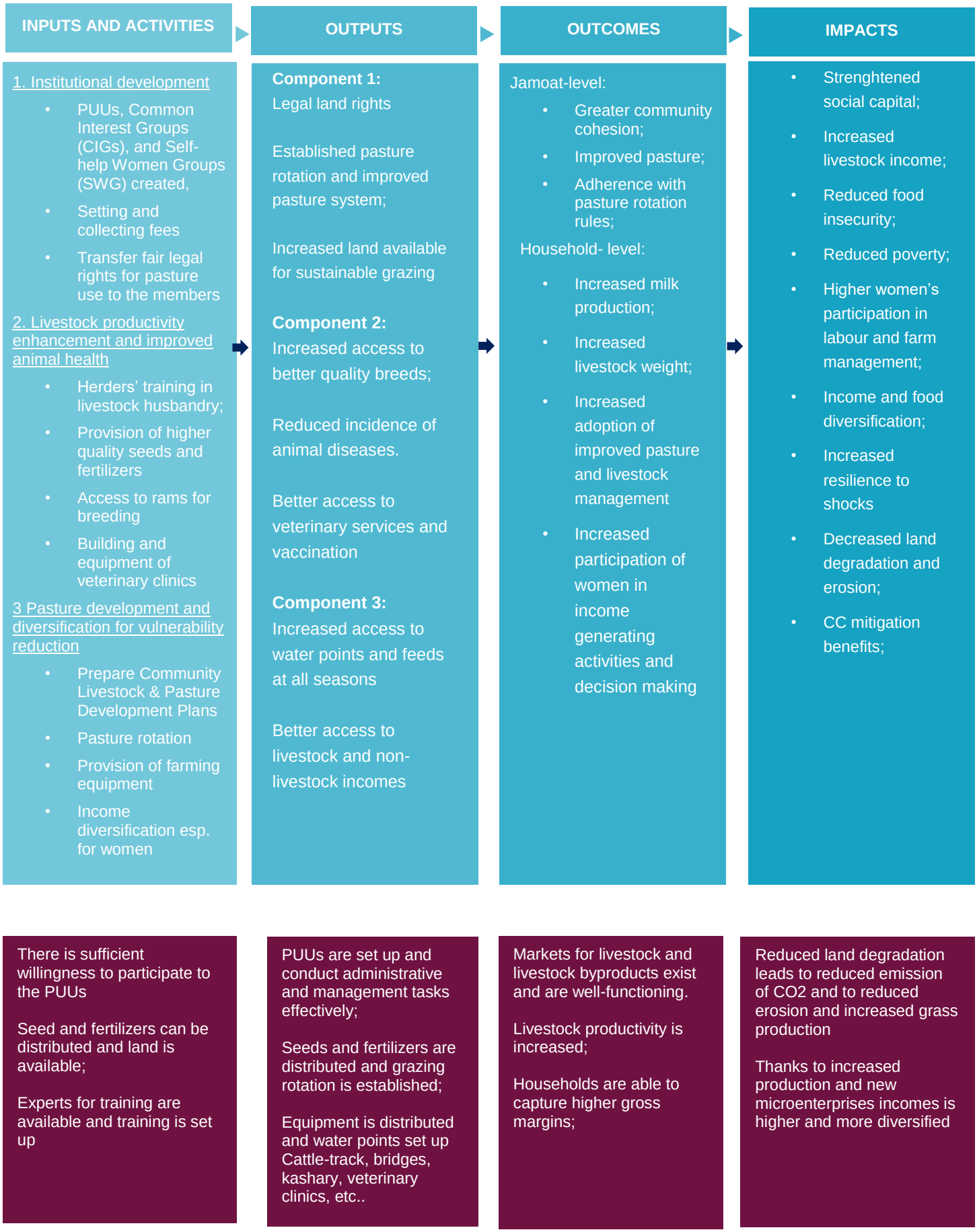
[1] The administration system in Tajikistan is hierarchically organized as follows: (i) Oblast (region) which are divided into (ii) Hukumat (district) which in turn are subdivided into (iii) Jamoat (village-level self-governing units) and then (iv) villages.

such as increased livestock productivity, income and food diversification and consumption (Hadush, 2017).

The third set of project activities is expected to improve women livelihood conditions by widening the spectrum of income generating activities available. In particular, it provides small ruminants, poultry and bee-keeping packages to female household-heads, which are expected to increase their income and, thus increase their bargaining power in the household decision-making process.

The three components of the projects are inter-linked and are expected to act together in increasing income, reducing poverty and achieving food security while contributing to climate change adaptation and mitigation. The efficiently planned use of pastures should rehabilitate fertility of degraded land due to overgrazing thereby contributing to adaptation to climate change (through sheds, water points and distribution of seeds) but also contribute to climate change mitigation benefits produced by rehabilitated pastureland. Moreover, given the gender dimension component, it is expected that the LPDP will lead to greater women empowerment smoothing the negative impacts of high rates of male migration.

Figure 1: The Theory of Change



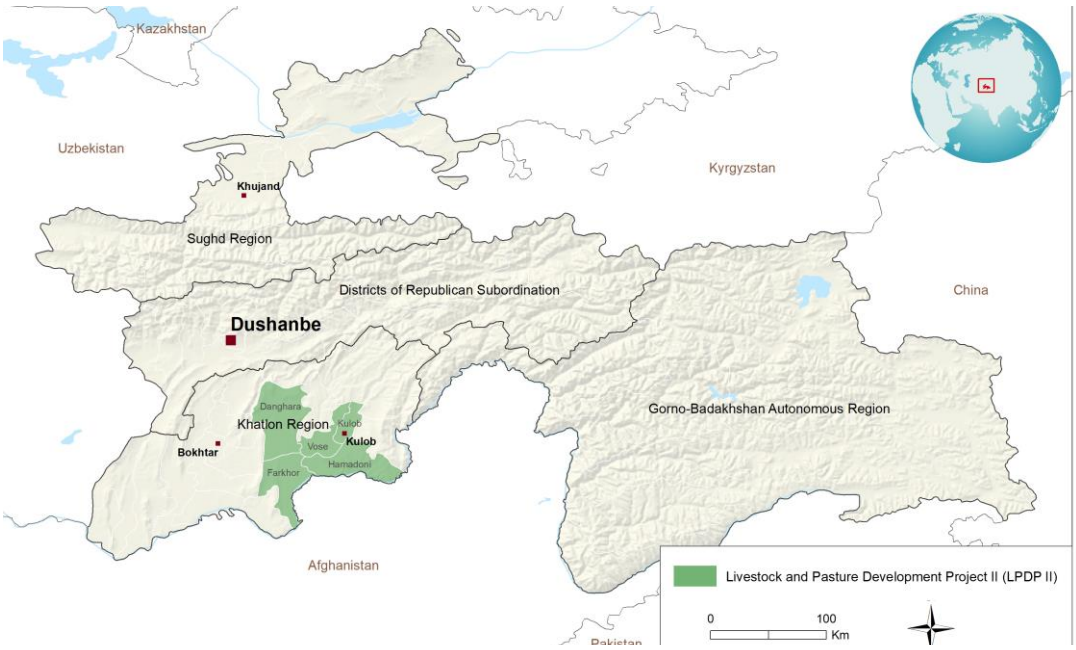
2.2 Project coverage and targeting

The LPDP II project has been implemented in selected districts of the Khatlon region which is the poorest region of the country with the largest share of poverty rate in the country[2]. The districts of Danghara, Farkhor, Hamadoni, Kulob and Vose were selected considering the level of poverty. Within each district, only jamoats with overall livestock carrying capacity of pasture below 5 where considered as eligible. This measure is calculated using the ratio between the overall pasture area available and the total number of sheep units, where the latter is a standardized measure of the livestock inventories based on their consumption of forage. Inside each targeted jamoat, the selected villages had to have: i) pasture area of more than 50 hectares and ii) a population of more than 50 but less than 500 households. Also important to note is that once a village has been selected to participate to the projects, there is perfect compliance at the village level, that is: the totality of the households residing in a given village are also part of the PUU and participate to the project.

Part of the challenges in conducting a rigorous IA relate to the proper identification of spillover effects and unintended impacts. The importance of taking into account spillover effects lies in the fact that it may imply a double underestimation or overestimation of project's impacts. In our particular case, since the veterinary clinics built and equipped by the project are freely accessible, we may suspect that not only households from eligible villages but also those from control villages may benefit from them. If this is the case, by simply comparing eligible and ineligible households, we would be (i) underestimating the effect of the provision of veterinary services on the treatment group and (ii) ignoring the positive effect of the treatment on the control group, leading to wrong policy recommendations (Angelucci and Di Maro, 2010). For this reason, it is also important to take into consideration the role played by the possible reduction in the likelihood of contagion when estimating the effect of veterinary clinics services on the incidence of animal diseases and mortality. On the other hand a properly managed pasture land combined with plots dedicated to fodder production through distribution of forage seeds, may produce not only the private benefits of increased fodder but also the off-site public benefits linked to increased soil fertility and reduced land erosion thanks to rotational plan and, last but not least, the global public benefits represented by CO2 sequestration and its consequent contribution to climate change mitigation. Another dimension to be considered is the estimation of unintended changes to the group of beneficiaries due directly or indirectly to the projects. Qualitative and quantitative assessment conducted for LPDP-I , (i.e. the first phase of the project that is being assessed in this report) an increase in school attendance among their children as well as reduction of costs thanks to the possibility to rent at a reasonable cost the farming equipment bought collectively by the PUUs have been assessed.

[2] Poverty figures obtained using Living Standards Measure Study-2009 data by World Bank, confirmed at national level by more recent data from World Bank and Asian Development bank.

Figure 2: LPDP II project areas



2.3 Research questions

The main purpose of this impact assessment is to report on the Tier II development impact indicators as defined in IFAD's Results Management Framework. These are the Economic goal (EG) of increasing incomes and the three Strategic Objectives (SOs) of improving productive capacities (SO1), market access (SO2) and strengthening environmental sustainability and climate resilience (SO3); as well as some of the mainstreaming themes (MTs) including nutrition, adaptation to climate change, and women's empowerment and other key indicators such as food security. We present the list of research questions related to each of these indicators in Table 1. We also try to disentangle the mechanisms that have led to impacts estimated and their role in determining impacts such as access to veterinary services and adoption of breeding techniques and livestock breeds, access to water points, compliance with rotational plans and others.

Using the intended LPDP II impacts and impact pathways outlined in the ToC, we assess each strategic objective and goal by analysing a number of its features. The EG assesses the impact of LPDP II on economic mobility as measured by household income, poverty status, and asset ownership. The SO1 includes all indicators related to increasing livestock and crop production and productivity, such as the weight of livestock and amount of milk production and productivity, as well as the adoption of improved livestock rearing and pasture management activities as pathways. In particular, the LPDP II aspired to increase the milk yields and weight of livestock by 15 and 10 per cent, respectively. The SO2 indicators include the probability of selling livestock, livestock products, and crops in the market, the share of crops sold over the production and revenues from crop sales. The SO3 assess the ability to recover from climatic and non-climatic shocks and factors that can increase household resilience, such as income and livestock diversification. Specifically, LPDP II through its ASAP component aspired to help households adapt to the impacts of climate change through reduced erosion and reduction of pasture degradation and through contribution to carbon sequestration thanks to reduced grazing. This, in turn, should reduce the vulnerability of small-scale farmers' livestock production to climatic shocks. For the mainstreaming themes, we measure the food and nutrition security using the standard indices widely adopted in the literature. We assess women's empowerment by reporting on LPDP II's impact on female-headed households' EG and SO1 indicators as well as female household members' participation in livestock and crop activities and decisions on management

of household assets. Finally, we report on strengthening of social capital through a set of indicators capturing whether or not the household belongs to a vibrant PUU or village organization such as community organizations that hold regular meetings and have strong member participation rates. The full list of indicators is included in Section 3.2. **Table 1: Matrix of research questions and IFAD's goal, strategic objectives (SOs) and mainstreaming themes (MTs)**

Research questions	EG	SO1	SO2	SO3	MT
Has the LPDP II increased household-level asset ownership and income?	X				
Has the LPDP II increased the adoption of improved livestock rearing and pasture management activities?		X		X	
Has LPDP II increased the production and productivity of livestock crops?		X			
Has LPDP II increased market participation and livestock revenues?			X		
Has LPDP II increased household resilience?				X	
Has LPDP II improved the food and nutrition security?					X
Has LPDP II increased women's empowerment (i.e. income of women headed households, asset ownership, and participation in livestock and crop activities)?					X
Has LPDP II increased social capital?					

Note: EG: Economic Goal; SO1: Productive capacities; SO2: Market access; SO3 Resilience; MT: Food and nutrition security: and Women's empowerment. Source: Authors' elaboration.

