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Family Planning, Irrigation, and Agricultural Cooperatives for Sustainable Food Security in Kenya

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Abstract

Rapid population growth causes smallholders to practice unsustainable forms of land intensification to meet increasing food demand. Food insecurity is exacerbated by unreliable rainfall. We revisit family planning, smallholder irrigation, and agricultural cooperatives as potential sustainable solutions. We use primary data from Kakamega Central and Navakholo in Kenya. Results from respondents indicate 83% had no family planning information, while 82% had no access to irrigation. The main reasons are poverty, illiteracy, misconceptions, gender inequality, and constraints in accessing credit, lack of investment in water resources, and lack of family planning. Lack of access to agricultural extension services limits the adoption of sustainable farming practices. Cooperatives' principles and values make them suitable pathways to reach the poorest and facilitate members' access to productive resources. Cooperatives can be used to train members in sustainable agricultural practices and educate members on family planning issues. Descriptive statistics and econometric regression results suggest that cooperatives have contributed to better yields, incomes, nutritional status, and reduced poverty. However, they are constrained by a lack of capital, credit, infrastructure, markets, training and technology, delayed payment, and low prices. Governments and development agencies should support the establishment and development of cooperatives with capacity building, market infrastructure, finance, and education in cooperative principles and values.

Keywords: Family planning, rainwater harvesting, supplementary irrigation, agricultural cooperatives, smallholders, rural Kenya

1. Introduction

Smallholders' constraints are multifaceted (Zerssa et al., 2021; Andersen & Watson II, 2011), with access to credit, input, and output markets being some of the most important. As much as these are essential, land resources, including soil, water, and biodiversity, are crucial. Rapid population growth is putting pressure on finite land resources (Garg, 2020; Miladinov, 2023), exacerbated by climate change effects such as erratic rainfall, recurrent floods, and droughts. The average land size of smallholders in Kenya was 4.1 ha in 1974, 2.1 ha in 2010 (Jayne, Chamberlin & Headey, 2014), and had declined to 0.47 ha by 2014 (Rapsomanikis, 2015). To meet the growing food demand, smallholders are resorting to unsustainable forms of land intensification (Mathinya et al., 2022; Jayne, Chamberlin & Headey, 2014), which threatens to stall progress towards the Sustainable Development Goals (SDGs). These circumstances call for population growth control and sustainable solutions for food security. Therefore, this paper focuses on family planning and supplementary irrigation through agricultural cooperatives as potential solutions. Total fertility rate (TFR) in Kenya was 7.99 in 1970, declined to 4.06 in 2015, and to 3.4 in 2022 (Seifu et al., 2023; UN Department of Economic and Social Affairs, Population Division, 2019). However, the rate of decline in TFR is not the same across socioeconomic groups and geographic locations (rural and urban areas), largely due to family planning issues.

Family planning services offer contraceptive methods that enable people to decide the number of children they have and determine the spacing of pregnancies, thereby preventing unintended pregnancies, limiting family size, controlling the population, and improving the quality of life of the people and the development of communities (WHO, 2018; Akamike et al., 2019). Ochako et al. found that awareness and knowledge of contraception do not always translate to use. The major barriers to uptake are (a) myths and misconceptions that women hear from

partners and peers about potential side effects (Wafula, Obare & Bellows, 2014); (b) inadequate availability of modern contraceptive methods, exacerbated by inequitable distribution of health facilities offering family planning services across Kenya (Wafula, Obare & Bellows, 2014; USAID, 2009); (c) people in poverty may not be able to afford modern contraceptives, amid insufficient support for family planning programs (Sinai, Omoluabi, Jimoh & Jurczynska, 2020); (d) a shortage of trained workforce and community health workers (Mugisha & Reynolds, 2008); (e) reproductive health particularly family planning programs are and remain underfunded, resulting in limited access to services and poor service delivery (Tiendrebeogo et al., 2022; Singh et al., 2009).

Poverty, illiteracy, misconceptions, and gender inequality create a vicious circle that prevents smallholders from adopting sustainable farming and land intensification practices. Lack of education and training limits smallholders' uptake of irrigation since they lack know-how on appropriate application that would lead to the benefits of good irrigation practices. Therefore they cannot make use of sustainable land intensification and crop diversification, instead resorting to unsustainable practices that include cutting down forests and planting crops on hilly slopes in order to obtain land for farming. Sociocultural norms that block women from equal access to productive resources, including land, hinder women from accessing credit since financial institutions often ask for a land title deed as collateral. Lack of credit is a barrier to the uptake and application of irrigation technology and other sustainable farming inputs.

The barriers to family planning uptake have contributed to the inadequate and inefficient use of family planning, consequently exacerbating the effects of rising population growth in Kenya. Population growth in Kenya threatens food security: its population density rose from 45.9 to 88.2 per Km^2 during 1993-2017 (UN Department of Economic and Social Affairs, Population Division, 2019). The forecast annual population percentage change, fertility rate, and population density per Km^2 for 2020 are 2.52, 3.77, and 94, while for 2050 they are 1.54, 2.61, and 168 respectively (UN Population Division, 2017). Although the fertility rate is declining, population density per Km^2 is alarming. Uncontrolled rapid population growth in Kenya is affecting agricultural output through (a) increased demand for food being higher than supply, which leads to higher prices for both inputs and food, and declining agricultural output exacerbating food insecurity (Korir, Rizov & Ruto, 2020; Muyanga & Jayne, 2014); and (b) farms getting smaller as farmers subdivide land among their children, resulting in the land's production becoming insufficient for sustenance. Farmers then take more land into cultivation through unsustainable farming practices such as the clearance of grasslands and forests of native vegetation, which subsequently results in soil degradation (Mugizi & Matsumoto, 2020).

How can family planning be integrated into agricultural cooperative activities? Cooperatives generally hold membership meetings monthly; during these meetings, government or non-governmental organization (NGO) support trained community health workers to reach the farmers who are otherwise unreachable due to remoteness or other such constraints. Community health workers can offer family planning education, and counseling, and distribute contraceptives (USAID, 2024).

Kenya is mostly arid and semi-arid land (ASAL), with an erratic and unreliable average annual rainfall of 500 mm. 66% of the country receives less than 500 mm annually (Koeva et al., 2020; Mogaka, 2006). The unsustainable farming practices that lead to land degradation increase rainwater losses through runoff, which in turn aggravates the impact of drought. The environmental degradation in question further contributes to land productivity decline, loss of biodiversity, and desertification (Kogo, Kumar & Koech, 2020; Davies, 2016). Agricultural production in Kenya is largely rain-fed: under climate change, there are shorter growing seasons, culminating in crop failures, and episodes of drought-related hunger and severe malnutrition, particularly among mothers and children, as well as rampant poverty levels (Ingutia & Sumelius, 2022).

Increasing demand for food due to population growth and the consequences of climate change and droughts, including rainfall variability, and soil degradation, require innovative technologies that will ensure sustainable intensification of production in high and medium potential lands and opening up of new land in the ASAL (Pachauri et al., 2014). This is possible through the application of irrigation technology that is decisive in securing water to bridge dry spells, and the improvement of soil management to increase nutrient availability and the water holding capacity of the soil profile (Etuk & Ayuk, 2021), in the process ensuring sufficient food supplies and better livelihoods by transforming subsistence farming into commercial farming (Wichelns & Oster, 2006; Mati, 2008). In Kenya, Mati (Mupaso, Makombe & Mugandani, 2023) found that the poverty and food insecurity rates of smallholders fell over a period of 2-3 years of practicing smallholder irrigation. Meanwhile, Mupaso et al. reported that investments in smallholder irrigation improve food security and reduce poverty rates.

Kenya has the potential to irrigate 540,000 ha of farmland, of which only 20% is currently irrigated (106,600 ha).

40% of the irrigated land is cultivated by large commercial farms, government-managed schemes take up 18%, while smallholder irrigation covers 42% of the irrigated land (Republic of Kenya, 1992; Osewe, Liu & Njagi, 2020). In this paper, smallholder irrigation includes irrigation activities of farmers who own plots of less than 2 ha who manage individual plots or are part of a community-managed scheme, and who completely control the water distribution and other key services without interference from government institutions (Nakawukaa, Langan, Schmittera & Barronc, 2018). A majority of smallholders, especially women, have not supplemented unpredictable rainwater with irrigation technologies, even in cases where water resources might be available in the community. This is because individual smallholders tend to face constraints in accessing credit, appropriate technologies, farm inputs, and output markets to invest in irrigation equipment (ICA, 2012).

