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Influence of Small-Scale Irrigation Systems on Livelihoods in Bura Scheme, Kenya

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Abstract
Food security is a fundamental right in pursuit of the UN Sustainable Development Goals by 2030. However, attaining household food security and sustainable livelihoods in arid and semi-arid counties, among them being Tana River in Kenya is usually hampered by extended periods of drought and shifting climatic patterns. This situation not only jeopardizes household provision of sustenance but also the establishment of sustainable livelihoods. Consequently, addressing these multifaceted issues becomes imperative through adoption of small-scale irrigation farming for food production and livelihood provision. This research aimed at providing insights into how small-scale irrigation could help mitigate food insecurity in Arid and Semi-Arid areas of Kenya. The study aimed at assessing the effects of small-scale irrigation systems on livelihoods. The research was anchored on the sustainable livelihood approach and based on pragmatic research philosophy. The study utilized the cross-sectional survey research design and targeted 2,225 Bura scheme farmers. The sample sizes of 340 were selected using multistage, stratified, simple random and purposive sampling methods. Data collection methods comprised surveys and key informant interviews. Quantitative analysis involved descriptive statistics using frequency, percentages and means, and inferential statistics using Chi-Square, Pearson correlation through the aid of SPSS version 25. While qualitative data was thematically analyzed by using NVivo 12. The findings showed the adoption significantly improved food security and livelihoods, raising average seasonal income from Kshs15,300 to Kshs45,800, enhancing purchasing power (Mean=3.93), and improving food availability, consumption, and dietary diversity (Mean=3.89). Positive transformations extended to income levels, consumption patterns, and employment stability (Mean=3.81). The study found a strong positive connection between small-scale irrigation and improved food security and livelihoods, with a Pearson correlation of r =0.736 (p=0.000). The Chi-Square tests confirmed these links, small-scale irrigation significantly impacts food security and livelihoods (X^2=393.238; p=0.000). Qualitative data analysis revealed positive impact of irrigation by increasing ability of farmers to afford basic needs, pay school fees, save income and also improving nutritional health among residents. The study concludes small-scale irrigation's in study area improves livelihoods and food security. The study highlights the transformative impact of small-scale irrigation in Bura, emphasizing strategies such as targeted adoption, knowledge empowerment, and community collaboration. It underscores the need for strengthening agricultural value chains, optimizing water management practices, and government support. Continuous monitoring and evaluation systems are recommended for assessing impact and guiding evidence-based interventions for sustained positive outcomes.
Keywords: Small-scale irrigation, Livelihoods, Bura Scheme, Food security, Sustainable livelihood approach& Kenya
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1. Introduction

Sustainable development, a comprehensive framework encompassing economic progress, societal well-being, and environmental conservation, is imperative in addressing global challenges, particularly the fundamental issue of ensuring access to adequate and safe food. Recent scholars such as Atukunda et al. (2021) and Mustafa et al. (2021) emphasize the interconnectedness of sustainable development, aligning with the United Nations' 17 Sustainable Development Goals (SDGs) designed to guide global efforts. Of particular concern is the escalating global food insecurity, highlighted by the United Nations' report (2021), revealing an alarming increase from 720 to 957 million individuals facing food starvation in 2020 and 2021, respectively. Food security, defined as constant access to adequate, high-quality, nutritious, and safe food, remains a pervasive challenge across continents, each facing

unique dynamics (FAO, 2020). In Kenya, a nation striving to achieve food security as a key component of its big four agenda, persistent food insecurity is a significant hurdle, as evidenced by the Integrated Food Security Phase Classification report (2022). The Arid and Semi-Arid Lands (ASAL) counties, constituting 80% of Kenya's land mass, bear the brunt of this challenge, particularly in Tana River County.

Tana River County, characterized by arid and semi-arid conditions, grapples with acute food insecurity, affecting predominantly pastoralists and mixed farmers (Reliefweb, 2017). The region experiences seasonal and erratic rainfall patterns, exacerbated by climate change, triggering challenges in traditional rain-fed agriculture (Ndiritu & Muricho, 2021). Prolonged droughts, a recurring issue, have been linked to changing climatic trends (Peter, 2011; Mango et al., 2018; Nonvide, 2020; Ngango & Seungjee, 2021; Jambo et al., 2021). Consequently, the population, particularly those near water sources, resorts to small-scale irrigation systems as a strategy to mitigate the impact of these climatic challenges (Burner & Naylor, 2012). In Kenya, where only 2% of arable land is currently equipped for irrigation (Asige & Rotich, 2021), the ASALs, home to over 10 million inhabitants, have been identified as having untapped potential for economic development (Blank et al., 2002). Despite their potential, ASALs face high poverty levels, and rain-fed agriculture has proven insufficient, making irrigation the essential hope for achieving food security (NIB, 2014). The Kenyan government has allocated resources to promote irrigation infrastructure in ASALs, recognizing its significance in preventing food insecurity and eradicating poverty (Blank et al., 2001). Tana River County, specifically, faces persistent food insecurity, with approximately 82 percent of its population relying on pastoralism and small-scale crop farming for livelihoods (Reliefweb, 2017; Muli et al., 2018). The establishment of the Bura Scheme, encompassing the Bura Irrigation Settlement, Hola, and Galana Kulalu, was a response to these challenges, aiming to enhance agricultural production through small-scale irrigation systems (Kamau, 2017). Despite these efforts, the potential benefits of small-scale irrigation in the Bura Scheme remain largely unexplored. Existing studies in Kenya have demonstrated the positive impact of small-scale irrigation on household food security and income levels in other regions (Ndirangu et al., 2018; Onyango et al., 2020). However, the unique context of the Bura Scheme demands dedicated investigation to fill the gap in the literature and provide empirical evidence on the influence of irrigation schemes on livelihoods and food security in this specific region (Muli et al., 2018).

