Sustainability and Biodiversity Conservation

Stakeholder perspectives on potential effects of irrigation agriculture on wildlife conservation: The case study of irrigation farming in Kenya

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Abstract

The study sought to examine the community and stakeholders' perspectives on the effect of irrigation agriculture on wildlife in Galana Kulalu, Kenya. The study was based on four hypotheses, which were that water uptake for irrigation agriculture had no significant effect on wildlife in Galana, land use change to irrigation agriculture had no significant effect on wildlife in Galana, there was no significant change in policy and planning for wildlife management in Galana ranch as a result of irrigation agriculture and that, the stakeholders and community members in Galana were not going to be significantly affected by irrigation agriculture in Galana. Mixed methods were used to collect primary and secondary data, and both qualitative and quantitative data were collected and analyzed using SPSS version 22 and IBM Amos version 21. Measurement and Structural Equation models were developed and analyzed. Hypotheses test results based on path analysis showed that wildlife was significantly associated with water (β=-1.156, t= -13.710, P<.001), with land (β=1.101, t= 38.654, P<.001), with policy and planning, (β=.892, t= 64.108, P<.001) and with the community, (β=-1.000, t= -7.650, P<.001). Most stakeholders and community members opine that irrigation agriculture will reduce the range and water available for wildlife in Galana. The study recommends further studies targeting an understanding of how specific wildlife species will be affected by irrigation agriculture.

Keywords: Wildlife, Irrigation agriculture, Community, Land, Water

Introduction

The world population, which stands at 8.045 billion according to UNFPA (2022), is increasing steadily and is expected to reach 10.5 billion by the year 2050 (UN-DESA (United Nations Department of Economic and Social Affairs, 2022); UNFPA, 2022). Projected declining levels of mortality, a reflection of an increase in life expectancy, it is estimated that the world's population could grow to 8.5 billion in 2030, 9.7 billion in 2050, and 10.4 billion in 2100 (UN-DESA, 2022). While sixty-five percent of the world's population is aged between 15 and 64 years (Chovhaniuk et al., 2023), it is projected that by the year 2050, sixty-eight percent of this population will live in urban areas (Moreira da Silva et al., 2024). The African continent is documented to be the most rapidly growing continent (Grinin & Korotayev, 2023), and its population is expected to reach 1.6 billion in the year 2050 (UN-DESA, 2022). It is predicted that the growth of the African continent could significantly influence ecology, and so could the agrarian sector (Grinin & Korotayev, 2023). In Kenya, the population is estimated to be about 54 million and is expected to reach 85 million in 2015 (UN-DESA, 2022; UNFPA, 2022). It is estimated that in the second half of the twenty-first century, Kenya's population will strike 150 million (Zinkina & Korotayev, 2014). Annual population growth in Kenya continues to exert pressure on available infinite land and natural resources (Thuku et al., 2013). This population needs to be fed on food that primarily comes from agricultural production, yet soil and water, two critical natural resources for successful agriculture, are increasingly under pressure (Velasco-Muñoz et al., 2019). This change is compounded by the fact that only 17% of Kenya's land is arable and that 81% of the country is arid and semi-arid (Otieno, 2020). Glamour for the subdivision of ranches and their conversion to arable farmland is on the rise (Okello et al., 2011) a phenomenon underpinned by the quest for an increase in food production to feed a growing population that is contributing to increased conflicts from the use of land, water, and other natural resources (Silvestri et al., 2013). Such attempts to increase agricultural production have exponentially increased human interference with the natural environment (Velasco-Muñoz et al., 2019). Whirls rain-fed agriculture constitutes 80% of global agriculture, continually being threatened by the growing world population, water scarcity, and climate change (Rao et al., 2015). During the growing seasons, agricultural productivity under a rain-fed system is severely affected by dry spells (Ogenga et al., 2018). The number of agricultural yields from rain dependent on the agricultural system is a function of many factors, including the amount of rainfall received during the planting season (Adamgbe & Ujoh, 2013). According to CBK (2023), rain-fed agriculture cannot meet the food needs of the growing population. This is because rain-fed agriculture is happening in areas where the population is proliferating, and with it is the rapid need for land for human settlement, resulting in the land under agriculture quickly reducing (CBK, 2023). Like in most African countries, the frequency of dry spells in Kenya is increasing (Ogenga et al., 2018), contributing to decreased spatial and temporal rainfall in the country (Gitau et al., 2012). In such a scenario, to increase food production to cater to the growing population, the focus is now away from dependence on rain-fed agriculture to irrigation agriculture, especially in arid and semi-arid areas (Otieno, 2020; Lemly, 1994). Irrigation farming, which is estimated to occupy 18% of the total arable land globally (Johansson et al., 2002), plays a fundamental role in the supply of food and raw materials (Velasco-Muñoz et al., 2019) and is essential in supporting increased agricultural production (Lemly et al., 2000). More so, because the availability of land in dry areas and improving technology in irrigation not only helps poor and smallholder farmers to increase their yields from crop production but also results in a positive impact on food production (Manap & Ismail, 2017; Otieno, 2020). An increase in the number of studies analyzing the sustainability of agricultural irrigation in terms of environmental, economic, and social impacts (Velasco-Muñoz et al., 2019; Otieno, 2020; Müller-Mahn et al., 2021) underpins the importance of irrigation in the era of climate change (Kalungu & Harris, 2013; Otieno, 2020). However, irrigation can harm the environment if care is not taken (Dougherty & Hall, 1995); FAO, 2011; Cabodevilla et al., 2022; Narayan & Rana, 2023).