What can facilitate smallholders' access to smallholder irrigation to maximize its benefits? Faced with numerous constraints, smallholders form farmer groups (cooperatives). The present study uses the terms "farmer groups" and "cooperatives" interchangeably. A cooperative is defined as "an autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly-owned and democratically-controlled enterprise" (Ingutia, 2021). By virtue of cooperatives' principles of operation, their values, including equality and equity, solidarity and social responsibility, economic participation, and concern for the community (Ingutia, 2021), place cooperatives in a unique position to enable smallholders to access the productive resources at the disposal of the cooperatives. Farmer groups are suitable pathways to reach the very poor at the grass-root level, hence governments, development agencies, and agribusiness companies have embraced the cooperatives' approach and use farmer groups to deliver services such as inputs, marketing, and training to the farmers (Sumelius, Bäckman & Bee, 2021). Cooperatives are known to empower their members economically and socially by offering them a range of services that facilitates access to productive resources (FAO, 2012; Wanyama, 2014; Sumelius et al., 2015; Sumelius, Bäckman & Bee, 2021). Ingutia and Sumelius (Ingutia & Sumelius, 2022) found that female farmers in Kenya who are members of cooperatives perform slightly better than non-members with regard to food security.

Our objective is to revisit family planning (FP), smallholder irrigation, and agricultural cooperatives as crucial factors in addressing the increasing demand for food sustainably. Given that agriculture is the main source of livelihood in rural Africa, cooperatives are a meeting point for farmers, and therefore to have an effective impact on family planning and smallholder irrigation requires their integration in cooperatives' activities. Another objective is to investigate the performance and problems of cooperatives. This paper is important, given that population growth impedes sustainable development (Norrman, 2023; Turner, 2009). Moreover, we are addressing family planning, smallholder irrigation, and cooperatives, which are mostly overlooked issues that are however critical in sustainable food security.

Studies tend to associate cooperatives with poverty reduction, food security, and employment generation through resource mobilization, agro-processing, and marketing of agricultural produce. We contribute to the ongoing research by indicating the need to integrate FP and smallholder irrigation into agricultural cooperative activities to boost sustainable agricultural practices. Governments, development agencies, and researchers should offer not only credit, inputs, technology, agro-processing, and marketing services to the farmers through farmer groups but should add FP and smallholder irrigation to the list of services. Efforts to increase food security are more effective if combined with population growth control and sustainable smallholder irrigation, given that Kenya is largely a water-scarce country. Furthermore, Kenya is mostly an agrarian economy, thus agricultural cooperatives are the lifeline of the majority of its inhabitants. Therefore, an inquiry into the performance and problems of cooperatives is to the benefit of smallholders, agricultural cooperatives' leadership, the government, researchers, development agencies, and rural communities at large. The rest of the paper is as follows: section 1.1 is on the background of family planning, irrigation, and cooperatives in Kenya. Section 2 presents materials and methods. Section 3 provides results and section 4 discussions. While section 4 concludes.

1.1 Background of Family Planning, Irrigation and Cooperatives in Kenya

1.1a. Family planning in Kenya

We explore family planning across various categories of people and trends, Figure 1 depicts the trends in total fertility rates in Kenya from 1960 through 2020.

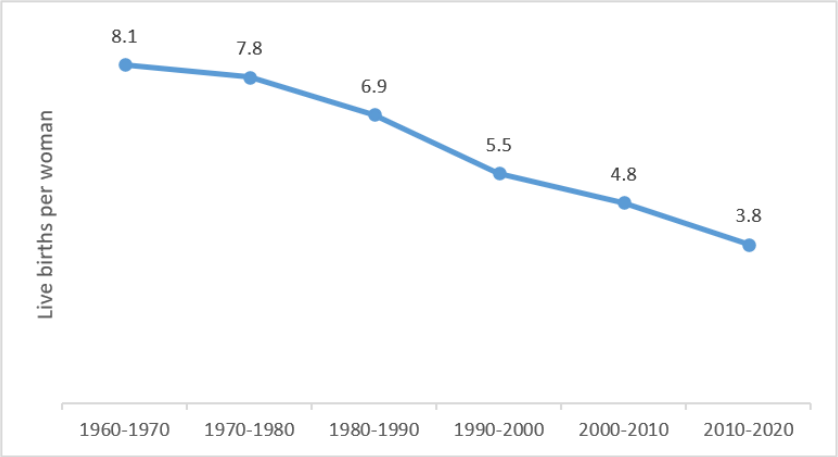

Figure 1. Trends in total fertility rates in Kenya, 1960-2020

Data source: (UN Population Division, 2017)

Figure 1 indicates a decline in total fertility rates (TFR) in Kenya. However, there are both disparities and plateaus in the rate of decline among different social groups. Why the disparity in the declining rates? Table 1 holds the answer for the plateaus and disparities in TFR, as it compares family planning issues across residence, education, and wealth quintiles.

Table 1. Comparison of family planning across categories of residence, education and wealth

Kenya	Urban	Rural	No educ/p	Sec/hi	WQ Lowes	WQ Hig
Total fertility rate 15-49	3	5	5	3	7	3
Unmet need FP	13	21	22	12	28	12
Met need FP	38	30	29	39	17	39
Total demand for FP	51	51	51	52	45	51
Demand for FP satisfied	74	58	56	77	37	77
FP on the radio -women	74	62	59	77	40	76
FP on TV -women	58	23	23	53	8	66
FP in newspapers -women	47	24	18	53	10	53
FP in none of these 3 media -women	19	35	38	15	58	15
FP on the radio -men	74	70	65	79	58	75
FP on TV-men	61	33	30	58	19	64
FP in newspapers- men	60	37	28	65	21	63
FP in none of these 3 media -men	18	27	32	14	41	16

Data source: (Demographic Health Surveys, 2023). Note: No educ/p – no education or with primary education. Sec/hi- secondary or higher education. WQ Lowes- lowest wealth quintile. WQ Hig-highest wealth quintile.

Table 1 indicates that fertility rates were highest among women from the lowest wealth quintile (TFR 7), followed by women without education or with primary education (TFR 5), and rural dwellers (TFR 5). There is a disparity in accessing information essential to influencing fertility preferences and family sizes. Table 1 shows that high percentages of women and men from the lowest wealth quintile, rural areas, and with no education or primary education have no access to radio, TV, or newspapers. Moreover, higher percentages of women and men in these categories have unmet family planning needs, making them more vulnerable to unintended pregnancies, which translate into high fertility rates, thereby stalling the overall decline of the fertility rate. There is a need for well-designed and implemented service delivery programs to reach underserved communities: rural dwellers, low income persons, and illiterate persons (Duvall et al., 2014). The structural adjustment programs (SAP) of the 1980s and 1990s led to retrenchment cuts in government expenditure in economic and social services that consequently contributed to the TFR plateaus between 1990 and 2000 (Rono, 2002). However, government-led reforms (Republic of Kenya, 1992) increased economic growth from 2.9% in 2003 to 7.1% in 2007 (Thuku, Gachanja & Obare, 2013). These changes are reflected in the recommencement of gradual fertility rate declines between 2000 and 2020 in Figure1.

1.1b. Smallholder Irrigation in Kenya

Kenya faces high levels of water scarcity. Droughts and floods have become endemic in some parts of Kenya, with the arid and semi-arid as well as the poorest regions being the most affected, threatening food security (Devereux, 2007). Droughts and floods cost the economy 2.4% of GDP annually (Mogaka, 2006). Food demand can be partially met by improving water productivity in crop production (Zheng et al., 2018). Efficient use of water resources is critical to crop production in Kenya, as the UN has classified Kenya as a chronically water-scarce country (Mulwa, Li & Fangninou, 2021). The sustainable options for meeting food demand by increasing crop production include the elimination of unsustainable practices like the depletion of soil and water resources, and clearing of forests; sustainable intensification of existing cropland by supplementing rainfed agriculture with supplementary irrigation; adaptation and improvement of high-yielding technologies; and adoption of drought and pest-resistant crops. Such measures could supply the food needs of an increasing population while protecting the environment (McLaughlin & Kinzelbach, 2015).

Irrigation development in Kenya dates back some centuries: traditional types of irrigation are still in practice. After independence, the government of Kenya set up large tenant-based irrigation schemes that have proved to be unsustainable because of overreliance on government subsidies, overexploitation of farmers, and farmers lacking control over the marketing of their produce; consequently, the tenants continued to live in poverty (Ngigi, 2002). There has been a shift of policy to facilitate the development of smallholder irrigation schemes to provide smallholders with an alternative to pastoralism, create employment, increase household income, and improve food security using community participation. However, despite the initial positive trend, the rate of development in government-supported large- and small-scale irrigation schemes has been declining. Poor water management leading to waterlogging and salinization has contributed to the decline in agricultural productivity of some irrigation schemes. Conversely, private individual and donor-supported irrigation development activities are increasing (Ngigi, 2002).

1.1c. Rainwater Harvesting and Supplemental Irrigation

Rainwater harvesting (RWH) is the act of storing and conserving rainwater or runoff for future use when water is scarce (Raimondi et al., 2023). Given that surface water is scarce and exploitation of groundwater is not economically feasible, sustainable rainwater catchment systems are one of the most viable options for water scarcity. The majority of the rural poor depend on rainfed agriculture rather than irrigated agriculture. Investment costs per ha to upgrade rainfed areas are normally relatively lower than for irrigated agriculture. Rainfed crop growth is generally poor, with low yields due to water scarcity during dry spells (Bal et al., 2022). Therefore, supplemental irrigation (SI) can be applied to ensure that a minimum amount of water is available during critical stages of crop growth to provide essential moisture for improved and stable production (Liu et al., 2022).