This study, therefore, sought to address the pressing need for a comprehensive understanding of the impact of small-scale irrigation on household food security and livelihood in the Bura Scheme, Tana River County, Kenya. By merging insights from global sustainable development goals, regional challenges in food security, and the specific dynamics of the Bura Scheme, this research strived to contribute empirical evidence that can inform targeted interventions, guide policymakers, and enhance the effectiveness of irrigation systems in mitigating food insecurity and improving livelihoods in arid and semi-arid regions like Bura Scheme, Kenya. Through this holistic approach, the study aimed to be a convincing resource for shaping sustainable development initiatives and achieving the broader objectives of global food security.

2. Theoretical Framework

This study was framed within the Sustainable Livelihoods Approach (SLA), a comprehensive theoretical framework introduced by the Department for International Development (DFID) in 1999, emphasizing the understanding of livelihood strategies in impoverished and vulnerable contexts (DFID, 1999). Represented in Figure 1, the SLA considers five asset types crucial for sustaining livelihoods: natural, physical, financial, human, and social. Natural assets encompassed land and water, physical assets involved irrigation infrastructure, financial assets included agricultural and other income sources, human assets comprised farmers' skills, and social assets pertained to farmers' networks and relationships. Aligned with SLA principles, this study's objectives focused on characterizing small-scale irrigation (related to physical capital), assessing its effects on household livelihoods (addressing human, social, financial, natural, and physical capital), and understanding challenges faced by households (related to social capital).

The SLA's relevance extended to recognizing the impact of external factors, such as policies and institutions, on livelihoods. In the context of this study, policies supporting irrigation development in Kenya and the institutional framework governing irrigation infrastructure management directly influenced the adoption and sustainability of small-scale irrigation. Employing the SLA as a theoretical framework facilitated a comprehensive analysis of available assets, their interplay, and their contribution to livelihood sustainability among small-scale farmers in the Bura Irrigation Settlement Scheme. Additionally, the SLA shed light on the significant role played by external factors, including policies and institutions, in shaping farmers' livelihoods.

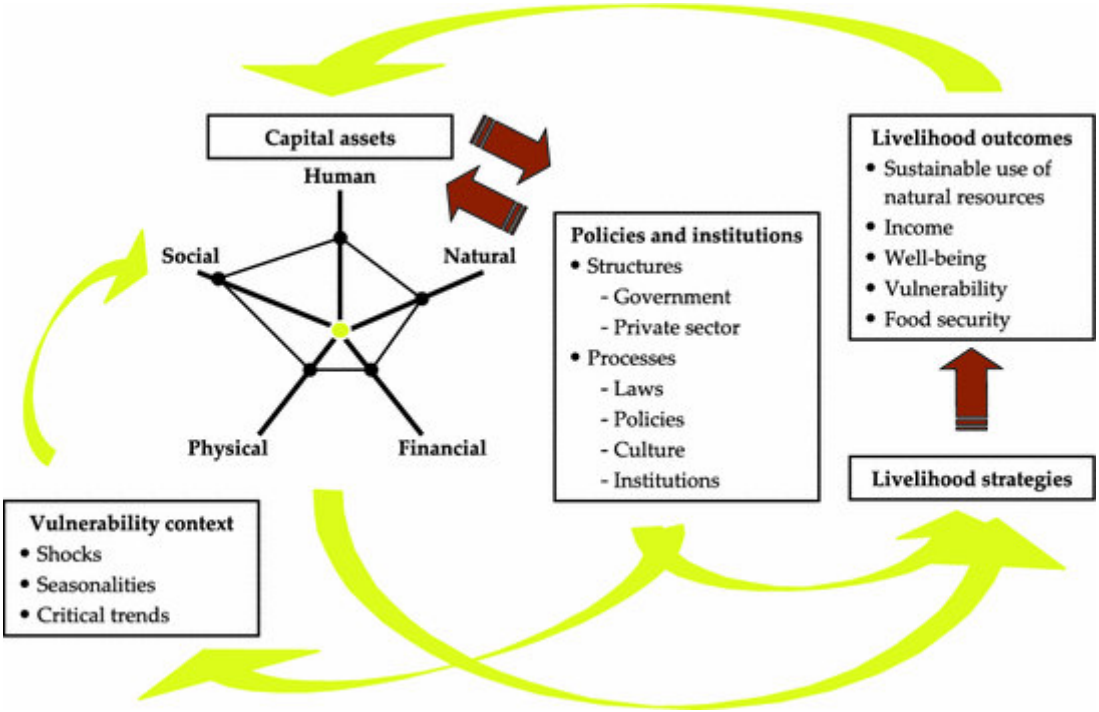

Figure 1: Sustainable Livelihood Approach

Adopted from DFID,1999

3. METHODOLOGY

This study adopted a pragmatic research philosophy, combining elements of positivism and interpretivism to gain a comprehensive understanding of the impact of small-scale irrigation systems on livelihoods in the Bura Scheme, Kenya. Pragmatism allows for the integration of both quantitative and qualitative methods, ensuring a nuanced exploration of irrigation practices and individuals' experiences. (Johnson & Onwuegbuzie, 2019). The chosen research design was a cross-sectional survey, known for efficiency and cost-effectiveness, aligning with the study's goal to assess the impact of small-scale irrigation on household livelihoods in the Bura scheme (Bryman, 2016). Despite potential limitations, the chosen design was deemed suitable for efficiently assessing effects of small-scale irrigation on household's livelihood in the Bura scheme. The study focused on Tana River County in Kenya, specifically the Bura Irrigation Settlement Scheme. Established in 1977, the scheme covers 6,700 hectares, drawing water from River Tana for gravity flow irrigation (NIA, 2021). The scheme supports agriculture, cultivating commercial maize, seed maize, and cereals, with ongoing efforts to introduce rice. The study maps the Tana North Sub County and Bura Irrigation Scheme Villages to provide spatial context.