With an acreage of about 1.75 million, the Agricultural Development Corporation (ADC) Galana Kulalu Ranch in Kilifi and Tana River Counties, which the Galana River bisects, offers a potential solution to food Security in Kenya (Müller-Mahn et al., 2021; Otieno, 2020; Ombaka, 2014). However, adjacent to Tsavo East National Park (Odinga, 2023), where the Ranch acts as a dispersal and spillover area for wildlife, the ecosystem is a unique area where conservation and development will compete (Mukeka et al., 2020). This is more so because over 50,000 tourists visit Tsavo National Parks (Odinga, 2023; Akama & Kieti, 2003), and the Tsavo ecosystem is very rich in flora and fauna (Mukeka et al., 2020; Odinga, 2023) some of which are water dependent and require a large range, any development in the area must consider the conservation and preservation of these biodiversity (Parker, 2018). It is against this backdrop that this study explored the stakeholder's and community members' perceptions of the effects of irrigation agriculture on wildlife at Galana Kulalu Ranch. The study's main objective was to examine the community and stakeholders' perspectives on the effect of irrigation agriculture on wildlife in Galana Kulalu, Kenya. The study was based on four hypotheses, which were: 1. Water uptake for irrigation agriculture will not significantly affect wildlife in Galana. 2. Land use change to irrigation agriculture will not significantly affect wildlife in Galana. 3There will be no significant change in policy and planning for wildlife management in Galana Kulalu Ranch due to irrigation agriculture; 4. The stakeholders and community members in Galana will not be significantly affected by irrigation agriculture.

Study area

As illustrated by Figure 1, Galana Kulalu Ranch is composed of Galana Ranch and Kulalu Ranch. The Ranch is located in Kenya's Coastal region within Kilifi and Tana River Counties and stretches along almost the entire eastern boundary of Tsavo East National Park. The Ranch is bisected by the Galana River, with Galana Ranch to the north and Kulalu Ranch to the south.

