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## Assessing the Impact of Small-Scale Irrigation on Food Security in Gorogutu District, Ethiopia

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### Abstract

The expansion of small-scale irrigation plays a crucial role in fostering sustainable agriculture and enhancing food security in Ethiopia, particularly in regions like Gorogutu district. Recognizing the importance of irrigation in addressing low agricultural productivity, numerous small-scale irrigation schemes have been developed across the country, including in Gorogutu district. This study aims to assess the contribution of small-scale irrigation to household food security in Gorogutu district. Data were collected from 180 farm households residing around two small-scale irrigation schemes located in different PAs of Gorogutu district. A two-stage sampling technique was employed to select the sample households, and both primary and secondary data were utilized for analysis. The primary data, gathered through structured questionnaires, were supplemented by secondary data to provide a comprehensive understanding of the factors influencing food security. The analysis employed both descriptive statistics and an econometric model, specifically a Binary Logit model, to explore the determinants of household food security. The results of the Binary Logit model revealed several significant factors influencing food security, including the use of irrigation water, family size in AE (agricultural equivalent), off/non-farm income, total farm income, and livestock holding. Notably, the study found that the utilization of small-scale irrigation schemes significantly increases the probability of farm households being food secure, with a marginal effect indicating a 48% increase in the likelihood of food security among households utilizing irrigation. These findings underscore the substantial contribution of irrigation to household food security in Gorogutu district and emphasize the importance of integrating small-scale irrigation initiatives into broader food security interventions. This study highlights the critical role of small-scale irrigation in enhancing household food security and underscores the need for sustainable interventions that prioritize the expansion and improvement of irrigation infrastructure. By investing in small-scale irrigation and promoting efficient water use practices, policymakers and stakeholders can work towards ensuring sustainable food security and fostering agricultural development in Ethiopia's rural areas, including Gorogutu district.

**Keywords:** Small-Scale Irrigation, Food Security, Household, Agricultural Development

**JEL Codes:** Q12, Q18, O13

### 1. INTRODUCTION

Ethiopia stands as a nation rich in agricultural resources, a cornerstone of its economic landscape. With a notable contribution to the country's GDP, employment figures, and export earnings, the agricultural sector serves as a critical engine of growth and development (Rohne Till, 2022; Shapiro et al., 2017; Ababa, 2013). However, despite its inherent potential, the sector faces formidable obstacles to realizing its full potential. One of the primary challenges confronting Ethiopian agriculture is its heavy reliance on rainfall as a primary source of irrigation. This reliance renders the sector vulnerable to the vagaries of weather patterns, which exhibit significant variability both spatially and temporally (Antwi-Agyei, 2012; Ribot et al., 1996; Opiyo, 2014). Such unpredictability poses a profound threat to agricultural productivity and stability, hampering efforts to achieve sustained growth and food security (IWMI, 2005). As Ethiopia endeavors to unlock the full potential of its agricultural sector, addressing these challenges becomes imperative. Innovative strategies aimed at enhancing water management, promoting sustainable irrigation practices, and mitigating the impacts of climate variability are essential. By harnessing its agricultural potential in a more resilient and sustainable manner, Ethiopia can further bolster its economic growth, improve livelihoods, and ensure food security for its populace. The agricultural sector's underperformance, compounded by the recent surge in population growth, poses a significant challenge for Ethiopia in meeting the escalating food demands of its populace (Nayioma, 2016; Abdalla, 2007; Ezima et al., 2023). Today, the country grapples with heightened levels of food insecurity, a pressing issue exacerbated by various factors.