Generally, a drip irrigation system using rainwater harvested from rooftops is one of the most efficient and accessible systems for credit-constrained farmers. The choice of rainwater harvesting technique depends on (a) the geographic locations to enable runoff water (Gebremedhn et al., 2023); (b) the method for storing water: reservoirs, tanks, drums, ponds, water pans, shallow wells, or dams; (c) whether there is a sufficient area of deep soil for collecting rainwater (Fiaz, Noor & Aldosri, 2018). The sustainable requirements for management of rainwater harvesting and supplemental irrigation are: (a) farmers need to receive information on the potential of rainwater runoff collection and supplemental irrigation practices, including how to manage soil water needs and rainfall promptly. Furthermore, information on crop water demand and storage capacities is required. (b) Extension officers need to be equipped to provide adequate rainwater harvesting services to small-scale farmers (FAO, 2014).

The advantages of RWH and SI are that: (a) in arid regions where water is a major constraint in expanding land under cultivation, the additional surface area is farmed using runoff water for irrigation (Gao et al., 2022); (b) RWH and SI give rise not only to an increase in crop yields and incomes but also opportunities to diversify income by selling surpluses. At the same time, water use efficiency reduces smallholders' vulnerability to the impacts of climate change on agriculture (Molla et al., 2021); (c) certain RWH and SI practices are based on simple low-cost techniques that require a low level of education (Rockström & Falkenmark, 2000; Roman et al., 2017) and are thus convenient for low education resource constraint smallholders; (d) they contribute to the development of agriculture and the conservation of resources in marginal areas; and (e) water also enables farmers to engage in livestock rearing, fish production, and poultry farming (Njuki et al., 2014).

Several studies, including Lebel et al; Amos et.al (Lebel et al., 2015; Amos et al., 2018), have found that rainwater harvesting has the potential to supply water for irrigation. Rainwater harvesting has proven to be successful in the Machakos and Meru counties of Kenya where SI during the dry spells has improved food

security, nutritional status, and augmented income (Ngigi, 2002). However, despite the efficacy of RWH and SI, their success is constrained by a lack of technical standards, a lack of investment in water resources, a lack of specific policies, and fragmented efforts in the implementation of RWH and SI (Trincheria et al., 2016). RWH and SI only allow low-density and low-yield crops as compared to conventional irrigation systems (Adriana et al., 2023). The benefits of irrigation technologies can be unevenly distributed: landowners are more likely to benefit than landless farmers. In particular, not only do female farmers lack access to land ownership, credit, and skills, but also their heavier workload limits the time they have available to seek and use information. Cultural norms tend to constrain women from applying certain irrigation technologies (Bryan & Garner, 2022).

1.1d. Introduction and Membership in Cooperatives

Cooperatives leverage collective action to access certain services, including access to credit, exchange of information, providing representation for members, marketing of produce, and buying of inputs. The economic benefits from the sale of farm produce are distributed to members after transaction costs have been covered (Shiferaw & Muricho, 2011). Cooperatives play a fundamental role in coordinating agricultural production and marketing services, thereby boosting smallholders' production, increasing food security, and reducing poverty levels (Zhang et al., 2023). Cooperatives tend to act as service providers for governments and, at the same time, are responsive to the needs of their members, who are often unable to access formal services. Some members of the community may be denied access to services due to cultural dynamics and norms; cooperatives are sensitive to such issues. Moreover, through participatory mechanisms, cooperatives can represent the rural poor at higher levels and advocate for their needs (Candemir, Duvaleix & Latruffe, 2021). Cooperatives can be used to inform and train members in sustainable agricultural practices, thereby supporting the implementation of sustainable development. The delivery of agricultural extension services by governments and development agencies is done through the network of cooperatives. Cooperatives are conducive to farmers' interaction, and sharing knowledge, experiences, and resources (Woomer, Omare & Mukhwana, 2004).

Women farmers who are not members of cooperatives miss out on services offered by the cooperatives and subsequently practice unsustainable agricultural practices. They thus face food insecurity issues and constraints on access to family planning services. Whereas women farmers who are members of cooperatives have possibilities of accessing services offered by cooperatives and thus have positive outcomes as compared to the non- members. Sumelius et al. point out that efficient cooperatives that adhere to principles of good governance, boosting culture of entrepreneurship, business promotion, job creation, and job training, enable their members to practice sustainable agricultural practices, leading to higher yields, food security, higher incomes and improved livelihoods.

2. Materials and methods

2.1 Description of Study Areas

We use recent primary data collected from Navakholo and Kakamega Central, in Kakamega County, Kenya, the map of the study area is Figure 1 in Appendix 1. Purposeful sampling was applied in determining the study areas, given their geographical locations and accessibility. Kakamega Central is right next to Kakamega municipality, thus it was assumed that farmers there had easier access to input and output markets as well as extension services whereas Navakholo is in the interior, further away from both input and output markets. In both study areas, small-scale subsistence farming is the main livelihood: the crops grown include maize, beans, bananas, sugarcane, sweet potatoes, fruits, and vegetables. Livestock farming is also practiced, consisting of mostly dairy cattle and poultry. The crops are grown once a year due to a lack of irrigation facilities during the drought season (Ingutia & Sumelius, 2022).

2.2 Sampling and Data Collection

Proportional sampling was applied to randomly sample rural small-scale women farmers who were members of cooperatives. The sampling was carried out on the basis of a list of all multipurpose cooperatives in both study areas and the number of women per group. In total, 347 smallholders, comprising 137 cooperative members and 210 nonmembers, were randomly sampled and interviewed (female farmers were the targeted group, but male farmers were the respondents in some households) using a pretested structured questionnaire. Leaders from 13 cooperatives participated in focus group discussions. The field survey was conducted with the help of trained research assistants. The author who traveled to the survey sites speaks the local language, a plus in interacting with the farmers.

Cooperatives are mostly formal groups with a larger membership, usually engaged in large-scale commercialized farming (Wennink, Nederlof & Heemskerk, 2007). In our study area, the kind of farmers' organizations in

existence are more appropriately referred to as farmer groups: with an average membership of 25, these groups are mostly informal. Most of the members are smallholders engaged in subsistence farming. These farmer groups can transform into cooperatives with time if they expand enough to meet the requirements to become cooperatives. Farmer groups range from small informal groups to large formal cooperatives (Poole & de Frece, 2010). The informal groups are mostly self-help groups built around customary principles and ideas of collective well-being. Figure 3 presents gender disaggregated data of membership in selected cooperatives, while Figure 4 depicts the percentages of female membership across selected cooperatives in Kakamega Central and Navakholo.

2.3 Data Analysis

The statistical tools applied during the study are descriptive statistics using Microsoft Excel 2016, and econometric analysis using STATA 18. The results are presented with the help of tables and figures. We apply descriptive statistics to provide a summary of the sample under observation with the help of the mean, as well as standard deviation to measure the variance from the mean. Pearson's and Fisher's exact tests are applied in Table 4 which depicts different levels of crop intensity and the number of farmers before and after joining cooperatives. Relationship between variables expressed mostly in percentages is analyzed using tools for a visual summary including line graphs, scatter plot and bar charts. Table 2 presents variable definition and summary statistics.

Table 2. Variable definition and summary statistics

Variable	Definition	Mean	Std.Dev.
Female cooperative member	1 if yes, 0 otherwise	0.31	0.46
Respondent age	In years	41.95	14.65
Farm size	Farm size in hectares	1.5	1.13
Irrigation	1 if farm is under irrigation, 0 otherwise	0.18	0.38
Extension visit	1 if receives an extension visit, 0 otherwise	0.41	0.49
Non-farm business	1 if does non-farm business, 0 otherwise	0.56	0.5
Access credit before joining a coop	1 if access credit, 0 otherwise	0.09	0.29
Access to credit after joining a coop	1 if access credit, 0 otherwise	0.32	0.47
Food security status	1 if food secure, 0 otherwise	0.58	0.49
%change yield female Coop-member	1 if there is % change, 0 otherwise	0.32	0.47
Coop_transparency	1 if there's coop transparency, 0 otherwise	0.38	0.49
Coop training your rights	1 if yes, 0 otherwise	0.38	0.49
Coop gives helpful information	1 if yes, 0 otherwise	0.35	0.48
Coop offers good prices	1 if yes, 0 otherwise	0.30	0.46
Timely payment by coop	1 if coop pays members on time, 0 otherwise	0.27	0.45
Input training before joining coop	1 if yes, 0 otherwise	0.09	0.29
Input training after joining coop	1 if yes, 0 otherwise	0.33	0.47
Access market info before joining the coop	1 if yes, 0 otherwise	0.10	0.29
Access market info after joining coop	1 if yes, 0 otherwise	0.33	0.47
Coop problems-inadequate capital	1 if yes, 0 otherwise	0.53	0.50
Coop problems inadequate loans	1 if yes, 0 otherwise	0.42	0.50
Coop problems mismanagement	1 if yes, 0 otherwise	0.27	0.45
Coop problems lack of skilled personnel	1 if yes, 0 otherwise	0.19	0.40
Coop problems- government interference	1 if yes, 0 otherwise	0.09	0.28
Coop problems high member illiteracy	1 if yes, 0 otherwise	0.17	0.38
Coop gives information on child spacing	1 if yes, 0 otherwise	0.42	0.34
Yearly income before joining coop	In Kenyan Shillings (1 Kenyan Shilling = US$ 0.0069)	51286	261923
Income after joining coop	In Kenyan Shillings. (1 Kenyan Shilling = US$ 0.0069)	70301	104345
Crop intensity before joining coop	1 lowest, 2 medium, 3 highest intensity	1.59	0.53
Crop intensity after joining coop	1 lowest, 2 medium, 3 highest intensity	2.19	0.44

Note: please see Table 1, appendix 1 for further explanation of food security status.