3. Impact assessment design: Data and methodology

3.1 Sample design

The main challenge for identifying impacts is to find a valid control group that has the same characteristics as the treatment group in the absence of the program. When the only difference between the treatment and comparison groups is that the members of the treatment group receive the project's activities, while the members of the comparison group do not, the observed difference in outcomes can be entirely attributed to the program and the causal impact can be identified (Ravallion, 2005).

Once the villages that comply with the eligibility criteria have been identified, finding a valid control group would require to randomly allocate the villages in the treatment and in the control group. The random selection of the treatment group out of the set of villages that satisfy the targeting criteria of the project would ensure that the members of the two selected groups would be asymptotically the same in terms of observed and unobserved characteristics.

Given the criteria used for selection of both LPDP-I and LPDP-II and after careful consideration of data available, the IA team in 2017 (at baseline for LPDP II) used Propensity Score Matching (PSM)

approach to construct the counterfactual or no LPDP II scenario from non-beneficiary villages.[3] The control villages should have similar characteristics to beneficiary villages in project's targeted districts of the Khatlon region using characterstics such as population, carrying capacity and pasture area, altitude, natural vegetation index (calculated through GIS techniques) and access to road and infrastructure. The idea is to find, from a large group of non-participants, villages that are "observationally" similar to selected villages not only in terms of pasture area but also in terms of additional characteristics not affected by the projects. Using PSM, each village selected for LPDP II was matched to a non-selected village on the basis of a single propensity score, reflecting the probability of being selected to be part of the project conditional on their observed characteristics.

The IA team at the time (i.e. in 2017) first selected from the list of villages belonging to the districts of LPDP-II, those villages that: 1) have a pasture area of more than 50 ha; 2) have more than 50 but less than 500 households.

Using the approve approach, IA team originally selected 120 villages (half treatment and half control) with 20 households to be selected in each village in order to reach the total estimated sample size of 2,400 households that was determined through a power calculation for detectable impacts on income indicators described in Table 3. Thus, the sample was originally composed of 1,200 households belonging to the treatment group (i.e., households who would eventually benefit from LPDP II activities) and the same number in the control group. These households were interviewed in 2018 that coincided with the end-line survey for the first phase of LPDP. The IA plan at the time envisaged using this original sample as baseline data for LPDP II and an ex-ante report was submitted based on this data. The plan was also to follow the same households from both groups at the end of LPDP II in 2021 and link the baseline and end-line data for LPDP II. This would have allowed for richer dataset and additional impact assessment methods such as difference-in-differences[4] using the same beneficiaries and control group of which a baseline survey was available and, given the richness of the earlier data set, also the sustainability of the project overtime.

In contrast to the original IA plan, most of the originally selected households in the control group received LPDP II benefits, which precluded them from being appropriate comparison group for the end-line survey. This is important because to estimate attributable impacts, it requires finding a suitable comparison (or control) group in the given setting.

For this reason, the Project Management Unit (PMU) for LPDP II, which oversaw the end-line survey for this project, randomly selected a new list of control households that did not receive LPDP II benefits but were considered comparable to the beneficiaries in terms of access to resources, agro-ecology, infrastructure and socio-economic status at the time of project implementation.

Overall, around 750 households were randomly selected in the treatment and control groups. We used statistical techniques to match or pair up households in the treatment and control groups based on key observable household and community level characteristics at baseline. We discuss the matching methods and these observable characteristics in sections 3.3 and 4.2 respectively.

In Table 2, we present the distribution of selected households and villages by district for both treatment (LPDP II) and control groups.

[3] See section 3.3 for a discussion on propensity scores. The scores represent the probability of receiving LPDP II benefits conditional on some observable characteristics.

[4] The difference-in-differences method is a quasi-experimental approach that compares the changes in outcomes (such as those in Table 4) over time between households enrolled LPDP II (the treatment group) and households that are not (the comparison group).

Table 2: Distribution of Sampled Villages and Households across Districts by Treatment Status

District	Treatment (LPDP II)		Control	
	Households	Villages	Households	Villages
Dangara	191	10	0	0
Farkhor	216	12	199	10
Hamadoni	95	6	10	1
Kulob	110	6	80	4
Qubodiyon	0	0	120	7
Shahritus	0	0	170	9
Temurmalik	0	0	170	9
Vose	135	8	0	0
Total	**747**	**42**	**749**	**40**

3.2 Questionnaire and impact indicators

Data at the community and household levels have been collected using Computer Assisted Personal Interviews (CAPI) through Survey Solutions software. Data collection has been carried out by the Public Organization "Nuri Umed", which was commissioned by the PMU for the LDPP II end-line survey.[5] We provided the questionnaire in CAPI and closely supervised the quality of data and gave continuous feedback during and after the data collection. The survey was conducted between July and October 2021. The reference period of both surveys is the previous 12 months (i.e. from October 2020 to September 2021).

The community survey covers a range of topics to capture the availability of infrastructure and public services, management of communal lands, and administration of PUUs or village organizations in the community. About 42 PUU heads in the treatment group and 40 village leaders in the control group took part in the community survey. The household survey includes questions on household demographic characteristics, income-generating activities, food consumption, housing quality and asset ownership before and after the interventions, access to credit and financial services, participation in PUU or village organizations, and exposure to and recovery from shocks. The sections on pasture management and livestock is extensive and takes into account LPDP II-related aspects such as livestock rearing and pasture management practices. The main set of impact indicators to answer the research questions listed above are constructed using the household data.

Table 3 shows the full list of impact indicators and their descriptions. All impact indicators represent annual values per household, unless otherwise indicated, and crop production related questions refer to the 2020/2021 agricultural season.

Table 3: Description of outcome and impact indicators

Indicator	Description
Economic Goal (EG)	

[5] Public Organization "Nuri Umed" has extensive experiencing in Tajikistan and completed data collection for various international organizations and donors including IFAD, USAID, UNODC, GIZ, and World Bank.

Gross household income per capital	Total gross income is based on the method developed by the team of the Rural Income Generating Activities (RIGA) project, which aggregates value of production plus cash income to make the income of rural households comparable across countries. The sources of income are crop production, livestock production, apiculture production, self-employment activities, wage employment, transfers (private and public) and other income sources in the last 12 months (Davis et al., 2010; Carletto et al., 2007). It is measured in LCU or TJS.
Poverty status of the household	The variables takes the value 1 if the gross household income per capita is below the national poverty line and zero otherwise
Extreme poverty status of the household	The variables takes the value 1 if the gross household income per capita is below the national extreme poverty line and zero otherwise
Gross income from crop production per capita	It is the sum of the value of sales of crop produce, the value of sales of by-products and the value of own production consumed (production excluding by losses and gifts) in the last 12 months (Davis et al., 2010; Carletto et al., 2007). . It is measured in LCU or TJS.
Gross income from livestock & livestock products (live, slaughter & products) per capita	It is the sum of the value of sales of livestock, the value of sales of slaughtered livestock, the value of sales of by-products, the value of own consumption of slaughtered livestock and the value of own consumption of by-products in the last 12 months (Davis et al., 2010; Carletto et al., 2007). . It is measured in LCU or TJS.
Gross transfers (private and public) per capita	The sum of gross private transfers (remittances, transfers from individuals) and public transfers (pensions, social transfers) (Davis et al., 2010; Carletto et al., 2007). It is measured in LCU or TJS
Household asset index	Index of durable assets calculated using principal component analysis (PCA) and normalized from 0 to 1. Durable assets include chairs, sofas, fans, sewing machines, refrigerators, charcoal stoves, kerosene stoves, electric stoves, radios, cd players, televisions, satellite dishes, solar panels, generators, smart phones, computers and jewellery (Smits and Steendijk, 2015; Kolenikov and Angeles, 2009; Booysen et al., 2008; Filmer and Pritchett, 2001).
Household's agricultural asset index	Index of agricultural assets calculated using PCA and normalized from 0 to 1. Agricultural assets include hand hoes, slashers, axes, saws, knifes, sickles, treadle pumps, hand carts, ox carts, ox ploughs, tractors, tractor ploughs, motorised pumps, mechanical dryers solar dryers, grain mills, poultry houses, livestock enclosures, storage houses, granaries, bicycles, motorcycles, car, lorries and boats (Smits and Steendijk, 2015; Kolenikov and Angeles, 2009; Booysen et al., 2008; Filmer and Pritchett, 2001)..
Housing index	Index of housing assets calculated using multiple correspondence analysis (MCA) and normalized from 0 to 1. Housing assets include wall type of the dwelling, roof type of the dwelling, floor type of the dwelling, number of rooms in the dwelling, type of toilet of the dwelling, and type drinking water of the dwelling (Smits and Steendijk, 2015; Kolenikov and Angeles, 2009; Booysen et al., 2008; Filmer and Pritchett, 2001)..
Livestock assets index (tropical livestock unit)	Index of livestock assets calculated by converting livestock numbers to a common unit (FAO 2011). Livestock assets include number of cattle animals owned (0.55), number of sheep owned (0.1), number of goats owned (0.1), number of horses owned (0.56), number of donkeys owned (0.5), and number of poultry animals owned (0.01).
Productive capacity (SO 1)	
Total value of crop production per ha	The total value of the harvested quantity of cultivated crops, valued at the market price in the last 12 months. Per hectare value is obtained by dividing this value by the total hectares of harvested land. It is measured in LCU or TJS.

Average weight of cattle	Average weight of cattle in kgs owned or kept by the household at the time of interview
Average weight of sheep	Average weight of sheep in kgs owned or kept by the household at the time of interview
Amount of milk production per year	Amount of milk production in litres from the household's cattle herd in the last 12 months
Amount of milk per animal per year	Average amount of milk produced by household's dairy cows in the last 12 months. It is measured in litres/animal
Adoption of livestock rearing activities	A set of indicators capturing whether or not the livestock farmer has used a certain practice in the last 12 months (the variable assumes the value of one if the farmer has practiced it and zero otherwise). The livestock rearing practices assessed include artificial insemination, vaccination/preventive treatment, Amount spent on preventive treatment per head of large ruminants, Amount spent on preventive treatment per head of small ruminants, household feeds cattle in pasture/natural grass in the summer, feeds cattle in standing hay in the summer, feeds cattle in pasture/natural grass in the winter, feeds cattle in standing hay in the winter, feeds cattle in unprotected range land in the summer, feeds cattle in protected range land in the summer, feeds cattle in unprotected range land in the winter, feeds cattle in protected range land in the winter, uses free range housing for cattle in summer, uses confined housing for cattle in summer (e.g. sheds), houses cattle in stalls in winter, cattle mainly drank from boreholes in summer, cattle mainly drank from rivers/springs in summer, cattle mainly drank from standing pipes in summer, cattle mainly drank from boreholes in winter, cattle mainly drank from rivers/springs in winter, cattle mainly drank from standing pipes in winter
Adoption of pasture management activities	A set of indicators capturing whether or not the livestock farmer or the village has used a certain practice in the last 12 months (the variable assumes the value of one if the farmer/village has practiced it and zero otherwise). The pasture management practices assessed include whether household has used ANY pasture in last 12 months, used PUU pasture in last 12 months, follows rotational plan for grazing, duration of grazing before rotation of land (months), paid for pasture usage last 12 months, PUU decides on exploitation of common pasture in village, village leader decides on exploitation of common pasture, village assembly decides on exploitation of common pasture in village, land authority and others decide on exploitation of common pasture in village, village follows rotational plan for pasture land, pasture land left fallow when not grazing in village, pasture land cultivated when not grazing in village, pasture land gets prepared when not grazing in village, reciprocity used to enforce rotational plan in village, village relies on expert assessment of restoration of grazing land, village relies on visual validation of restoration of grazing land
Market access (SO 2)	
Market participation for live livestock	This variable takes the value 1 if household sold livestock alive in the last 12 months and 0 otherwise.
Market participation for meat	This variable takes the value 1 if household sold livestock meat in the last 12 months and 0 otherwise.
Market participation for cattle milk	This variable takes the value 1 if household sold cattle milk in the last 12 months and 0 otherwise.
Market participation for livestock other by-products	This variable takes the value 1 if household sold other livestock-related products (cheese, eggs, or wool), in the last 12 months and 0 otherwise.
Market participation for live livestock or any product	This variable takes the value 1 if household sold livestock alive or any by-product in the last 12 months and 0 otherwise.

