IMPACT ASSESSMENT REPORT

Federal Democratic Republic of Nepal

High Value Agriculture Project in Hill and Mountain Areas (HVAP)

Authors:
Kashi Kafle, Kwabena Krah, Tisorn Songsermsawas

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Investing in rural people

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Executive summary

This report assesses the impact of the High Value Agriculture Project in Hill and Mountain Areas (HVAP) of Nepal co-financed by the International Fund for Agricultural Development (IFAD), the Government of Nepal (GoN), and the SNV Netherlands Development Organization. The project was implemented between February 2011 and September 2018, and aimed at reducing rural poverty and improving food security in the remote hill and mountainous areas of the landlocked state. Nepal's geographical landscape presents numerous challenges to local economic growth and rural development. The livelihood of the people living in Nepal's rugged landscape is often characterized by low agricultural productivity, and limited access to markets and services.

HVAP is a unique project both in terms of its geographical coverage and its type of interventions provided to the target groups. Its unique feature is the *inclusive value chain development* component which links different actors in the agricultural value chain including producers, retailers, wholesalers, input suppliers, technical service providers, credit and commerce groups, and government line ministries and agencies. In addition, the project helps strengthen the agricultural service delivery by facilitating the linkages among producers, crop and livestock extension speacialists, and technical service providers such as agrovets, para-vets, and plant protectionists through the *service market strengthening* component.

The project covers seven hill and mountaneous districts in Karnali Province (formerly the Mid-Western Development Region)[1] and identifies seven agricultural commodities as high value commodities in this area: apple, ginger, vegetable seeds, off-season vegetables turmeric, timur (Sichuan pepper), and goat. To ensure gender representativeness and promite social cohesiveness, all support services are delivered through producer organizations (PO) which are local producer groups or co-operatives that are representative of women and ethinc minorities in the area. The project supported smallholder farmers in 456 POs by strengthening their access to input markets, output markets, and service markets as well as their skills and capacity to produce market-oriented high value agricultural commodities. As part of the awareness and skill development training, the project provided a 30-day business literacy curriculum to both female and male farmers. The project also offered technical support to service markets through providing technical training activities and market information to service providers.

[1] One district is now in another province according to Nepal's newly enacted adminsitrative system.

The *ex post* impact assessment of HVAP follows a mixed-method approach including qualitative interviews of key informants and PO leaders and quantitative surveys administered to approximately 3,000 households residing in both project and outside areas. The qualitative interviews aim at collecting information about the project's targeting strategy, implementation experience, and lessons for improvements. The quantitative survey collects information related to household socio-economic characteristics, agricultural production, access to markets and infrastructures, and decision-making. The research design uses a statistical approach along with local information to identify the valid counterfactual – member farmers of POs that did not receive the project but are characteriscally similar to the project groups.

Results show positive and significant project impacts on poverty reduction (8.0% reduction in poverty) through increased household income (36.8% increase) and asset growth (9.8% increase in durable asset and 6.5% increae in productive asset). The growth in household income are primarily driven by increases in crop (49.9% increase) and livestock income (92.9% increase). In addition, beneficiary farmers also have better access to markets compared to non-beneficiaries. The positive impacts on income and market access translate further into improved dietary diversity; in particular, beneficiary households reported to have consumed more vegetables, fruits, and milk and other dairy products compared to non-beneficiaries. This finding is consistent with evidence in the literature on the linkage between agriculture and food security.

Several lessons emerge from this impact assessment, which are useful for future project design, country strategies, and policy design. There are at least three aspects of the project that have led to its success. First, the project design is very focused because it concentrates on a small number of value chains which are interlinked. The focused project design led to project activities customized and catered to specific local needs of smallholder farmers in the target group. The focused approach facilitates channelling of resources and services to ensure strong and positive project results. Second, the project worked with small and cohesive groups of farmers (25 to 40 members in a group). The manageable size of POs allows project staff to engage closely with each group and monitor project activities to accommodate the needs of each group and its members. Third, the project uses a mix of top-down and bottom-up approaches to link producers to traders, government agencies, commerce and finance departments, and scientists to address the absence of product and input markets, marketing facilities, credit, and policy support. This combined approach results in the successful identification of appropriate set of activities to its beneficiaries.

1. Introduction

Nepal's agricultural sector accounts for approximately 29% of its total GDP, and more than half of its total value of exports (Government of Nepal, 2017). Given that the agricultural sector employs a large share of Nepal's population, improving agricultural productivity and creating opportunities to increase farm income are crucial to moving smallholder farmers out of poverty. However, this pathway is often constrained by lack of access to infrastructures, resources, and markets.

Central to the development constraints facing Nepal is its geographical attributes. In addition to being land-locked (surrounded by China and India), Nepal's geographical characteristics are largely characterized by mountainous and hilly regions which account for approximately 80% of the total land area (Savada, 1991). Approximately half of Nepal's population lives in the mountainous and hilly areas where the primary form of livelihood is traditional and subsistence agriculture (Sharma, 2006). The rugged terrain not only limits the amount of arable land available, but also poses a significant challenge to agricultural production activities. Such terrain limits both public and private sectors' capacity to implement agricultural interventions aimed at improving productivity. As a consequence, smallholder farmers residing in these areas have limited access to markets and other services, if at all (Khadka, 1998; Deraniyagala, 2005).

The High Value Agriculture Project in Hill and Mountain Areas (HVAP) is a project supported by IFAD and implemented by the Ministry of Agriculture and Livestock Development of the Government of Nepal (GoN).Out of the total project cost of US$18.9 million, IFAD provides majority of the support through a combination of loan and grant valued US$15.3 million. The rest of the project cost is co-financed by GoN, the SNV Netherlands Development Organization, agribusinesses, and beneficiary contributions. The project aims at addressing the development challenges in rural areas of Nepal through inclusive value chain development for high value agricultural commodities. The project is designed to contribute to the Government of Nepal's twin goal of poverty reduction and improved food security through increased productivity of high-value agricultural crops and livestock. The project covers seven highly vulnerable hilly and mountainous districts in the Mid-Western Development Region (now Karnali Province, since February 2018). Its interventions focus on facilitating the linkages between different value chain actors such as agribusinesses and producers; enhancing market access through infrastructure

development such as marketing facilities, storage facilities, roads, and irrigation; and providing skill development and awareness training on multiple themes including business literacy, entrepreneurship, marketing strategies, agricultural production, gender balance, and social inclusion. The project was implemented between February 2011 and September 2018.

The main goal of HVAP is to reduce poverty and improve food security in the most challenging rural hilly areas of Nepal through developing inclusive value chain development and service market strengthening. HVAP's main objective is fully aligned with Nepal's Agriculture Development Strategy (ADS) 2015 to 2035 (Government of Nepal, 2015) which aims to enhance agricultural productivity in rural areas by promoting high-valued agricultural production. Specifically, the HVAP interventions contribute directly to two highly coveted programs under the Agriculture Development Strategy; the Decentralized Science, Technology and Education Program and Value Chain Development Program.

Based on the supervision reports and annual outcome surveys, HVAP interventions has been regarded as a highly successful intervention, particularly in terms of increasing linkages between farms and markets of high value crops and livestock. To that end, IFAD and GoN have agreed to scale up the project to include a larger geographical area, larger number of beneficiaries, and a greater number of value chains. The scaled-up intervention of HVAP is called the Agriculture Sector Development Program (ASDP). ASDP was approved by IFAD's Executive Board in December 2017 and entered into force in June 2018. In addition to the supervision reports and annual outcome surveys, the success of HVAP interventions are confirmed also by anecdotal evidence and case studies conducted in the region. However, the project impacts have not been examined rigorously yet. In this light, this analysis presents an ex post impact assessment of HVAP that carefully assesses and estimates the impact of the intervention. The aim of this impact assessment is to report on key outcome indicators identified in HVAP's logical framework and rigorously examine the impact of the intervention on these indicators. As ASDP is in its early stages of implementation, it could benefit from a validation of which of HVAP's impact pathways have been more effective. The key outcome and impact indicators of interest in this impact assessment relate closely to the IFAD's Strategic Goal of increased economic mobility and three Strategic Objectives: increased agricultural productive capacity, increased market access, and increased resilience.

The goals and strategic objectives form the basis of IFAD's Results Measurement Framework and this impact assessment exercise is guided by the

RMF. This impact assessment aimed at producing robust estimates of both direct and indirect impacts of HVAP on various livelihood domains, as captured by the outcome and the impact indicators of the target population along with the other indicators listed in the Project Completion Report (PCR) guideline and proposed by the government and project staff members. In so doing, this specific exercise involves the use of both quantitative and qualitative data for both project beneficiaries and non-beneficiaries to scientifically identify the impact of the intervention among the project beneficiaries compared to non-beneficiaries. Furthermore, this impact assessment serves as a means to evaluate the extent to which HVAP interventions led to changes in project outcome and impact indicators.

Impact assessments are important for policy makers, donors, and researchers alike because they provide evidence to gauge accountability and attribution of the underlying intervention, and help generate lessons for future project design and implementation (Gertler et al., 2016). Even though a significant proportion of development budget of governments and donors goes to agricultural development, little has been done to carefully assess the impact of such interventions (Winters et al., 2010; World Bank, 2011). This impact assessment is a part of IFAD's corporate level efforts to generate knowledge through systematic and scientific assessments of IFAD supported agricultural interventions to improve future project designs and support governments for evidence-based policy making. This impact assessment is of particular importance to the implementing institutions at the regional, national, and international levels. In addition, this serves as a public knowledge for anyone interested in rural agricultural development.

The dataset used in this analysis came from primary household and community surveys IFAD conducted between May and July 2018. Community surveys were conducted at the producer organization (POs) level. The surveys collected information from households and communities in project (treatment) and non-project (control) POs. The household dataset contains information about socio-economic characteristics, housing quality and asset ownership, agricultural and livestock production and sales, household consumption, intra-household decision-making, access to markets and information, shocks and resilience, and environmental sustainability. The community dataset contains information related to access to value chain, markets, infrastructures, and services.

The rest of the report is organized as follows. First, in Section 2, the report presents HVAP's theory of change including background of the project, targeting criteria and geographical coverage, relevant research questions, and relevance of

this impact assessment to existing literature. Then, it describes the overall empirical approach to assess the project, and the methodology to construct the counterfactual whose outcome and impact indicators would be compared to those of the project beneficiaries to quantify project impact. Following this section, it presents the profile of the project beneficiaries from the sample. Next, it presents the results from the full sample and from the sub-samples determined by type of project intervention received and the poverty status of the county, and discusses the findings. Finally, the report concludes with a summary of lessons learned and policy implications.

2. Theory of change and main research questions

2.1 HVAP theory of change

HVAP intervention is one of the ongoing efforts to address Nepal's development challenges by developing inclusive value chains in hilly and mountainous areas. The project targets POs, which are mainly pre-existing

groups or cooperatives locally formed for agricultural production, microfinance, marketing, or user right groups. Figure 1 summarizes the theory of change for the HVAP project which illustrates the causal mechanism that shows how project impacts emerge from inputs and activities. The theory of change closely follows the project logical framework and has been widely discussed with field staff and the project staff. HVAP's inputs and activities are rather focused, which consist of two components: (1) inclusive value chain development, and (2) service market strengthening.

Earlier theoretical works in the literature conceptualize the role of the transactions costs as a form of market frictions which prevent smallholder farmers from participating in formal value chains (de Janvry et al., 1991; Key et al., 2000; Alene et al., 2008). Thus, policies or interventions that may reduce the transactions costs farmers face when marketing their crops may help improve farm revenues, and thus have a direct implication on welfare outcomes (Besley and Burgess, 2000; Barrett, 2008; Chamberlin and Jayne, 2013).