3. Results

3.1 Family Planning and Irrigation in the Study Area

Given the wide disparity in accessing family planning services between urban and rural Kenya, we therefore turn to rural Kenya. Figure 2 illustrates the socioeconomic status of women in Kakamega Central and Navakholo, since socioeconomic status are determinant in the uptake of both family planning and irrigation strategies.

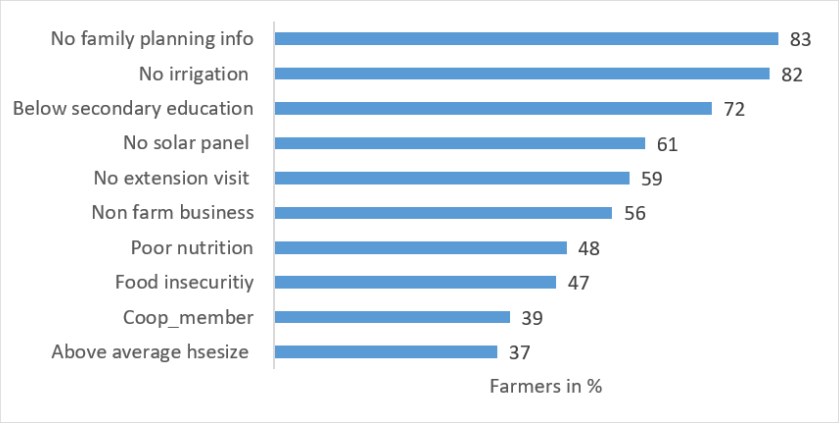

Figure 2. Socioeconomic status of women in Kakamega Central and Navakholo

Household size is a determinant factor in poverty, well-being, sustainable development, and patterns of consumption that shape the human impact on the environment. The average household size in Kenya is 4.0 (UN Population Division, 2017), but disaggregated data reveals that it is 5.3 in the area under study and Figure 2 indicates that 37% of households were above this average. In Figure 2, 83% of the respondents had no access to family planning information. This has certainly contributed to large household sizes in Kakamega Central and Navakholo. Education is associated with both delayed age at first birth, thereby lowering fertility rate, and lower child mortality, which influences fertility choices, Jiang; Kebede et al. had similar findings. In general, women with more than primary education have substantially lower fertility than those with no education. Furthermore, empirical studies confirm that after controlling for other factors, including family income, rural-urban residence, and husband's education; the effect of the wife's education remains more statistically significant (Kebede, Striessnig & Goujon, 2022). Despite the critical role that education plays in controlling fertility rates, Figure 2 reveals that 72% of the women had either no education or had only primary education.

Kakamega Central and Navakholo districts are among the parts of Kenya underserved by irrigation systems. Figure 2 shows that 82% of the households did not practice any form of irrigation. Furthermore, being in rural districts, they had no access to electricity. 61% did not have access to solar panels and therefore could not use solar-powered irrigation as an alternative to electricity. Falchetta et al. noted that renewable energy was critical for irrigation. Agricultural extension services are meant to provide education and access to technical support for those engaged in agriculture,_but Figure 2 shows that 59% of the female farmers had no access to extension services. This partly explains why 47% were food insecure and 48% had poor nutrition. We find that agricultural extension officers are critical because they create awareness of the benefits of sustainable agriculture. Moreover; they provide education, training, and other farm inputs to the farmers, thereby improving farming practices and increasing food security, had similar findings (Falchetta et al., 2022).

3.2 Disaggregated Coop Membership

Figure 4 depicts disaggregated membership of coops with membership information in the study area.

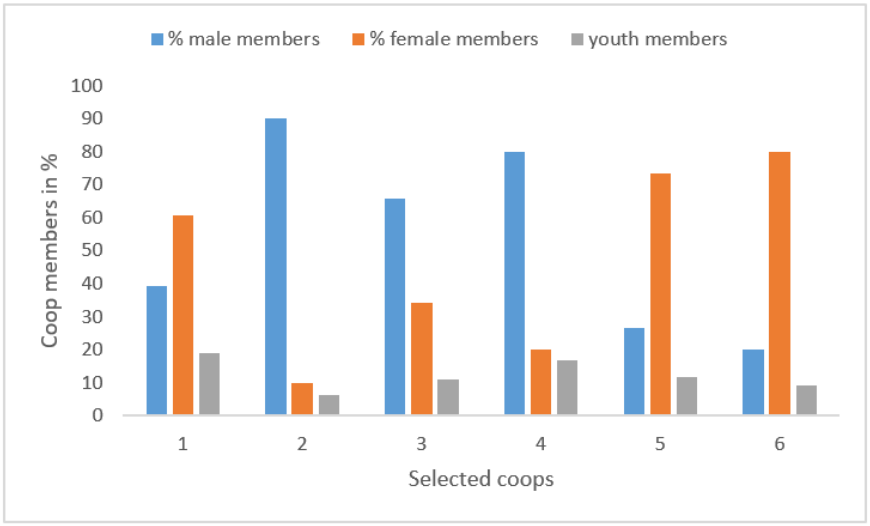

Figure 3. Disaggregated membership in selected cooperatives in Kakamega Central and Navakholo

Figure 3 shows a wide disparity in the pattern of membership: for instance, coop 2 is largely male-predominant, while coop 6 is female-predominant. Notably, youth membership is low in all six coops. All the coops charge a membership fee that turns out to be an entry barrier to the poor without sufficient funds. Only 39% of the households in our study area were members of cooperatives (figure 2), and 51% of non-coop members said they could not meet entry requirements. Entry barriers limit economies of scale that increase with group size. However, there is a need for a membership fee, as it signifies a strong commitment to the principles of collective action. 42% of the non-members pointed out they were not interested in joining cooperatives while 7% said they were not members because of the long distance to the nearest coop. Figure 4 presents the percentages of female membership across respective coops in Kakamega Central and Navakholo**.**

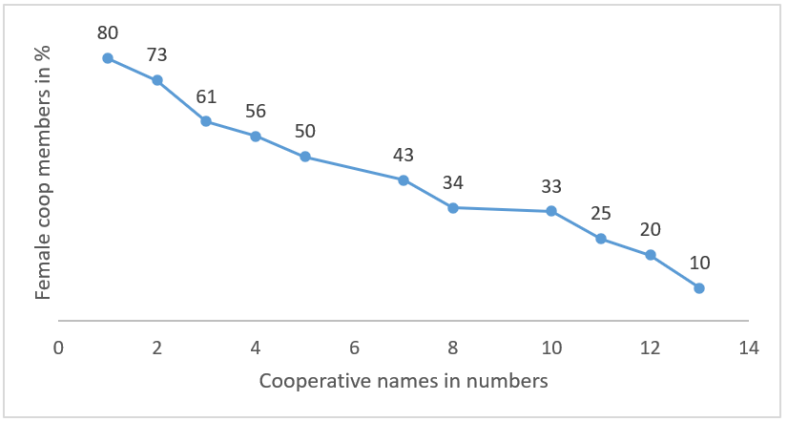

Figure 4. Percentages of female membership across coops in Kakamega Central and Navakholo

Figure 4 shows that the pattern of female membership across the cooperatives varies, ranging from 80% in Cooperative 1 to 10% in Cooperative 13, which suggests that the respective cooperatives have different entry conditions with regard to female members.

3.3 Performance of Cooperatives in Kakamega Central and Navakholo

We follow Bernard et al. in analysing the performance of cooperatives. Bernard et al. define the performance of farmer groups as the "effectiveness of servicing their members", which they measure by the percentage of members who report having benefitted from the coops. The performance of coops in selected variables is displayed in Table 3.