Total household value of livestock sales (live animals, slaughtered animals and products)	Total revenues from sales of all livestock activities (live animals, slaughtered animals and livestock by-products) in the last 12 months. It is measured in LCU or TJS.
Market participation for crops	This variable takes the value 1 if household sold crops in the last 12 months and 0 otherwise.
Share of agricultural sales in total agricultural production value	Total value of agricultural sales (in TJS) divided by total agricultural production value (in TJS).
Resilience (SO 3)	
Mean perceived ability to recover from shocks	Self-reported ability to recover from shocks experienced since 2017. Higher value indicates higher ability to recover. The shocks considered include drought, flood, changes in rainy season, crop or livestock disease, difficulty to buy agricultural inputs, difficulty to sell agricultural outputs, illness, accident or death of a household member, loss of employment.
Mean perceived ability to recover from shocks	Self-reported recovery from worst shocks experienced since 2017. This variable takes the value 1 if household recovered from worst shocks (all, climatic shocks, and non-climatic shocks) in the last 12 months and 0 otherwise.
Gross income diversification (Gini Simpson index)	It is equal to 1 - $\sum \alpha_i^2$ where $\alpha_i$is the gross income share from the ith household income source in the last 12 months.
Livestock diversification index (Gini Simpson index)	It is equal to 1 - $\sum \alpha_i^2$ where α_i is the share of total value of owned animals from the ith livestock category in the last 12 months.
Food and nutrition security	
Household dietary diversity score	A 0-12 scale index (from 0 low dietary diversity to 12 high dietary diversity) based on the consumption of 12 food groups in the past week.
Food insecurity experience scale (FIES)	A 0-8 scale index (from 0 full food secure to 8 full food insecure) based on eight questions regarding food insecurity in the last 12 months, also adopted by SDGs (2.1.2).
Food insecurity experience scale raw score SECURE (less than 4 Yes=1 No=0)	This variable takes the value 1 if the FIES of the households was less than 4, and 0 otherwise.
Food insecurity experience scale raw score MODERATE (between 4 and 6 Yes=1 No=0)	This variable takes the value 1 if the FIES of the households was between 4 and 6, and 0 otherwise.
Food insecurity experience scale raw score SEVERE (more than 6 Yes=1 No=0)	This variable takes the value 1 if the FIES of the households was greater than 6, and 0 otherwise.
Women's empowerment (MT)	
Female headed household income and productive capacity	Female headed households' EG and SO1 indicators as described above.
Female participation in decisions on household and agricultural assets	This variable takes the value 1 if a female household member participates in decisions on management of household and agricultural assets and 0 otherwise.
Female participation in livestock and crop activities	A set of indicators capturing whether or not, women within the households participate alone or jointly with men in a given activity. The activities considered are livestock feeding, cattle milking, and cropping.
Social capital	
Household belongs to vibrant PUUs or village organization	A set of indicators capturing whether or not the household belongs to a vibrant PUU or village organization (the variable assumes the value of one if the PUU/village organization achieves the measure and zero otherwise). The features to

	measure vibrancy of PUUs include whether PUU members hold meetings every month or more frequently, at least 50% of PUU members regularly attend meetings, PUU regularly collect membership fees, at least 40% of PUU members regularly pay membership fees

Source: Authors' elaboration

3.3 Impact estimation

We estimate the impact attributable to the LPDP II using non-experimental ex-post methodologies. As discussed earlier, the main challenge is that we cannot observe what would have happened to households if they had not participated in the programme, nor what would have happened to those who did not participate if they had participated. Both LPDP II beneficiary and non-beneficiary households are consistently observed only at the end of the programme. In such situations, the potential outcome framework (Rubin, 1974) is widely adopted by the literature as it estimates the Average Treatment Effect on the Treated (ATET) (Imbens and Wooldrige, 2009). ATET is formally defined as:

$$ATET = E(y_1 - y_0|t = 1) \quad (1)$$

Where *E* is the expectation operator, y is the outcome variable such as income or food insecurity status that would be obtained if the household is treated (y_1) or not treated (y_0) conditional on $t = 1$, which is the treatment or LPDP II beneficiary status indicator. We estimate ATET using the Inverse-Probability-Weighted Regression Adjustment (IPWRA) model.

The IPWRA is a doubly robust estimation approach that models both the outcome and selection equations (Wooldridge, 2007, 2010). This means that if either the outcome or selection model are incorrectly specified (but not both) IPWRA estimates would still be consistent (Imbens and Wooldridge, 2009). The IPWRA uses the inverse-probability weights (IPW) from the estimation of the predicted probability of receiving treatment to account for the missing data problem arising from the fact that each household is only observed in one of the potential outcomes that is as a beneficiary or control household (Hirano et al., 2003). In the case of ATET, the IPW is computed as follows:

$$IPW_{ATET} = t + \frac{p(X)(1-t)}{1-p(X)} \quad (2)$$

Where t and $p(X)$ are defined as:

$$p(X) \equiv \Pr(t = 1|X) = E(t|X) \quad (3)$$

Where $p(X)$ is the estimated propensity score, t is the treatment indicator, which equals one if the community or household is treated or received LPDP II and zero otherwise, X is a matrix of observable characteristics in the treatment model (see section 4.2 for the descriptive analysis of these variables). Thus, $p(X)$ represents the probability that communities or households receive LPDP II conditional on observable characteristics

In equation (2), all treatment households are assigned a weight of one, while control households are weighted by the second term, which means that control households that are more similar to a treatment household (or with higher probability of being treated) are assigned a higher weight. Using the computed IPW, a weighted regression model is then used to estimate the predicted value of the outcome for the treatment and the control group. The regression model is specified as follows:

$$y_i = \alpha + \beta t_i + \gamma X_i + \delta(X_i - E[X_i|t_i = 1])t_i + \varepsilon_i \quad (4)$$

Where y_i is the outcome for household i, t_i is the treatment status for household i, X_i is the matrix of control variables, $E[X_i|t_i = 1]$ is the average values of X_i for the treated sample and γ and sigma are the respective vector of coefficients to be estimated, β is the coefficient of the treatment indicator, α is the constant and ε_i is the error term. The model is estimated using ordinary least squares and

standard errors are clustered at the jamoat level. The control variables in the matrix X_i are factors that are expected to influence the outcome variable, while not having been directly affected by LPDP II. The full list of variables in the outcome equations are presented in Appendix 1. The ATET is then calculated as the difference between the predicted values for the treatment and control groups, as follows:

$$ATET = \hat{y}_1 - \hat{y}_0 \quad (5)$$

Where $\hat{y}_1$ is the average expected outcome for the treatment households, and $\hat{y}_0$ is the average expected outcome for control households obtained from Equation 4.

4. Profile of the project area and sample

4.1 Overview of the study area

As described earlier, both phases of the LPDP project were implemented in the Khatlon region of Tajikistan. According to the latest data by the National Statistics Committee, 26.3 per cent of the population of the country was below the national poverty line in 2019 (World Bank, 2020). Poverty is mainly a rural phenomenon in Tajikistan, with the rural poor accounting for 75 per cent of all poor and 72 per cent of the extreme poor. There are significant regional differences in the incidence of poverty. The nature of the regional differences is based primarily on the different income levels, the cost of living and the overall level of socio-economic development of the various regions. The poverty rate in Khatlon region is among the largest with 32.8 per cent of residents in this region falling below the national poverty line.

Non-income dimensions of poverty have shown limited progress over time. Pressure on public service delivery grew significantly after independence due to rapid population growth and reduced public spending. As a result infrastructure is of poor quality; access to electricity, heating, and safe drinking water is limited; and unofficial payments for services are high and widespread. At the same time many poor households cannot afford to pay for these utilities and the government does not have the resources to maintain these services properly. The social protection system is rudimentary, dominated by old-age and disability pensions with virtually no social assistance. A large part of the payments, where they are collected for water or utilities, are diverted towards discharging Government's social fund liabilities. Low levels of investments in social sectors coupled with poor salary and performance incentives have persuaded many qualified staff to leave in search of better prospective outside the country. Together, these factors have constrained access to education and health services, especially for the poor in rural areas.

4.2 Selected characteristics of sample households and communities

Table 4 provides summary statistics of the relevant matching variables for treatment and control communities and households. Note that most of these variables are measured for baseline (2017) as they determine the initial conditions between the two groups and proxy for the selection criteria of LPDP II villages and households in the Khatlon region. The average calculations are weighted using the IPW weights described in equation (2).

The descriptive analysis results show that treated or LPDP II households tend to have bigger household size with older household heads and owned more durable household assets, agricultural assets, and

better housing quality at baseline than the control group. On the other hand, treated households had lower livestock assets at baseline than the control group. At the village level, the treated villages tend to have better access to weekly output markets, hospitals, banks, and live in more densely populated areas than the control group. On the other hand, control villages have better access to hospitals, secondary schools, agricultural input markets, and butchery services at baseline than LPDP II households. These results suggest that simply comparing the averages of treatment and control households without controlling for these important initial or baseline characteristics will bias the attributable impact estimates of the project.

We estimate the probability that households receive LPDP II conditional on the observable characteristics described in Table 4 (see also equation 3). We then check the overlap between the estimated probabilities of treated and control households before and after matching each treated household with their nearest-neighbour control household in terms of these propensity scores. The results are presented in a chart in Appendix 2 and show remarkable overlap between treated and control households' chances of being included in the project especially after matching. As noted earlier, the IPWRA uses the inverse-probability weights (IPW) from the estimated predicted probability of receiving treatment to account for the fact that each household is only observed in one of the potential outcomes as a beneficiary or non-beneficiary comparison household.

Table 4: Descriptive statistics of matching variables for treatment and control households.

Matching variables	Treated		Control		Difference (T-C)
	Mean	Obs.	Mean	Obs.	
Household Size	6.85	728	6.01	738	0.83***
Female headed household	0.13	728	0.14	737	-0.00***
Age of head in 2017	52.93	728	49.82	737	3.11***
Tropical Livestock Units (TLU) at baseline	2.09	728	2.37	737	-0.28***
Durable household asset index (PCA) at baseline (normalized 0 to 1)	0.29	728	0.22	738	0.07***
Household's agricultural asset index (PCA) at baseline (normalized 0 to 1)	0.25	728	0.21	738	0.05***
Housing assets index (MCA) at baseline (normalized 0 to 1)	0.77	728	0.64	738	0.13***
Vehicles access main road all year in the village at baseline (Yes=1 No=0)	0.85	728	0.84	658	0.02***
Distance (km) to weekly market from village baseline	10.06	728	13.45	658	-3.39***
Village has secondary school at baseline (Yes=1 No=0)	0.90	728	0.97	658	-0.07***
Village has hospital at baseline (Yes=1 No=0)	0.56	728	0.31	658	0.25***
Village has bank at baseline (Yes=1 No=0)	0.20	728	0.02	658	0.19***

Village has agricultural input market at baseline (Yes=1 No=0)	0.10	728	0.27	658	-0.17***
Village has butchery at baseline (Yes=1 No=0)	0.29	728	0.53	658	-0.24***
Quality of livestock water in the village is at least average at baseline (Yes=1 No=0)	0.75	728	0.77	658	-0.02***
Share of households in the village owning land	66.38	728	78.58	658	-12.20***
Average population density in 1000 square meter in 2014/16	18432.08	728	8620.95	738	9 811.13***

Note: Columns (2) and (4) report the mean in the sample for treated and control households, columns (3) and (5) report the number of observations for each variable, and column (6) reports the difference between treated and control households' averages. The sample is weighted using IPW analytical weights. The asset variables are as described in Table 4. Asterisks indicate the level of statistical significance from the t-test of mean differences: * < 0.10; ** < 0.05; *** < 0.01.

5. Results

In section 5, we discuss the estimated attributable impacts of LPDP II on indicators presented in Table 4, as well as other outcome indicators that help us investigate the channels through which the impacts may have been realized. The attributable impact estimates were generated from the IPWRA model discussed in section 3.3.

To facilitate interpretation, we report the magnitude of the impact in per cent or percentage point change[6] and the potential outcome mean (POM). POM represents what the treated or beneficiary households would have had if they had not benefited from the programme.[7] Each table includes four columns: the first column shows the key indicators we are estimating, that is the outcome indicators, the second column reports the estimated impact of the programme (ATET) on the beneficiaries for each corresponding indicators in column one, the third column reports the POM and the fourth column the number of observations. All annual values estimated refer to the agricultural production season that runs from September 2020 to October 2021, which is roughly after 3 years of interventions. Monetary values are in local currency values (Tajikistani Somoni or TJS). We also discuss the USD equivalent of the impacts where applicable. We note also that ATET captures the average impact of LPDP II assuming largely similar type and intensity of interventions on the beneficiary population. Finally, non-beneficiary households are the comparison group (i.e. a control group in an experimental design) representing what beneficiary households would have been like if they had not benefited from LPDP II.

[6] The interpretation of the ATET coefficient has to take into account the different construction of the impact variable. When the impact variable is the logarithmic transformation of a continuous variable (e.g. monetary value or litres of milk), the ATET coefficient is interpreted as per cent change of $[\exp(ATET) - 1] * 100$. When the impact variable is a binary variable that assumes the value of one or zero (e.g. one if the household used an input and zero otherwise), the ATET coefficient is interpreted as the change in percentage points, i.e. the percentage difference between the treated group and the control group. When the impact variable is a score or index value, the ATET coefficient is divided over the potential outcome mean to convert the impact into per cent change.