The target population included 2,225 farmers practicing irrigation in the Bura Settlement, Kenya, supplemented by key informants from various stakeholder groups. Key informants included National Irrigation Authority officials, village elders, county agricultural extension officers, NGO officials, a market trader, and leaders of farmers' groups. The study population was distributed across 11 villages within the Bura Scheme (see Table 1 and Table 2).

Table 1: Primary Target Population

Village	Population
1	134
2	267
3	84
4	111
5	401
6	200
7	223
8	94
9	290
10	178
11	243
Total	**2,225**

Source (NIA, 2023)

The study used the formula proposed by Israel (1992) to obtain the necessary sample size. A 95% confidence interval and a P value of 0.05 was chosen due to the study's social scientific nature.

$$n = \frac{N}{1 + N(e)^2}$$

Where
n = Sample size
N = Population
e = Level of significance
2245
1+2245(0.05)²
= 340.

Table 2: Sample Distribution of the Primary Target Population

Village	Population	Sample
1	134	20
2	267	41
3	84	13
4	111	17
5	401	61
6	200	31
7	223	34
8	94	14
9	290	44
10	178	27
11	243	37
Total	**2225**	**340**

The study utilized a multistage sampling technique. The first stage involved purposive sampling, selecting 11 villages within the Bura Scheme. The second stage employed stratified random sampling to divide the 2,225 farmers into strata for representativeness. The sample size, calculated using proportionate allocation, ensured proportional representation from each stratum. Key informants were purposively selected for their specific experience and knowledge relevant to the study focus.

The study employed various methods for data collection, distinguishing between primary and secondary data. Secondary data were sourced from government reports, academic papers, NGO reports, and online databases to support and enhance research objectives. Primary data were collected using surveys and key informant interviews.

Surveys targeted 340 residents of the Bura Scheme, addressing aspects of household food security and livelihoods. Key informant interviews involved experts providing detailed insights into small-scale irrigation. Four focus group discussions were conducted, involving small-scale irrigators, non-irrigators, key informants, and a combined group, facilitating diverse perspectives.

To ensure the validity and reliability of data, the study employed the KMO test and Bartlett's test for factor analysis suitability. The study utilized a mixed-methods approach, utilizing SPSS for quantitative and Nvivo 12 for qualitative data analysis. Quantitative data underwent coding and cleaning before analysis in SPSS, employing descriptive and inferential statistics. Qualitative data were analyzed using thematic coding in Nvivo 12.

The study received clearance from Moi University School of Graduate Studies and a research permit from the National Commission for Science, Technology, and Innovation (NACOSTI) in Kenya. Informed consent was obtained in the local language, emphasizing participants' rights and confidentiality. The study considered minimal risks and highlighted the benefits of sharing experiences on household food security and irrigation. Confidentiality was ensured through unique identification numbers, data storage precautions, and the use of fictitious names. The researchers-maintained research integrity, acknowledging funding sources and potential conflicts of interest. The robust methodology ensured the study's credibility, validity, and reliability, providing a solid foundation for exploring the effects of small-scale irrigation systems on livelihoods in the Bura Scheme, Kenya.

4. Data Findings, Analysis&Presentations

The study aimed at assessing the effects of small-scale irrigation systems on household livelihood in Bura Scheme, utilizing a 5-point Likert scale to assess households' perspectives. This analysis focused on various aspects, including basic needs affordability, food availability, dietary diversity, access to food resources, crop cultivation practices, income levels, employment stability, agro-processing, livelihood diversification, and social networks. The study also examined the influence of small-scale irrigation on primary livelihood sources, reduction of consumption shortfalls, and stabilization of food prices. The findings, presented in Table 3, provide insights into

the effects of small-scale irrigation on households' well-being and overall food security in the community.

Table 3: Effects of Small-Scale Irrigation Systems on Livelihoods and Food Security in Bura Scheme.

Effects of Small-Scale Irrigation Systems on Livelihoods and Food Security	Response						
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Standard Deviation
The adoption of small-scale irrigation has contributed to an increased ability among farmers to afford basic needs, pay school fees and save income.	14(4%)	14(4%)	38(11%)	190(56%)	84(25%)	3.93	0.94
Small-scale irrigation has enhanced food availability, household food consumption, and dietary diversity in the community.	14(4%)	14(4%)	30(9%)	218(64%)	64(19%)	3.89	0.90
The implementation of small-scale irrigation has improved access to food, utilization of food resources and improved nutritional health in the area.	14(4%)	14(4%)	40(12%)	206(61%)	66(19%)	3.87	0.91
Small-scale irrigation has facilitated the cultivation of high-value crops, multiple cropping practices, and crop diversification.	14(4%)	14(4%)	45(13%)	215(64%)	52(15%)	3.81	0.92
Positive changes have occurred in household income levels, consumption patterns, and employment stability with the adoption of small-scale irrigation.	14(4%)	14(4%)	55(16%)	195(58%)	62(18%)	3.81	0.89
Small-scale irrigation has positively impacted agro-processing, value addition, horticulture, livestock rearing, and aquaculture activities.	14(4%)	14(4%)	51(15%)	208(61%)	53(16%)	3.81	0.93
The introduction of small-scale irrigation has created positive employment opportunities and diversified livelihoods, increased rural wages, including off-farm and micro-enterprises.	14(4%)	14(4%)	57(17%)	192(57%)	63(18%)	3.80	0.90
Small-scale irrigation has positively impacted the main sources of livelihood and agricultural production practices among farmers.	14(4%)	14(4%)	60(18%)	202(59%)	50(15%)	3.76	0.90
Small-scale irrigation has positively influenced food preferences and social networks/support systems among farmers.	14(4%)	14(4%)	59(17%)	214(63%)	39(12%)	3.74	0.87
The implementation of small-scale irrigation has led to reduced consumption shortfalls and stabilized food prices in the community.	14(4%)	14(4%)	63(18%)	210(62%)	39(12%)	3.72	0.87

Table 3 outcomes above demonstrate a substantial improvement in farmers' financial capabilities through small-scale irrigation adoption. This is apparent in addressing basic needs, covering school fees, and saving income, with an 81% agreement level indicating strong consensus. It's clear irrigation has improved participant well-being through irrigation, supporting financial stability and income generation. This emphasizes irrigation's role in poverty alleviation and long-term growth, aligning with studies in developing nations (Ayana & Hirpa, 2017; Dhungana et al., 2018). The findings indicate reduced financial challenges, minimized asset selling for essential needs, and increased savings, highlighting irrigation's contribution to heightened financial security.