Table 3. Performance of coops in selected variables between 0-100 scores

Coops in numbers	Female land rights	Provide water	Cheaper inputs	Cheaper credit	Farmer training	Modern technology	Provide storage
1	71	-	71	-	71	71	71
2	43	71	71	-	71	-	71
3	-	14	57	14	43	57	57
5	71	57	29	43	57	-	-
6	14	57	14	14	14	-	14
8	-	14	71	29	0	-	71
9	71	14	71	14	14	-	-
10	57	14	57	-	-	-	14
11	71	14	71	14	14	-	-
12	57	71	14	14	-	-	-
13	71	14	14	14	-	-	-

Note: *Coops- cooperatives. The results of coops 4 and 7 are missing because the coop members did not have the records. The scores indicate the percentage of members who reported to have benefited from coops' services.*

The results from personal interviews with the leaders of the 13 cooperatives in the study area on the services they provide to members are reported in Table 3. The table shows cooperatives' performance in selected variables; 0 is the least score while 100 is the best scores. The table indicates that the 11 cooperatives working on female land rights were all more than 50% engaged in female land rights, except coop (2) with 43% and coop (6) with a mere 14% engagement. Provision of water for irrigation is a major challenge among smallholders: only four cooperatives were providing water for over 50% of their members, while the rest provided water for only 14%. Most of the coops have enabled their members to access inputs at cheaper prices, except for Coop 5 (29%) and Coops 6, 12, and 13 with 14%. Access to cheap credit is a constraint in all the coops, and so is farmer training: only three coops offered training to more than 50% of their farmers, while only two coops enabled their members to access modern technology. The rest did not have modern technology among their activities. In addition, none of the cooperatives provided services like family planning, nutrition education, prenatal and postnatal education and care for mothers and babies, childcare services, or training. Access to credit being a critical issue, Figure 5 portrays the information on the percentage of credit applicants, sources of credit and constraints to accessing credit.

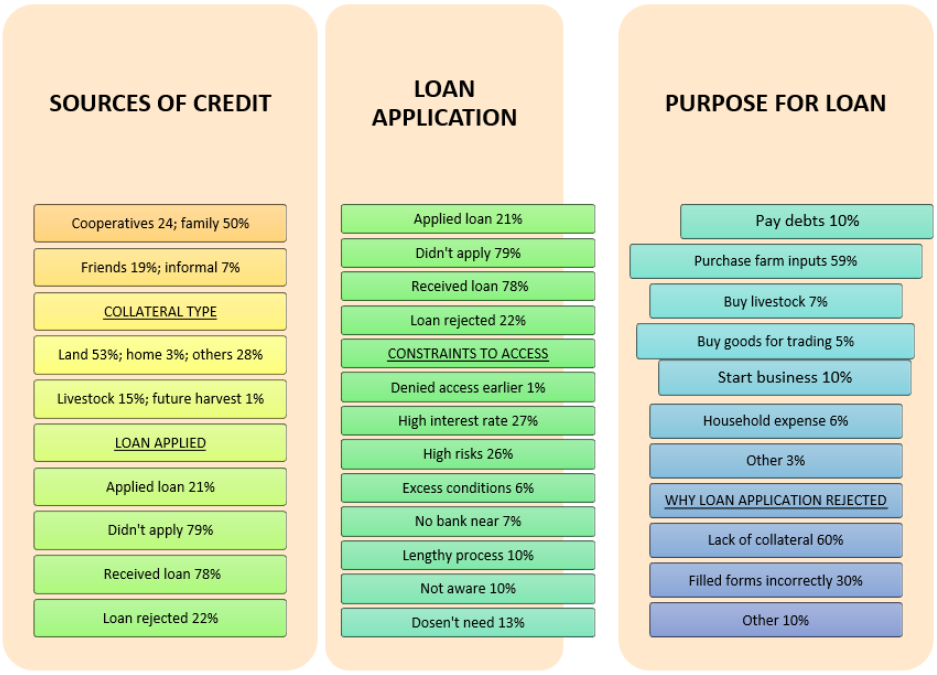

Figure 5. Information on % of credit applicants, sources of credit & constraints to access credit

Figure 5 analyses farmers' access to credit because farmers' main reason for joining cooperatives is to facilitate access to credit, input, and output markets. At the same time, cooperatives serve as entry points for credit providers (Asante-Addo et al., 2017), thus cooperatives' performance can be partly gauged by how well the members access credit. Figure 5 reveals that as much as access to credit is important in both adopting sustainable agricultural practices and increasing production, 79% of the respondents did not apply for credit largely due to high interest rates and being risk-averse. A majority of those who had been rejected for credit reported that it had been due to lack of collateral (60%). 53% of credit recipients gave title deeds as collateral, and only 1% of the recipients received credit with future harvests as collateral. 59% of the recipients used credit to purchase farm inputs, pointing to the central role of credit in adopting sustainable agricultural practices. Nasereldin et al (Nasereldin et al., 2023), found that access to credit from financial institutions in Sudan contributed to smallholders' purchase of inputs that boosted sustainable agriculture. The major source of credit was family (50%), while only 24% of credit applicants applied for credit from cooperatives.

Financial institutions' conditions for accessing, credit such as land for collateral, are highly disadvantageous to women, as they are constrained from owning land due to cultural norms. Consequently, food production and household nutrition are negatively affected, given that women play a key role in agricultural activities. Furthermore, Murungi et al reports that a negligible percentage of the available credit goes to agriculture in Kenya, women receive the least percentage of the credit to smallholders. This negatively affects women's incentives in pursuing productive income-generating activities. Cooperatives fail to fully facilitate this constraint because of low funds. Besides credit, cooperatives provides access to other services, Figure 6 indicates the percentages of farmers accessing these services.

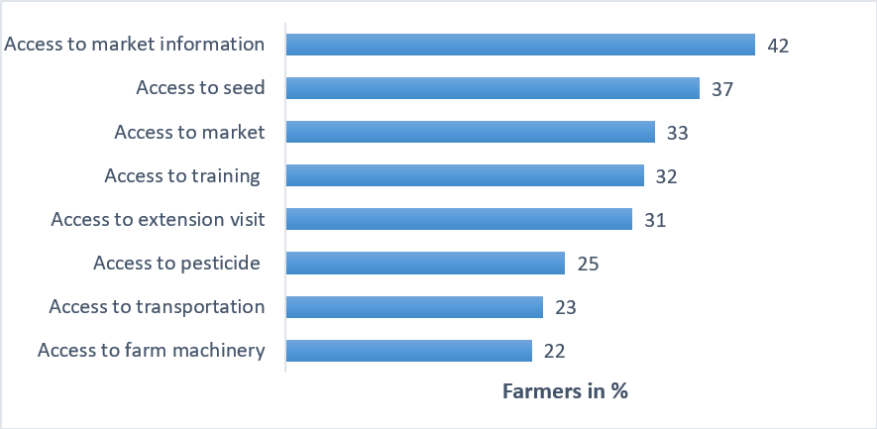

Figure 6. Percent of farmers accessing coop services

Next to farmers' access to credit is access to market information and market access. Table 3 depicts coop leaders' perspective of the services they provide, whereas Figure 6 presents regular members' responses to the services they get from their coops. Figure 6 indicates that only 42% of the farmers had access to market information, 33% had market access, and 23% had access to transportation. In general, cooperatives promote collective marketing to enable smallholders to share the fixed costs of marketing, enhance their ability to negotiate for better input and output prices, and improve their market power. Farm inputs, including machinery (22%), seeds (37%), and pesticides (25%), are largely unavailable to or unaffordable by smallholders, as evidenced in Figure 6 by the low percentages accessing these inputs. One wonders why the percentages accessing inputs are low because in Table 3 a majority of the coops' leadership reported that they were providing inputs at affordable prices.

Collective marketing minimizes the costs of accessing farm inputs, thereby enabling farmers to adopt new technologies, increase productivity, and transform from subsistence to commercial farming. Only 33% of coop members access markets and yet it is assumed that collective marketing gives access to larger markets because it creates an enabling environment for contract farming between large buyers and small producers; it would otherwise be almost impossible for such buyers to negotiate, monitor, and enforce contracts with many dispersed individual farmers. Access to information (42%) enables farmers to share information on sustainable farming practices as well as market conditions to meet market preferences. Only 31% received extension services: consequently, a mere 32% received training thereby preventing 68% of the farmers from adopting sustainable farming practices. Extension limitations include a shortage of qualified female extension staff, inappropriate

extension packages, lack of flexibility in extension services, and a tendency for extension services oriented towards crops traditionally grown by men largely limiting women from accessing extension services (Meinzen-Dick et al., 2014). 78% of the farmers lack access to farm machinery, result in low production, particularly among women who are predominantly labour-intensive, with most of the farm work done by family and child labour.

3.4 Impact of Cooperatives on Farmers

Does joining cooperative increase crop intensity? This question is taken up in Table 4.