[7] The POM value could be different from the weighted means of both treated and control groups because the variable on which POM is calculated can be logarithmic transformed and POM is estimated by considering a set of control variables that might affect the outcome.

a) Economic goal: Household income and assets

The ultimate goals of LPDP II include increased household income and asset ownership and reduction in poverty in Khatlon region of Tajikistan. We assess the impact on the economic goal through the total annual gross income per capita and annual gross livestock and crop income per capita (value of sales and home consumption), agricultural and non-agricultural wage income per capita, ownership of livestock, durable and productive assets, and housing quality. We present the impact for these indicators in Table 5.

LPDP II increased gross livestock income per capita of beneficiary households by 109.6 per cent compared to the control group.[8] This means an increase by approximately 465 TJS per person (equivalent to US$41.2). These results are similar to the IA results for LPDP I in that both phases of the project significantly increased gross livestock incomes (Cavatassi and Mallia, 2018). The estimated impacts on the total gross income per capita and poverty rates are not statistically significant. This shows that the increase in livestock income, which is the main source of income targeted by LPDP II representing around 33 per cent of total income among livestock herders (see Figure A3.1 in the appendix for the share of gross income across different sources), is not entirely reflected in the total income. This is possibly the result of substitution effect on income sources and a larger timeline needed to translate into total income increase. Nonetheless, the first phase of LPDP significantly increased gross income of beneficiary households (Cavatassi and Mallia, 2018) in nearby jamoats and for beneficiaries that received about five years of benefits from LPDP.

Looking at determinants of income, it is shown that LPDP II participants had about 44 per cent lower transfer incomes from remittances as well as from public transfers (e.g. social protection) than the comparison group.[9] The reduced transfers are clearly contributing to the insignificant impact of LPDP II on total income for beneficiaries despite the high positive impact on livestock income.

Another key outcome indicator for the project is represented by livestock assets, which we measure through the Tropical Livestock Units (TLU)[10]. The project aimed at reducing the ecological footprint of livestock herd whilst increasing livestock productivity, which implies higher amount of milk and larger livestock weight with less livestock inventory or TLU. When looking at the TLU, we found that it declined by 29 per cent as a result of participation in LPDP II for beneficiaries compared to the comparison group.

The negative impacts on livestock assets or herd size as measured by TLU suggest that the project has been successful in reducing livestock herds and their ecological footprint. In the next sub-section, we will see whether this is achieved while also increasing livestock productivity, in addition to increased livestock income.

The decreasing herd size of the beneficiary households suggests that treatment villages were able to overcome the "tragedy of commons" situation that arises when the direct benefits from livestock activities are privatized or internalized while the concomitant environmental costs are externalized to the public. This could be achieved through better adherence to the rules set by PUUs in treatment villages such as pasture rotations and control over the size of the grazing stock to better manage and rehabilitate common pastures. Indeed, the Project Completion Report (PCR) of the project states that awareness raising around the effects of overgrazing and climate change together with the other components of the project may have contributed this result (IFAD, 2022).

[8] There is no difference between the impact on total and per capita values in ATET. Therefore, we only report per capita impact.

[9] see Figure A3.2 in the appendix for the share of transfer income from private and public sources by treatment status.

[10] TLU, or Tropical Livestock Units are livestock numbers converted to a common unit. The assets include number of cattle, sheep, goats, horses, donkeys, and poultry owned. See Table 4 for description of all the outcome variables.

Impacts on other outcomes such as agricultural assets, household durables, housing quality, income from crop production, and agricultural and non-agricultural wages are not statistically significant. These results are in contrast to the IA estimates for LPDP I where Cavatassi and Mallia (2018) found positive impacts on household and livestock assets and suggest an interesting trend of project implementation towards a higher and more effective awareness and impact on the environmental indicators.

The results in Table 6 also show that beneficiary households are just as likely to receive incomes from livestock, agricultural and non-agricultural wages, and self-employment as the comparison group (i.e. indicators not significantly different across the two groups). Beneficiary households are 18 percentage points more likely to receive transfers compared to the comparison group. However, as we saw from Table 5, among transfer recipients, beneficiaries receive 44 per cent less amount of transfers per capita than the comparison group.

Table 5: LPDP II impacts on Economic Goal (EG)

	ATET (%)	PO mean	Nb. of obs.
OG-Economic mobility and income			
Gross income per capita	-7.69	3327.58	1,398
Household is poor (Yes=1 No=0)	0.07	0.28	1,398
Household is extremely poor (Yes=1 No=0)	0.08	0.20	1,398
Gross livestock income per capita	109.59**	424.11	1,069
Gross crop income per capita	27.12	454.86	752
Agricultural wages per capita	-72.75	4964.16	163
Non-agricultural wages per capita	191.54	658.52	687
Gross self-employment income per capita	-35.6	1510.2	244
Gross transfers (private and public) per capita	-44.01**	1199.91	897
Livestock assets index (TLU)	-29.43*	3.33	1,398
Durable household asset index (PCA)	-10.71	0.28	1,398
Household's agricultural asset index (PCA)	18.52	0.27	1,398
Housing asset index (MCA)	-5.75	0.87	1,398

Note: Impacts are reported in per cent change and are estimated using IPWRA regressions with standard errors clustered at Jamoat level, including covariates as described in Appendix 3. POM indicates the potential outcome beneficiary households would have had if they had not benefited from the programme and it is expressed in the outcome's original unit. Monetary values are expressed in LCU (TJS). The poverty and extreme poverty lines were calculated using data from Statistical Agency under President of the Republic of Tajikistan (2019). The extreme poverty line is calculated using the minimum expenditure needed to cover basic food consumption while the poverty line considers both basic food and non-food expenditures. Asterisks indicate the level of statistical significance: * at 10 per cent; ** at 5 percent; *** at 1 per cent.

Table 6: LPDP II impacts on probability of receiving income from different sources

	ATET (%)	PO mean	Nb. of obs.
OG-Economic mobility and income (extensive margin)			
Household has income from agricultural wages (Yes=1 No=0)	0.03	0.1	1,398
Household has income from non-farm wage (Yes=1 No=0)	0.00	0.49	1,398
Household has income from livestock (Yes=1 No=0)	-0.03	0.82	1,398
Household has income from self-employment (Yes=1 No=0)	-0.16	0.36	1,398
Household has income from transfers (private or public) (Yes=1 No=0)	0.18*	0.48	1,398

Note Impacts are reported in percentage point change and are estimated using IPWRA regressions with standard errors clustered at Jamoat level, including covariates as described in Appendix 3. POM indicates potential outcome beneficiary households would have had if they had not benefited from the programme and it is expressed in proportion. Asterisks indicate the level of statistical significance: * at 10 per cent; ** at 5 per cent; *** at 1 per cent.

b) Strategic objective one (SO1): Productive capacities

We assess the impact on SO1 through average weight of livestock (also differentiated by type) kept by the household, milk production and productivity, value of other livestock by-products, and value of crop production per hectare. We then discuss potential impact channels using two categories of indicators (i) adoption of livestock breeds and rearing practices; and (ii) adoption of pasture management practices.

(i) Livestock and crop production and productivity

The second objective of LPDP II was to enhance livestock productivity and improve animal health as a result of the adoption of animal husbandry and management practices, pasture management and feed preparation, and access to private veterinary services. We present the impact for livestock production and productivity in Table 7.

The aforementioned increase in livestock income is associated with a remarkable rise in the productivity of cattle among LPDP II beneficiaries as shown in Table 7. This was one of the key objectives of the project. Notably, the average weight of cattle per animal is 30 per cent higher for beneficiaries compared to the control group, which is equivalent to around 44 kg per animal. Similarly, cattle kept by households in the treatment group had more total milk production and productivity than households in the control group. Beneficiary households' annual milk production from the cattle herd increased by 120 per cent (around 531 liters) compared to the control group. Similarly, annual milk productivity increased by around 99 per cent (around 352 liters per animal) for LPDP II beneficiaries. These results appear to have reversed the negative impacts on milk production and productivity found for the first phase of LPDP (Cavatassi and Mallia, 2018) indicating an interesting learning trend over time.

We did not find significant impact on average weight of sheep while the average weight of goats decreased by 42 per cent among LPDP II beneficiaries. Note, however, that only less than 10 per cent of treated and control households keep goats and goats are not the focus of LPDP II interventions. We also do not find significant impact on value of crop production per hectare. For LPDP I, overall adult ruminants were significantly higher in weight in the beneficiary group than in the comparison group for cattle, goats and sheep, whereas the opposite is true for young animals (Cavatassi and Mallia, 2018).

Table 7: LPDP II impacts on production and productivity (SO1)

	ATET (%)	PO mean	Nb. of obs.
SO1-Productive capacity			
Average weight of cattle (kg)	29.69***	145.47	1,250
Average weight of sheep (kg)	-10.42	46.53	207
Average weight of goat (kg)	-42.31**	47.94	94
Amount of milk production per year (liters)	120.34*	441.42	900
Amount of milk per animal per year (liters)	99.37**	354.25	903
Value of livestock by-products (excluding milk)	-77.24	487.85	228
Total value of crop production per ha	0.09	3165.29	759

Note: Impacts are reported in per cent change and are estimated using IPWRA regressions with standard errors clustered at Jamoat level, including covariates as described in Appendix 3. POM indicates the potential outcome beneficiary

households would have had if they had not benefited from the programme and it is expressed in the outcome's original unit. Monetary values are expressed in LCU (local currency unit or Somoni). Asterisks indicate the level of statistical significance: * at 10 per cent; ** at 5 percent; *** at 1 per cent.

(ii) Impact Channels: Adoption of livestock breeds and rearing practices

The impacts on production have been facilitated partly through the promotion of animal husbandry and management practices. In this section, we present the impacts on adoption of specific livestock breeds and rearing practices in Tables 8 and 9 respectively.

LPDP II activities did not influence adoption of most livestock breeds among beneficiary households compared to the control group (Table 8). The only exception is the black motley breed cattle that was found to be 10 per cent points more likely to be raised by LPDP II households. Gissarian breed sheep, which is more resilient to harsher environments, was also promoted by the project but we did not find significant impact on uptake of this breed perhaps because of limited availability. The results in Table 8 suggest that the type of livestock breed raised did not mediate the positive impacts on production and livestock income.

Table 8: LPDP II impacts on adoption of livestock breeds

	ATET (%)	PO mean	Nb. of obs.
Adoption of different livestock breeds			
Owns black motley breed cattle (Yes=1 No=0)	0.1***	0.02	1,251
Owns Tajik breed cattle (Yes=1 No=0)	-0.12	0.75	1,267
Owns Gissarian breed sheep (Yes=1 No=0)	0.03	0.25	207
Owns Tadzhik breed sheep (Yes=1 No=0)	-0.04	0.75	207
Owns Tajik breed goat (Yes=1 No=0)	-0.17	0.9	94

Note: Impacts are reported in percentage point change and are estimated using IPWRA regressions with standard errors clustered at Jamoat level, including covariates as described in Appendix 3. POM indicates potential outcome beneficiary households would have had if they had not benefited from the programme and it is expressed in proportion. Asterisks indicate the level of statistical significance: * at 10 per cent; ** at 5 per cent; *** at 1 per cent.

The impact estimates in Table 9 show that cattle keepers in the treatment group were 18 per cent more likely to use preventive treatment (especially vaccinations) and spend 46 per cent lower per cattle for this treatment. Similarly, Cavatassi and Mallia (2018) found significantly higher percentage of animals vaccinated or cured among LPDP I households.

We also found that LPDP II households are 21 percentage points less likely to practice artificial insemination to reproduce livestock. This low demand by beneficiaries was also reflected in the 2020 LPDP II supervision report (IFAD, 2021). This low or even negative demand does not seem to have been addressed. The IA results for LPDP I show that beneficiaries were more likely to adopt controlled mating to improve animal species (Cavatassi and Mallia, 2018).

Regarding livestock feeding, LPDP II households are 21 percentage points more likely to feed their livestock from protected rangeland in the summer and 13 percentage points less likely to rely on unprotected rangeland during the winter due to their participation in LPDP II. During wintertime, beneficiary households are 23 percentage points more likely to use stalls to house their livestock. This could contribute to weight maintenance or even gain during winter as the herd for beneficiaries expend less calories and fat to maintain body temperature in the cold season compared to living outside. For LPDP I, Cavatassi and Mallia (2018) found no impact on use of fodder whereas beneficiaries are more likely to have their livestock graze on their own land in the summer.