Additionally, the positive impacts of small-scale irrigation on the community's food access and consumption are evident in Table 3. An overwhelming 83% expressed agreement, highlighting the community's willingness to enhance food security through localized irrigation. The results underscore the favorable effects of small-scale irrigation on food security, consumption patterns, and dietary diversity. By enabling diverse crops throughout the year, irrigation improves nutritional quality and accessibility for households, addressing food insecurity. This positive influence, observed globally and in recent Kenyan studies (Kiptot et al., 2017; Ndiritu et al., 2020), underscores irrigation's role in increasing crop yields, dietary diversity, and overall food security. Consistent with international studies in Nepal, Ethiopia, Nigeria, and Bangladesh (Wagle & Bhattarai, 2017; Teklu et al., 2017; Oyinbo et al., 2019; Thapa et al., 2019; Islam et al., 2019), the findings confirm irrigation's universal contribution to enhancing food production and security.

Moreover, as depicted in Table 3, 61% of participants concurred, and 19% strongly concurred, that the positive influence of small-scale irrigation extends to food accessibility, utilization of food resources, and nutritional well-being. In total, 81% of respondents acknowledge the significance of this impact. The substantial consensus underscores the pivotal role played by small-scale irrigation in augmenting access to food and fostering consumption within the community. The data, with a mean score of 3.87 and a standard deviation of 0.91, indicates widespread recognition that the transformations induced by small-scale irrigation are viewed as advantageous. The results emphasize the constructive effect of small-scale irrigation on household food security, facilitating access through heightened income, improved transportation, and resilience against drought, aligning with similar conclusions in various regions (Mengistu and Kassa, 2018; Wekesa et al., 2020). Furthermore, the findings stress the positive impact of irrigation on health, consistent with research suggesting enhanced dietary diversity and diminished malnutrition (Karki et al., 2020; Asenso-Okyere et al., 2011). Similarly, it affirms that irrigation contributes to altering food preferences, resonating with studies proposing its role in fostering healthier diets and crop diversification (Gichuhi et al., 2017; Gupta et al., 2018). These insights underscore the multifaceted advantages of small-scale irrigation in fortifying food security, influencing dietary patterns, and enhancing overall nutritional well-being.

Table 3 above emphasizes that small-scale irrigation significantly supports the cultivation of high-value crops, multiple cropping, and crop diversification, leading to enhanced food availability. The substantial 79% agreement among respondents underscores the widespread recognition of irrigation's positive impact on agricultural practices, with a mean score of 3.81 indicating a favorable perception. Table 3 insights strongly indicate that small-scale irrigation significantly boosts crop productivity and sustainability in the study area, with implications for food security and rural development. This aligns with research in India (Kumar et al., 2017) and Ethiopia (Alemu et al., 2019), highlighting irrigation's pivotal role in enhancing crop yield and diversification. Further it emphasizes that irrigation not only increases food availability and economic stability but also enhances overall crop quality and diversity. Similar positive effects on crop yield are noted in studies from India (Tiwari and Singh, 2017) and Ethiopia (Fufa et al., 2020). These findings affirm that irrigation promotes high-value crops, multiple cropping practices, and year-round crop production, emphasizing its critical role in advancing crop diversity, food security, and agricultural progress in the study region.

The study's results reveal that the introduction of small-scale irrigation had positive effects on household income, consumption patterns, and job stability. As indicated in Table 3, a considerable proportion of respondents (76%) acknowledged these impacts, with 58% in agreement and 18% strongly supporting the notion. The mean score of 3.81 and a standard deviation of 0.89 indicate a generally favorable reception of these improvements. Table 3 further demonstrates that irrigation contributes to increased farm income, aligning with existing research confirming the positive influence of irrigation on crop income and household food consumption. An Indian study (Bhattacharyya et al., 2018) underscored irrigation's role in enhancing crop yields and subsequently elevating farmers' incomes. Similarly, research conducted in Ethiopia (Dawit and Mulugeta, 2018) emphasized irrigation's contribution to heightened food production and improved food security for farming households.

To better understand the beneficial outcomes of embracing small-scale irrigation on household income, participants were asked about their earnings both before and after the adoption of irrigation. The outcomes are outlined in Table 4.

Table 4. Aggregated Income

Attributes of Aggregated income of Income	Before Irrigation Amount(Ksh)	After irrigation Amount(Ksh)
Range	88,000	85,000
Minimum	2,000	10,000
Maximum	90,000	95,000
Mean	15,300	45,800
Standard deviation	10,082	14,233

Before the implementation of irrigation, Table 4 illustrates a broad spectrum of household incomes in the study area, ranging from Kshs 2,000 to Kshs 90,000, with an average income of Kshs 15,300 and a standard deviation of Kshs 10,082. This indicates considerable income diversity, with many households having relatively low earnings. It's crucial to consider factors like housing type, educational levels, skills, and local job opportunities influencing these income variations.