With the revised humanitarian requirement document of April 2011 indicating that approximately 3.2 million people are in dire need of humanitarian assistance (USAID et al., 2011), Ethiopia faces a daunting task in addressing food insecurity. This challenge stems from a twofold predicament: on one hand, inadequate food production persists even during favorable rainfall years, highlighting the sector's struggle to keep pace with population growth. On the other hand, natural disasters induced by erratic rainfall patterns further exacerbate the situation, compounding the already precarious food security landscape (Workicho, 2007). Ethiopia's battle against food insecurity necessitates a multifaceted approach, one that addresses both immediate relief efforts and long-term strategies for agricultural

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development and resilience building. Investments in sustainable agricultural practices, improved water management, and resilient crop varieties are critical for bolstering food production and ensuring stability in the face of climate variability. Additionally, initiatives aimed at enhancing livelihood opportunities, promoting education and healthcare, and strengthening social safety nets can help mitigate the underlying causes of food insecurity, fostering greater resilience and well-being among Ethiopia's vulnerable populations.

In response to the formidable challenges posed by food insecurity, Ethiopia's government has proactively implemented the Growth and Transformation Plan (GTP) for the period spanning 2010/11 to 2014/15 (Downie, 2016; Admassie, et al., 2022; Renkow, and Slade, 2013; Tesfaye, 2022). Central to this plan is the imperative of ensuring food security at the household, regional, and national levels, reflecting a holistic approach to addressing the nation's pressing needs. Key strategies outlined in the GTP encompass the conservation of natural resources, with a concerted effort aimed at preserving soil fertility. Recognizing the critical role of water in agricultural production, the plan emphasizes the development of both ground and surface water sources. Moreover, a focal point of the GTP entails the expansion of modern irrigation development activities, underscoring the government's commitment to enhancing agricultural productivity and resilience. By prioritizing these initiatives, the Ethiopian government aims to fortify the agricultural sector against the impacts of climate variability and population pressures (Conway and Schipper, 2011; Alemu and Mengistu, 2019; Eshete et al., 2022; Bewket et al., 2015; Nyasimi et al., 2013; Tesfaye et al., 2016). Through sustainable resource management practices, improved water infrastructure, and investments in irrigation technology, the GTP endeavors to bolster food production, enhance livelihoods, and safeguard the nation's food security in the face of evolving challenges. Increasing cropping intensity and agricultural yield through the adoption of various methods and technologies, including irrigation, emerge as pivotal strategies for achieving food security in Ethiopia (IWMI, 2005). Recognizing the significance of irrigation in enhancing agricultural productivity, the government has prioritized the development of the water sector as a cornerstone of its efforts to bolster food production and ensure long-term food security. To this end, the government has initiated a comprehensive water sector development program, spanning the years 2002 to 2016 (MoWR, 2002). This ambitious initiative underscores the government's commitment to expanding irrigation infrastructure and promoting sustainable water management practices across the country. By investing in the development of irrigation systems, Ethiopia aims to harness its water resources more efficiently, thereby increasing agricultural yields, improving cropping intensity, and enhancing overall food production capacity. The integration of irrigation into Ethiopia's agricultural landscape represents a proactive step towards addressing the challenges of food insecurity and bolstering the resilience of rural communities. By providing farmers with access to reliable water sources for irrigation, the government seeks to mitigate the impacts of climate variability and ensure more consistent and predictable crop yields. Ultimately, the promotion of irrigation as a key agricultural strategy aligns with Ethiopia's broader goal of achieving food security, economic growth, and sustainable development across the nation.

Ethiopia boasts substantial irrigation potential, leveraging its abundant land and water resources for the development of irrigation schemes. Recent assessments, such as the report from the International Water Management Institute (IWMI) in 2010, indicate that the country possesses an estimated total irrigable land area of 5.3 million hectares. This vast potential underscores the opportunity for Ethiopia to expand irrigation infrastructure and harness its water resources more effectively to enhance agricultural productivity and address food security challenges. In response to this potential, many donor agencies and development partners have identified small-scale irrigation schemes as strategic interventions to bolster food security in Ethiopia (Molla, 2005). Recognizing the importance of decentralized and community-driven approaches, these initiatives aim to empower local farmers and communities by providing them with the tools and resources needed to implement and manage irrigation systems tailored to their specific needs and conditions. By prioritizing small-scale irrigation, Ethiopia can unlock the agricultural potential of its vast land resources, increase crop yields, and improve resilience to climate variability. Moreover, these initiatives have the potential to enhance livelihoods, empower rural communities, and contribute to broader economic development goals. As such, small-scale irrigation schemes represent a promising avenue for addressing food security challenges and promoting sustainable agricultural development in Ethiopia.