Regarding livestock drinking, the results in Table 9 show that LPDP II beneficiaries are 17 and 19 percentage points more likely to water cattle from boreholes and standing pipes respectively. These are relatively safer and healthier water sources for livestock. As a result, beneficiaries are 32 percentage points less likely to use rivers and springs during winter, which are less healthy. Cavatassi and Mallia (2018) found similar impact estimates for LPDP I where project beneficiaries had better access to closer and safer water points than non-beneficiaries.

These results suggest that the project succeeded in enhancing livestock productivity and livestock income partly through increased access to preventive treatment, feeding, housing, and water points. These were all activities promoted by both phases of the project.

Table 9: LPDP II impacts on livestock rearing practices

	ATET (%)	PO mean	Nb. of obs.
Artificial insemination, livestock disease, death, and treatment			
Household practices artificial insemination (Yes=1 No=0)	-0.21***	0.22	1,307
Cattle suffer any disease in the last 12 months (Yes=1 No=0)	-0.05	0.17	1,307
Cattle received vaccination/preventive treatment in the 12 months (Yes=1 No=0)	0.18**	0.55	1,278
Livestock suffer any disease in the last 12 months (Yes=1 No=0)	-0.07	0.20	1,360
Livestock suffer any death in the last 12 months (Yes=1 No=0)	0.02	0.06	1,362
Livestock received vaccination/preventive treatment in the last 12 months (Yes=1 No=0)	0.13*	0.6	1,360
Amount spent on preventive treatment per head of large ruminants (cattle)	-45.66*	28.22	828
Amount spent on preventive treatment per head of small ruminants (sheep and goats)	-36.87	9.3	343
Livestock feeding			
Household feeds cattle in pasture/natural grass in the summer (Yes=1 No=0)	0.09	0.63	1,307
Household feeds cattle in standing hay in the summer (Yes=1 No=0)	-0.10	0.36	1,307
Household feeds cattle in pasture/natural grass in the winter (Yes=1 No=0)	-0.39**	0.47	1,307
Household feeds cattle in standing hay in the winter (Yes=1 No=0)	0.05	0.24	1,307
Household feeds cattle in protected range land in the summer (Yes=1 No=0)	0.21**	0.03	1,307
Household feeds cattle in unprotected range land in the winter (Yes=1 No=0)	-0.13*	0.2	1,307
Household feeds cattle in protected range land in the winter (Yes=1 No=0)	-0.04	0.08	1,307
Household uses free range housing for cattle in summer (Yes=1 No=0)	0.03	0.29	1,307
Livestock housing			
Household uses confined housing for cattle in summer (e.g. sheds) (Yes=1 No=0)	-0.03	0.71	1,307

Household houses cattle in stalls in winter (Yes=1 No=0)	0.23***	0.7	1,307
Livestock drinking			
Household's cattle mainly drank from boreholes in summer (Yes=1 No=0)	0.11	0.10	1,307
Household's cattle mainly drank from rivers/springs in summer (Yes=1 No=0)	-0.17	0.54	1,307
Household's cattle mainly drank from standing pipes in summer (Yes=1 No=0)	0.07	0.20	1,307
Household's cattle mainly drank from boreholes in winter (Yes=1 No=0)	0.17**	0.05	1,307
Household's cattle mainly drank from rivers/springs in winter (Yes=1 No=0)	-0.32**	0.52	1,307
Household's cattle mainly drank from standing pipes in winter (Yes=1 No=0)	0.19**	0.2	1,307

Note: Impacts are reported in per cent change if the variables are continues (e.g. amount spent on preventive treatment) and in percentage point change for dummy variables (e.g. Livestock suffer any disease in the last 12 months (Yes=1 No=0)). Impacts are estimated using IPWRA regressions with standard errors clustered at Jamoat level, including covariates as described in Appendix 3. POM indicates the potential outcome beneficiary households would have had if they had not benefited from the programme and it is expressed in the outcome's original unit. Monetary values are expressed in LCU (local currency unit or Somoni). Asterisks indicate the level of statistical significance: * at 10 per cent; ** at 5 percent; *** at 1 per cent.

(iii) Impact Channels: Adoption of pasture management practices

In addition to livestock rearing activities discussed so far, LPDP II also promoted community resilient pasture management and investments by addressing issues of degradation of pasture resources and deterioration of pasture infrastructure. To achieve this, various interventions took place including pasture rotations to regulate intensive grazing, sowing of forage crops, and planting shrubs and trees to increase vegetation cover and make pastures resilient to climate change and soil degradation. These were all activities pertaining to the third component of LPDP II and received ASAP funding.

We present the attributable impacts on adoption of pasture management practices in Table 10. The results show that livestock farmers in the treatment group are 16 percentage points more likely to use pastures to feed their livestock and especially PUU managed pastures (42 percentage points) compared to the control. Treatment villages are 52 percentage points more likely to follow rotational plans but we did not find significant impacts on duration of grazing between rotations. LPDP II villages are also 48 percentage points less likely to rely on reciprocity to enforce rotational plan in the village. The fact that they are less likely to resort to punitive measures on those that did not follow the rotational plan is also beneficial to increase social capital and cohesion in treatment villages.

The results in Table 10 also show that the village assembly is 27 percentage points less likely to decide on exploitation of common pastures in the treatment villages while they are 9 percentage points more likely to rely on land authorities and owners to set the usage parameters compared to the control villages. When common pastures are not grazed, or are rested, treatment villages are 13 percentage points more likely to work to restore them from degradation and prepare them for future grazing compared to the control group. Treatment villages are also 29 percentage points more likely to rely on visual validation of restoration of pastures and, therefore, 26 percentage points less likely to depend on expert assessment of pasture restorations before resuming grazing on common pastures. This is perhaps because the PUU members in LPDP II villages were trained to independently assess restoration of grazing land. We also assessed if the pasture restoration efforts of degraded land have any effect on objective GIS measures of vegetation as captured by the maximum normalized difference vegetation index (or NDVI) at the village level for the top three green months of 2020. We

did not find attributable impacts of the project on maximum NDVI in 2020 (Table 10). Cavatassi and Mallia (2018) found similar results on NDVI for LPDP I.

Table 10: LPDP II impacts on pasture management practices and vegetation index

	ATET (%)	PO mean	Nb. of obs.
Pasture management			
Household has used ANY pasture in last 12 months (Yes=1 No=0)	0.16*	0.52	1,398
Household has used PUU pasture in last 12 months (Yes=1 No=0)	0.42**	0.48	841
Village follows rotational plan for pasture land (Yes=1 No=0)	0.52***	0.34	1,398
Duration of grazing before rotation of land (months)	29.69	1.58	1,268
Reciprocity used to enforce rotational plan in village (Yes=1 No=0)	-0.48***	1.0	1,398
Household paid for pasture usage last 12 months (Yes=1 No=0)	0.15	0.61	843
PUU decides on exploitation of common pasture in village (Yes=1 No=0)	0.11	0.56	1,398
Village leader decides on exploitation of common pasture (Yes=1 No=0)	-0.06	0.37	1,398
Village assembly decides on exploitation of common pasture in village (Yes=1 No=0)	-0.27**	0.62	1,398
Land authority and others decide on exploitation of common pasture in village (Yes=1 No=0)	0.09**	0	1,398
Pasture land left fallow when not grazing in village (Yes=1 No=0)	-0.18	0.80	1,398
Pasture land cultivated when not grazing in village (Yes=1 No=0)	0.09	0.15	1,398
Pasture land gets prepared when not grazing in village (Yes=1 No=0)	0.13**	0.00	1,398
Village relies on expert assessment of restoration of grazing land (Yes=1 No=0)	-0.26***	0.6	1,398
Village relies on visual validation of restoration of grazing land (Yes=1 No=0)	0.29***	0.32	1,398
Average maximum normalized difference vegetation index (NDVI) for the top 3 months in 2020	-1.98	2344.9	1,398

Note: Impacts are reported in percentage point change and are estimated using IPWRA regressions with standard errors clustered at Jamoat level, including covariates as described in Appendix 3. POM indicates potential outcome beneficiary households would have had if they had not benefited from the programme and it is expressed in per cent. Asterisks indicate the level of statistical significance: * at 10 per cent; ** at 5 per cent; *** at 1 per cent.

These are remarkable achievements and correspond to the project's theory of change described earlier. Over the life and phases of LPDP, training and support towards achieving productivity objectives aligned with environmental objectives. These include pasture rotation to restore degraded pasture ecosystem and increase carbon sequestration through reduced grazing and sustainable pasture management thanks to rotational plans. These activities strengthened during LPDP II and became a key focus of the project to the extent that the project became part of the Adaptation for Smallholder Agriculture Programme (ASAP) funding for adaptation to climate change.

c) Strategic objective two (SO2): Access to markets

We assess the impact on SO2 through whether LPDP II beneficiaries have higher access to different livestock markets (live animals, meats, milk, and other by-products) and the value and share of livestock and agricultural sales. It is important to note, however, that the theory of change as well as implementation of the project in both phases has not focused on improving the commercialization potential of beneficiary households to be engaged in livestock output markets. We nevertheless assess the impact on access to markets as it is an important strategic objective of IFAD and a potential learning opportunity for future projects of this type.

We present the impact on market access indicators in Table 11. While the project generated increased livestock income and productivity (see sections 5.a and 5.b), it did not increase market access to livestock sold alive or for livestock by-products such as milk and eggs. In fact, we found that LPDP II households had 12 percentage points less access to livestock meat markets than the control group. As a result, the total value of livestock sales is not different between LPDP II beneficiaries and the comparison group. However, the results in Table 11 also show that LPDP II households are 19 percentage points more likely to sell crops than the comparison group. The results also show that in the absence of LPDP II (the Po mean column), only about 32 per cent of beneficiaries would have sold livestock alive in the last year. In addition, only 6 per cent of beneficiaries would have milk in the market with or without LPDP II. These results underscore the fact that the project has not promoted market-oriented livestock production. Cavatassi and Mallia (2018) found similar results for LPDP I where access to markets as measured by the number of transactions was similar between treated and non-treated households.

Table 11: LPDP II impacts on market access (SO2)

	ATET (%)	PO mean	Nb. of obs.
SO2-Market access			
Market participation for live livestock (Yes=1 No=0)	0.04	0.32	1,398
Market participation for meat (Yes=1 No=0)	-0.12**	0.13	1,398
Market participation for cattle milk (Yes=1 No=0)	0.01	0.06	905
Market participation for livestock other by-products (Yes=1 No=0)	-0.03	0.5	228
Market participation for live livestock or any product (Yes=1 No=0)	-0.04	0.47	1,398
Total household value of livestock sales (live animals, slaughtered animals and livestock products)	330.6	796.32	578
Market participation for crops (Yes=1 No=0)	0.19**	0.15	759
Share of agricultural sales in total agricultural production value	700	0.01	773

Note: Impacts are reported in per cent change if the variables are continues (e.g. Share of agricultural sales in total agricultural production value) and in percentage point change for dummy variables (e.g Market participation for live livestock (Yes=1 No=0)). Impacts are estimated using IPWRA regressions with standard errors clustered at Jamoat level, including covariates as described in Appendix 3. POM indicates the potential outcome beneficiary households would have had if they had not benefited from the programme and it is expressed in the outcome's original unit. Monetary values are

expressed in LCU (local currency unit or Somoni). Asterisks indicate the level of statistical significance: * at 10 per cent; ** at 5 percent; *** at 1 per cent.

d) Strategic objective three (SO3): Resilience

The LPDP II project aimed at improving the resilience capacity of beneficiary households to climate change related shocks such as droughts and frost through ASAP supported and related activities. In particular, greater resilience to weather shocks was expected as a result of restoration of degraded pasture resources and infrastructure, adequate access to livestock feeding, drinking, and housing, and adoption of climate-resilient livestock breeds.

Other factors can also affect the resilience capacity of farmers. In the absence of formal markets for risk management, income and livestock diversification strategies are integral parts of adaptation measures to cope with shocks. Indeed, LPDP through both phases aimed to support farmers in this way. Livestock diversification increases the resilience capacity of farmers in several ways including by increasing the probability of raising the best-adapted livestock for a given environment, adapting to climatic conditions, help reduce intensive grazing, and to mitigate the effect of livestock disease. Livestock diversification can also reduce the temporal and physical requirement of labour, the exposure of farmers to price volatility affecting individual livestock products, and input expenditure through economies of scale. In the same way, income diversification enables rural households to cope with adverse shocks (Alfani et al. 2021; Arslan et al., 2018).