As part of the inclusive value chain development, the project helps to establish contractual agreements between producer groups and agribusinesses; facilitates business to business connection such as a linkage between small traders with large traders; and provide capacity and skill development trainings (such as credit mobilization, business literacy) to producers and traders. Under the first component, HVAP also provides support to enhance processing and market facilities and strengthen institutional capacity by providing market information, support services, and infrastructures e.g. collection centres, cold storages, etc.

Previous studies have shown that linkages between farmers and traders, and as well as between small traders and large traders can help increase market access and value chain participation (Michelson et al., 2012; Barrett et al., 2012; Wang et al., 2014). Michelson et al. (2012) note that for farmers in Nicaragua, although the mean prices they receive from selling their produce to Walmart are smaller than prices in traditional markets, these smallholders prefer Walmart contract since such contract reduces price fluctuations. Further, existing evidence has indicated that market linkage interventions are more likely to succeed if sufficient support is provided through all stages in the value chain (Ashraf et al., 2011; Cavatassi et al., 2011; González-Flores et al., 2014). While there is increasing government support for promotion of contract farming, there are increasing debates on whether smallholders from contract farming arrangements are better off (Ton et al. 2018).

The project also supports activities to assure gender and social representativeness such as awareness trainings on social inclusion and gender balance**.** Under the service market strengthening component, the project

provides technical training and market information to service providers e.g. agro-vets, trader associations, and agribusinesses.

These inputs and activities are expected to benefit project beneficiaries in the following ways. First, the established or strengthened linkages between farmers and markets, and between small and large enterprises should reduce the transactions costs farmers face when marketing agricultural produces (Key et al., 2000; Alene et al., 2008; Markelova et al., 2009). Second, as a result of various capacity building and skill development training related to agricultural and livestock production and marketing, agricultural productivity is expected to increase and producers can expect to receive better prices for their agricultural produces (Davis et al., 2012; Emerick et al., 2016; Kondylis et al., 2017; Verkaart et al., 2017). Third, establishing or upgrading market structures such as collection centres and cold stores helps to stabilize market prices and reduce vulnerability (Mu and Van de Walle, 2011). Finally, the social inclusion and gender balancing approach of the project helps to empower women and marginalized population, enhance social capital, increase social support, and reduce social inequality within the project communities.

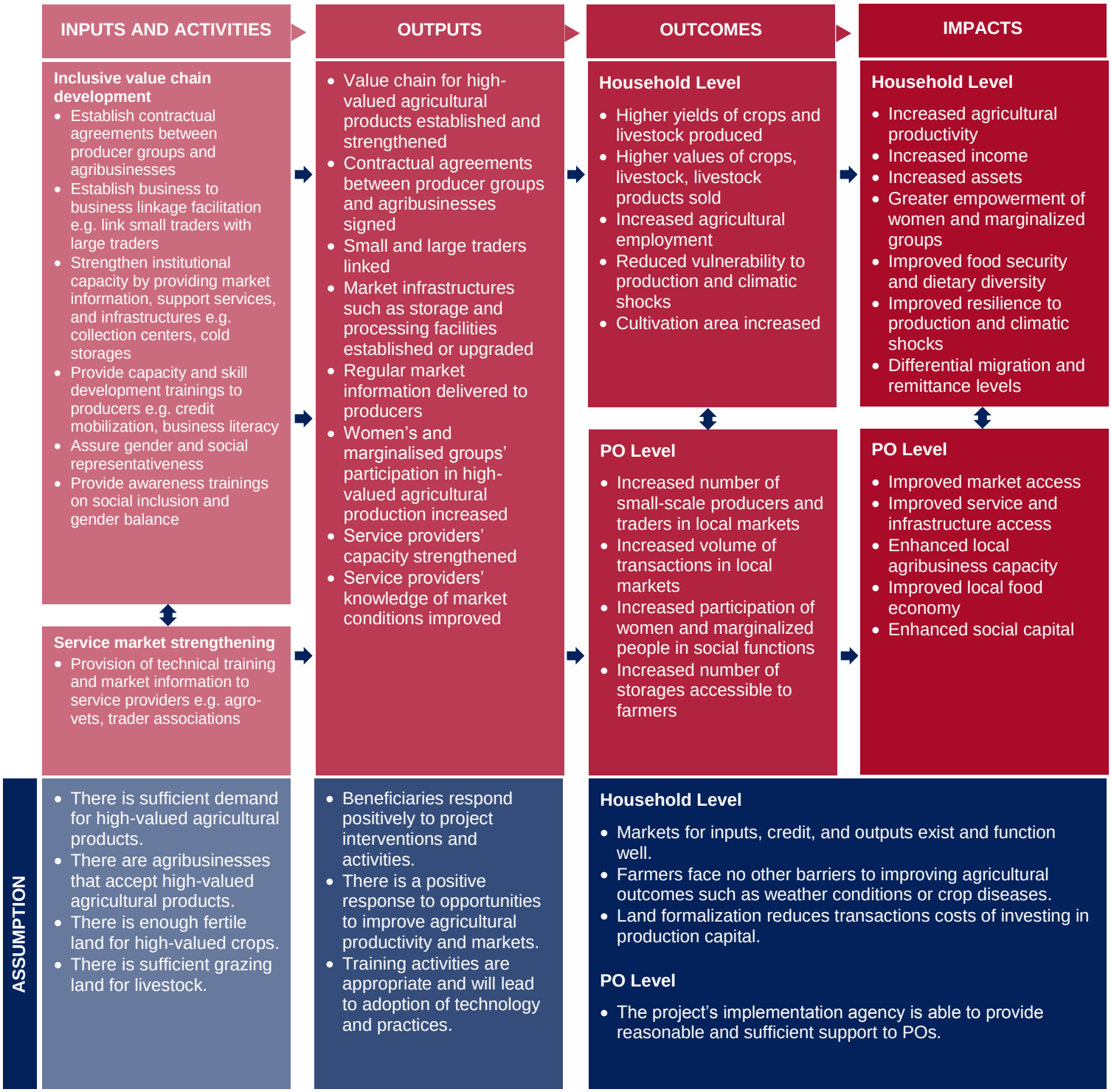
The impact pathway illustrated in the theory of change operates under various assumptions that may or may not be testable directly with empirical data. For example, HVAP's inputs and activities lead to outputs if and only if there is sufficient demand for high-valued crops and livestock produce, agribusinesses are able and willing to purchase and trade the items, and sufficient fertile land is available for crop and livestock production. The project outputs lead to outcomes if beneficiaries take up the intervention by responding positively to services delivered, utilizing opportunities to improve productivity, and using access to markets and service providers for buying inputs and selling outputs. In addition, outputs may not lead to outcomes if agricultural technologies and capacity building and skill development training delivered by the project are not adopted. For the outcomes to lead to project impacts, it is assumed that input, credit, and output markets exist and function well, other barriers in agricultural production such as adverse weather conditions or crop diseases are minimal, and land markets function well. It is also assumed that the project implementation agency can provide reasonable and sufficient support to beneficiaries throughout the project duration. In this context, these assumptions are critical to HVAP's success, as input, credit, and output markets highly depend on access to rural infrastructures and services, which might still be lacking in many areas of rural Nepal.

Even though different project components may provide distinct causal channels for changes in the outcomes at both household- and PO- levels, it is imperative

to recognize and understand both how different project activities and interventions interact and complement each other and how these interactions are related to potential observed changes in outcome and impact indicators. Having a clear idea of how project components interact allows researchers to design the surveys to collect comprehensive outcome and impact indicators that are not so obvious but implicit in the project logic. For example, providing real-time, accurate market information through improved linkages between farmers and markets allows farmers to increase agricultural revenue by accessing markets at the right time to receive higher prices. Similarly, project activities that work to strengthen producer groups can also lead to improved individual empowerment, increased agricultural productivity, and better social inclusion through group members' increased awareness and capacity development. In addition to the interactions between project components, activities in the project areas can spillover to nearby areas leading to unintended positive or negative impacts.

There are two important considerations required to capture any spillover effects in an impact assessment framework; (1) the nature of spillover effects that could arise from project interventions, and (2) the mechanism through which the spillover effects emerge. Both the nature and mechanism of spillover effects influence the impact assessment design and underlying identification strategy. In this setting, HVAP project activities may increase demand for agricultural labour from non-beneficiaries through improvements in rural infrastructures and enhanced marketing linkages (Headey et al., 2010; Mu and Van de Walle, 2011). Another source of spillover is knowledge or skill spillover; farmers who receive training from the project may share the knowledge with their peers outside of project areas. Given the difficulties in access to frequent transportation and communication, it is reasonable to assume that the extent of knowledge spillover is minimal and that it should not be a major concern in this impact assessment (Witt et al., 2008; Songsermsawas et al., 2016).

Figure 1: HVAP's theory of change



2.2 Project coverage and targeting

HVAP interventions cover seven districts from Mid-Western Development Region (Karnali Province in the newly adopted system). The project works with producer organizations (POs) and a total of pre-existing 456 POs (which consist of groups and cooperatives) in 144 village development committee (VDCs) are covered. Figure 2 shows HVAP coverage area on the map of Nepal.

Figure 2: HVAP project areas on the map of Nepal

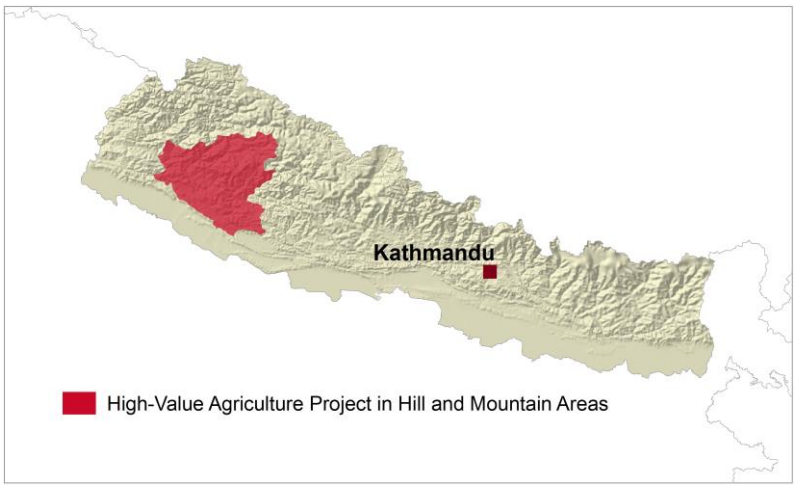


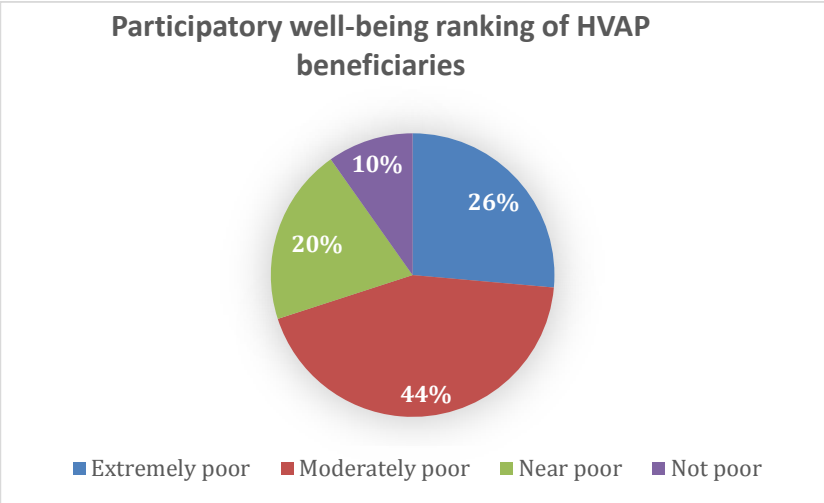
Table 1 presents the number of local government institutions (VDCs in rural areas and Municipalities in town or cities) in each district covered by HVAP. VDCs and municipalities are administrative units and therefore are mutually exclusive. Each VDC contains multiple POs. Since membership in a PO is optional and depends on scores of factors, only a subset of the VDC population is covered by POs. HVAP covers a total of 144 VDCs, 456 POs, and 15,965 households.