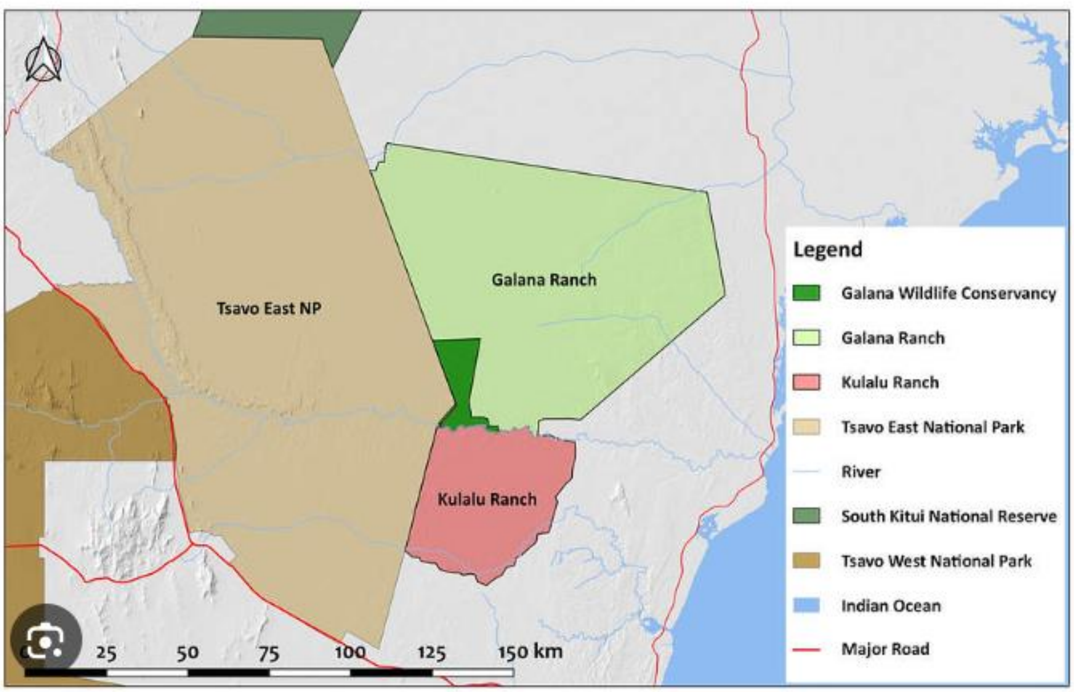

Figure 1. Study site (Source: https://www.sheldrickwildlifetrust.org)

Material and methods

A pragmatic approach that advocates for mixed methods for data collection and analysis was adapted for the study. Qualitative and quantitative secondary and primary data were collected and analyzed. To collect primary data, a combination of non-probability sampling techniques, which included convenience sampling, purposive, judgment sampling, and snowball sampling, was used to collect data from key informants and community members using questionnaires that had both closed-ended and open-ended questions. Non-probability sampling techniques are usually used in exploratory research to develop an initial understanding of an under-researched population (McCombes, 2023). Secondary data was collected through library research and internet searches. Methodological triangulation was used to compare and contrast qualitative and quantitative data (Bekhet & Zauszniewski, 2012). The qualitative data collected complemented and helped clarify the quantitative findings by identifying common themes.

Literature review

There will always be a spatial-temporal competition between development and conservation (Sayer et al., 2013; Büscher & Schoon, 2009). This is so because development and conservation, more often than not will happen in the same space and compete for the same resources (Sayer et al., 2013). Therefore, it's incumbent upon developers to strike a balance for a win-win situation (Kalvelage et al., 2021; Oldekop et al., 2010). Developers and conservationists working together will help to maintain intra-generational and inter-generational equity for natural resources and sustainable development (Kalvelage et al., 2021; Sayer et al., 2013; Oldekop et al., 2010) as envisioned in the UN Sustainable Development Goals (SDGs) no. 1 No poverty; no.2 Zero hunger; no. 3 Good health and well-being; no.8 Decent work and economic growth; no.10 Reduced inequalities; no.11 Sustainable cities and communities; no.13 Climate action; no.14 Life below water and no.15 Life on land (UN, 2017). The Kenya Agricultural Policy 2021 advocates for the promotion of the private sector, adoption of principles that promote conservation agriculture, promote the use of technology, support of the utilization of land in all agro-ecological zones, promote water harvesting and investment in irrigation infrastructure to increase food production in the light of climate change challenges and population growth (GoK, 2021). The potential for irrigation in Kenya without water storage or damming is estimated at 1.2 million hectares, further, there are some 9.2 million hectares of land in arid and semi-arid lands (ASALs) which have high potential for crop production if irrigation was to be carried out (Mati, 2023). However, the IPCC (2023) states that irrigation agriculture is usually practiced in arid or semi-arid areas where there is mostly already a strain on available natural resources. As a result, there is a likelihood of substantial increases in the costs of irrigation to take care of competing interests and increased moisture losses (IPCC, 2023). Uniform irrigation water application is important for the efficient operation of an irrigation system (Darko et al., 2017). Pressurized irrigation systems improve irrigation efficiency at the field level compared to non-pressured systems as they reduce application losses and improve distribution efficiency (Howell, 2001).