We present the impact on resilience indicators in Table 12. Beneficiary households' ability to recover from any type of shocks experienced since 2017 is not statistically different from the control group. When looking separately at the type of shock experienced, namely, economic- or climate-related, we find that only 11 per cent of beneficiaries have experienced climatic shocks compared to 22 per cent of non-beneficiaries. As a result, thanks to LPDP II beneficiary households are 27 percentage points less likely to report experiencing weather shocks compared to the control group. Of the shocked households, however, LPDP II households are 76 percentage points less likely to recover from the worst climatic shocks such as droughts, frost, and flooding. These results suggest that the project may have prevented noticeable climatic shocks from affecting treated households in the first place compared to the control group. This is likely linked to beneficiaries being better adapted to climate change thanks to better access to water points, veterinary services, and technical support. The perception of households that suffer climate related shocks to be less able to recover than the comparison group may also indicate a different level of awareness triggered by training and technical support.

We also did not find significant impacts of LPDP II on resilience to non-climatic weather shocks, which includes economic (e.g. loss of income, low demand for livestock products), health (e.g. death or illness of household member), livestock disease, among others. For LPDP I, Cavatassi and Mallia (2018) found generally increased income and assets for climate shocked (i.e. drought and frost) and non-climate shocked (i.e. economic and crop disease) beneficiary households compared to similarly shocked control group.

LPDP II also did not lead to a rise in households' diversification in livestock activities, as reported in Table 12. Treated households raise similar number of livestock types compared to control households. Diversification of income sources is similarly unaffected by the project. This is in contrast to LPDP I where treated households were significantly more diversified than control households (Cavatassi and Mallia, 2018).

Table 12: LPDP II impacts on resilience (SO3)

	ATET (%)	PO mean	Nb. of obs.
SO3-Resilience			
Household experienced any shock (Yes=1 No=0)	-0.19	0.73	1,398
Household experienced climatic shock (drought/flood/frost) (Yes=1 No=0)	-0.27**	0.37	1,398
HH experienced non-climatic shock (economic/health/conflict etc) (Yes=1 No=0)	0.07	0.36	1,398
Ability to recover from all shocks	-1.87	2.67	707
Ability to recover from climatic shocks	-43.75	3.2	139
Ability to recover from non-climatic shocks	-6.40	2.97	561
Household recovered from worst shock (Yes=1 No=0)	-0.07	0.42	750
Household recovered from worst climatic shock (Yes=1 No=0)	-0.76**	0.85	171
Household recovered from worst non-climatic shock (Yes=1 No=0)	-0.1	0.53	596
Livestock diversification (Gini Simpson index)	11.76	0.17	1,398
Gross income diversification (Gini Simpson index)	-15.38	0.52	1,398

Note: Impacts are reported in per cent change if the variables are continues (e.g. livestock diversification) and in percentage point change for dummy variables (e.g HH recovery from worst shock (Yes=1 No=0)). Impacts are estimated using IPWRA regressions with standard errors clustered at Jamoat level, including covariates as described in Appendix 3. POM indicates the potential outcome beneficiary households would have had if they had not benefited from the programme and it is expressed in the outcome's original unit. Monetary values are expressed in LCU (local currency unit or Somoni). Asterisks indicate the level of statistical significance: * at 10 per cent; ** at 5 percent; *** at 1 per cent.

e) Food and nutrition security (MT)

Increasing food and nutrition security of beneficiary households was the ultimate goal of LPDP II along with income and asset ownership. We present the impact on food security and nutrition indicators in Table 13.

The results suggest that LPDP II had no impact on household food security or dietary diversity. The food insecurity experience scale (FIES) does not significantly differ between treated and control households. To further understand what is happening in this domain, we created 3 binary variables to categorize households among those with limited food insecurity (binary variable FIES score "SECURE", households with FIES less than 4), those with moderate food insecurity (binary variable FIES score "MODERATE", households with FIES between 4 and 6) and those with severe food insecurity (binary variable FIES score "SEVERE", households with FIES more than 6). The results in Table 13 shows that the project did not have significant impact on the likelihood of being in any of the food insecurity categories. We note, however, that the vast majority of LPDP II households (92 per cent) are food secure even in the absence of LPDP II (see PO mean column).

We also found that though the impact on dietary diversity is insignificant, beneficiary households would have consumed more than 8 of the 12 food groups (cereals, tubers, vegetables, etc) even in the absence of the project. These results indicate positive situation for the communities overall. These results, together with the limited market participation results, also suggest that livestock farmers in the project areas rely on home production and consumption of food.

Regarding LPDP I, beneficiary households were significantly less food secure and diversified in their dietary intakes than control households despite positive impacts on all measure of economic mobility. Impacts on anthropometrics show, however, that LPDP I had positive impacts on children's growth with regard to height, but not on weight for height and BMI (Cavatassi and Mallia, 2018).

Table 13: LPDP II impacts on food and nutrition security (MT)

	ATET (%)	PO mean	Nb. of obs.
Food security			
Household dietary diversity score based on 7 day recall (HDDS)	1.19	8.38	1,398
Food insecurity experience scale raw score (FIES)	11.43	1.4	1,384
Food insecurity experience scale raw score SECURE (less than 4 Yes=1 No=0)	-7.61	0.92	1,398
Food insecurity experience scale raw score MODERATE (between 4 and 6 Yes=1 No=0)	233.3	0.03	1,398
Food insecurity experience scale raw score SEVERE (more than 6 Yes=1 No=0)	-75	0.12	1,398

Note Impacts are reported in percentage or percentage point change and are estimated using IPWRA regressions with standard errors clustered at Jamoat level, including covariates as described in Appendix 3. POM indicates potential outcome beneficiary households would have had if they had not benefited from the programme and it is expressed in per cent. Asterisks indicate the level of statistical significance: * at 10 per cent; ** at 5 per cent; *** at 1 per cent.

f) Women's empowerment (MT)

Promoting gender equality and women's empowerment in rural areas is one of the key objectives of IFAD.[11] Women headed households and women belonging to poor households were among the primary target groups of the project (IFAD, 2021). Out of the almost 50 thousand households reached by the project, women headed 8 per cent. By the end of 2020, LPDP II established 135 Women Income Generating Groups (WIGGs) with a total membership of 914 women. These WIGGs were involved in milk production and marketing, turkey breeding, beekeeping, cultivation and processing of rosehip among others. In addition to this, all PUU boards in LPDP II villages had maintained a minimum of 30 per cent women among their members. As a result, they were direct recipients of PUU capacity building activities supported by the project through workshops and training sessions.[12]

We present the impact on women's empowerment in Table 14. The results show that women headed households in the treatment group have much higher livestock income (661 per cent), crop income (114 per cent), milk production per year (19 per cent), milk production per animal per year (12 per cent), and total annual value of livestock sales (80 per cent) compared to women headed households in the control group. Within LPDP II households, male only members are 23 percentage points more likely to feed livestock compared to control households. As a result, joint female and male responsibilities of feeding livestock are 38 percentage points less likely in LPDP II households compared to the control group. Men household members in the treatment group are also 19 percentage points more likely to make decisions on management of household and agricultural assets than female members vis-à-vis the control group. These results suggest that LPDP II was successful in significantly

[11] IFAD gender equality and women's empowerment policy comprises three dimensions: economic empowerment to enable both rural women and men to participate in and benefit from profitable economic activities (economic empowerment); both women and men have equal voice and influence in rural institutions and organizations, including decision making processes at the household, community, or local level (voice and decision-making); and a more equatable balance workloads and in the sharing of economic and social benefits between women and men (equitable workloads). IFAD policy on gender equality and women's empowerment is available at https://www.ifad.org/en/-/document/ifad-policy-on-gender-equality-and-women-s-empowerment-new.

[12] The topics of these sessions include "Development of Community Livestock and Pasture Management Plan", "Pasture Management", "Use of innovative devices called Groasis Waterboxx", "Livestock breeding, Health and Foddering", "Financial Management and Sustainability of PUUs" and "Entrepreneurship Development" (IFAD,2021).

increasing the economic outcomes and productive capacities of women headed households compared to the control group. When considering all households, however, we found that female members in the treatment group have less agency or decision power over household owned assets compared to the control group.

For LPDP I, women beneficiaries had significantly higher decision-making roles than control households with regards to breeding and on management of agricultural earnings. Women-headed households in the beneficiary groups also reported higher livestock income and livestock assets as measured by TLU (Cavatassi and Mallia, 2018).

Table 14: LPDP II impacts on women's empowerment (MT)

	ATET (%)	PO mean	Nb. of obs.
Women headed households			
Gross income per capita	44.77	1826.21	206
Gross livestock income per capita	661.41*	95.58	148
Gross crop income per capita	113.83***	146.94	76
Livestock assets index (TLU)	-25.21	2.34	206
Durable household asset index (PCA)	22.22	0.18	206
Household's agricultural asset index (PCA)	-3.57	0.28	206
Housing asset index (MCA)	2.5	0.8	206
Average weight of cattle (kg)	4.44	4.96	171
Amount of milk production per year (litres)	18.73***	5.66	126
Amount of milk per animal per year (litres)	12.15***	5.76	126
Total household value of livestock sales (live animals, slaughtered animals and livestock products)	79.71**	4.19	68
Livestock feeding activity done by:			
Females ONLY (Yes=1 No=0)	0.09	0.21	1,360
Males ONLY (Yes=1 No=0)	0.23***	0.13	1,360
Jointly by females and males (Yes=1 No=0)	-0.38***	0.71	1,360
Cattle milking done mainly by:			
Females (Yes=1 No=0)	0.08	0.77	905
Decisions on cropping activities done by:			
Females ONLY (Yes=1 No=0)	-0.02	0.07	774
Males ONLY (Yes=1 No=0)	0.10	0.52	774
Jointly by females and males (Yes=1 No=0)	-0.10	0.43	774
Decisions on household and agricultural assets done by:			
Females ONLY (Yes=1 No=0)	0.02	0.06	1,398
Males ONLY (Yes=1 No=0)	0.19**	0.45	1,398
Jointly by females and males (Yes=1 No=0)	-0.19**	0.46	1,398

Note Impacts are reported in percentage or percentage point change and are estimated using IPWRA regressions with standard errors clustered at Jamoat level, including covariates as described in Appendix 3. POM indicates potential outcome beneficiary households would have had if they had not benefited from the programme and it is expressed in per cent. Asterisks indicate the level of statistical significance: * at 10 per cent; ** at 5 per cent; *** at 1 per cent.

g) Social capital

Outcomes of development interventions will be more sustainable and bring about real and shared benefits when they also promote strengthening of social capital (Anyonge et al. 2015). IFAD has a long history of supporting community-driven development (CDD) projects. Between 1978 and 2018, 20 per cent of IFAD's total approved budgets went to CDD related operations (IFAD, 2020). In the context of LPDP II, these mainly involved the establishment and support to the PUUs.

We present the impact on social capital in Table 15. The results show that PUUs in treatment villages are 26 percentage points more likely to hold frequent meetings (every month or more frequently) and 40 percentage points more likely to attract strong participation in PUU meetings (more than half members participating) compared to the control group. These results are similar to LPDP I in that beneficiary households were more likely to belong to PUUs (Cavatassi and Mallia, 2018). LPDP II supported PUUs are also 37 percentage points more likely to regularly collect membership fees compared to PUUs in control groups though we did not find any impact on substantial share of members regularly paying to get PUU services. Overall, these results suggest that pasture use unions in LPDP II villages are more vibrant with increased frequency of meetings and stronger membership participation. This will likely promote increased social capital and better channel livestock and pasture management training and other services through local institutions.

Table 15: LPDP II impacts on social capital

	ATET (%)	PO mean	Nb. of obs.
Participation in Pasture Use Unions (PUUs)			
PUU members hold meetings every month or more frequently (Yes=1 No=0)	0.26**	0.11	1,398
At least 50% of PUU members regularly attend meetings (Yes=1 No=0)	0.4***	0.46	1,398
PUU regularly collect membership fees (Yes=1 No=0)	0.37***	0.27	1,398
At least 40% of PUU members regularly pay membership fees (Yes=1 No=0)	0.23	0.41	1,398

Note Impacts are reported in percentage point change and are estimated using IPWRA regressions with standard errors clustered at Jamoat level, including covariates as described in Appendix 3. POM indicates potential outcome beneficiary households would have had if they had not benefited from the programme and it is expressed in per cent. Asterisks indicate the level of statistical significance: * at 10 per cent; ** at 5 per cent; *** at 1 per cent.

6. Conclusion

The LPDP II aimed to increase incomes, food and nutrition security of livestock farmers by boosting livestock production, productivity, and restoration of degraded pastures in the Khatlon region of Tajikistan.

This IA study was conducted as part of IFAD11 IA agenda using end-line data commissioned by the PMU that cover 1,500 households (both beneficiaries and non-beneficiaries) collected in August-October 2021. We analysed LPDP II impacts on IFAD's goal, strategic objectives and some of the

IFAD's mainstreaming themes, using non-experimental impact analysis methods that allow us to attribute impacts to the interventions.