Table 1: Number of VDCs, POs, and households covered by HVAP

District	VDCs	POs	Households
Achham	9	26	928
Dailekh	28	63	2,097
Jajarkot	20	59	2,826
Jumla	22	57	1,721
Kalikot	17	59	1,812
Salyan	11	44	1,176
Surkhet	37	148	5,405
Total	**144**	**456**	**15,965**

According to the project-level database, HVAP has benefitted approximately 15,965 households, which consists of 107,860 people. The distribution of the beneficiary households according to their well-being ranking is illustrated in Figure 3.[2]

Figure 3: Well-being ranking distribution of HVAP beneficiaries



Based on the review of HVAP project documents and the discussions with project staff, the targeting criteria to select POs and households to participate in HVAP interventions include the following eligibility rules:

[2] The well-being ranking is determined based on a participatory approach at the community level, where community members have an active role in validating the well-being ranking of each household within the community.

Table 2: HVAP project targeting criteria

Targeting criteria	Eligibility rule
Travel time to markets (one-way)	
< 3 hours	Eligible for fresh vegetables
3 - 6 hours	Eligible for ginger, turmeric, apple
6 - 12 hours	Eligible for goat, timur, vegetable seeds
Well-being ranking	Eligible if households fall into first three categories: extreme poor, moderately poor, and near poor
Income level	Eligible if per capita income is less than Rs. 2,000 a year
Landholding size	Eligible if landholding size is 0.5 Ha or less per household

2.3 Research questions

Based on the project's theory of change illustrated in Figure 1, this impact assessment will answer several research questions. The main research questions the impact assessment address are presented below in the order of project logic from inputs/activities, outputs, outcomes, and impacts.

1. Does the intervention help to reduce poverty among project households? How did the intervention lead to reduced poverty rates?
2. Do households in project areas benefit from greater access to market infrastructures? Specifically, do they have greater access to collection centres, cold storages, or other market-related facilities?
3. Does the intervention lead to higher levels of technology adoption, and use of complementary cash inputs (e.g. fertilizer, pesticide, and other improved crop cultural practices)? Similarly, are households in project areas more likely to use improved livestock management practices (e.g. improved sheds, drenching, vaccination, and other veterinary services)?
4. Does the intervention improve beneficiary households' access to information about agricultural production, markets, and prices?
5. Does the intervention improve access to credit, other rural financial services, and insurance services?
6. Is the agricultural yield and revenue for project households higher than control households? What leads to the higher yields; higher levels of technology adoption, or use of complementary inputs, or improved livestock management practices?
7. Does the intervention help to improve dietary diversity and food security situation among recipient households?

8. Does the intervention contribute to improve women's decision-making within project households and communities?
9. Are project households more resilient to negative exogenous shocks than non-project households? Specifically, are participants able to recover from shocks better than non-project households?

3. Impact assessment design: Data and methodology

3.1 Data

To address the research questions outlined in the previous section, the impact assessment design adopts a mixed-method approach to collect both quantitative and qualitative data. Quantitative surveys consist of two surveys: one for collecting data at the household level and the other for collecting data at the PO level. Qualitative surveys consist of key informant interviews (KIIs) and focus group discussions (FGDs). KIIs are conducted with PO leaders, input suppliers, and agribusinesses or agricultural service providers (such as agro-veterinarians and extension agents). FGDs are conducted with district line agencies, which are district-level government entities responsible for different development issues. While the main results of the impact assessment of HVAP will be drawn from the quantitative questionnaires, the qualitative surveys will be used to triangulate results and support quantitative findings.

Being able to obtain a valid counterfactual allows us to estimate the outcome of the treatment group in absence of the project interventions, which is essential to obtaining rigorous measures of project impact. The strategy to construct a valid counterfactual uses a combination of statistical matching and local information to ensure that treatment and control groups are similar and comparable at project baseline.

The impact assessment design uses data from the National Population and Housing Census 2011 conducted by the Central Bureau of Statistics which was conducted before the project interventions were rolled out to match VDCs with and without project interventions. Then, the research team consult the project staff to identify the best matches of project and non-project VDCs to ensure that they are similar in terms of both observable and unobservable characteristics, and also that matched non-project VDCs would have been eligible to receive HVAP interventions.[3]

In each district, treatment POs are randomly selected from the full list of all POs that receive HVAP interventions. Each treatment PO is then paired with another non-project PO that is similar to the project PO and would have been eligible to receive the project interventions at baseline. Within each PO,

[3] The variables used to match project and non-project VDCs include dwelling ownership, type of roof, type of wall, type of roof, access to water protection facility, access to improved energy sources, access to improved toilet, use of improved cooking fuel, ownership of dweeling by female, household size, and literacy rate.

approximately 12 to 13 households that are members of the PO to be randomly selected be interviewed.[4]

The total sample consists of 3,028 households (1,504 treatment and 1,524 control households) in 235 POs or clusters (117 treatment POs and 118 control POs). The distribution of the sample size is proportional to the number of project beneficiaries in each district. Table 3 below reports the distribution of the sample by district.

Table 3: Sample distribution by district

District	Treatment POs	Control POs	Total POs	Treatment HHs	Control HHs	Total HHs
Achham	7	6	13	91	78	169
Dailekh	17	18	35	221	234	455
Jajarkot	15	15	30	192	195	387
Jumla	15	15	30	193	193	386
Kalikot	15	16	31	193	206	399
Salyan	11	15	26	139	189	328
Surkhet	37	33	70	475	429	904
Total	**117**	**118**	**235**	**1,504**	**1,524**	**3,028**

There are eight households in the dataset with substantial missing data, and thus are removed from the analysis. Thus, the dataset used to start the analysis contains 3,020 households (1,500 treatment and 1,520 control households). A propensity score matching is conducted to improve the quality of the counterfactual group based on a number of observable characteristics to control directly for selection on observables and to ensure that there is sufficient common support between in treatment and control households. Having a sufficient common support helps confirm that households in the control group represent a valid counterfactual to those in the treatment group (Heckman et al., 1999; Bryson et al.; 2002).

Treatment and control households are matched separately by district. Results show that the Rosenbaum and Rubin bias shows a reduction from 18.7% before matching to 2.8% after matching, which is lower than the recommended threshold of 25% as suggested in the literature (Rubin, 2001). Further, the

[4] The research team conduct a listing exercise to collect the information of households that are members each PO prior to the collection of our quantitative surveys. The team use the lists of members for each PO as the sampling frame to randomly select the households from each PO to be interviewed.

relative ratio between the variances of all covariates in treatment and control groups is 0.94, which is within the recommended bound of (0.8, 1.25) as suggested in the literature (Rubin, 2001). Following the standard practice in the matching literature, the matched sample is trimmed at the 2% lowest and the 98% highest propensity scores to improve the common support (Leuven and Sianesi, 2003).

Table 4 reports the descriptive statistics of households in treatment and control groups, before and after matching. While it is observed that some household-level characteristics are statistically different between treatment and control groups before matching, they appear to be statistically similar after matching. These results confirm that the propensity score matching improves the common support between households in both groups, which lead to a more balanced sample. Appendix 1 (Figures 4-6) presents the background results from the propensity score matching, which help confirm that there is sufficient balance between treatment and control households in the sample. The matched sample used to estimate the project impact consists of 2,874 households (1,417 treatment and 1,457 control households).

One important consideration to note in the dataset is the definition of dalit, janjati, and ethnic minority groups in the dataset. *Dalit* and *Janjati* are socially marginalized groups within the caste system. In our sample, dalit, janjati, and other ethnic minority (DJEM henceforth) group represents approximately 26% of the households in our sample. Of the DJEM sample used in the analysis, the proportion of each ethnicity represented are: Magar 9.3%, Gurung 0.6%, Tamang 0.03%, Newar 0.2%, Damai/Dholi 2.5%, Kami 10.7%, Sakri 1.7%, Tharu 0.2%, and Rai 0.2%. They own small size of land (0.4 hectares on average versus 0.5 hectares on average for non ethnic minority households), cultivate crops on this land, and sell these crops in small quantities to the market.

Table 4: Descriptive statistics of the sample before and after matching

Variable	Before matching			After matching		
	Treat. Mean	Control Mean	Diff.	Treat. Mean	Control Mean	Diff.
Age of head (years)	45.77	44.71	0.02**	45.71	45.64	0.88
Schooling of head (=1 if ever attended school)	0.52	0.54	0.22	0.52	0.52	0.93
Education of head (=1 if literate)	4.11	4.67	0.001***	4.13	4.11	0.92
Sex of head (=1 if male)	0.73	0.74	0.36	0.73	0.73	0.88
Household size (count)	5.09	5.12	0.64	5.06	5.10	0.66
Adult equivalent scale	4.51	4.52	0.91	4.49	4.52	0.64
Share of female in household	0.54	0.53	0.59	0.54	0.54	0.99
Dependency ratio	0.78	0.89	0.0001***	0.79	0.79	0.92
Share of literate household members	0.65	0.65	0.90	0.65	0.65	0.95
Land ownership (hectare)	2.13	2.07	0.06*	2.12	2.13	0.82
DJEM household (=1 if yes)	0.26	0.26	0.84	0.26	0.25	0.79
Number of observations	1,500	1,520		1,417	1,457	

Note: .01 - ***; .05 - **; .1 - *;

3.2 Questionnaire and impact indicators

The quantitative (both at the household level and at the PO level) and qualitative data in this impact assessment were collected between May and July 2018. While the qualitative interviews focus on collecting information about the project implementation details and the lessons learned, the quantitative surveys collect extensive information during the twelve-month period preceding the timing of the survey. In particular, the survey collects extensive detailed about agricultural production (both crop and livestock production) from the most recent agricultural production cycle, which covers two main seasons namely the wet season (around May to October 2017) and the dry season (around November 2017 to April 2018). The household survey questionnaire consists of questions related to socio-economic status, agricultural and livestock production, other sources of income, dietary status, and household decision-making. The PO survey questionnaire focuses mainly on indicators related to access to services and infrastructures, communal

groups, agricultural and livestock production, commodity prices, and economic activities.

The broad range of information collected from both household and PO surveys allows the impact assessment of HVAP to include a large set of indicators. In this impact assessment, the analysis focuses on estimating the project impact on four sets of indicators based on the project logic described in the project's theory of change as shown in Figure 1. First, the analysis begins by estimating the project impact on agricultural production indicators (crop and livestock). Second, estimates of project impact on economic mobility indicators namely income and assets are reported. The third set of focus on social indicators food security, dietary diversity, resilience indicators, decision making by gender. And finally, project impacts on poverty reduction indicators are reported. The full list of indicators used for the analysis is reported in Appendix 2.

3.3 Impact estimation

The analysis focuses mainly on ATT or the impact of the HVAP intervention on project households. The analysis starts with the propensity score matching (PSM) method.[5] In the PSM framework, the impact of the project (T_i) on household i can be written as follows:

$$\delta_i = \frac{Y_{i1}}{m_i} - \frac{Y_{i0}}{m_i},$$

where δ_i is the impact of the project (or average treatment effects), Y_{i1} refers to the outcome of interest for project household i, Y_{i0} is the outcome of interest for household i in the absence of the project, and m_i is the number of observations in each cluster (in this case $m_i = 12$). Treatment effects on the treated (ATT) can be estimated using following expression:

$$ATT_{PSM} = E(\delta_i|T = 1) = E(Y_{i1} - Y_{i0}|T = 1) \quad (1)$$

In this framework, the key identifying assumption is the conditional independence assumption which assumes that the treatment status is independent of the outcomes of interest, contingent on the observable characteristics (Rosenbaum and Rubin, 1983). Mathematically, if X_i is a vector of observable characteristics, then $T_i \perp (Y_{i0}, Y_{i1})|X_i$.