Following the introduction of irrigation, the range of household incomes became more focused, varying from Kshs 10,000 to Kshs 95,000, with a noteworthy increase in the mean income to Kshs 45,800 and a standard deviation of Kshs 14,233. The substantial rise in mean income and reduced variance suggests a positive impact of irrigation on household incomes. Various factors could contribute to this increase, including enhanced agricultural

productivity and sales due to irrigation. Research on agricultural productivity supports this, indicating that irrigation significantly boosts crop production for both consumption and sale. Additionally, irrigation may have generated new employment opportunities in the region, particularly in management, maintenance, repair, logistics, and transportation. Lastly, the implementation of irrigation might have elevated land and property values, providing additional income to households owning or renting land.

Further exploration into the earnings of farmers engaged in small-scale irrigation within the settlement scheme, carried out via a Key Informant Interview, yielded positive findings. Mr. Mwendandu, a 40-year-old project officer at the National Irrigation Authority, shared valuable information :

> *"The Bura Irrigation Scheme has had a significant impact on the economy of Bura town and Tana River County. Before the onset of irrigation, these economic benefits never used to exist. Now, farmers have earned a total of Kshs 390 million from seed maize contracted farming by Kenya Seed Company Limited in the 2016-2017 (Kshs 60 million), 2017-2018 (Kshs 15 million), 2018-2019 (Kshs 28 million), 2019-2020 (Kshs 39 million) and 2020-2021 (Kshs 48 million) seasons, and Kshs 216 million from Kwamboka rice farming in the 2021-2022 season. In addition, they earn an average of Kshs 200 million annually from horticultural crops production, such as watermelon, tomatoes, and bulb onions. Moreover, they earn approximately Kshs 250 million from rice, commercial maize, pulses, and cotton production. The community living along the 50km main canal also benefits from the scheme by using water from the canal for their livestock and households."*

The information presented in Table 3, Table 4, and Mr. Mwendandu's insights collectively affirm the positive outcomes associated with the adoption of irrigation, particularly in terms of income, consumption, and employment stability. This aligns with findings from diverse studies in different regions, indicating that irrigation positively influences income stability, consumption behaviors, and employment opportunities. Notably, research conducted in China (Cai et al., 2017) and Pakistan (Khan and Hanjra, 2009) highlighted how irrigation contributes to increased farmer income by boosting crop yields and generating employment. Additionally, Ethiopian studies by Shimelis et al. (2014) demonstrated that irrigation plays a crucial role in enhancing household food security and nutrition through increased crop production. Furthermore, the results in Table 4 validate the favorable impact of irrigation on household incomes in the study area. Pre-irrigation, households exhibited diverse and relatively low income levels. Post-irrigation, reported incomes showed less variation, accompanied by a notable increase in the mean income level. Factors contributing to this positive change include improved agricultural production and sales, the creation of job opportunities, and an increase in land and property values. The Key Informant Interview underscored the significant economic impact of the Bura Irrigation Scheme, emphasizing substantial income gains for farmers and broader community benefits along the main canal.

Small-scale irrigation has emerged as a catalyst for positive changes in various agricultural sectors, including agro-processing, value addition, horticulture, livestock farming, and aquaculture, as illustrated in Table 3 above. The substantial consensus among respondents, with 61% in agreement and an additional 16% strongly supporting this perspective, emphasizes the widespread acknowledgment of the favorable impact of small-scale irrigation on these activities, culminating in an overall agreement of 77%. This collective affirmation is further supported by the mean score of 3.81 and a standard deviation of 0.93, indicating that farmers perceive small-scale irrigation as a crucial tool for improving diverse agricultural practices in the study area. The insights gathered from the Key Informant interview, as reflected in Mr. Mlegwa's viewpoints, reaffirm the documented positive impact of small-scale irrigation on various agricultural sectors within the Bura scheme:

> *"The introduction of small-scale irrigation has had a significant positive impact on various agricultural activities in our area. Farmers have embraced agro-processing, value addition, horticulture, livestock rearing, and aquaculture more effectively, thanks to irrigation. This has resulted in increased productivity and income for farmers, contributing to the overall development of our rural community. Irrigation has opened up new opportunities and transformed our agricultural landscape, allowing farmers to diversify their activities and improve their livelihoods. It's been truly transformative for our community."*

The findings in Table 3, coupled with Mr. Mlegwa's perspective, reinforce a positive perception of the impact of small-scale irrigation on various agricultural activities. Consistent with research by Kumar et al. (2017) in India and Alemu et al. (2019) in Ethiopia, our study aligns with reported favorable effects of irrigation on crop productivity, agro-processing, value addition, and horticulture. Notably, our observations of increased aquaculture adoption correspond to findings in Nepal by Shrestha et al. (2018), highlighting irrigation's role in diversifying agricultural practices. Nevertheless, studies such as Lee et al.'s (2016) in South Korea may present differing results, suggesting that while irrigation positively affects some activities like horticulture, its impact on livestock husbandry might be minimal.

The data in Table 3 above underscores the substantial positive impact of small-scale irrigation on employment and livelihoods in the Bura Scheme, with 75% of respondents acknowledging its role in job creation and income diversification. The favorable mean score of 3.80 suggests that farmers not only recognize but also appreciate irrigation as a valuable tool for increasing earnings and expanding livelihood options. This view emphasizes the

significance of irrigation, not just in enhancing agricultural income but also in contributing to overall economic well-being. For farmers in the Bura Scheme, the benefits of irrigation extend beyond traditional farming, offering potential advantages such as economic stability, reduced reliance on farming, and improved resilience to market fluctuations. These outcomes collectively contribute to higher family incomes and a more robust community economy. Mr. Karani, a 66-year-old successful farmer and key informant who has been part of the scheme since its inception, supports the idea that irrigation has led to an increase in both on-farm and off-farm employment opportunities and rural wages. He laments:

> *"I have seen firsthand how irrigation has transformed our community, creating both on-farm and off-farm employment opportunities for many," Mr. Karani emphasizes. With the implementation of irrigation, there has been a substantial increase in agricultural productivity and crop yields, which in turn has led to a growing demand for labor in various farming activities. This surge in employment opportunities has not only resulted in increased rural wages but has also significantly improved the livelihoods of many households in our community. "Farming activities such as planting, leveling, and guarding against pests have required more hands, allowing us to hire more labor," he adds.*

Small-scale irrigation has not only transformed agriculture but has also led to the establishment of off-farm enterprises, providing community members with diverse income opportunities and strengthening economic resilience. *"Our community is now more vibrant, with various businesses flourishing alongside traditional farming,"* Mr. Karani proudly notes.