The analysis indicates that the project led to positive and significant improvements in economic mobility/income and productive capacity. These impacts seem to be driven by gains in production: households who received LPDP II benefits have more productive animals and a greater access to key livestock inputs. These positive impacts are even more pronounced among women headed households. On the other hand, we did not find significant positive impacts on access to markets for livestock and livestock products, perceived ability to recover from shocks, diversity of nutrition intake and food insecurity, and women's decision power over management of assets. But let's look in more details at impacts assessed.

Concerning economic mobility, we find that LPDP II had a positive and significant impact on livestock income, that is LPDP II participants reported higher livestock income compared the their comparison group. On the other hand incomes coming from transfers and livestock herd/assets is lower for project's participants. Livestock income makes up the largest share of beneficiary incomes and is the income source targeted by the project, however it did not translated into increasing total income which is not significantly different for projects' beneficiaries with respect to the comparison group. We find no significant higher values on agricultural assets, household durables, housing quality, income from crop production, and agricultural and non-agricultural wages.

Regarding the objective of increasing livestock production, LPDP II had a positive impact on beneficiaries' cattle productivity as evidenced by their higher average weight, annual milk production and productivity. The channels through which the aforementioned livestock production impacts have been realized include increased adoption of project promoted livestock rearing and pasture management activities. Beneficiary households were more likely to use preventive treatment (especially vaccinations) and spend lower per cattle for this treatment. LPDP II households are also more likely to feed their livestock from protected rangeland, use stalls to house their livestock, and source from safer and healthier water points than the control group. On pasture management, beneficiary farmers are more likely to use rotational plans, rely more on land authorities and owners to set the pasture usage parameters, and count on visual validation of restoration of pastures compared to the control villages. Treatment villages are also more likely to work to restore degraded pastures compared to non-beneficiaries.

Looking at the specific objectives of the project and at its theory of change, which is meant to increase livestock production and productivity while preserving the environment and adapting to climate change, the project has successfully achieved its results: livestock production and productivity has indeed increased while reducing livestock herd and respecting rotational pasture, thus reducing the ecological footprint.

Market access is not significantly higher for projects' participants compared to the comparison group for livestock sold alive nor for livestock by-products such as milk and eggs and is lower for meat markets than the control group. Hence, the total value of livestock sales is not different between LPDP II beneficiaries and the comparison group. However, LPDP II households are more likely to sell crops than the comparison group. The overall results on market access underscore the fact that the project has not promoted market-oriented livestock production.

The attributable impact on increasing the resilience of LPDP II beneficiaries in the face of climate and non-climate shocks appears weak. The self-reported ability to recover from shocks (climate and non-climate combined) is similar between beneficiaries and the comparison group but beneficiaries are less likely to recover from climatic shocks such as droughts, frost, and flooding. However,

beneficiaries are half as likely to report experiencing climatic shocks suggesting that the project may have prevented noticeable climatic shocks from affecting treated households in the first place compared to the control group. The perception of households that suffer climate related shocks to be less able to recover than the comparison group may also indicate a different level of awareness triggered by training and technical support.

Regarding IFAD's mainstreaming themes; we find that the LPDP II had no impact on household food security or dietary diversity. However, the project significantly increased women headed households' livestock income, crop income, annual milk production and productivity, and total annual value of livestock sale. When considering all households, however, we found that female members in the treatment group have less agency or decision power over household owned assets compared to the control group. Regarding social capital, we found that PUUs in LPDP II villages are more vibrant with increased frequency of meetings and stronger membership participation. This will likely promote increased social capital and better channeling of livestock and pasture management training and other services through the local institutions.

We present below a list of key lessons learned from the IA findings and recommendations to inform future design and implementation. Table 16 summarizes the practical implications of these lessons in terms of advantages, disadvantages, and risks. From a broader perspective of transformative change towards better livelihood opportunities, many insights are drawn by this impact assessment of the project.

Lesson learned 1: improvements in livestock production and productivity are possible even while lowering the impact on the environment and the ecological footprint. Project's participants have indeed increased the former indicators while reducing livestock herd and respecting rotational plans. This is likely possible thanks to technical assistance in feeding practices, veterinary services, water points and reproductive assistance while also raising awareness and social capital through the PUU on the importance of restoring degraded pasture and of lowering the ecological footprint through rotational use of pasture to avoid the tragedy of the commons.

Lesson learned 2: transformation is better achieved when linked to market and value chain. The study did not find that the project enabled more households to sell their animals or livestock production in the output markets. This suggests that these households face market barriers preventing them from commercializing their outputs and discouraging market-oriented production. We found that only about 36% of livestock producing LPDP II households sold livestock alive in the last year. In addition, less than 10% of beneficiaries sold meat and milk in the market. Future projects should integrate livestock production and pasture development with market access.

Lesson learned 3: The project activities assessed here may have encouraged people to focus on livestock production and specialize rather than diversify across different income opportunities. Beneficiary households were less likely to diversify their incomes beyond livestock and do not raise different types of livestock than the comparison group. Encouraging participation of beneficiary households in the livestock value chains such as in processing, storage, transportation, and marketing of livestock products will help diversify incomes while strengthening the value chain and the rural-urban link. The PUUs could be good entry points for this.

Lessons learned 4: Regarding resilience, we found that beneficiaries are less likely to experience shocks than the comparison group. This is likely linked to beneficiaries being better adapted to

climate change and animal disease thanks to better quality herd, veterinary services, and technical support. The perception of households that suffer climate related shocks to be less able to recover than the comparison group may also indicate a different level of awareness triggered by training and technical support.

Lessons learned 5: Concerning women's empowerment, while the project remarkably increased women headed households' welfare, it was less effective in empowering women to make decisions jointly with men or separately over assets in beneficiary households. This is an important element to reflect on for similar future interventions in terms of the importance of factoring in the gender dimension and promote activities aimed at ensuring gender balance and women empowerment within beneficiary households.

Table 16: Summary of policy implications

Policy implications	Benefits	Disadvantages	Risks
Ensuring the sustainability of PUUs and the resting of pastures	Sustained increase in livestock productivity and income.	No disadvantages	
Identifying barriers to output markets	Increase in revenues from sales of production. Access to better inputs.	No disadvantages	
Leveraging PUUs to strenghten the livestock value chain and diversify incomes	- Greater diversification of incomes and livestock types - Reduced vulnerability to shocks. - Stronger livestock value chain and rural-urban link.	Increased cost	Resistance from PUU members and stretching of resources between different priorities
Leverage PUUs to promote greater involvement of women in decisions within and outside of the household	Women would benefit from project activities reducing gender inequalities within the household	No disadvantages	Opposition of men in PUUs

References

Abadie, A., Athey, S., Imbens, G., & Wooldridge, J. (2017). When Should You Adjust Standard Errors for Clustering? https://arxiv.org/abs/1710.02926.

Alfani, F., Arslan, A., McCarthy, N., Cavatassi, R. and Sitko, N., 2021. Climate resilience in rural Zambia: Evaluating farmers' response to El Niño-induced drought. *Environment and Development Economics*, 1-23.

Angelucci, Manuela & Di Maro, Vincenzo, 2015. *Program Evaluation and Spillover Effects*. IZA Discussion Papers 9033, Institute for the Study of Labor (IZA).

Arslan, A., Asfaw, S., Cavatassi, R., Lipper, L., McCarthy, N., Kokwe, M. and Phiri, G., 2018. *Diversification as part of a CSA strategy: the cases of Zambia and Malawi*. In Climate smart agriculture (pp. 527-562). Springer, Cham.

Ballard, T., Kepple, A., & Cafiero, C. (2013). The Food Insecurity Experience Scale: Development of a Global Standard for Monitoring Hunger Worldwide. FAO Technical Paper. FAO. Rome, Italy.

Bebe, B.O., Udo, H.M.J., Rowlands, G.J. and Thorpe, W. (2003) Smallholder dairy systems in Kenya highlands: breed preferences and breeding practices. Livestock Production Science, 82(2-3), pp. 117-127.

Bezabih, MY, Berhane, G. (2014). Livestock Production Systems Analysis. American International Journal of Contermporary Scientific Research.

Bryson, A., Dorsett, R., & Purdon, S. (2002). The Use of Propensity Score Matching in the Evaluation of Labour Market Policies. Working Paper No. 4, Department for Work and Pensions.

Busso, M, DiNardo, J. & McCrary, J. (2009a). New Evidence on the Finite Sample Properties of Propensity Score Matching and Reweighting Estimators. IZA Discussion Paper no. 3998 (February).

Busso, M, DiNardo, J. & McCrary, J. (2009b). Finite Sample Properties of Semiparametric Estimators of Average Treatment Effects. University of Michigan, Department of Economics (June).

Carletto, G., Covarrubias, K., Davis, B., Krausova, M. & Winters, P. (2007). Rural Income Generating Activities Study: Methodological note on the construction of income aggregates. FAO, Rome, Italy (available at http://www.fao.org/fileadmin/user_upload/riga/pdf/ai197e00.pdf).

Cavatassi, R., Mallia P. (2018). Impact assessment report: Livestock and Pasture Development Project (LPDP), Tajikistan. IFAD, Rome, Italy.

Hadush, M. 2017. "Implication of Animal Feed and Water Scarcity on Labor Allocation, Food Production and Per Capita Food Consumption in Tigrai Region, Ethiopia," Journal of Economic Development, Chung-Ang Unviersity, Department of Economics, vol. 42(4), pages 59-93, December.

Hirano, K., Imbens, G., & Ridder, G. (2003). Efficient Estimation of Average Treatment Effects Using the Estimated Propensity Score. *Econometrica* 71, 1161-1189.

IFAD. 2022. Livestock and Pasture Development Project II. Project Completion Report. Near East, North Africa and Europe Division, Programme Management Department. Rome, Italy.

IFAD. 2021. Rural Development Report 2021: Transforming food systems for rural prosperity. Rome, Italy.

Imbens, G. W. (2000). The role of the propensity score in estimating dose–response functions. Biometrika 87, 706–710.

Jin M, Iannotti LL. Livestock production, animal source food intake, and young child growth: The role of gender for ensuring nutrition impacts. Soc Sci Med. Elsevier Ltd; 2014;105: 16–21. pmid:24606793

Mekonnen A, Damte A, Deribe R (2015) The impact of natural resource scarcity on agriculture in Ethiopia, The environment for Development Discussion Paper-Resources for the Future (RFF)

Mottet, Anne & De haan, Cornelis & Falcucci, Alessandra & Tempio, G & Opio, Carolyn & Gerber, Pierre J.. (2017). Livestock: On our plates or eating at our table? A new analysis of the feed/food debate. Global Food Security. 14. 10.1016/j.gfs.2017.01.001.

Moll, H.A.J. (2005) Costs and benefits of livestock systems and the role of market and nonmarket relationships. Agricultural Economics, 32(2), pp. 181-193.

Neumann C., D. M. Harris, and L. M. Rogers. 2002. Contribution of animal source foods in improving diet quality and function in children in the developing world. Nutr. Res. 22(1–2):193–220.

Ostrom E, Burger J, Field CB, Norgaard RB, Policansky D. 1991. Revisiting the commons: local lessons, global challenges. Science 284:278-282

Pica-Ciamarra, Ugo; Tasciotti, Luca; Otte, Joachim; Zezza, Alberto. 2011. Livestock assets, livestock income and rural households : cross-country evidence from household surveys (English). Washington, DC;World Bank Group http://documents.worldbank.org/curated/en/101271468151472539/Livestock-assets-livestock-income-and-rural-households-cross-country-evidence-from-household-surveys

Randolph TF, Schelling E, Grace D, Nicholson CF, Leroy JL, Cole DC, Ruel M (2007) Role of livestock in human nutrition and health for poverty reduction in developing countries. Journal of animal science

Robinson, S. 2020. Livestock in Central Asia: From rural subsistence to engine of growth? Discussion Paper, No. 193, Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Halle (Saale), http://nbn-resolving.de/urn:nbn:de:gbv:3:2-120441

Sedik, D. (2009). The Feed-Livestock Nexus in Tajikistan: Livestock Development Policy in Transition. FAO Regional Office for Europe and Central Asia Policy Studies on Rural Transition No. 2009-2

Smith, J. Sones, K. Grace, K., MacMillan, S., Tarawali, T. and Herrero, M. (2013), Beyond milk, meat, and eggs: Role of livestock in food and nutrition security, Animal Frontiers, Volume 3, Issue 1, 1 January 2013, Pages 6–13, https://doi.org/10.2527/af.2013-0002

Upton, M. (2004) The Role of Livestock in Economic Development and Poverty Reduction. PPLPI Working Paper No. 10, Pro-poor Livestock Policy Initiative (PPLPI), FAO, Rome.USAID (2015). Grazing Lands, Livestock and Climate Resilient Mitigation in Sub-Saharan Africa: The State of the Science. USAID.