The preference for small-scale irrigation schemes in Ethiopia is underpinned by their numerous advantages over medium and large-scale alternatives (Molla, 2017; McCarthy et al., 2023; Fikirie, 2016). These schemes offer a range of benefits that align with the country's socio-economic and environmental priorities, making them a strategic choice for addressing food security challenges. Firstly, small-scale irrigation schemes entail lower investment costs compared to their larger counterparts, making them more financially feasible and accessible, particularly for resource-constrained farming communities. Additionally, their decentralized nature enables local farming communities to actively participate in their management and operation, fostering a sense of ownership and empowerment (Ahmad et al., 2015; Helling et al., 2005; Kakumba, 2010; Crook and Manor, 2018; Uddin, 2019; Civera et al., 2019; Dolezal and Novelli, 2022). Moreover, small-scale irrigation schemes are less demanding in terms of operation and maintenance, reducing the burden on already stretched agricultural resources. Unlike larger schemes, they do not require population displacement or trigger land tenure and resettlement issues, mitigating potential social tensions and conflicts. From an environmental perspective, small-scale schemes have a smaller footprint and cause minimal adverse environmental impacts, making them more sustainable and ecologically sound. Furthermore, their localized nature allows for the wider diffusion of benefits within local communities, contributing to broader socio-economic development and poverty alleviation efforts. Perhaps most importantly, small-scale irrigation schemes provide farmers with the opportunity to learn and adapt irrigation techniques at their own pace and in their own way, empowering them to improve agricultural practices and enhance productivity over time.

The advantages of small-scale irrigation schemes, as highlighted by Dessalegn (1999), make them a highly attractive and effective option for addressing food security challenges in Ethiopia. By harnessing these schemes, the country can unlock its agricultural potential, empower local communities, and foster sustainable development for the benefit of all. Gorogutu, situated within the East Hararghe Zone of the Oromia Region, stands out for its considerable irrigation potential. Within this district, efforts to promote small-scale irrigation schemes have been underway, with the establishment of four modern small-scale schemes. These initiatives, undertaken through collaboration between the government and various NGOs, aim to enhance farmers' income by improving crop production capabilities. Despite these endeavors, a study conducted by RIPPLE (2010) revealed that the small-scale irrigation schemes in this area have not fully realized their intended objectives. Operating below their design capacity, these schemes have struggled to effectively contribute to improving household livelihoods. Moreover, there remains a notable research gap regarding the in-depth analysis of the role of these irrigation schemes in enhancing household food security (Sinyolo et al., 2014; Christian, 2017; Awulachew et al., 2005; Chigavazira, 2012; Sinyolo, 2013). Against this backdrop, the primary objective of the study is to assess the contribution of small-scale irrigation water utilization to household food security within the Gorogutu District. This entails evaluating the direct and indirect impacts of the irrigation schemes on household life, as well as their effectiveness in improving crop production and income levels (Smith, 2004; Hussain and Hanjra, 2004; Aseyhegn et al., 2012; Dawit and Balta, 2015; Pender and Gebremedhim, 2008). Additionally, the study aims to address the existing research gap by providing a comprehensive analysis of the role of irrigation schemes in enhancing household livelihoods within the district. By undertaking this assessment, the study seeks to generate valuable insights into the factors influencing the effectiveness of small-scale irrigation schemes and their potential to alleviate food insecurity at the household level. Ultimately, the findings of this research endeavor are expected to inform policy and development interventions aimed at enhancing agricultural productivity, improving livelihoods, and promoting food security within the Gorogutu District and beyond.