To supplement the PSM results, the analysis employs regression-based analysis to consistently estimate treatment effects while controlling directly for selection into project participation based on observable characteristics. The regression method will be similar to the one used in Godtland et al. (2004) to estimate the

[5] To ensure that our PSM results are robust to different specifications, we employ alternative matching approaches to validate the PSM results.

impact of farmer field schools on the returns to potato production in Peru, and in Rejesus et al. (2011) to estimate the impact of an improved irrigation technology on rice production in The Philippines.[6] Specifically, the regression specification is as follows:

$$Y_i = \alpha + \beta T_i + \gamma \boldsymbol{X}_i + \delta(\boldsymbol{X}_i - \bar{\boldsymbol{X}})T_i + \varepsilon_i \quad (2)$$

where Y_i is an outcome of interest, $\boldsymbol{X}_i$ is the vector of observable characteristics of household i, $\bar{\boldsymbol{X}}$ is the vector of the average of the observable characteristics of household i, and ε_i is the error term. In Equation (2), β is the ATE estimate. Replacing $\bar{\boldsymbol{X}}$ with $\bar{\boldsymbol{X}}_1$ (where $\bar{\boldsymbol{X}}_1$ is the average over treatment households only) yields the ATT estimate.

Finally, to complement the two approaches described above, the analysis uses doubly robust methods such as the inverse-probability-weighted regression-adjustment (IPWRA) estimator (Wooldridge, 2007; Wooldridge, 2010). This approach models the likelihood of being treated by an intervention and estimates the impact from participating in the intervention. A major advantage of this estimation approach is that only one of the two estimation equations needs to be specified correctly, and thus has the "double-robust" property. This method follows the similar approach as the regression-based method. However, each observation in the dataset is assigned weights according to the following matrix:

$$\omega(t,x) = t + (1-t)\frac{\hat{P}(X)}{1-\hat{P}(X)},$$

where $\omega(t,x)$ is the weight applied, t represents $T_i = 1$, $\hat{P}(X)$ is the estimated propensity score, and X is a vector of covariates.

Table 5 summarizes the models we will use to estimate the treatment effects of HVAP. Note that i denotes household, T denotes treatment indicator (1 if in the HVAP sample and 0 otherwise), Y_i denotes outcome of interest, $\boldsymbol{X}_i$ is a vector of observable characteristics.

[6] See also Wooldridge (2010) for more details about this approach.

Table 5: Identification strategies and treatment effect models

Method	Treatment effects	Formula
Propensity score matching	ATT	$E(Y_{i1} - Y_{i0}\|T = 1)$
Regression based method	ATT	$Y_i = \alpha + \beta T_i + \gamma \boldsymbol{X}_i + \delta(\boldsymbol{X}_i - E[X_i\|T_i = 1])T_i + \varepsilon_i$
Doubly robust method	ATT	$Y_i = \alpha + \beta T_i + \gamma \boldsymbol{X}_i + \delta(\boldsymbol{X}_i - E[X_i\|T_i = 1])T_i + \varepsilon_i$ with weights $\omega(t,x) = t + (1-t)\frac{\hat{P}(X)}{1-\hat{P}(X)}$

3.4 Differential impacts

Project design report for HVAP indicates that eligibility criteria differ by the type of value chain, well-being ranking, and ethnicity. After estimating the overall impact of HVAP, the analysis explores the impact of the intervention for various sub-groups. According to the discussions with the project team, the two heterogeneous analyses of interest are by the sex of the household head (male vs. female) and by the ethnicity of the household (whether the household belongs to the DJEM group, or not).

4. Profile of the project area and sample

As mentioned in the introduction section, the HVAP project supports seven value chains: six crop value chains and a livestock (goat) value chain. However, no project district received support covering all seven value chains due to eligibility criteria and agro-climatic suitability. Table 6 provides an overview of value chain coverage by project districts. Kalikot received support for the least number of value chains, apple, goat, and off-season vegetables (three value chains in total), and Salyan and Surkhet both received support for the highest number of value chains, which are all but apple value chain (six value chains in total). Similarly, the apple value chain is supported only in two districts, Jumla and Kalikot, because the agro-climatic conditions in other districts are less favorable for apple production due to its lower altitude and warmer climate. Goat and off-season vegetables are supported in all seven districts, but the varieties of vegetables and meat goat species differ by district according to its agro-ecological condition.

Table 6: Value chain coverage by district

Districts	Apple	Ginger	Goat	Off-season vegetables	Timur	Turmeric	Vegetable seeds
Achham			x	x	x	x	
Dailekh		x	x	x		x	x
Jajarkot			x	x	x		
Jumla	x		x	x			x
Kalikot	x		x	x			
Salyan		x	x	x	x	x	x
Surkhet		x	x	x	x	x	x

Note: HVAP project value chain coverage by district. There are 31 unique district-value chain combinations.

Potential differences in project supported value chains across different districts provide an opportunity to disaggregate the project participants by district and by value chain. Table 7 presents the distribution of the sampled POs for the treatment group only as the sampled POs for the control group may or may not be part of the same value chain as those in the treatment group. As HVAP focuses on developing value chains by working with POs already formed, the project might have resulted in changing the value chains which resulted in switching crops grown or livestock raised by the POs receiving project interventions.

Table 7: Project coverage by district and by value chain (treatment group only)

District	Value chain	POs	Households
Achham	Goat	2	25
Achham	OSV	4	52
Achham	Timur	1	11
Dailekh	Goat	7	83
Dailekh	OSV	8	101
Dailekh	Turmeric	1	13
Dailekh	Vegetable seeds	1	12
Jajarkot	Goat	6	72
Jajarkot	OSV	3	37
Jajarkot	Timur	5	65
Jajarkot	Turmeric	1	11
Jumla	Apple	9	108
Jumla	Goat	2	25
Jumla	OSV	4	45
Kalikot	Apple	8	88
Kalikot	Goat	2	25
Kalikot	OSV	5	62
Salyan	Ginger	3	37
Salyan	Goat	2	24
Salyan	OSV	2	24
Salyan	Timur	2	24
Salyan	Turmeric	2	24
Surkhet	Ginger	7	81
Surkhet	Goat	8	98
Surkhet	OSV	17	209
Surkhet	Turmeric	3	37
Surkhet	Vegetable seeds	2	24
Total		**117**	**1,417**

Note: OSV stands for off-season vegetables.

Before moving on to discuss the results from the impact estimates, Table 8 presents the sources of income that the farmers in the sample earned on an annual basis. On average, farmers in the sample earn 44% of their total annual income from crop production and sales, 16% of livestock production and sales, 12% from wage labor, 4% from self employment and self enterprise, 4% of sales of products, goods, or services, 13% from remittances coming from migrated household members, and 7% from other transfers and pension. Moreover, of the total crop income, income from crops focused by HVAP (apple, ginger, off-season vegetables, vegetable seeds, turmeric, and timur) accounts for approximately 15% of total crop income. Of the total livestock

income, income from livestock focused by HVAP (goat) represents about 25% of total livestock income.

Table 8: Share of total income of households within sample by source

Source of income	Share of total income
Crop income	44%
Livestock income	16%
Wage income	12%
Self-employment and self-enterprise income	4%
Sales of products, goods, and service income	4%
Remittance income	13%
Transfer and pension income	7%
Total income	**100%**

Source: Authors' calculations from survey data

5. Results

Results are presented in the following order. First, results on the full sample (pooled across treatment and control groups) are presented. Then, the analysis explores the heterogeneous impacts of the project by the household head's gender and by ethnicity. Section 5.1 reports the impact estimates from the full sample. The preferred estimator is the inverse probability weighted regression adjustment (IPWRA) but there are four additional estimators to verify the robustness of the results. The additional estimators include (1) inverse probability weighting (IPW) estimator, (2) covariate matching estimator based on five nearest neighbours (NN), (3) propensity score matching estimator based also on five nearest neighbours (PSM), and (4) regression adjustment (RA) estimator, the base-case specification. All five model specifications control for potential effects from covariates not correlated to the intervention.[7]

Based on the specific definitions of the indicators, the magnitudes of impact estimates reported are either expressed in percentages or in levels. When relevant, the narrative of results converts impact estimates from percentages to levels to illustrate the magnitude of project impact relative to the control groups means based on the IPWRA estimates reported.

Section 5.2 presents results from the heterogeneity analysis by household head's gender and ethnicity. All impact estimates from heterogeneity analyses are based on our preferred specification; IPWRA estimator. As with other heterogeneity analyses, there can be a small sample size bias that might affect the significance of heterogeneous impact estimates. Thus, it is suggested that the results from the heterogeneity analyses be interpreted with caution.

5.1 Overall impacts of HVAP

5.1.1 Agricultural production indicators

Table 9 presents the impacts of HVAP on agricultural production indicators. All agricultural indicators are based on a 12-month recall from the time of data collection. Results show that the number of crop rotations cultivated by farmers in the treatment group increases by 0.5% relative to that of the control group during the wet season (May to October), but not for the dry season (November to April).

[7] Control variables used for all specifications include age of household head, schooling of household head, education of household head, sex of household head, household size, adult-equivalent scalre, share of female in household, dependency ratio, share of literate household members, landholding size, and ethinicity (=1 if belonging to DJEM groups).

One of the focuses of HVAP is to ensure that beneficiary households (PO members) have improved and sustained access to input and output markets along the value chain throughout the year. Access to markets is measured with frequency of selling products or buying inputs through traders instead of middlemen. Results show that treatment households are more likely to sell their crops through traders in both wet and dry seasons. Households in the treatment group are 4.7% points more likely to sell their crops to a trader during the wet season, and 5.6% points more likely to sell their crops to a trader during the dry season. The significant increase in the likelihood of treatment households selling their crops to a trader in both seasons is consistent across all five specifications indicating that the result is robust. This finding confirms that HVAP has contributed to improving farmers' access to markets. Qualitative evidence indicates that the improved access to markets is not only specific to the project crops, but also extends to other crops that farmers commonly cultivate and sell.

The analysis also estimates the impact of the intervention on post-harvest losses, but discovered that post-harvest losses among project households are smaller but not statistically different from project households. Since the average post-harvest loss is very low for the control households, the absence of impact on post-harvest loss could be coming from improvement in post-harvest loss among both control and project households from reasons other than HVAP interventions.

Table 9: Project impacts on agricultural production indicators (full sample)

	(1)	(2)	(3)	(4)	(5)	(6)
	IPWRA	IPW	NN	PSM	RA	Control mean
Agricultural production indicators, wet season						
Number of crop rotations	0.005*	0.004	0.005*	0.005*	0.005*	1.000
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	
Post-harvest losses (kg)	-0.005	-0.003	-0.002	-0.004	-0.004	0.039
	(0.005)	(0.005)	(0.003)	(0.005)	(0.005)	
Share of farmers selling crops to traders	0.047***	0.046***	0.051***	0.046***	0.046***	0.022
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	
Agricultural production indicators, dry season						
Number of crop rotations	-0.001	-0.002	-0.002	-0.001	-0.001	1.002
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	
Post-harvest losses (kg)	-0.002	-0.003	-0.004	-0.002	-0.001	0.053
	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)	
Share of farmers selling crops to traders	0.056***	0.057***	0.057***	0.056***	0.056***	0.009
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	
Number of observations	2,874	2,874	2,874	2,874	2,874	1,457

Notes: Level of significance *** p<0.01; ** p<0.05; and * p<0.1. Standard errors are in parentheses. IPWRA denotes Inverse Probability Weighted Regression Adjustment, IPW denotes Inverse Probability Weighting, NN denotes Nearest Neighbourhood matching, PSM denotes Propensity Score Matching, and RA denotes Regression Adjustment.

5.1.2 Income and asset indicators

Table 10 reports the project impacts on total household income and individual components of household income, by type of income source. All components of income are calculated using a 12-month recall period preceding the survey. Throughout the analysis, all income indicators are presented in the logarithmic scale, so the point estimates on income variables are interpreted as percentage changes.