Yilma Z, Guernebleich E, Sebsibe A, Fombad R (2011) A review of the Ethiopian dairy sector. Addis Ababa, Ethiopia, FAO Sub-Regional Office for Eastern Africa (FAO/SFE).

WHO Multicentre Growth Reference Study Group. WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development. Geneva: World Health Organization, 2006

Wooldridge, J. M. (2010). Econometric Analysis of Cross Section and Panel Data. 2nd ed. Cambridge, MA: MIT Press.

World Bank (2020). Poverty in Tajikistan 2020: Infographic. https://www.worldbank.org/en/news/infographic/2020/10/15/poverty-in-tajikistan-2020

Appendix 1:

Table A1.1: The list of variables included in the outcome equation

	INCOME AND NON-LIVESTOCK ASSETS	LIVESTOCK	CROP	RESILIENCE	NUTRITION AND FOOD SECURITY	WOMEN'S EMPOWERMENT
Female headed household (Yes=1 No=0)	X	X	X	X	X	
Household size in adult equivalence	X	X	X	X	X	X
Total area of pasture (in ha) in the village	X	X		X	X	X
Total area cultivated by hh (hectares)			X			
HH experienced climatic shock (drought/flood/frost) (Yes=1 No=0)	X	X	X		X	X
HH experienced economic shocks (loss of income etc.) (Yes=1 No=0)	X	X	X		X	X
Average annual maximum (NDVI) for the top 3 months of the year in 2017/20	X	X	X	X	X	X
Average annual maximum NDVI for the top 3 months of the year in 2000/20	X	X	X	X	X	X
Ratio of mean of annual maximum NDVI in 2014/16 over 2007/16	X	X	X	X	X	X
Total seasonal rain in 2019/20	X	X	X	X	X	X

Average seasonal rain in 1981/2020	X	X	X	X	X	X
Ratio of covariance of total seasonal rain in 2017/20 over 2007/16	X	X	X	X	X	X
Average seasonal minimum temperature in 1981/2019	X	X	X	X	X	X
Average seasonal minimum temperature in 2019/21	X	X	X	X	X	X
Average seasonal maximum temperature in 1981/2019	X	X	X	X	X	X
Average seasonal maximum temperature in 2019/21	X	X	X	X	X	X
Average population density (in 1000 square meters) in 2017/20	X	X	X	X	X	X
Ratio of average population density in 2017/20 over 2007/16	X	X	X	X	X	X

Note: NDVI=normalized difference in vegetation index

Appendix 2:

Figure 3: Common support between treatment and control groups

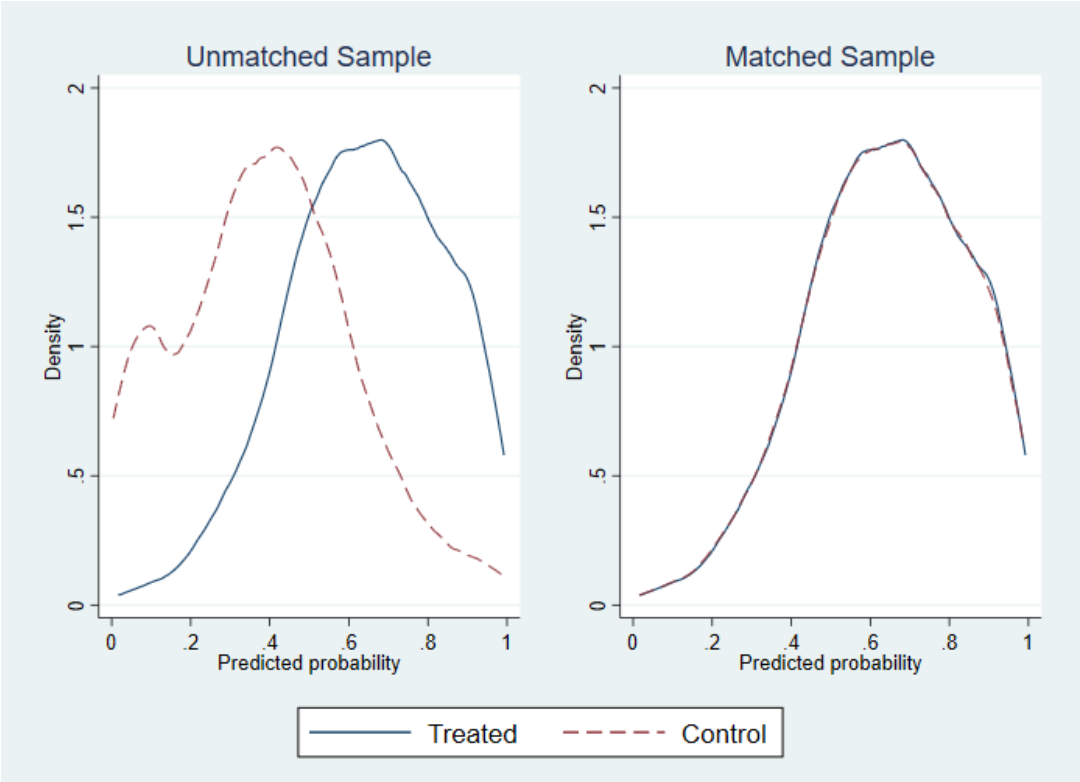
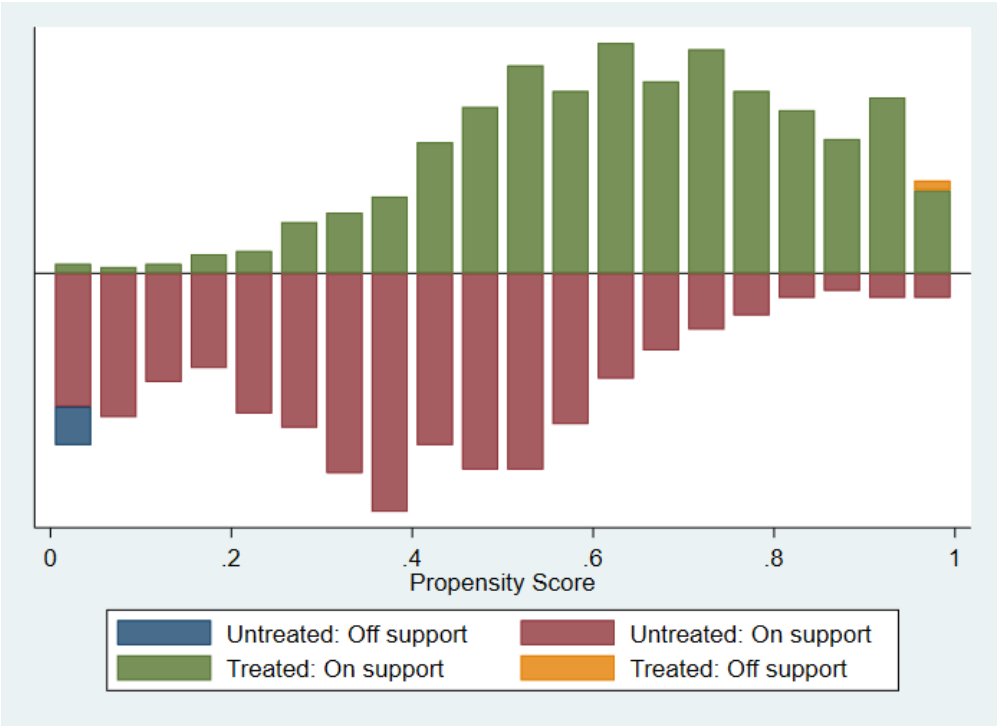


Figure 4: Distribution of propensity scores between treated and untreated households



Appendix 3:

Figure 5: Share of gross income across different sources by treatment status

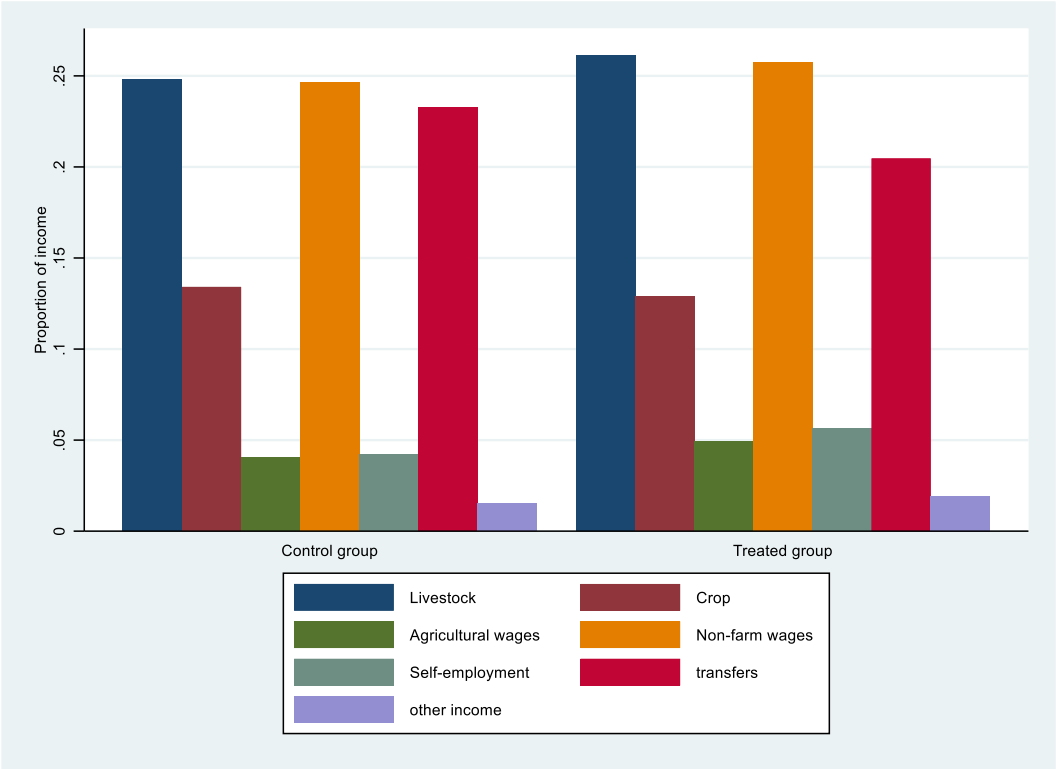
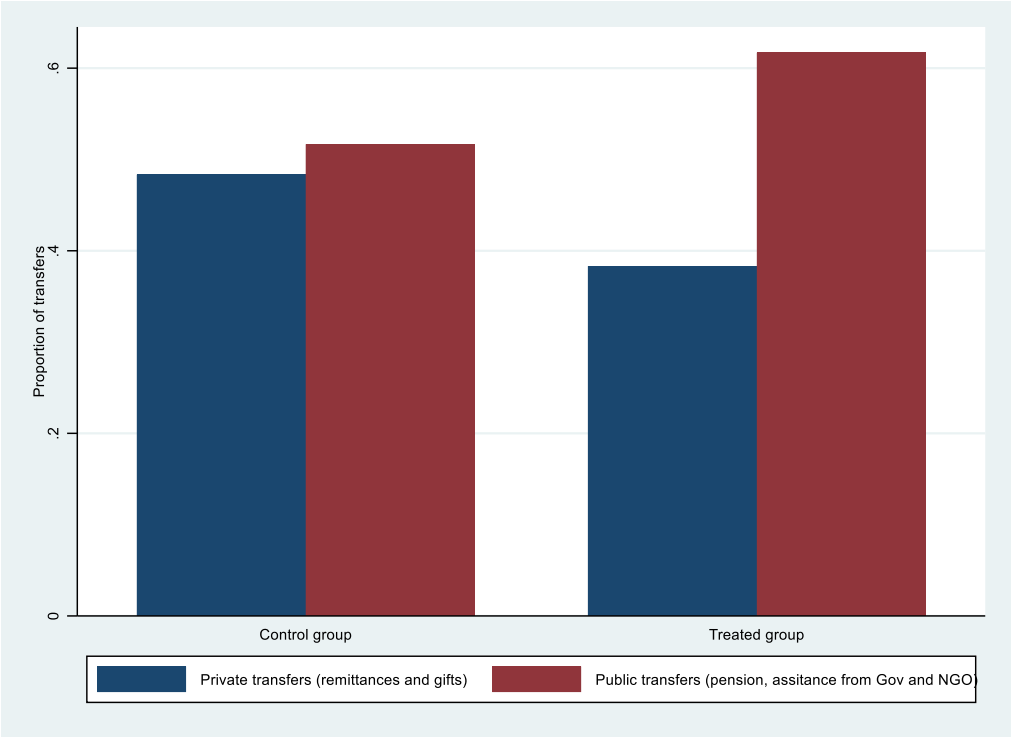


Figure 6: Share of transfer income between private and public sources by treatment status



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