Table 4. Levels of crop intensity & number of farmers before & after joining cooperatives

Levels of crop intensity	crop intensity before coop	crop intensity after coop
1	53	1
2	68	97
3	2	23

Pearson chi2(6) = 5.4283 P = 0.490

Fisher's exact = 0.222

This paper uses the term crop intensity to describe an increase in crop production, pattern, and diversity (Rafif et al., 2021), to meet the increasing food demand or to improve the low crop yields. Farmers are asked to assess their crop intensity activities before and after joining the cooperatives that have enabled them to access farm inputs that contribute to crop intensity. The farmers are asked to rate their changed cropping practices based on a three-point scale (1- somehow increased 2- increased 3- increased very much). Table 4 compares levels of crop intensity among farmers in numbers before and after joining cooperatives. Level one is the lowest and level three the highest in terms of crop intensity. Before joining cooperatives, 53 farmers were at the lowest level of crop intensity, while only two were at the highest level (3). On joining cooperatives, the benefits of membership resulted in reducing the number of farmers in the lowest level from 53 to one and increasing those in level 2 by 43%, from 68 to 97 farmers. The number of farmers at the highest level increased from two to 23, about a 10fold increase. Our null hypothesis was that levels of crop intensity would be the same for farmers before joining and after joining the cooperatives. We used Fisher's test to test whether the differences were statistically significant. Differences between the two groups are statistically significant and we reject the null hypothesis at the significance level $p< 0.2$. Figure 7 indicates the percentage change in crop yields after joining the cooperatives.

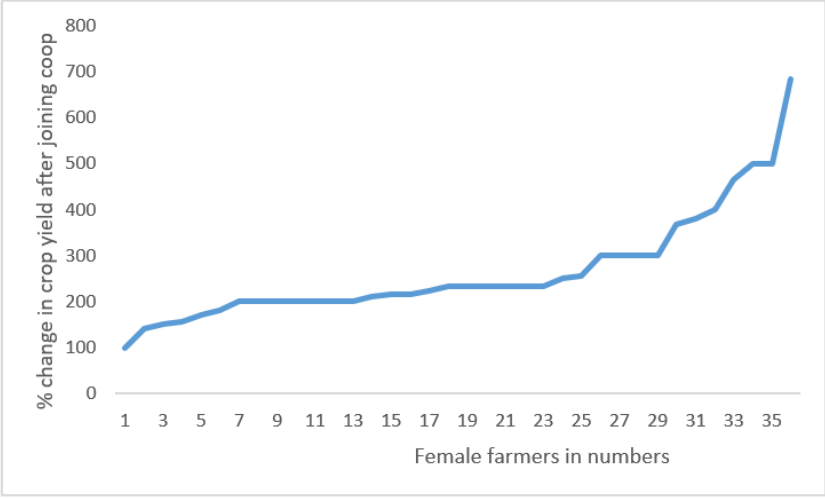

Figure 7. Percentage change in crop yield after joining cooperatives

On joining cooperatives, female farmers apply intensive crop farming systems, leading to increases in crop yields. Figure 7 indicates that all female farmers experienced percentage increases in crop yields with 100% being the lowest change, the mode being 200% and the highest percentage change in crop yield being 684%. Ma et al. found that agricultural cooperatives are capable of minimizing crop failure, leading to increased yields. Figure 8, demonstrates the percentage change in income after joining the cooperative.

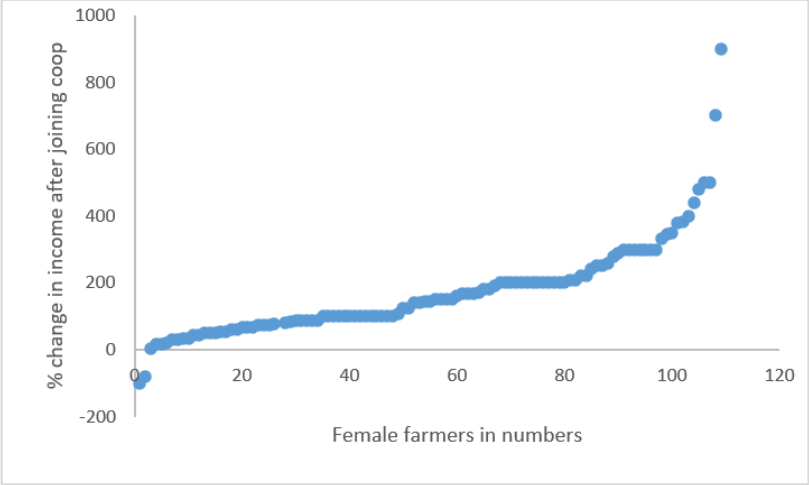

Figure 8. Percentage change in income after joining the cooperative

Improvements in crop yields led to income changes, as shown in Figure 8. Farmers could easily gauge changes in income levels rather than changes in crop intensity levels, thus more female farmers reported changes in income levels than in crop yields. However not all experienced positive changes: two farmers reported 80% negative income changes. Income changes depend on several factors: therefore, individual farmers had different changes in income levels, and the mode was 100. Figure 8 shows that the dots on the scatter plot are concentrated, forming a concave curve that gradually rises from 100% to approximately 300% and then to 500%, after which the curve shoots to 700% and then 900%. Nurudeen and Ganiyu found that rural income generated by a cooperative member tends to be approximately 10% higher than that generated by non-coop members.

Increasing participation by female members increases crop yields (Figure 7) and income (Figure 8) because of having access to credit with ease as compared the female farmers who are non-members. Table 3 indicates that female land rights are addressed in nearly all the cooperatives. Women generally do not own land to act as collateral in accessing credit, but as members of cooperatives, they can access credit because banks lend to groups to minimize credit risk. Access to credit enables the purchase of farm inputs that enhance crop yields and increase incomes. Moreover cooperative members benefit from the economies of scale in both input and output markets since the transactions are carried out in groups. Improved income levels is mostly associated with better diet, Figure 9, takes up the task of demonstrating percentage changes in meals daily, in fruits, and in proteins weekly after joining coops.

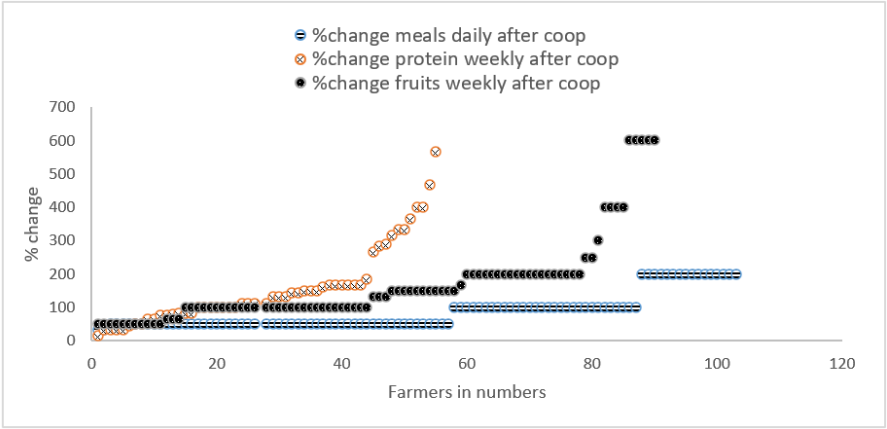

Figure 9. Percentage changes in meals daily, in fruits, and in proteins weekly after joining coops

An increase in crop yields contributes to both food security and an increase in income as farmers transition from subsistence farming to commercial farming. These changes affect household nutritional status positively. Figure 9 depicts changes in meal intake daily. The changes are clusters in scatter plots: the first cluster shows 57 households increased their meal daily intake by 50%, followed by a cluster of 30 households that increased by

100%, and 15 households that increased by 200%. The average percentage increase in meal intake daily was 88%. 77 households reported changes in fruit intake on a weekly basis after joining cooperatives. The largest cluster of increased fruit intake weekly had 29 households that increased by 100%; the average increase in fruit intake was 169%. Clusters with the highest percentages of fruit increase had 400% and 600% with 4 and 5 households respectively. Changes in protein intake weekly do not depict patterns of clusters. Only 54 households reported changes in protein intake, and protein consumption is expensive given the high poverty levels. 16 of the households had below 100% increase in protein intake weekly, while 18 had between 100-150%, 8 had 161-183% and 9 had 267-400%. Outliers were 467% and 567%. Mihrshahi et al. noted that members of food coops had a tendency for higher fruit and vegetable intake as compared to non-members.

The econometric analysis results on food security and its determinants in Table 1, appendix 1 are supportive of the descriptive findings. The estimates family planning and female farmers who are members of coops are statistically significant with positive signs. This suggests that female farmers who are coop members have access to coops' services such as family planning information that contributes to having smaller families; while access to credit with ease and other farm inputs improves and increases food production as well as income levels. Thus female coop members are likely to be more food secure and financially better off as compared to their counterparts.