Overall, total household income growth among treatment households is 36.8% higher than among control households. In absolute terms, household income for treatment households increases by 56,466 rupees per year relative to control households.[8] The growth in household income by 36.8% exceeds the project goal of increasing income by 30% and demonstrates the success of HVAP intervention.What is more appealing is that the growth in total household income primarily came from growth in crop and livestock incomes coupled with significant decrease in remittance flow. This finding is very encouraging because it provides critical evidence that HVAP interventions are effective in deterring migration and promoting agricultural transformation at the same time.

Crop incomes increases by about 50% among project households and livestock incomes grew by about 93%. This increase means that compared to control households, treatment households earn 15,333 rupees more per year from crop cultivation and 19,231 rupees more per year from livestock keeping. Comparing the levels of increase in income from crop production and livestock production indicates that livestock production contributes more to household income growth than crop production, among treatment households.

Among other income components, wage income and income from social transfers are slightly higher for project households and income from self-employment/enterprise and sales of goods and services are slightly lower for project households than control households, but none of them are statistically significant. In terms of remittances, the amount of remittances received by treatment households is 31.5% (9,011 rupees per year) lower than the remittances received by control households. This finding, although only suggestive due to the absence of a true baseline dataset, complements to the finding in the literature about the crowding out of private transfers by public transfers (Angelucci, 2015; Nepal, 2016), which in this case is the support from the HVAP project.

[8] 1 US$ is equivalent to 113 Nepalese rupees (December 2018).

Table 10: Project impacts on income indicators (full sample)

	(1)	(2)	(3)	(4)	(5)	(6)
	IPWRA	IPW	NN	PSM	RA	Control mean
Income indicators						
Total household income (Log, Rs.)	0.368***	0.364***	0.346***	0.371***	0.368***	153,440.4
	(0.048)	(0.048)	(0.056)	(0.051)	(0.048)	
Crop income (Log, Rs.)	0.499***	0.499***	0.465***	0.489***	0.499***	30,728.55
	(0.089)	(0.089)	(0.097)	(0.093)	(0.089)	
Livestock income (Log, Rs.)	0.929***	0.938***	0.898***	0.919***	0.932***	20,701.72
	(0.176)	(0.189)	(0.199)	(0.177)	(0.176)	
Wage income (Log, Rs.)	0.269	0.387**	0.209	0.270	0.271	26,614.857
	(0.167)	(0.169)	(0.190)	(0.166)	(0.166)	
Self-employment and self-enterprise income (Log, Rs.)	-0.132	-0.143	-0.128	-0.137	-0.133	19,085.22
	(0.135)	(0.141)	(0.160)	(0.136)	(0.135)	
Sales of products, goods, and service income (Log, Rs.)	-0.0536	-0.0657	-0.0606	-0.0594	-0.0551	21,777.32
	(0.138)	(0.145)	(0.163)	(0.139)	(0.138)	
Remittance income (Log, Rs.)	-0.315*	-0.334*	-0.402**	-0.321*	-0.309*	28,607.55
	(0.166)	(0.180)	(0.181)	(0.166)	(0.166)	
Transfer and pension income (Log, Rs.)	0.215	0.162	0.292*	0.208	0.217	6,917.63
	(0.160)	(0.170)	(0.173)	(0.160)	(0.159)	
Number of observations	2,874	2,874	2,874	2,874	2,874	1,457

Notes: Level of significance *** p<0.01; ** p<0.05; and * p<0.1. Standard errors are in parentheses. IPWRA denotes Inverse Probability Weighted Regression Adjustment, IPW denotes Inverse Probability Weighting, NN denotes Nearest Neighbourhood matching, PSM denotes Propensity Score Matching, and RA denotes Regression Adjustment.

Asset-based indicators are also commonly used in the literature to analyse poverty and economic mobility issues when monetary indicators such as income and expenditures are not available or are measured with errors (Filmer and Pritchett, 2001; Sahn and Stifel, 2003).

Table 11 presents the impact estimates of HVAP on asset indicators. While there is no significant impact on housing quality index (or housing characteristics), there are significant project impacts on durable assets, durable assets, and livestock ownership (as measured by the tropical livestock unit or TLU). Results show that the HVAP intervention contributed to growth in accumulation of durable assets, durable assets, productive assets, and livestock ownership. Given that households use asset accumulation as a saving strategy, growth in asset index implies that the intervention helped improve household wellbeing through increased asset accumulation of variety of assets.

Table 11: Results on asset indicators from the full sample

	(1)	(2)	(3)	(4)	(5)	(6)
	IPWRA	IPW	NN	PSM	RA	Control mean
	Full sample	Full sample	Full sample	Full sample	Full sample	Full sample
Asset indicators						
Housing quality index (MCA)	0.007	0.006	0.009	0.006	0.007	0.235
	(0.006)	(0.007)	(0.007)	(0.006)	(0.006)	
Durable asset index (PCA)	0.097***	0.103***	0.118***	0.093***	0.096***	0.993
	(0.034)	(0.035)	(0.036)	(0.034)	(0.034)	
Productive asset index (PCA)	0.164***	0.161***	0.184***	0.163***	0.164***	2.53
	(0.034)	(0.038)	(0.037)	(0.034)	(0.034)	
Tropical Livestock Unit (TLU)	0.232***	0.239***	0.198***	0.229***	0.233***	2.70
	(0.062)	(0.064)	(0.070)	(0.062)	(0.062)	
Number of observations	2,874	2,874	2,874	2,874	2,874	1,457

Notes: Level of significance *** p<0.01; ** p<0.05; and * p<0.1. Standard errors are in parentheses. IPWRA denotes Inverse Probability Weighted Regression Adjustment, IPW denotes Inverse Probability Weighting, NN denotes Nearest Neighbourhood matching, PSM denotes Propensity Score Matching, and RA denotes Regression Adjustment.

5.1.3 Poverty reduction indicators

As the main goal of the value chain development supported by HVAP is to contribute to poverty reduction among the project beneficiaries, Table 12 presents the impact estimates of HVAP on poverty reduction indicators. The common practice in the literature is to set the poverty lines at the 40^{th} and the 60^{th} percentiles of the wealth indicators (Booysen et al. 2008). In the analysis, the poverty lines are set using the distributions of the asset-based indicators, namely durable asset and productive asset.

Using durable asset-based poverty lines, treatment households are 7.2% and 6.4% more likely to be non-poor when setting the poverty line using the 40^{th} and the 60^{th} percentile ranks of the durable asset distribution of the control group. Further, when referring to productive asset-based poverty lines, households in the treatment group are 8.0% and 6.9% more likely to be above the poverty line when using the productive asset distribution of the control group to set the poverty lines at its 40^{th} and 60^{th} percentile ranks.

Table 12: Results on poverty reduction indicators from the full sample

	(1)	(2)	(3)	(4)	(5)	(6)
	IPWRA	IPW	NNM	PSM	RA	Control mean
	Full sample	Full sample	Full sample	Full sample	Full sample	Full sample
Poverty reduction indicators						
Above the 40th poverty line, durableasset	0.072***	0.076***	0.081***	0.070***	0.071***	0.601
	(0.016)	(0.018)	(0.019)	(0.016)	(0.016)	
Above the 60th poverty line, durable asset	0.064***	0.072***	0.067***	0.061***	0.063***	0.401
	(0.017)	(0.017)	(0.019)	(0.017)	(0.017)	
Above the 40th poverty line, productive asset	0.080***	0.077***	0.094***	0.079***	0.080***	0.601
	(0.017)	(0.019)	(0.019)	(0.017)	(0.017)	
Above the 60th poverty line, productive asset	0.069***	0.073***	0.072***	0.068***	0.069***	0.400
	(0.017)	(0.019)	(0.020)	(0.017)	(0.017)	
Number of observations	2,874	2,874	2,874	2,874	2,874	1,457

Notes: Level of significance *** p<0.01; ** p<0.05; and * p<0.1. Standard errors are in parentheses. IPWRA denotes Inverse Probability Weighted Regression Adjustment, IPW denotes Inverse Probability Weighting, NN denotes Nearest Neighbourhood matching, PSM denotes Propensity Score Matching, and RA denotes Regression Adjustment.

5.1.4 Dietary diversity and household resilience indicators

Table 13 reports the results of the impacts of HVAP on dietary diversity and resilience indicators. In terms of the impact on household-level dietary diversity, results show that the dietary diversity score of households in the treatment group is significantly higher than that of the control group by 1.4%. This result corresponds with the small but growing literature that investigates the relationship with agricultural development interventions and dietary outcome of their beneficiaries (Zeweld et al., 2015; Jodlowski et al., 2016; Upton et al., 2016).

Resilience is proxied by the perceived ability to recover from subjective occurrences of shocks. Results indicate that there is no statistically significant difference in the perceived ability to recover from shocks between households in treatment and control groups. This finding is not surprising for two reasons.

First, according to the summary statistics in the sample, households in both groups report very low shock occurrence. Second, HVAP interventions, which mainly consisting of strengthening the capacity of POs to access markets and value chains, do not involve activities that would directly contribute to resilience building capacity of the beneficiaries.

Table 13: Results on dietary diversity and household resilience indicators from the full sample

	(1)	(2)	(3)	(4)	(5)	(6)
	IPWRA	IPW	NNM	PSM	RA	Control mean
	Full sample	Full sample	Full sample	Full sample	Full sample	Full sample
Dietary diversity and resilience indicators						
Dietary diversity score	0.088*	0.088*	0.111**	0.081*	0.086*	6.47
	(0.048)	(0.053)	(0.053)	(0.048)	(0.048)	
Ability to recover from shocks	-0.005	-0.043	-0.088	-0.003	-0.005	2.64
	(0.066)	(0.075)	(0.078)	(0.066)	(0.065)	
Number of observations	2,874	2,874	2,874	2,874	2,874	1,457

Notes: Level of significance *** p<0.01; ** p<0.05; and * p<0.1. Standard errors are in parentheses. IPWRA denotes Inverse Probability Weighted Regression Adjustment, IPW denotes Inverse Probability Weighting, NN denotes Nearest Neighbourhood matching, PSM denotes Propensity Score Matching, and RA denotes Regression Adjustment.

5.1.5 Household decision-making indicators

The final set of indicators to report consists of indicators related to intra-household decision-making. The survey contains a set of questions about household members who make decisions related to different issues including crop cultivation, crop sales, livestock rearing, and livestock sales. The possible responses to these questions are whether the decisions are made by (1) male household members, (2) female household members, or (3) jointly by male and female household members. We combine responses (2) and (3) to create women's decision-making power which measures whether or not any female household member has decision-making power on decisions related to production and sales of crop and livestock.

Results in Table 14 show that no statistically significant differences in any of the decision-making issues between households in treatment and control groups. There are two possible explanations to this finding. First, the survey asks the questions only to one respondent per household, and most of which are male. This interview approach might lead to systematic biases in the reporting of responses as the survey did not get to interview both male and female

members of the same household. Therefore, it is not possible to capture the differences in the reporting between male and female household members about decision-making on the same topics. Second, summary statistics from the dataset indicate relatively high shares of women having decision-making power within the households related to crop and livestock production (between 84% to 89%).