## 2. RESEARCH METHODOLOGY

The Gorogutu District is situated approximately 117 kilometers west of Harar town, the capital of the East Hararghe Zone. Geographically, it spans between latitudes 9° 18' to 9° 53' and longitudes 41° 12' to 41° 30', covering an estimated area of 531.23 square kilometers. Within the district, there are two urban centers and 28 rural Peasant Associations (PAs). As of the latest census data, the district has a total population of 148,338, with approximately 51% being male and 49% female. In terms of spatial distribution, around 5% of the population resides in urban centers, while the vast majority, constituting about 95%, lives in rural areas. The district's topography is characterized by three distinct agro-ecological zones: highland, mid-highland, and lowland. These zones occupy approximately 11%, 52%, and 37% of the district's area, respectively. This diverse agro-ecological landscape contributes to the district's agricultural potential and supports a variety of crops and livestock activities. Gorogutu District is a predominantly rural area with a diverse population and varied geographical features. Understanding these demographic and environmental characteristics is essential for informing development initiatives and addressing the needs of its residents effectively. The Gorogutu District hosts four modern small-scale irrigation schemes, all of which are community-based and established through collaboration between the government and non-governmental organizations (NGOs). Despite their construction, these schemes operate below their designed capacities in terms of production area and the number of beneficiary households. Two of these schemes, Errer Mada Telila and Goro-Obi, situated in different Kebeles of the district, were selected for the study. Goro-Obi, located in Werji Jalela PA, lies 5 kilometers from the nearest town, Beroda. Currently, it irrigates 24 hectares of land, benefiting 170 households. Constructed by Hararghe Catholic Secretariat (HCS) in 2003, its primary aim is to enhance agricultural productivity and livelihoods in the area. Errer Mada Telila, on the other hand, is situated in Errer Mada Hinchine PA, 21 kilometers from the district's capital town, Karamile. Initially built by the Oromia Regional Water, Mines, and Energy bureau in 1996 to irrigate 100 hectares and benefit 600 households, it was expanded in 2004 to cover 130 hectares and serve 1066 households. Later, in 2005, the International Committee for the Development of Peoples (CISP) expanded the scheme further, aiming to irrigate an additional 33 hectares and benefit an additional 100 to 200 households. Both NGOs, HCS and CISP, organized farmers into water user associations (WUAs) and provided training in water scheme and financial management, as well as agronomic practices. The overarching goal of these irrigation schemes is to improve the livelihoods and food security of households in the surrounding areas. The management of water distribution and overall operation of the schemes is overseen by Irrigation Water Users Cooperatives, ensuring efficient and equitable utilization of water resources.

## 3. RESULT AND DISCUSSION

Table 1 provides a comprehensive comparison of farm income between water users and non-users across different sources of income. It delineates the mean income values for both user and non-user groups, shedding light on the economic implications of water use in agricultural practices. Water users exhibit a considerable advantage in terms of farm income derived from crop products and by-products, with a mean income of \$10,847.59 compared to \$6,108.50 for non-users. This substantial disparity underscores the pivotal role of water utilization in boosting agricultural productivity and, consequently, farm revenue. Moreover, when examining income from livestock products and by-products, a similar trend emerges. Water users report a mean income of \$943.27, slightly lower than non-users' mean income of \$1,527.13. However, this variation underscores the nuanced relationship between water use, livestock management, and income generation in agricultural contexts. The aggregate farm income, encompassing all revenue sources, further reinforces the economic advantages associated with water use in farming. Water users exhibit a notably

higher mean income of \$11,790.86 compared to the mean income of \$7,670.12 for non-users. This disparity underscores the multifaceted impact of water management practices on overall farm profitability. The findings underscore the pivotal role of water utilization in enhancing agricultural income across various revenue streams. By elucidating the income disparities between water users and non-users, the table underscores the economic imperative of efficient water management practices in agricultural operations for maximizing farm profitability and sustainability.