According to Dougherty and Hall, (1995), in addition to other challenges, irrigation can have negative effects on the environment and wildlife, on humans for example, irrigation can lead to an increase in diseases such as malaria, schistosomiasis (bilharzia), lymphatic filariasis (elephantiasis), cholera, typhoid, and skin diseases (FAO, 2011). Irrigation agriculture is documented to have had both positive and negative changes in the composition of the community of birds of prey and corvids in the Mediterranean region agrosystem. (Villanúa et al., 2023) As a result, irrigation may lead to new bird communities as the local bird communities are edged out. For this reason, irrigation should be implemented carefully, and areas with species high species diversity or areas with endangered species should be avoided (Cabodevilla et al., 2022). The main human activities associated with irrigation that lead to wildlife losses include hunting, poaching, agriculture, pollution, livestock husbandry, goat/sheep herding, road traffic, and institutional factors such as poor legal frameworks (Narayan & Rana, 2023). Irrigation seriously threatened the survival of riverine forests and wildlife in the Bura irrigation scheme in Tana River County, Kenya, as the human population increased, leading to a huge fuel-wood shortage in the area. This was worsened by the neglect of the planned fuel wood plantations (Ledec, 1987). In cases where irrigation cannot be avoided, efforts should be made to avoid monocultures (Cabodevilla et al., 2022).

Results

Data analysis

Data was analyzed in five steps: Step 1 involved checking the data for response rate and respondent misconduct. This was done using SPSS. Step 2 then followed, demographic data was analyzed. Step 3 involved preliminary analysis of the scale by using Exploratory Factor Analysis (EFA). This was done using Varimax in SPSS. Step 3 followed, where further validation of the EFA results was done by Confirmatory Factor Analysis (CFA) using a measurement model developed in AMOS. Finally, the data was subjected to Step 5, where a Structural Equation Model (SEM) was developed in AMOS to test the hypotheses. For factor analysis, the data was divided into two halves randomly, with one half of the data being subjected to EFA and the other half being subjected to CFA.

Demographic statistics

Since the data collection method was nonprobability, the response rate was above 95%. The data was checked for respondent misconduct using SPSS. Respondent misconduct is detected if the standard deviation of a questionnaire scale item is found to be below 0.25 (Collier, 2022). For this study, all the questionnaire scale items were found to have a standard deviation of >.30; thus, no respondent misconduct was detected.

Table 1. Gender of respondents

	Gender	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	68	44.7	44.7	44.7
	Female	84	55.3	55.3	100.0
	Total	152	100.0	100.0	

Irrigation projects tend to affect women mostly in a negative way, while will be engaged in projects offering skilled and unskilled labor, usually few women will be directly absorbed (FAO, 2011). Maybe it's for this reason that more women than men were willing and available to respond to this study more than men as shown in Table 1.

Table 2. Age of respondents

Age		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 20 Yrs	10	6.6	6.6	6.6
	21 to 29 Yrs	49	32.2	32.2	38.8
	30 to 39 Yrs	42	27.6	27.6	66.4
	Above 40 Yrs	51	33.6	33.6	100.0
	Total	152	100.0	100.0	

Most of the respondents in the study were above the age of 40 years as indicated in Table 2 and more than 93% of the respondents were adults above the age of 20 years. Thus, the study received views from mature people who have some experience with wildlife and irrigation agriculture.

Table 3. Marital status of respondents

	Marital Status	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Single	33	21.7	21.7	21.7
	Married	105	69.1	69.1	90.8
	Divorced	6	3.9	3.9	94.7
	Widowed	8	5.3	5.3	100.0
	Total	152	100.0	100.0	

The majority of the respondents were married at 69.1% as shown in table 3, this is typical of rural communities in Kenya (KNBS, 2023) and Galana was no exception.