Table 14: Results on household decision-making indicators from the full sample

	(1)	(2)	(3)	(4)	(5)	(6)
	IPWRA	IPW	NNM	PSM	RA	Control mean
	Full sample	Full sample	Full sample	Full sample	Full sample	Full sample
Women's decision-making indicators						
Decision-making of women about crop cultivation	-0.010	-0.013	-0.018	-0.011	-0.010	0.86
	(0.012)	(0.013)	(0.014)	(0.012)	(0.012)	
Decision-making of women about crop sales	-0.0034	-0.0016	-0.012	-0.004	-0.003	0.85
	(0.012)	(0.013)	(0.014)	(0.012)	(0.012)	
Decision-making of women about livestock rearing of large animals	-0.006	-0.006	-0.020	-0.007	-0.006	0.88
	(0.011)	(0.012)	(0.012)	(0.011)	(0.011)	
Decision-making of women about livestock rearing of small animals	0.0004	0.001	-0.007	-0.0004	0.0003	0.87
	(0.011)	(0.011)	(0.012)	(0.011)	(0.011)	
Decision-making of women about livestock sales	-0.003	-0.005	-0.017	-0.004	-0.003	0.86
	(0.012)	(0.012)	(0.013)	(0.012)	(0.012)	
Number of observations	2,874	2,874	2,874	2,874	2,874	1,457

Notes: Level of significance *** p<0.01; ** p<0.05; and * p<0.1. Standard errors are in parentheses. IPWRA denotes Inverse Probability Weighted Regression Adjustment, IPW denotes Inverse Probability Weighting, NN denotes Nearest Neighbourhood matching, PSM denotes Propensity Score Matching, and RA denotes Regression Adjustment.

5.2 Heterogeneous impacts of HVAP

5.2.1 Agricultural production indicators

Table 15 reports the impact estimates of HVAP on agricultural production indicators on the sub-samples by sex of the household head and by ethnicity. There appears to be a slightly significant increase (approximately by 0.8%) in the number of crop rotations during the wet season (May to October) among non-DJEM households, but there are no other significant impacts on the number of crop rotations on other sub-groups or for the number of crop rotations during the dry season (November to April). In terms of post-harvest losses, there are no significant impacts on post-harvest losses in either season across all sub-groups.

In terms of the shares of households in the sample selling their crops through a trader, findings indicate positive project impacts among male-headed and non-DJEM households. During the wet season, male-headed households and non-DJEM households in the treatment are 5.5% and 5.8% percentage points more likely to sell their crops through a trader compared to their respective control groups. During the dry season, the increases in percentage points are 6.4% and 6.4% relative to their control groups. Also, during the dry season, female-headed households in the treatment group are 3.0% percentage points more likely to sell their crops to a trader.

Qualitative evidence also confirms that limited market access remains a development challenge among vulnerable groups including female-headed households and DJEM households. Further, several POs supported by HVAP do not have sufficient representation of DJEM members. Thus, additional efforts to ensure that vulnerable groups namely women and DJEM groups have sufficient representation in POs and project activities as well as improved market access could increase their income-generating activities.

Table 15: Results on agricultural production indicators from the sub-samples

	(1)	(2)	(3)	(4)
	IPWRA	IPWRA	IPWRA	IPWRA
	Male-headed HH	Female-headed HH	Non-DJEM	DJEM
Agricultural production indicators, wet season				
Number of crop rotations, wet season	0.006	0.003	0.008**	-0.003
	(0.004)	(0.003)	(0.004)	(0.003)
Post-harvest losses, wet season (kg.)	-0.006	0.003	-0.0004	-0.028
	(0.006)	(0.006)	(0.002)	(0.027)
Share of farmers selling crops to traders, wet season	0.055***	0.019	0.058***	0.013
	(0.010)	(0.015)	(0.010)	(0.014)
Agricultural production indicators, dry season				
Number of crop rotations, dry season	-0.002	0.001	-0.0003	-0.006
	(0.001)	(0.004)	(0.002)	(0.005)
Post-harvest losses, dry season (kg.)	-0.003	0.006	-0.002	0.003
	(0.004)	(0.007)	(0.004)	(0.009)
Share of farmers selling crops to traders, dry season	0.064***	0.030**	0.064***	0.024
	(0.010)	(0.015)	(0.010)	(0.016)
Number of observations	2,120	754	2,136	738

Notes: Level of significance *** p<0.01; ** p<0.05; and * p<0.1. Standard errors are in parentheses. IPWRA denotes Inverse Probability Weighted Regression Adjustment.

5.2.2 Income and asset indicators

Table 16 presents the estimates of project impacts on total household income and its different components. Relative to the control group, total household income of households in the treatment group significantly increases by 38.9% and 34.0% for male-headed and female-headed households. Further, total household income increases by 41.2% in the treatment group for non-DJEM households and by 16.4% in the treat for DJEM households.

Turning to income from crop production, estimates show that the crop income of HVAP beneficiaries increases by 58.0% among male-headed households and by 38.9% among female-headed households relative to the control group. Further, the increases in crop income among the treatment group are 42.6% and 92.0% for non-DJEM households and DJEM households when compared to those of the control group. These results show that HVAP is quite successful in increasing crop income among its DJEM beneficiaries, raising their crop income by approximately 24,852 rupees per year compared to only by 13,640 rupees per year among non-DJEM beneficiaries.

Results show that treatment households have 114.7% and 59.8% increases in livestock income for male-headed households and female-headed households when compared to the control group. Among non-DJEM households in the treatment group, the positive and significant increase in livestock income is 99.0%. For DJEM households in the treatment group, the project impact on livestock income is 62.1% relative to that of the control group.

Although overall households in the treatment group receive significantly remittances from migrated household members than those in the control group, the impact of the project on cash remittances within the sub-sample consisting of male-headed households. Results show that the remittances received by male-headed households in the treatment group are 49.0% lower than those in the control group.

Table 17 reports the project impacts of asset indicators on different sub-samples. While there is no significant overall project impact on housing quality when analysing the full sample, the value of housing quality index of non-DJEM in the treatment group increases by 6.2% compared to the control group.

For durable assets, there is positive and significant impact of the project on durable assets among male-headed households and non-DJEM households in the treatment group. Their value of durable asset index is 9.4% and 14.2% higher than that of the control group. For productive assets, there exists positive and significant project impact in all sub-samples. Relative to the control group, impact estimates indicate that the productive asset index significantly increases by 6.0%, 8.7%, 6.3%, and 8.4% for male-headed households, female-headed households, non-DJEM households, and DJEM households in the treatment group. And for livestock ownership, the value of TLU in the treatment group is significantly higher than that of the control group by 11.0%, 7.8%, and 15.2% among male-headed households, non-DJEM households, and DJEM households. However, there is no significant impact of the project on livestock ownership among female-headed households.

Table 16: Results on income indicators from the sub-samples

	(1)	(2)	(3)	(4)
	IPWRA	IPWRA	IPWRA	IPWRA
	Male-headed HH	Female-headed HH	Non-DJEM	DJEM
Income indicators				
Total household income (Log, Rs.)	0.389***	0.340***	0.412***	0.164*
	(0.058)	(0.103)	(0.056)	(0.092)
Crop income (Log, Rs.)	0.580***	0.389*	0.426***	0.920***
	(0.099)	(0.215)	(0.103)	(0.199)
Livestock income (Log, Rs.)	1.147***	0.598*	0.990***	0.621*
	(0.209)	(0.353)	(0.205)	(0.365)
Wage income (Log, Rs.)	0.241	0.323	0.295	0.154
	(0.206)	(0.280)	(0.193)	(0.341)
Self-employment and self-enterprise income (Log, Rs.)	-0.098	-0.290	-0.012	-0.530*
	(0.169)	(0.229)	(0.156)	(0.279)
Sales of products, goods, and service income (Log, Rs.)	-0.0004	-0.268	0.097	-0.541*
	(0.173)	(0.232)	(0.160)	(0.283)
Remittance income (Log, Rs.)	-0.490***	0.187	-0.266	-0.406
	(0.172)	(0.383)	(0.192)	(0.331)
Transfer and pension income (Log, Rs.)	0.202	0.278	0.228	0.065
	(0.183)	(0.327)	(0.186)	(0.323)
Number of observations	2,120	754	2,136	738

Notes: Level of significance *** p<0.01; ** p<0.05; and * p<0.1. Standard errors are in parentheses. IPWRA denotes Inverse Probability Weighted Regression Adjustment.

Table 17: Results on asset indicators from the sub-samples

	(1)	(2)	(3)	(4)
	IPWRA	IPWRA	IPWRA	IPWRA
	Male-headed HH	Female-headed HH	Non-DJEM	DJEM
Asset indicators				
Housing quality index (MCA)	0.004	0.014	0.014**	-0.012
	(0.007)	(0.012)	(0.007)	(0.014)
Durableasset index (PCA)	0.097**	0.073	0.135***	-0.021
	(0.041)	(0.058)	(0.038)	(0.073)
Productive asset index (PCA)	0.158***	0.191***	0.161***	0.203***
	(0.041)	(0.059)	(0.041)	(0.060)
Livestock asset (TLU)	0.312***	0.027	0.218***	0.368***
	(0.075)	(0.106)	(0.073)	(0.109)
Number of observations	2,120	754	2,136	738

Notes: Level of significance *** p<0.01; ** p<0.05; and * p<0.1. Standard errors are in parentheses. IPWRA denotes Inverse Probability Weighted Regression Adjustment.

5.2.3 Poverty reduction indicators

Table 18 presents the heterogeneity analysis on poverty reduction indicators. Similar to the analysis using the full sample, results indicate that positive and significant impact on poverty reduction when setting the poverty line at the 40th percentile rank of both durable and productive asset distributions of the control group across all sub-samples.

However, when using the 60th percentile rank of the durable asset and the productive asset distributions of the group to set the poverty line, the positive and significant impact on poverty reduction is only observed among male-headed households and non-DJEM households in the treatment group. While there seems to be a slightly positive impact of HVAP on productive asset among female-headed households, the point estimates were not consistently significant across all specifications.

Table 18: Results on poverty reduction indicators from the sub-samples

	(1)	(2)	(3)	(4)
	IPWRA	IPWRA	IPWRA	IPWRA
	Male-headed HH	Female-headed HH	Non-DJEM	DJEM
Poverty reduction indicators				
Above the 40th poverty line, durable asset	0.070***	0.089***	0.070***	0.089***
	(0.019)	(0.034)	(0.019)	(0.033)
Above the 60th poverty line, durable asset	0.063***	0.045	0.081***	0.0004
	(0.020)	(0.033)	(0.020)	(0.034)
Above the 40th poverty line, productive asset	0.076***	0.094***	0.091***	0.080**
	(0.019)	(0.035)	(0.020)	(0.033)
Above the 60th poverty line, productive asset asset	0.071***	0.067**	0.082***	0.045
	(0.021)	(0.032)	(0.020)	(0.032)
Number of observations	2,120	754	2,136	738

Notes: Level of significance *** p<0.01; ** p<0.05; and * p<0.1. Standard errors are in parentheses. IPWRA denotes Inverse Probability Weighted Regression Adjustment.

5.2.4 Dietary diversity and resilience indicators

Table 19 reports the results on dietary diversity and resilience indicators separately by sub-sample. According to the estimates, there appears to be positive and significant impact on dietary diversity of households in the treatment group among non-DJEM households. Specifically, their dietary diversity score is higher than that of their control group by 1.9%. Summary statistics indicate that the increase in the dietary diversity score is driven by the increased consumption of vegetable, fruits, and milk and other dairy products. There is no significant impact of the project on dietary diversity among DJEM households.

As for the impact on resilience indicator, as measured by the self-reported ability to recover from shocks, the analysis yields similar results to those presented in Table 13. Overall, results from the heterogeneity analysis indicate

that there is no significant impact on the ability to recover from shocks across all sub-samples.

Table 19: Results on dietary diversity and household resilience indicators from the sub-samples

	(1)	(2)	(3)	(4)
	IPWRA	IPWRA	IPWRA	IPWRA
	Male-headed HH	Female-headed HH	Non-DJEM	DJEM
Dietary diversity and resilience indicators				
Dietary diversity score	0.056	0.100	0.121**	0.002
	(0.055)	(0.103)	(0.055)	(0.103)
Ability to recover from shocks	0.027	-0.074	0.028	-0.126
	(0.079)	(0.126)	(0.080)	(0.129)
Number of observations	2,120	754	2,136	738

Notes: Level of significance *** p<0.01; ** p<0.05; and * p<0.1. Standard errors are in parentheses. IPWRA denotes Inverse Probability Weighted Regression Adjustment.