3.5 Members' Opinions on Cooperatives and their Contribution to the Community.

According to Figure 10, 66% of the members felt that cooperatives had reduced poverty levels, 23% noted that cooperatives had promoted business, and 10% said cooperatives had created jobs. 32% of the members were very satisfied with the cooperatives, 50% were satisfied, 16% were neutral, and 2% were dissatisfied.

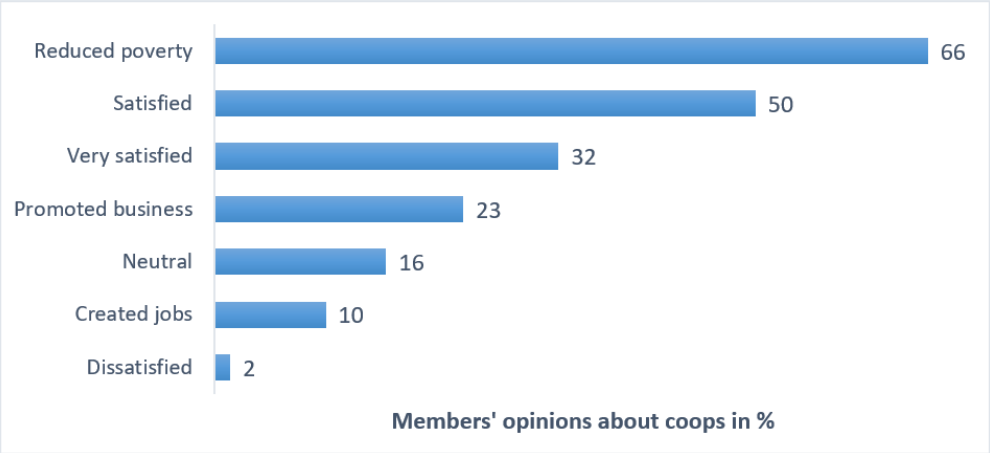

Figure 10. Members' opinions on cooperatives and their contribution to the community

3.6 Constraints Facing Cooperatives.

3.6a. Problems Mentioned by Cooperative Leaders

Table 5 illustrates constraints experienced by cooperatives from the perspective of the cooperative leadership.

Table 5. Constraints facing cooperatives from a cooperative leadership point of view

Problem description	Mentions (n=13)
Lack of funds & access to credit to buy inputs and diversify farming activities	11
Long distance to seasonal water source thus no facilitation of irrigation	6
Lack of access to technology to improve production & lower costs of production	1
No modern equipment to keep pace with modern technology to process animal feeds	1
Lack of access to inputs due to high prices and distant markets	1
No livestock as a source of household nutrition and income	2
Poor infrastructure to access markets, particularly for vegetable and dairy farmers	2
Illiteracy rates among members limit them from keeping up with cooperative activities	1
No extension service to train in sustainable farming	1
Do not receive support from either the government or development agencies	13
Youth are not interested in farming	1

Focus group discussions with the leadership from 13 cooperatives in the study area revealed the common problems in cooperatives, as indicated in Table 5. This table shows that lack of funds and access to credit is the constraint most frequently mentioned by coop leadership. Demand for credit and collateral have been discussed in this paper under section 3.3 on the performance of cooperative services, Figure 5. Cooperatives in rural Africa are mostly weak in terms of financial capacity to meet the needs of their members. Several factors contribute to their low financial capacity, including the low income levels of their members leading to low contributions and savings. Furthermore, Table 5 shows that all 13 cooperative leaders pointed out that they do not receive support from the governments or development agencies but depend entirely on members' contributions. Moreover, they have limited competitive markets to sell their products, which are generally low volume due to the lack of application of modern technology such as improved seeds, and lack of training in sustainable farming practices due to the absence of extension services (Mhembwe & Dube, 2017).

Water scarcity was pointed out six times in Table 5. This is because Kenya is mostly arid and semi-arid with erratic and unreliable rainfall, as discussed in the introduction section. Rainwater harvesting (RWH) and supplemental irrigation (SI) are the most viable options for resource-poor smallholders, but the success of RWH and SI are constrained by a lack of investment in water resources, a lack of technical standards, and a lack of specific policies. Poor transportation infrastructure increases production costs and is a barrier to integrating local markets with national markets, and therefore contributes to regional price differences. Figure 11 shows the constraints facing cooperatives, as assessed by members of cooperatives.

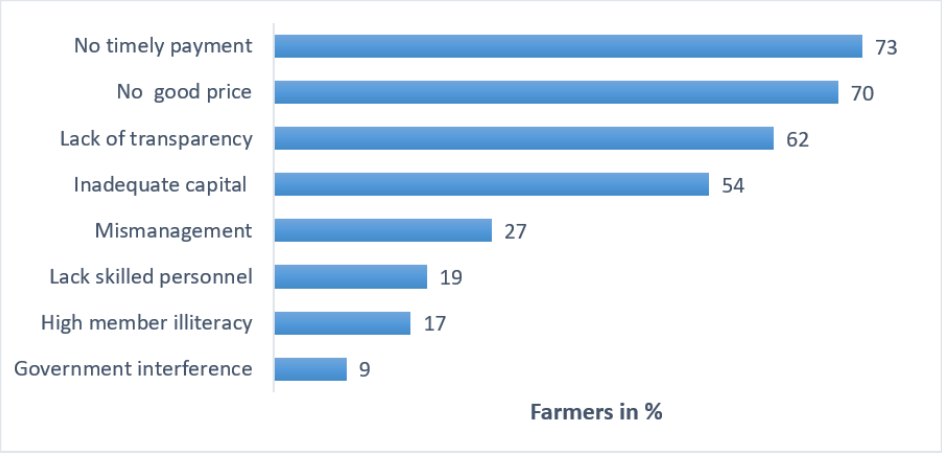

Figure 11. Constraints facing cooperatives from cooperatives' members' point of view

The commercial incentives that cause farmers to join cooperatives are collective marketing of farmer groups that tend to get higher prices for products marketed because of strong bargaining power as a group and lower prices for products purchased in bulk. Contrary to the norm, Figure 11 indicates that 70% of the members felt that they were not getting good prices. As a result, coop members end up selling their produce through local middlemen who offer competitive prices. Another reason why farmers opt for local middlemen is that 73% of the farmers reported that cooperatives generally delay paying them for their products, while middlemen pay immediately. Smallholders have limited funds and thus are not in a position to wait to be paid by cooperatives (Latynskiy & Berger, 2016). Cooperatives delay paying members mainly because they lack working capital and thus have to wait for payment from buyers before paying their members.

62% of the members expressed a lack of transparency in the cooperatives: although 10 of the 13 cooperatives reported having regular members' meetings twice monthly, only 42% of the members (Figure 6) had access to information. Thus, a majority of the members lacked an understanding of the functionality of the cooperatives. The absence of clearly communicated rules and transparency of cooperatives' services and benefits may create mistrust among the regular members. 54% of the members complained of experiencing inadequate capital in their cooperatives: this complaint is in line with Figure 6, which indicates that only 24% of the members had received credit from the cooperatives. Lack of external support (Table 6) indicates the limited liquid assets of cooperatives; in turn, they cannot provide greater credit to their members.

4. Discussion

Although there is controversy about the link between population and poverty, a consensus is emerging that rapid population growth increases the number of poor people (Cleland et al., 2006). FP enables women to advance

their education and careers by delaying or limiting childbearing, ultimately increasing economic productivity (McDougal et al., 2021). FP reduces child and maternal morbidity and mortality by preventing unintended pregnancies (Stover & Ross, 2010). FP enables birth spacing, ultimately enhancing the nutritional status of both mother and child. Children born at less than four-year intervals are reported to be 27% more prone to stunting and 23% more likely to be underweight as compared to those born after a four-year interval (Ruistein, 2014). Recent existing evidence, such as Yavinsky et al. shows that integrating FP into non-health projects like natural resource management improves the environment while increasing the uptake of FP, leading to declines in total fertility rates. The success of cooperatives in FP depends on institutional support with funding and training of farmer groups' staff to act as community health agents. Cooperatives can in turn improve FP services through (a) promoting the effective use of FP to their members by creating awareness through information and education, and (b) improving both the supply and accessibility of family planning services at the community_level (Akamike et al., 2019). These activities save time and resources since they take place during agricultural meetings and visits to homes and fields.

As for irrigation, large plots and smallholders' irrigation schemes supported by the government are declining and unsustainable due to waterlogging and salinity; at the same time they are not inclusive, as evidenced by 82% of the households in the study area not having access to irrigation. Given that smallholders mostly lack the resources to access irrigation technology, there is a need to integrate smallholder irrigation into cooperatives' activities to facilitate access. Following the same line of argument in terms of cooperatives providing FP services, with adequate support cooperatives can step up irrigation services and train members in sustainable irrigation practices. Rainwater harvesting and supplemental irrigation are the most efficient and accessible systems for credit-constrained smallholders. Furthermore, pump-fed systems have not been sustainable whereas gravity-fed systems are sustainable and economically feasible (Leng, Leung & Huang, 2017).