Table 4 . The education level of respondents

Education		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Primary	82	53.9	53.9	53.9
	Secondary	37	24.3	24.3	78.3
	Tertiary	12	7.9	7.9	86.2
	No Education	21	13.8	13.8	100.0
	Total	152	100.0	100.0	

Even though 13.8% of the respondents were found to have no education, the majority of the respondents 86.2% had some level of formal education, as illustrated in Table 4. Again, this is characteristic of rural communities more so those of the coastal communities in Kenya (KNBS, 2023).

Table 5. Duration of stay in Galana of respondents

	Years of Stay in Galana	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 Year	15	9.9	9.9	9.9
	2 to 3 Years	33	21.7	21.7	31.6
	More than 3 Years	104	68.4	68.4	100.0
	Total	152	100.0	100.0	

The majority of the respondents, 68.4%, had stayed in Galana for more than 3 years, as illustrated in Table 5. Thus, they had stayed in the study area long enough to understand its socioeconomic aspects.

Exploratory factor analysis

Exploratory factor analysis using the variable rotation was used to analyze the factor structure and correlation between scale items. The KMO Measure of Sampling Adequacy value was .938, which is above 0.50 as recommended by Collier (2020); thus, the criteria of sampling adequacy were met. The Bartlett test of sphericity was statistically significant (P<.001); thus, the correlation matrix was statistically different from an identity matrix, as recommended by Collier (2020), as illustrated in Table 6. The results of the exploratory factor analysis EFA further show that the solution was based on five factors, and all items were loaded on their respective factors except three items that had cross-loadings. These were WLD 3 (Wildlife affects agricultural activities in Galana). WLD 4 (Wildlife affects water availability in communities in Galana) & PPG 5 (Irrigation agriculture will call for amendments of existing laws in wildlife management). These three questionnaire items were excluded from further future analysis. The five-factor solution explained 59.3% variance of the total cumulative variance. From the EFA results it can be concluded that the factors had a good level of validity.

Table 6. KMO measure of sampling adequacy

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.938
Bartlett's Test of Sphericity	Approx. Chi-Square	10764.015
	Df	276
	Sig.	.000

Confirmatory factor analysis results

AMOS version 21 statistical software was used to perform the Confirmatory Factor Analysis (Arbuckel, 2009). The model was used to test the variables' normality, reliability, convergent validity, and discriminant validity. Table 7 illustrates that the skewness and kurtosis of almost all the variables were within the required limits, as suggested by Collier (2020). An absolute skewness up to +/-3 is acceptable, while a Kurtosis range of up to between −10 and +10 is acceptable (Collier, 2020).

Table 7. Assessment of normality

Variable	Min	Max	Skew	c.r.	Kurtosis	c.r.
WLD_1	1.000	5.000	-1.051	-5.292	.082	.207
WLD_2	1.000	5.000	-.938	-4.723	-.831	-2.092
CMY_7	1.000	5.000	1.302	6.554	-.082	-.207
CMY_6	1.000	5.000	.575	2.892	-1.413	-3.556
CMY_5	1.000	5.000	-.797	-4.014	-1.073	-2.700
CMY_4	1.000	5.000	-3.108	-15.645	8.976	22.590
CMY_3	1.000	5.000	-.240	-1.206	-1.708	-4.298
CMY_2	1.000	5.000	-3.755	-18.900	13.743	34.586
CMY_1	1.000	5.000	-2.550	-12.833	5.416	13.631
PPG_4	1.000	5.000	-.579	-2.912	-1.254	-3.157
PPG_3	1.000	5.000	-.172	-.868	-1.652	-4.157
PPG_2	1.000	5.000	.047	.234	-1.692	-4.257
PPG_1	1.000	5.000	-.165	-.833	-1.732	-4.359
LUC_5	1.000	5.000	-.608	-3.062	-1.352	-3.403
LUC_4	1.000	5.000	-.903	-4.546	-.877	-2.206
LUC_3	1.000	5.000	-1.657	-8.339	1.433	3.606
LUC_2	1.000	5.000	-.859	-4.322	-.900	-2.265
LUC_1	1.000	5.000	-1.240	-6.241	-.064	-.161
WTU_5	1.000	5.000	.023	.115	-1.739	-4.376
WTU_4	1.000	5.000	-.421	-2.120	-1.423	-3.581
WTU_3	1.000	5.000	.080	.405	-1.798	-4.525
WTU_2	1.000	5.000	-.129	-.650	-1.726	-4.344
WTU_1	2.000	5.000	-1.240	-6.240	-.009	-.023
Multivariate					189.486	34.444