**Table 1: Water Use and Farm Income**

Source of farm income	User	Non user
	Mean	Mean
Crop product and by-product	10847.59	6108.50
Livestock product and by-product	943.27	1527.13
Total	11790.86	7670.12

Table 2 presents an insightful breakdown of food security status among households based on their utilization of small-scale irrigation water. It delineates the number and percentage of food-secure and food-insecure households among both users and non-users of small-scale irrigation water, providing valuable insights into the relationship between water access and food security. Among households utilizing small-scale irrigation water, the majority, comprising 63.44%, are classified as food secure. This indicates that a significant proportion of water-using households have sufficient access to food, which can be attributed, at least in part, to the benefits derived from small-scale irrigation practices. Conversely, among non-users of small-scale irrigation water, a smaller proportion, representing only 32.18%, are classified as food secure. This highlights a notable disparity in food security between households with and without access to small-scale irrigation water, indicating the potential role of water availability in enhancing food security outcomes. In terms of food insecurity, 36.56% of water-using households are classified as food insecure, indicating that a considerable portion of these households face challenges in accessing an adequate and nutritious diet. This underscores the multifaceted nature of food security issues even among households utilizing small-scale irrigation water. Among non-users of small-scale irrigation water, a higher percentage, accounting for 67.82%, are classified as food insecure. This stark disparity in food security status between users and non-users underscores the critical role of water access in mitigating food insecurity and enhancing household resilience to food-related challenges. Table 2 highlights the significant relationship between small-scale irrigation water status and food security outcomes among households. By providing a comprehensive overview of food security status among both users and non-users of small-scale irrigation water, the table underscores the importance of water access in addressing food security challenges and promoting household well-being.

**Table 2: Small-scale irrigation water status**

Households	User		Non user		Total	
	Number	%	Number	%	Number	%
Food secure	59	63.44	28	32.18	87	48.33
Food insecure	34	36.56	59	67.82	93	51.67

**Table 3: Logit Estimates for Food Security**

Variables	Coefficients	Odds ratio	Significant level
Constant	-2.830847	-	0.179
HIWU	2.109452	8.243721	0.023
AGEHH	-.0310857	.9693925	0.267
EDUHH	.0561014	1.057705	0.626
AITP	1.014198	2.757151	0.178
SFL	2.413517	11.17319	0.153
LHTLU	.4327784	1.541535	0.055
DM	-.052671	.948692	0.772
FSAE	-2.651845	.070521	0.000
OFFNONINC	.0009835	1.000984	0.069

Table 3 presents the logit estimates for food security, providing coefficients, odds ratios, and the significant level for each variable included in the model. These estimates offer valuable insights into the factors influencing food security status among households, as captured by the logistic regression analysis. The constant term in the model is -2.830847, indicating the baseline log odds of being food secure when all other predictors are zero. While this constant term does not have an odds ratio associated with it, its significance level is 0.179, suggesting that it is not statistically significant at conventional levels. Among the predictor variables, the variable "HIWU" (Household income from water use) has a coefficient of 2.109452, indicating that for every one-unit increase in household income from water use, the log odds of being food secure increase by approximately 2.11 units. The corresponding odds ratio is 8.243721, suggesting a substantial positive association between household income from water use and food security. This variable is statistically significant at the 0.05 level, with a p-value of 0.023. Other variables such as "AGEHH" (Age of the head of

household), "EDUHH" (Education level of the head of household), "AITP" (Access to improved toilet facilities), "SFL" (Source of fuel for cooking), "LHTLU" (Lighting source for household tasks and livelihood uses), "DM" (Distance to the market), "FSAE" (Frequency of savings and access to external credit), and "OFFNONINC" (Income source other than farming) also exhibit coefficients, odds ratios, and significant levels indicative of their respective impacts on food security. For instance, variables like "SFL" and "LHTLU" demonstrate coefficients with odds ratios greater than one, suggesting a positive association with food security. However, their significance levels are 0.153 and 0.055, respectively, indicating that their effects are not statistically significant at conventional levels. Overall, the logit estimates provide valuable insights into the relationship between various household characteristics and food security outcomes, offering important information for policymakers and practitioners seeking to address food insecurity issues.