Mr. Karani's experiences align with the findings in Table 3, reflecting a widespread consensus among respondents regarding the positive impact of small-scale irrigation on employment and overall livelihood improvement. His acknowledgment that irrigation contributes to prosperity by ensuring a stable income resonates with the data, emphasizing its transformative effect on essential needs and the overall quality of life. The insights from Table 3, combined with Mr. Karani's perspective, highlight the role of irrigation in generating both on and off-farm employment, leading to increased rural wages. This not only signals an improvement in crop yield but also underscores irrigation's contribution to stimulating economic activity and fostering employment in the study area. Similar conclusions drawn from studies in India (Meinzen-Dick et al., 2002; Kirimi et al., 2006 in Kenya) further substantiate the idea that irrigation significantly enhances agricultural productivity, income, and employment opportunities across various sectors.

Table 3 illustrates that a substantial majority of participants in the Bura Scheme (74%, comprising 59% in agreement and 15% strongly in agreement) recognize the favorable impact of small-scale irrigation on their main sources of income and agricultural methods. This collective acknowledgment, reflected in the mean score of 3.76, underscores the transformative role of irrigation in enhancing livelihoods and farming activities specific to the Bura Scheme. This widespread recognition emphasizes the crucial contribution of small-scale irrigation to increased agricultural productivity, higher income, and improved economic stability in this particular study area. Mr. Munyoto, a 44-year-old farmer and key informant, echoed the prevalent view that small-scale irrigation has positively influenced farmers' primary livelihoods and agricultural practices.:

> *"I can confidently say that small-scale irrigation has been a game-changer for us farmers in this community. Before irrigation, we relied solely on rain-fed agriculture, and our yields were often unpredictable. We faced challenges in meeting our basic needs, and income opportunities were limited. But with the implementation of irrigation, everything changed for the better. The availability of water throughout the year allowed us to cultivate our crops more efficiently. We no longer have to worry about rainfall shortages or droughts negatively impacting our livelihoods. Our yields have significantly increased, and this has boosted our incomes. Additionally, we have been able to diversify our crops and engage in high-value agricultural practices such as horticulture, livestock rearing, and aquaculture. Furthermore, irrigation has not only improved our financial situation but also transformed our overall livelihoods. We now have access to more stable employment opportunities, both within and outside the farm. Many of us have started small agro-processing and micro-enterprises, creating more jobs for our community members. Moreover, the social fabric of our community has strengthened due to irrigation. We share knowledge and best practices with each other, which has improved our farming techniques and productivity. We support and uplift one another, making our community more resilient and united. Overall, the introduction of small-scale irrigation has brought prosperity to our lives. It has positively impacted our main sources of livelihood and agricultural practices, leading to increased productivity, diversified income streams, and enhanced social cohesion. We are grateful for this transformation, and it gives us hope for a brighter and more sustainable future!"*

Mr. Munyoto's narrative highlights the affirmative effects of small-scale irrigation on both livelihoods and agricultural practices in the research area. The implementation of irrigation has resulted in heightened productivity, expanded income streams, and enhanced social bonds among farmers, fostering a more prosperous and resilient community.

In terms of the influence of small-scale irrigation on main livelihoods and agricultural practices, Mr.

Mwakalibela, a 49-year-old key informant, shared his viewpoints:

> "*Before irrigation, the majority of people in Bura settlement schemes relied on wages and food aid as their main sources of livelihood due to the semi-arid nature of the area, making it challenging to cultivate crops and raise livestock without sufficient water. As a result, the community had limited agricultural production, and individuals had to depend on wages from casual labor or urban employment to make ends meet. Frequent droughts and food shortages also necessitated food aid, which led to malnutrition and hunger. However, the implementation of small-scale irrigation farming brought about a significant positive impact on the community's livelihoods. After irrigation was introduced, a large percentage of the population started relying on irrigation as their main source of livelihood, leading to increased agricultural production, job opportunities, and better food security. The government declared the area to be food secures 15 years after irrigation was introduced, and people no longer relied on food aid as a source of livelihood.*"

The results in Table 3, along with perspectives from Mr. Munyoto and Mr. Mwakalibela, affirm the substantial impact of the irrigation scheme on the community's livelihoods. This impact is evident through increased water availability for agriculture and other purposes, leading to positive outcomes such as enhanced employment opportunities and improved food security. These findings resonate with research conducted in Ethiopia, exemplified by Tsegay et al. (2018), emphasizing irrigation's role in enhancing food security, income, and agricultural productivity for smallholder farmers. Similarly, studies in Nepal, such as Ojha et al. (2018), suggest that irrigation contributes to increased agricultural productivity and income, thereby improving food security and reducing poverty. The notion that irrigation introduces alternative means of subsistence aligns with various studies, including de Fraiture et al. (2018), which indicate that irrigation plays a crucial role in promoting employment, particularly within the agricultural sector, in rural areas.

To confirm the favorable influence of adopting small-scale irrigation on farmers' agricultural practices, respondents were asked about the state of their agricultural production before and after the introduction of irrigation. The results are presented in Table 5.