Table 8. Model fit measure

Model Fit measure	Index name	Adequate fit benchmark	Default model Value	Remarks
Absolute Fit measure	CMIN/Df	< 5	3.560	Benchmark achieved
	GFI	> 0.90	0.903	Benchmark achieved
	AGFI	>0.90	0.901	Benchmark achieved
	RMSEA	< 0.10	0.067	Benchmark achieved
Incremental fit measure	NFI	> 0.90	0.912	Benchmark achieved
	CFI	> 0.90	0.904	Benchmark achieved
	TLI	> 0.90	0.993	Benchmark achieved
	IFI	> 0.90	0.996	Benchmark achieved
Parsimonious fit measure	PGFI	> 0.50	0.511	Benchmark achieved
	PCFI	> 0.50	0.521	Benchmark achieved
	PNFI	> 0.50	0.510	Benchmark achieved

As illustrated in Table 8, the results of the measurement model used in confirmatory factor analysis (CFA) show that model had good fit statistics including X^2/df=3.56, RMSEA of 0.067, and CFI of .904 as per the guidelines given by Hu and Bentler (1998), Collier (2020) and Ringler et al, (2023) (RMSEA<.08, RMR<.05, CFI>.90). Table 9 shows that almost all the items' standardized factor loading was above 0.50 except CMY2, CMY 4 and WLD 1, while the Average Variance Extracted (AVE) for all the items was above 0.50. This indicated good convergent validity (Ringle et al., 2023). The Cronbach alpha and composite reliability (CR) for all variables was above 0.70; thus, the variables were of good reliability. The Fornell & Larcker (1981) classical criteria were used to establish discriminant validity. The requirement is that the square root of AVE values should be higher than the values of the inter-variable correlation. Using these criteria, all the variables were found to be of good discriminant validity.

Table 9. Validity test results

CODE		Construct	Factor Loading	Cronbach Alpha	AVE	CR
WTU_1	<---	WATER	.773			
WTU_2	<---	WATER	.994			
WTU_3	<---	WATER	.982			
WTU_4	<---	WATER	.959			
WTU_5	<---	WATER	.986	.973	0.888	0.975
LUC_1	<---	LAND	.964			
LUC_2	<---	LAND	.993			
LUC_3	<---	LAND	.909			
LUC_4	<---	LAND	.995			
LUC_5	<---	LAND	.966	.983	0.933	0.986
PPG_1	<---	POLICY	.991			
PPG_2	<---	POLICY	.981			
PPG_3	<---	POLICY	.987			
PPG_4	<---	POLICY	.959	.991	0.959	0.991
CMY_1	<---	COMMUNITY	.614			
CMY_2	<---	COMMUNITY	.415			
CMY_3	<---	COMMUNITY	.968			
CMY_4	<---	COMMUNITY	.466			
CMY_5	<---	COMMUNITY	.952			
CMY_6	<---	COMMUNITY	.846			
CMY_7	<---	COMMUNITY	.592	.886	0.525	0.876
WLD_2	<---	WILDLIFE	.976			
WLD_1	<---	WILDLIFE	-.441	.882	0.712	0.908

Hypothesis testing

To test the hypothesis, a Structural equation model (Figure 2) was developed, and results obtained from it were analyzed.