5.2.5 Women's decision-making indicators

And finally, Table 20 presents the project impact on decision-making related to crop and livestock of female household members. While there is some evidence of significant differences in decision-making of women about crop cultivation among non-DJEM households and in decision-making women about livestock sales among DJEM households in the treatment group, the results are not consistently significant across all specifications. Thus, it is reasonable able to conclude that these results are robust and significant.

Table 20: Results on household decision-making indicators from the sub-samples

	(1)	(2)	(3)	(4)
	IPWRA	IPWRA	IPWRA	IPWRA
	Male-headed HH	Female-headed HH	Non-DJEM	DJEM
Women's decision-making indicators				
Decision-making of women about crop cultivation	-0.006	-0.005	-0.027*	0.027
	(0.016)	(0.012)	(0.015)	(0.019)
Decision-making of women about crop sales	0.005	-0.014	-0.013	0.016
	(0.017)	(0.012)	(0.015)	(0.019)
Decision-making of women about livestock rearing of large animals	0.002	-0.012	-0.019	0.019
	(0.015)	(0.011)	(0.014)	(0.017)
Decision-making of women about livestock rearing of small animals	0.006	-0.005	-0.009	0.015
	(0.015)	(0.011)	(0.014)	(0.016)
Decision-making of women about livestock sales	0.004	-0.012	-0.019	0.032*
	(0.016)	(0.011)	(0.015)	(0.018)
Number of observations	2,120	754	2,136	738

Note: .01 - ***; .05 - **; .1 - *; standard errors in parentheses

6. Conclusion

The impact assessment is an effort to measure and report results, summarize lessons learned, and inform project design and policy discussions from a rural development project aimed at reducing poverty and improving food security in rural Nepal as a case study. HVAP delivered a focused set of interventions consisting of inclusive value chains development and service market strengthening. To assess the project impact of HVAP, this work uses primary household and community surveys consisting of 2,874 households and 235 POs to estimate and report project impact on a wide range of outcome and impact indicators namely agricultural production, income, asset, dietary diversity, resilience, and women's decision-making.

Results from the impact assessments demonstrate positive and significant project impact on market access. Specifically, farmers in the treatment group are more likely to sell their cultivated crops through a formal marketing channel (a trader). Further, findings indicate increases in household income, particularly crop income and livestock income, among households receiving project interventions. These results correspond with previous studies documenting the role of market access to alleviate poverty through opening up opportunities for farmers to access productivity-improving inputs and earning higher revenues from output sales (Barrett, 2008; Chamberline and Jayne, 2013). Treatment households receive significantly lower cash remittances from migrated household members, evidence that public transfers in the form of a rural development project in like HVAP might crowd out private transfers in the form of remittances (Angelucci, 2015; Nepal, 2016). Results show that there are significant project impacts on asset, which indicate that households in the treatment group have greater durable and productive asset accumulation compared to those in the control group. Finally, there is greater dietary diversity (in particular the consumption of vegetables, fruits, and milk and other dairy products) at the household level in the treatment group, which fits existing literature examining the linkages between agricultural interventions and food security (Zeweld et al., 2015; Jodlowski et al., 2016; Upton et al., 2016).

The findings from this impact assessment document lessons that could be useful for future project design, country investment strategies, and policy. First, the project implements a set of interlinked activities related to production and marketing specifically tailored to only a small number of value chains. This more focused set of less diversified interventions result in a clear and consistent project logic to deliver intended outcomes and impacts through the causal

chain, and are likely to have resulted in positive and significant impacts observed on a range of outcome and impact indicators following the project's theory of change. This is not only true for direct impact indicators such crop or livestock income, but also for indirect but related indicator such as dietary diversity through the consumption of livestock-derived products among targeted farmers. Second, POs formed by HVAP and receiving project activities are of considerable size (approximately 25 to 40 members per PO). The relatively compact sizes of targeted POs allow close engagement between project staff and PO members and allow sufficient field monitoring and supervision to ensure that demands of PO members are accommodated and that project activities achieve their goals of strengthening linkages along the value chain. And finally, qualitative evidence suggests that another feature of the project design that has led to its success is its combination of top-down and bottom-up approaches to strengthen the linkages between smallholder producers and other actors within the value chain namely traders, government agencies, commerce and finance departments, and scientists. Not only this approach ensures that the project to achieve its goal to develop inclusive value chain in the project areas by address market frictions facing local producers, it also helps the project identify and select the most appropriate set of activities and interventions to deliver to project beneficiaries.

References

Alene, A. D., Manyong, V. M., Omanya, G., Mignouna, H. D., Bokanga, M., & Odhiambo, G. 2008. Smallholder market participation under transactions costs: Maize supply and fertilizer demand in Kenya. Food Policy, 33(4), 318-328.

Angelucci, M. 2015. Migration and financial constraints: Evidence from Mexico. Review of Economics and Statistics, 97(1): 224-228.

Ashraf, N., Giné, X. and Karlan, D. 2009 Finding missing markets (and disturbing epilogue): Evidence from an export crop adoption and marketing intervention in Kenya. American Journal of Agricultural Economics, 91 (4): 973-990.

Barrett, C. B. 2008. Smallholder market participation: Concepts and evidence from Eastern and Southern Africa. Food Policy, 33(4): 299-317.

Barrett, C.B., Bachke, M.E., Bellemare, M.F., Michelson, H.C., Narayanan, S. and Walker, T.F., 2012. Smallholder participation in contract farming: Comparative evidence from five countries. World Development, 40(4): 715-730.

Booysen, F., Van Der Berg, S., Burger, R., Von Maltitz, M. and Du Rand, G., 2008. Using an asset index to assess trends in poverty in seven Sub-Saharan African countries. World Development, 36(6): 1113-1130.

Bryson, A., R. Dorsett, and S. Purdon 2002. The Use of Propensity Score Matching in the Evaluation of Labour Market Policies, Working paper, Department for Work and Pensions, Washington, DC.

Cavatassi, R., González-Flores, M., Winters, P., Andrade-Piedra, J., Espinosa, P. and Thiele, G., 2011. Linking smallholders to the new agricultural economy: The case of the Plataformas de Concertación in Ecuador. Journal of Development Studies, 47(10): 1545-1573.

Chamberlin, J. and Jayne, T. 2013. Unpacking the meaning of market access: Evidence from rural Kenya. World Development, 41:245-264.

Davis, K., Nkonya, E., Kato, E., Mekonnen, D.A., Odendo, M., Miiro, R. and Nkuba, J., 2012. Impact of farmer field schools on agricultural productivity and poverty in East Africa. World Development, 40(2): 402-413.

Deraniyagala, S., 2005. The political economy of civil conflict in Nepal. Oxford Development Studies, 33(1): 47-62.

Emerick, K., de Janvry, A., Sadoulet, E. and Dar, M.H., 2016. Technological innovations, downside risk, and the modernization of agriculture. American Economic Review, 106(6): 1537-1561.

Filmer, D. and Pritchett, L.H., 2001. Estimating wealth effects without expenditure data or tears: An application to educational enrollments in states of India. Demography, 38(1): 115-132.

Gertler, P. J., Martinez, S., Premand, P., Rawlings, L. B., and Vermeersch, C. M. 2016. Impact Evaluation in Practice. World Bank Publications, Washington, DC.

González-Flores, M., Bravo-Ureta, B.E., Solís, D. and Winters, P., 2014. The impact of high value markets on smallholder productivity in the Ecuadorean Sierra: A Stochastic Production Frontier approach correcting for selectivity bias. Food Policy, 44: 237-247.

Headey, D., Bezemer, D. and Hazell, P. B., 2010. Agricultural employment trends in Asia and Africa: Too fast or too slow? World Bank Research Observer, 25 (1): 57-89.

Heckman, J., LaLonde, R., and Smith, J. 1999. The Economics and Econometrics of Active Labor Market Programs, in Handbook of Labor Economics Vol.III, ed. by O. Ashenfelter, and D. Card, pp. 1865-2097. Elsevier, Amsterdam, Holland

Jodlowski, M., Winter-Nelson, A., Baylis, K. and Goldsmith, P.D., 2016. Milk in the data: Food security impacts from a livestock field experiment in Zambia. World Development, 77; 99-114.

Key, N., Sadoulet, E. and De Janvry, A., 2000. Transactions costs and agricultural household supply response. American Journal of Agricultural Economics, 82(2): 245-259.

Khadka, N., 1998. Challenges to developing the economy of Nepal. Contemporary South Asia, 7(2): 147-165.

Kondylis, F., Mueller, V. and Zhu, J., 2017. Seeing is believing? Evidence from an extension network experiment. Journal of Development Economics, 125: 1-20.

Leuven, E., Sianesi, B. 2003. PSMATCH2: Stata module to perform full Mahalanobis and propensity score matching, common support graphing, and covariate imbalance testing. http://ideas.repec.org/c/boc/bocode/s432001.html.

Markelova, H., Meinzen-Dick, R., Hellin, J., & Dohrn, S. 2009. Collective action for smallholder market access. Food Policy, 34(1), 1-7.

Michelson, H., Reardon, T. and Perez, F., 2012. Small farmers and big retail: Trade-offs of supplying supermarkets in Nicaragua. World Development, 40(2): 342-354.

Mu, R., and Van de Walle, D., 2011. Rural roads and local market development in Vietnam. Journal of Development Economics, 47(5): 709-734.

Nepal, A. 2016. Impact of the Poverty Alleviation Fund Program on Migration and Remittances in Nepal, Working paper, Universtiy of Illinois, Urbana, IL.

Nepal, Government of, 2015. Agriculture Development Strategy (ADS) 2015 2035, Ministry of Agricultural of Development, Kathmandu, Nepal.

Nepal, Government of, 2017. Economic Survey: Fiscal Year 2016/2017, Ministry of Finance, Kathmandu, Nepal.

Rubin, D.B., 2001. Using propensity scores to help design observational studies: Application to the tobacco litigation. Health Services and Outcomes Research Methodology, 2(3-4): 169-188.

Sahn, D.E. and Stifel, D., 2003. Exploring alternative measures of welfare in the absence of expenditure data. Review of income and wealth, 49(4): 463-489.

Savada, A.M., 1991. Nepal: A country study. GPO for the Library of Congress, Washington, DC.

Sharma, K., 2006. The political economy of civil war in Nepal. World Development, 34(7): 1237-1253.

Songsermsawas, T., Baylis, K., Chhatre, A., and Michelson, H. C. 2016. Can peers improve agricultural productivity? World Development, 83: 163-178.

Ton, G., Vellema, W., Desiere, S., Weituschat, S., & D'Haese, M. 2018. Contract farming for improving smallholder incomes: What can we learn from effectiveness studies? World Development, 104, 46-64.

Upton, J.B., Cissé, J.D. and Barrett, C.B., 2016. Food security as resilience: Reconciling definition and measurement. Agricultural Economics, 47(S1): 135-147.

Verkaart, S., Munyua, B.G., Mausch, K. and Michler, J.D., 2017. Welfare impacts of improved chickpea adoption: A pathway for rural development in Ethiopia? Food Policy, 66: 50-61.

Wang, H.H., Wang, Y. and Delgado, M.S., 2014. The transition to modern agriculture: Contract farming in developing economies. American Journal of Agricultural Economics, 96(5): 1257-1271.

Winters, P., Maffioli, A. and Salazar, L., 2011. Introduction to the special feature: Evaluating the impact of agricultural projects in developing countries. Journal of Agricultural Economics, 62(2): 393-402.

Witt, R., Pemsl, D.E. and Waibel, H., 2008. The farmer field school in Senegal: Does training intensity affect diffusion of information? Journal of International Agricultural and Extension Education, 15(2): 47-60

World Bank, 2011. Impact evaluations in agriculture: An assessment of the evidence. Technical report, World Bank, Washington, DC.