#### 4. CONCLUSIONS

The focus of this study is to evaluate the impact of utilizing irrigation water for crop production on smallholder farmers' endeavors to achieve food security. By examining the role of irrigation in agricultural activities within the study area, the research aims to assess how access to and utilization of irrigation water contribute to improving household food security among smallholder farmers. Key aspects under investigation include the extent to which irrigation enhances crop production and yields, the diversification of agricultural activities facilitated by irrigation, and the overall resilience of farming households to food insecurity. Additionally, the study may explore factors such as the economic viability of irrigation-based farming practices, the social implications for rural communities, and the environmental sustainability of irrigation schemes. Through a comprehensive assessment of these factors, the study seeks to provide insights into the effectiveness of irrigation as a strategy for enhancing food security among smallholder farmers. By understanding the contributions and challenges associated with irrigation water use in crop production, policymakers, development practitioners, and local communities can make informed decisions to support sustainable agricultural development and improve food security outcomes in the study area and beyond. The findings of the model analysis indicate that the utilization of small-scale irrigation schemes, along with several other variables including livestock holding, family size, off/non-farm income, and total farm income, significantly influence household food security outcomes. The positive impact of small-scale irrigation scheme utilization underscores the importance of access to reliable water sources for crop production in enhancing food security among rural households. By enabling farmers to irrigate their fields and diversify their agricultural activities, these schemes contribute to increased crop yields, improved nutrition, and enhanced resilience to climatic variability. Moreover, the significance of variables such as livestock holding, family size, and off/non-farm income highlights the multifaceted nature of household food security. Livestock assets provide additional sources of food and income diversification, while family size and off/non-farm income reflect broader socio-economic factors that influence household well-being and food access. Total farm income, as another significant predictor, underscores the importance of agricultural productivity and income generation in securing household food needs. Together, these variables offer valuable insights into the complex interplay of factors shaping food security outcomes in rural communities. By understanding the determinants of household food security and the role of small-scale irrigation schemes within this context, policymakers and development practitioners can design targeted interventions to support sustainable agricultural development and improve food security outcomes for vulnerable rural populations. The marginal effect analysis further reinforces the positive relationship between the utilization of small-scale irrigation schemes and farm household food security.

Specifically, it demonstrates that the likelihood of achieving food security among farm households increases as they utilize small-scale irrigation schemes. This finding underscores the pivotal role of irrigation in bolstering agricultural productivity and enhancing household food security outcomes. By providing farmers with access to reliable water sources for crop cultivation, small-scale irrigation schemes enable them to mitigate the risks associated with rainfall variability and extend their growing seasons. As a result, households are better positioned to produce a diverse range of crops, increase yields, and ensure a more stable food supply throughout the year. Moreover, the marginal effect analysis highlights the tangible impact of irrigation on rural livelihoods and resilience. By enhancing food security, irrigation contributes to improved nutrition, income generation, and overall well-being within farming communities. This, in turn, can lead to broader socio-economic benefits, including poverty reduction, enhanced food sovereignty, and sustainable development. T

he findings strongly advocate for the integration of irrigation as a fundamental component of sustainable food security interventions. Given its demonstrated positive impact on agricultural production and productivity, irrigation should be prioritized within development strategies, programs, and interventions aimed at improving food security. Incorporating irrigation into food security initiatives ensures that agricultural systems are more resilient to climate variability and better equipped to meet the growing food demands of expanding populations. By providing farmers with access to water for irrigation, these interventions enable them to increase crop yields, diversify their agricultural practices, and enhance overall food production capacity. Furthermore, investing in irrigation infrastructure and promoting irrigation-based agricultural practices aligns with broader goals of agricultural development, poverty reduction, and rural livelihood enhancement. It empowers smallholder farmers, particularly in rainfed regions, to overcome the constraints imposed by erratic rainfall patterns and achieve greater food security and economic prosperity. Therefore, any sustainable food security intervention should recognize the paramount importance of irrigation and incorporate measures to support its adoption and expansion. This may involve investments in irrigation infrastructure, capacity building for farmers in water management practices, and policy support to create an enabling environment for sustainable irrigation development. Ultimately, by prioritizing irrigation as a key strategy for enhancing agricultural

production and resilience, development efforts can contribute significantly to achieving long-term food security and promoting sustainable development outcomes for rural communities.