Table 5 : Changes in Agricultural Production

	Before Irrigation		After irrigation	
Agricultural Production	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Sufficient for less than 6 months	198	58.2	29	8
Sufficient for 6 months	75	22.1	94	28
Sufficient for annual household consumption	46	13.5	139	41
Excess for annual consumption	21	6.2	78	23
Total	340	100	340	100

As per the outcomes presented in Table 5 regarding agricultural production, the introduction of irrigation had a beneficial impact on households' ability to fulfill their consumption needs through increased agricultural output. Initially, a majority of households (58.2%) reported having agricultural production lasting less than six months, indicative of food scarcity. Post-irrigation, the percentage dropped significantly to 8.0%, highlighting that irrigation augmented agricultural production and improved short-term consumption needs. Similarly, a smaller proportion of households (22.1%) in Table 5 indicated having sufficient agricultural production for six months before irrigation. After the implementation of irrigation, this percentage rose to 28.0%, signifying an enhancement in agricultural production and an extended duration of meeting consumption needs. Furthermore, only a limited number of households (13.5%) in Table 5 reported having enough agricultural production for annual household consumption prior to irrigation. However, after irrigation, the percentage increased substantially to 41.0%, demonstrating that irrigation significantly boosted agricultural production, enabling households to fulfill their annual consumption requirements. Moreover, before irrigation, a small percentage of households (6.2%) in Table 5 reported surplus agricultural production for annual consumption, indicating a lack of excess produce. Post-irrigation, the number of households with surplus production for annual consumption surged to 23.0%, underscoring that irrigation enhanced agricultural output, allowing households to have surplus produce beyond their annual consumption needs. The Table 5 findings align with global research, affirming irrigation's positive impact on agricultural productivity and households' ability to meet consumption needs. In India, Smith et al. (2018) observed increased self-sufficiency and improved agricultural output post-irrigation. Similarly, Makurira et al. (2016) noted enhanced agricultural output in Sub-Saharan Africa. Research by Timmer et al. (2017) in Southeast Asia highlighted improved food security through irrigation. In South America, Gonzalez et al. (2015) found that irrigation positively influenced agricultural output, ensuring surplus produce. These studies collectively underline irrigation's transformative impact on agricultural productivity and food security worldwide.

Table 3 provides a visual representation of widespread consensus (75%) regarding the favorable influence of small-scale irrigation on food choices and social interactions. The average score of 3.74 serves to affirm this agreement, suggesting that respondents commonly perceive irrigation as a positive factor in shaping dietary practices and fostering community ties. This optimistic outlook further supports the argument for the pivotal role

of irrigation in guaranteeing food security and nurturing resilient communities. Mr. Kilonzi's supportive comments further reinforce the positive impact on food decisions and social connections:

> *"Prior to the implementation of irrigation, our community faced significant financial challenges and minimal household interactions. Dependence on government and NGO aid was high to enhance food security. Nevertheless, since the introduction of irrigation, there has been a remarkable improvement in social networks and support systems. Small-scale irrigation has played a pivotal role in transforming the dynamics of our community. Enhanced communication through WhatsApp groups and community meetings has resulted in improved cooperation and knowledge sharing amongst farmers, resulting in higher crop yields and increased incomes. The exchange of ideas and agricultural practices within these forums has empowered us with valuable insights to optimize our farming techniques. As a result, the overall productivity of our farms has increased, leading to greater self-sufficiency and reduced reliance on external assistance. Moreover, access to markets has improved the financial status of the community, leading to reduced dependence on external aid. With the increased production enabled by irrigation, we have been able to sell our surplus produce in the market, generating additional income for our households. This newfound economic stability has bolstered our resilience against food shortages and economic fluctuations. During last year's severe drought, the WhatsApp group was a critical source of information, where farmers shared valuable tips on how to access water, grow drought-resistant crops, and manage the situation. This information proved to be invaluable and saved many farmers' crops from total loss. The solidarity and support fostered within the community through these digital platforms have strengthened our ability to withstand adverse climatic conditions and other challenges. Furthermore, the positive impact of small-scale irrigation has transcended the mere improvement in food production. It has nurtured a sense of community and cooperation among farmers, fostering a spirit of mutual assistance and camaraderie. We no longer solely depend on Government and NGO aid to enhance food security at our households, as irrigation has empowered us to take charge of our agricultural endeavors and forge a brighter future for ourselves and our families. Small-scale irrigation has truly been a catalyst for positive change in our lives, leading to improved food preferences, stronger social networks, and greater self-reliance."*

The data in Table 3, coupled with Mr. Kilonzi's insights, indicates that irrigation adoption has enhanced social connectivity and reduced dependence on external support for food security. This aligns with prior research, exemplified by an Indian study emphasizing irrigation's role in improving farmer well-being (Ghosh et al., 2015), and Ethiopian research highlighting its positive impact on social networks and knowledge exchange (Gebremedhin et al., 2015).

Table 3 further reveals that a significant proportion of participants holds the belief that small-scale irrigation has alleviated consumption gaps and stabilized food prices in the locality. Approximately 74% acknowledge that irrigation contributes to stabilizing food prices and addressing hunger, with 62% in agreement and 12% strongly supporting this notion. This emphasizes the pivotal role of irrigation in enhancing the community's access to nutritious food, as indicated by an average score of 3.72. While perspectives may vary, the prevailing sentiment recognizes irrigation as a key factor in improving food security and ensuring consistent food availability in the area. Aligning with the identified trends suggesting that irrigation can reduce consumption gaps and stabilize food prices, Mrs. Mwangi, a 56-year-old Key Informant, shared her insights on the impact of irrigation on food security and accessibility in the research locale:

> *"The implementation of small-scale irrigation has been a transformative experience for our community, revolutionizing our approach to agriculture and food security. With access to reliable water for irrigation, our farmers have witnessed a significant increase in productivity, enabling year-round cultivation of crops. This shift away from solely relying on unpredictable rain patterns has led to reduced crop failures and uncertainty during harvest seasons, allowing us to confidently grow a diverse range of crops and achieve higher overall yields, ensuring a steady food supply for our families. One of the most remarkable impacts of irrigation has been the positive change in food availability and affordability. With increased crop production, we have witnessed a substantial reduction in consumption shortfalls and a stabilization of food prices within our community. This has alleviated the burden of food scarcity and reduced our dependency on external food sources, making essential food items more accessible and affordable to everyone. As a result, our families no longer live with the constant fear of food shortages, significantly improving our overall food security. Looking to the future, we are optimistic that the benefits of irrigation on food security and accessibility will continue to expand. As our farmers become more skilled in harnessing the potential of irrigation, we anticipate even higher yields and a wider variety of crops to meet the diverse needs of our community. The exchange of experiences and knowledge among farmers through this irrigation initiative has fostered a strong spirit of cooperation and community support. Farmers have come together, sharing insights and best practices, creating an environment of continuous learning and innovation that propels us towards a more prosperous and sustainable future. The impact of small-scale irrigation on our livelihoods and food security has been*

truly transformative, offering a brighter and more resilient path for our community's agricultural development."

The adoption of small-scale irrigation emerges as a pivotal factor in addressing food security and enhancing accessibility within our community, as evident from the insights presented in Table 3 and Mrs. Mwangi's viewpoints. Numerous studies examining the impact of irrigation on food security and accessibility align with these findings. Notably, research conducted in India emphasized the role of irrigation in augmenting agricultural productivity and reducing food prices, ultimately bolstering food security (Kumar and Singh, 2018). Similarly, a study conducted in Ethiopia demonstrated that irrigation not only led to increased agricultural production but also contributed significantly to a reduction in food insecurity, thereby improving overall food access (Mekonnen and Tesfaye, 2018).

The study utilized inferential statistics to assess the relationship between small-scale irrigation practices and their impact on livelihoods and food security. The Chi-Square test, with 56 degrees of freedom, revealed a highly significant association ($\chi^2 = 393.238$, $p < 0.001$) between these variables. This indicates that the effects of small-scale irrigation on livelihoods and food security are not random but are indeed connected to the adoption of irrigation practices. Households involved in small-scale irrigation are more likely to experience positive impacts on livelihoods and food security compared to those not engaged in such practices. Furthermore, Pearson Correlation was employed to measure the strength and direction of the relationship between small-scale irrigation and its effects on livelihoods and food security. The correlation coefficient ($R = 0.736$) indicated a strong positive correlation. The associated t-value of 72.151 with a p-value of 0.000 affirmed the statistical significance of this correlation. This robust positive correlation implies that as the level of engagement in small-scale irrigation increases, the positive effects on livelihoods and food security also increase. In simpler terms, households actively practicing small-scale irrigation witness greater improvements in both livelihoods and food security.

Conclusion

The study's comprehensive assessment of small-scale irrigation systems in the Bura Scheme reveals significant positive impacts on livelihoods and food security. Farmers experienced enhanced financial capacities, improved access to food, increased agricultural productivity, and diversified cropping practices. The transformative effects of small-scale irrigation extended to social dynamics, reducing consumption gaps, stabilizing food prices, and fostering community well-being. The study applied the Sustainable Livelihoods Approach (SLA) to assess the impact of small-scale irrigation on food security and livelihoods in the Bura scheme. Small-scale farmers effectively utilized human, natural, financial, social, and physical assets, including obtaining irrigated land through government redistribution. The adoption of irrigation positively influenced food security and livelihoods, with increased crop production and engagement in income-generating activities. External factors like government policies and NGO support played a crucial role in shaping small-scale farmers' access to assets and opportunities. The study validates the relevance of the SLA framework in understanding the multifaceted impact of small-scale irrigation on farmers' lives.

Recommendations

The study's findings underscore the transformative effects of small-scale irrigation on livelihoods and food security in the Bura Scheme, highlighting key areas for further enhancement:

I. Promote Adoption Strategies: Given the positive correlation between small-scale irrigation adoption and improved livelihoods, targeted strategies should be employed. Initiatives should include technical support, comprehensive training programs, and facilitating access to affordable irrigation technologies to encourage widespread adoption.

II. Leverage Agricultural Value Chains: Building on the observed impacts on diverse cropping practices and heightened income, efforts should focus on strengthening agricultural value chains. Encouraging agro-processing, value addition, and promoting activities in horticulture, livestock, and aquaculture can unlock the full potential of increased agricultural productivity facilitated by irrigation.

III. Empower through Knowledge: Recognizing the pivotal role of knowledge in maximizing irrigation benefits, capacity-building programs should be prioritized. Training farmers in modern agricultural practices, marketing, and financial management can optimize irrigation outcomes, creating more income-generating opportunities.

IV. Foster Community Collaboration: Social dynamics play a crucial role in the success of small-scale irrigation. Community engagement initiatives, including forums and knowledge-sharing platforms, should be facilitated. This will encourage collaboration among farmers, promoting the exchange of best practices and reinforcing the positive impacts on livelihoods.

V. Optimize Water Management Practices: Sustainable water use is fundamental to the success of irrigation. Implementing efficient water management practices is imperative to prevent water scarcity and ensure the longevity of small-scale irrigation initiatives.

VI. Governmental Support and Policy Advocacy: Governments should actively support irrigation adoption by providing policy frameworks, financial incentives, and resources. Policymakers should recognize the positive correlation between small-scale irrigation, livelihoods, and food security, aligning policies with the goal of widespread adoption.

VII. Continuous Monitoring and Evaluation: Establishing robust monitoring and evaluation systems is critical. These systems should provide continuous assessments of the impact of small-scale irrigation, identify areas for improvement, and inform evidence-based interventions for sustained positive outcomes.

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