Zeweld, W., Huylenbroeck, G. V., Hidgot, A., Chandrakanth, M. G., and Speelman, S. 2015. Adoption of small-scale irrigation and its livelihood impacts in Northern Ethiopia. Irrigation and Drainage, 64(5): 655-668.

Appendix 1: Propensity score matching results

Figure 4: Balance between treatment and control groups

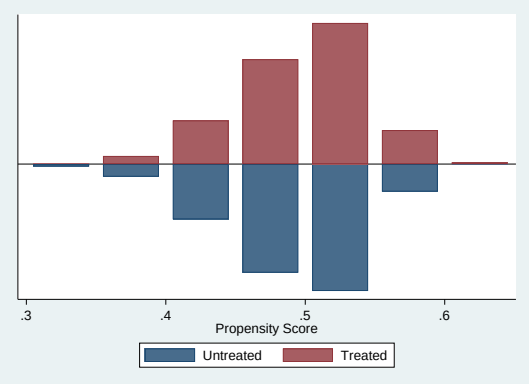


Figure 5: Common support between treatment and control groups

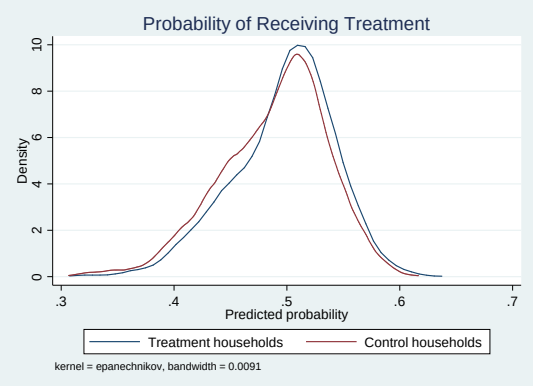
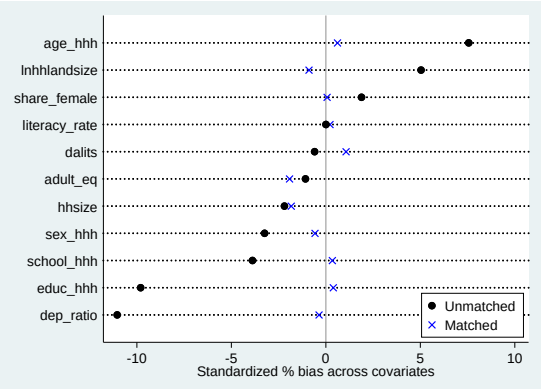


Figure 6: Bias reduction between treatment and control groups



Appendix 2: Definitions of indicators

Table 20: Definitions of outcome and impact indicators reported in the analysis

Indicator	Definition
Agricultural production indicators, wet season	
Number of crop rotations, wet season	Number of crop cycle cultivated in an agricultural season (May –October 2017)
Post-harvest losses, wet season (kg.)	Total amount of crops losses after harvest due to drought, irregular rain, snow/frost, flood, landslide, fire, insects, animals, diseases, or theft during an agricultural season (May –October 2017)
Share of farmers selling crops to traders, wet season	Dummary variable (=1 if yes) to indicate whether the household has sold their crops to a trader during an agricultural season (May –October 2017)
Agricultural production indicators, dry season	
Number of crop rotations, dry season	Number of crop cycle cultivated in an agricultural season (November 2017-April 2018)
Post-harvest losses, dry season (kg.)	Total amount of crops losses after harvest due to drought, irregular rain, snow/frost, flood, landslide, fire, insects, animals, diseases, or theft during an agricultural season (November 2017-April 2018)
Share of farmers selling crops to traders, dry season	Dummary variable (=1 if yes) to indicate whether the household has sold their crops to a trader during an agricultural season (November 2017-April 2018)
Income indicators	
Total household income (Rs.)	Total household income including crop income, livestock income, wage income, self-employment and self-enterprise income, remittance income, and transfer and pension income (May 2017 – April 2018)
Crop income (Rs.)	Total income from crop sales and value of home-consumed crops (May 2017 – April 2018)
Livestock income (Rs.)	Total income from livestock sold either alive or slaughtered (May 2017 – April 2018)
Wage income (Rs.)	Total income from work as an employee for a wage, salary, commission, or any payment in kind: including doing paid apprenticeship, domestic work or paid farm work (May 2017 – April 2018)
Self-employment and self-enterprise income (Rs.)	Total income from self-employment or enterprises that the household or household member operated (May 2017 – April 2018)
Sales of products, goods, and service income (Rs.)	Total income from sales of products, goods, and services the household or household member conducted (May 2017 – April 2018)
Remittance income (Rs.)	Total income received from migrated household member (May 2017 – April 2018)

Table 20 (cont.): Definitions of outcome and impact indicators reported in the analysis

Indicator	Definition
Asset indicators	
Housing quality index (MCA)	Asset index consisting of housing characteristics computed using MCA
Durable asset index (PCA)	Asset index consisting of household durable asset (such as TV, tables, chairs, softa, etc.) computed using PCA
Productive asset index (PCA)	Asset index consisting of household durable asset (such as carts, miller, irrigation pumps etc.) computed using PCA
Livestock asset (TLU)	Livestock count computed using weights defined by TLU scale
Poverty reduction indicators	
Above the 40th poverty line, durable asset	Dummy variable (=1 if yes) if the household is above the poverty line set using the 40th percentile rank of the durable asset distribution of the control group
Above the 60th poverty line, durable asset	Dummy variable (=1 if yes) if the household is above the poverty line set using the 60th percentile rank of the durable asset distribution of the control group
Above the 40th poverty line, productive asset	Dummy variable (=1 if yes) if the household is above the poverty line set using the 40th percentile rank of the productive asset distribution of the control group
Above the 60th poverty line, productive asset asset	Dummy variable (=1 if yes) if the household is above the poverty line set using the 60th percentile rank of the productive asset distribution of the control group
Dietary diversity and household resilience indicators	
Dietary diversity score	Count variable calculated from a set of dummy variables whether households membes have consumed any of the 16 food groups and reclassified to a dietary diversity score between 0 and 12
Ability to recover from shocks	Perceived ability to recover from shocks (=1if did not recover, =5 if not affected by shock)

Table 20 (cont.): Definitions of outcome and impact indicators reported in the analysis

Indicator	Definition
Household decision-making indicators	
Decision-making of women about crop cultivation	Dummy variable (=1 if yes) indicating whether at least one female household member has decision-making power about crop cultivation (e.g. crop choice, planting time, harvest time, etc.)
Decision-making of women about crop sales	Dummy variable (=1 if yes) indicating whether at least one female household member has decision-making power about crop sales (e.g. sale time, market location, prices, etc.)
Decision-making of women about livestock rearing of large animals	Dummy variable (=1 if yes) indicating whether at least one female household member has decision-making power about large livestock rearing (e.g. animal choice, feed and inputs, etc.)
Decision-making of women about livestock rearing of small animals	Dummy variable (=1 if yes) indicating whether at least one female household member has decision-making power about small livestock rearing (e.g. animal choice, feed and inputs, etc.)
Decision-making of women about livestock sales	Dummy variable (=1 if yes) indicating whether at least one female household member has decision-making power about livestock sales (e.g. sale time, market location, prices, etc.)

Appendix 3: Descriptive statistics (control group means) relevant to the analysis of the heterogeneous impacts of HVAP

Table 21: Descriptive statistics of agricultural production indicators from the sub-samples

	(1)	(2)	(3)	(4)
	Control	Control	Control	Control
	Male-headed HH	Female-headed HH	Non-DJEM	DJEM
Agricultural production indicators, wet season				
Number of crop rotations, wet season	1.001	1.000	1.000	1.003
Post-harvest losses, wet season (kg.)	0.039	0.039	0.034	0.052
Share of farmers selling crops to traders, wet season	0.022	0.023	0.024	0.021
Agricultural production indicators, dry season				
Number of crop rotations, dry season	1.002	1.003	1.002	1.003
Post-harvest losses, dry season (kg.)	0.052	0.058	0.054	0.053
Share of farmers selling crops to traders, dry season	0.009	0.013	0.007	0.019
Number of observations	1,085	372	1,081	376

Table 22: Descriptive statistics of income indicators from the sub-samples

	(1)	(2)	(3)	(4)
	Control	Control	Control	Control
	Male-headed HH	Female-headed HH	Non-DJEM	DJEM
Income indicators				
Total household income (Rs.)	154,360.7	150,756.1	150,339.7	162,354.9
Crop income (Rs.)	33,244.37	23,390.76	32,020.83	27,013.25
Livestock income (Rs.)	20,859.6	20,237.44	18,556.62	26.915.96
Wage income (Rs.)	30,314.56	15,814.91	27,456.88	24,192.07
Self-employment and self-enterprise income (Rs.)	21,476.92	12,122.31	19,190.92	18,781.91
Sales of products, goods, and service income (Rs.)	24,648.2	13,419.35	21,590.36	22,313.83
Remittance income (Rs.)	18,426.96	58,309.68	25,424.79	37,757.98
Transfer and pension income (Rs.)	6,539.39	8,020.83	6,579.53	7,898.30
Number of observations	1,085	372	1,081	376

Table 23: Descriptive statistics of asset indicators from the sub-samples

	(1)	(2)	(3)	(4)
	Control	Control	Control	Control
	Male-headed HH	Female-headed HH	Non-DJEM	DJEM
Asset indicators				
Housing quality index (MCA)	0.239	0.225	0.226	0.263
Durable asset index (PCA)	1.030	0.885	0.949	1.120
Productive asset index (PCA)	2.639	2.208	2.565	2.424
Livestock asset (TLU)	2.838	2.312	2.802	2.421
Number of observations	1,085	372	1,081	376

Table 24: Descriptive statistics of poverty reduction indicators from the sub-samples

	(1)	(2)	(3)	(4)
	Control	Control	Control	Control
	Male-headed HH	Female-headed HH	Non-DJEM	DJEM
Poverty reduction indicators				
Above the 40th poverty line, durable asset	0.628	0.522	0.608	0.580
Above the 60th poverty line, durable asset	0.416	0.358	0.387	0.441
Above the 40th poverty line, productive asset	0.633	0.505	0.600	0.601
Above the 60th poverty line, productive asset asset	0.438	0.290	0.407	0.380
Number of observations	1,085	372	1,081	376

Table 25: Descriptive statistics of dietary diversity and household resilience indicators from the sub-samples

	(1)	(2)	(3)	(4)
	Control	Control	Control	Control
	Male-headed HH	Female-headed HH	Non-DJEM	DJEM
Dietary diversity and household resilience indicators				
Dietary diversity score	6.459	6.497	6.499	6.383
Ability to recover from shocks	2.670	2.581	2.679	2.562
Number of observations	1,085	372	1,081	376

Table 26: Descriptive statistics of household decision-making indicators from the sub-samples

	(1)	(2)	(3)	(4)
	Control	Control	Control	Control
	Male-headed HH	Female-headed HH	Non-DJEM	DJEM
Household decision-making indicators				
Decision-making of women about crop cultivation	0.812	0.981	0.849	0.872
Decision-making of women about crop sales	0.799	0.987	0.835	0.880
Decision-making of women about livestock rearing of large animals	0.845	0.989	0.876	0.900
Decision-making of women about livestock rearing of small animals	0.852	0.987	0.880	0.904
Decision-making of women about livestock sales	0.812	0.987	0.848	0.880
Number of observations	1,085	372	1,081	376

International Fund for Agricultural Development
Via Paolo di Dono, 44 - 00142 Rome, Italy
Tel: +39 06 54591 - Fax: +39 06 5043463
Email: ifad@ifad.org
www.ifad.org
ifad-un.blogspot.com
www.facebook.com/ifad
instagram.com/ifadnews
www.twitter.com/ifadnews
www.youtube.com/user/ifadTV