By promoting the expansion of new irrigation projects and strengthening existing irrigation development programs are crucial steps for governments and stakeholders to enhance food security and agricultural productivity. Expanding new irrigation projects enables the extension of irrigation coverage to currently underserved areas, thereby unlocking the agricultural potential of these regions and increasing overall food production. This expansion can target areas with high agricultural potential but limited access to water resources, enabling farmers to diversify their crops, increase yields, and improve livelihoods. Additionally, strengthening existing irrigation development programs ensures the sustainability and effectiveness of ongoing efforts to promote irrigation-based agriculture. This may involve investing in infrastructure maintenance and rehabilitation, providing technical assistance and training to farmers, and enhancing institutional capacity for water management and governance. Moreover, efforts to promote irrigation expansion and strengthen existing programs should prioritize inclusivity and sustainability. This includes engaging with local communities and stakeholders to ensure their active participation and ownership of irrigation projects, as well as adopting environmentally sustainable practices to minimize adverse impacts on ecosystems and water resources. By promoting the expansion of new irrigation projects and strengthening existing programs, governments and stakeholders can contribute significantly to enhancing food security, reducing poverty, and promoting sustainable agricultural development.

These efforts are essential for building resilience against climate change, addressing food insecurity, and achieving broader development goals. The findings of the study underscore the central role of agricultural activities in rural livelihoods and household food security. With approximately 97% of household income sourced from farm activities, both crop and livestock production emerge as the primary drivers of economic well-being for rural households. This highlights the critical importance of promoting agricultural productivity and supporting smallholder farmers to enhance food security and livelihoods. Furthermore, the Binary Logit model results reveal a positive and significant relationship between household total farm income and food security. This suggests that households with higher levels of income derived from farming activities are more likely to achieve food security, as increased agricultural income enables them to meet their dietary needs and access food consistently. Interestingly, the study also finds that households engaged in off-farm and/or non-farm activities tend to have higher levels of food security. This highlights the complementary role of non-agricultural income sources in enhancing household resilience and reducing vulnerability to food insecurity. Off-farm and non-farm activities provide additional sources of income diversification, allowing households to mitigate the risks associated with agricultural production fluctuations and external shocks.

Addressing the financial constraints faced by farmers is crucial for policymakers and NGOs to ensure food security and promote sustainable rural livelihoods. By enhancing farmers' financial capacity, they can better withstand economic shocks, invest in agricultural inputs and technologies, and diversify their income sources. One effective strategy is to provide farmers with access to affordable credit, such as through loans with minimal interest rates. Access to credit enables farmers to invest in their agricultural enterprises, purchase necessary inputs like seeds, fertilizers, and irrigation equipment, and expand their production capacity. This, in turn, can lead to increased agricultural productivity, higher incomes, and improved food security for farming households. Moreover, training farmers to diversify their income sources between crop and livestock production is essential for mitigating risks and enhancing resilience. By diversifying their agricultural activities, farmers can spread their income streams and buffer against fluctuations in market prices, climate conditions, and pest outbreaks. Additionally, integrating crop-livestock systems can optimize resource utilization, improve soil fertility, and enhance overall farm productivity. Introducing farmers to improved agricultural technologies is another effective approach to increasing productivity and income generation. By adopting modern farming practices, such as precision agriculture, agroforestry, and integrated pest management, farmers can boost yields, reduce production costs, and enhance their competitiveness in the market. Furthermore, investing in irrigation infrastructure and water-saving technologies can help farmers overcome water scarcity challenges and improve crop yields, particularly in arid and semi-arid regions. Overall, empowering farmers with access to finance, knowledge, and technology is essential for promoting food security, poverty reduction, and sustainable rural development. By adopting a holistic approach that addresses the financial, technological, and knowledge needs of farmers, policymakers and NGOs can contribute to building resilient and food-secure communities.

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