The success of farmer groups faces challenges, including a lack of resources in terms of finances, infrastructure, capabilities, and information, lack of support from government and development agencies, lack of transparency, and low membership, commitment, and participation. Access to credit is the greatest constraint as per the assessment of both leaders and regular members of cooperatives. Improving farmers' access to credit requires solutions to issues that are barriers to credit, including the use of land as collateral, high-interest rates, illiteracy, and microfinance institutions' lack of capital. Osewe et al. recommend that government should improve roads, remove market barriers, and make affordable and suitable credit facilities available. There is a need for efficient and effective cooperatives that adhere to the principles of good governance. They should bolster a culture of entrepreneurship, business promotion, job creation, and training in sustainable farming practices. Transparency in cooperative management would enable the members to access information and have the freedom to know and exercise their rights (Sumelius, Bäckman & Bee, 2021). Cooperatives can train members in context-specific (considering the type of soil, the slope, rate of infiltration, and the amount of rainfall) methods of rainwater harvesting (Rao et al., 2017), as well as assisting farmers with the appropriate tools to harvest rainwater. Rainwater harvesting taps water from rainfall and stores it for irrigation to make up for drought seasons, thereby enabling farmers to intensify and diversify crop production. Rainwater harvesting upholds sustainable agriculture because the availability of surface water minimizes the extraction of groundwater, as well as controlling floods (López-Felices et al., 2020).

5. Conclusion

Rapid population growth has contributed to growing food demand, and food insecurity is exacerbated by erratic unreliable rainfall in Kenya. To meet increasing food demand, this paper revisits family planning, smallholder irrigation, and agricultural cooperatives, and advocates for integrating family planning and smallholder irrigation in agricultural cooperatives' activities since the latter reaches the very poor at the grassroots level. In addition, the paper has investigated the performance and problems of cooperatives. Why integrate family planning into cooperatives' activities? Reduction of child malnutrition or hunger, in general, depends on the size of the future population, thus requiring investment in family planning. Family planning (FP) has the potential to reduce fertility rates and slow population growth, thereby reducing pressure on land and minimizing unsustainable farming practices that lead to land degradation.

Our results point out the disparity in access to FP services, with high percentages of the population in the lowest wealth quintile, rural inhabitants, and people with no education or primary education being mostly cut off from FP services. These categories of people can effectively be reached and served through the channel of farmer groups (cooperatives); since farmer groups are potential pathways to reach the very poor in the remotest regions. Cooperatives' principles of operation and their values, including equality and equity, solidarity and social responsibility, economic participation, and concern for the community, position them to resolve barriers to FP

uptake by creating awareness of the benefits of FP while being sensitive to cultural norms and meeting unmet needs.

Governments and development agencies should train cooperative staff in rainwater harvesting techniques and sustainable management of rainwater harvesting and equip them to provide adequate rainwater harvesting services to smallholders. Coops will take into account gender issues that normally constrain female farmers from accessing irrigation technologies. Poor prices and payment delays could be some of the reasons why 42 % of non-coop members said that they were not interested in becoming members of cooperatives. There is a need to create incentives for farmers to join cooperatives by capacity building of cooperatives' management, empowering cooperatives to provide better services, including high prices, timely payment, extension services, and transparency in cooperatives services such as market information, as these factors determine farmers' decisions to join cooperatives.

In the course of the survey, we noted that farmers mentioned that extension officers lack transportation and demonstration materials. Concerned institutions should give due support to extension agents so that the latter can offer need-based services to farmers without access. Despite the challenges faced by cooperatives, they have contributed to increases in crop yields, leading to food security, better nutritional status, increased incomes, reduced poverty rates, promoted businesses, and created jobs. Furthermore, 82% of the members expressed satisfaction with cooperatives.

There is a need for governments and development agencies to support the establishment and development of economically viable and self-sustaining cooperatives, and increase extension services to complement government extension. This calls for investment in market infrastructure, capacity building, access to finance, and provision of enabling regulatory and legal frameworks to establish better governance and accountability systems. Levels of youth participation can be increased by involving youths in group leadership and all cooperative activities, as well as by the creation of opportunities for young farmers to access productive resources. Subsequently, cooperatives will become transparent, and market-led, enhancing farmer access to markets, technologies, training, and services, thereby fostering sustainable agricultural practices that lead to productivity growth and overall development.

In sum, cooperatives can integrate family planning and irrigation in the quest to achieve sustainable agriculture and food security. The training, information, knowledge, and access to farm input services including access to credit smallholders receive from agricultural cooperatives contribute to (a) better farming and rainwater harvesting and irrigation practices, thereby advancing sustainable agriculture, while (b) family planning counseling, information, and access to contraceptives reduce the size of families, thereby reducing the high population pressure on land, a plus to sustainable agriculture. The study's limitation is that not all 13 cooperatives reported information on their performance in the variables of our interest as evidenced by Table 3. This limits the understanding of their performance and recommendations to improve the running of cooperatives. Given that accessing credit to finance farming activities is critical, future studies could investigate potential sources of off-farm income for smallholders.

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Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Obtained.

Ethics approval

The Publication Ethics Committee of the Canadian Center of Science and Education.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

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The data that support the findings of this study are available on request from the corresponding author.

Data sharing statement

No additional data are available.

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Appendix

Appendix 1

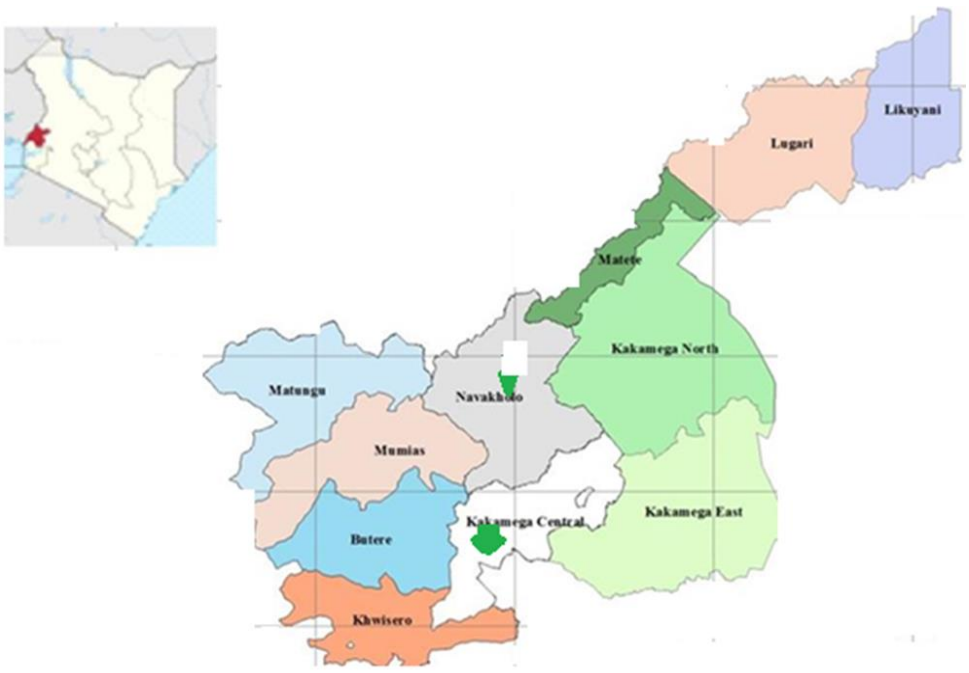

Figure 1. Location of the study sites in Kakamega County and the latter's location on the Kenyan map

Table 1. Probit regression on family planning, irrigation, and cooperatives for sustainable food security

Variables	Probit coefficients		Marginal effects	
	Coefficients	Std.Err	Coefficients	Std. Err
Constant	-0.274*	0.175		
	(-1.57)			
Family planning	0.818***	0.245	0.277***	0.067
	(3.34)		(4.13)	
Female coop member	0.442***	0.163	0.165***	0.058
	(2.71)		(2.83)	
Mobile phone for farming	0.383**	0.155	0.146**	0.058
	(2.47)		(2.51)	
Irrigation	0.408**	0.195	0.149**	0.067
	(2.09)		(2.23)	
Kakamega Central	-0.315**	0.149	-0.122**	0.058
	(-2.10)		(-2.11)	
Poor shelter	-0.269*	0.155	-0.103*	0.058
	(-1.74)		(-1.77)	
R^2	0.12			
Log likelihood	208.43			
Number of observations		347		

Note: The estimate Kakamega Central represents location fixed effects. The dependent variable food security status is based on 12 food groups (cereals, roots and tubers, vegetables, fruits, meat and poultry, eggs, fish and seafood, pulses/legumes/nuts, milk and milk products, oils/fats, sugar/honey, and miscellaneous). Each food group was assigned a value of either 1 or 0 determined by whether or not the food had been consumed within the past week in respective households. The average diversity among the 33% of households with the greatest diversity was used as a pointer to food insecure households that consumed less than four food groups per week (119).