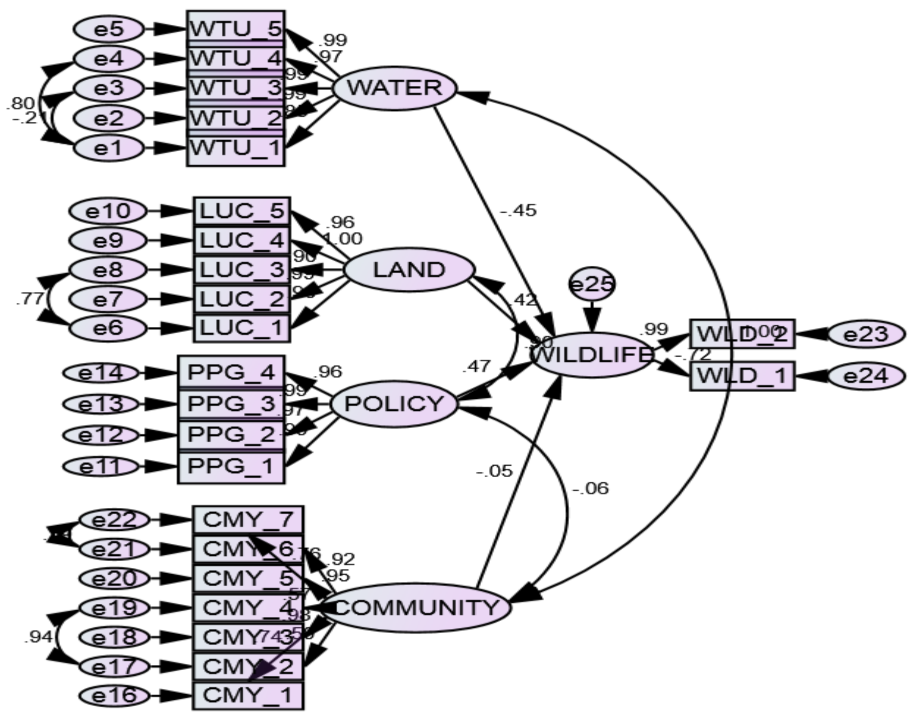

Figure 2. Structural equation model for study

Table 10. Hypothesis test results

Hypothesis	Estimate (β)	S.E.	C.R. (t)	P	Remarks
Water uptake for irrigation agriculture will have no significant statistical effect on wildlife in Galana,	-1.156	.084	-13.710	***	Hypothesis not supported
Land use change to irrigation agriculture will have no significant statistical effect on wildlife in Galana	1.101	.028	38.654	***	Hypothesis not supported
There will be no significant change in policy and planning for wildlife management in Galana ranch as a result of irrigation agriculture	.892	.014	64.108	***	Hypothesis not supported
The stakeholders and community members in Galana will not be significantly statistical affected by irrigation agriculture in Galana.	-1.000	.131	-7.650	***	Hypothesis not supported

According to Collier (2020), a t-value greater than +2 or less than - 2 is good and acceptable. The higher the t-value, the higher the confidence there is in the coefficient as a predictor. Hypotheses test results based on path analysis show that Wildlife is significantly associated with water, (β=-1.156, t= -13.710, P<.001), Wildlife is significantly statistically associated with land, (β=1.101, t= 38.654, P<.001), Wildlife is significantly statistically associated with the policy, (β=.892, t= 64.108, P<.001) and Wildlife is significantly associated statistically with community, (β=-1.000, t= -7.650, P<.001). Based on these results, the entire null hypothesis was not supported, as illustrated in Table 10.

Table 11. Water use

	Water Use				
	N	Minimum	Maximum	Mean	Std. Deviation
Irrigation agriculture will reduce water available for wildlife	152	2.00	5.00	4.2895	1.08957
Irrigation agriculture will reduce range for wildlife.	152	1.00	5.00	4.0395	1.47330
Irrigation agriculture will increase water for wildlife.	152	1.00	5.00	3.4211	1.58439

Irrigation agriculture will increase competition for water	152	1.00	5.00	3.0987	1.74826
Irrigation agriculture might introduce other predators.	152	1.00	5.00	2.9803	1.72811
Irrigation agriculture will pollute water for wildlife	152	1.00	5.00	2.9145	1.80119
Valid N (list wise)	152				

With a mean of 4.2 and Std. deviation of 1.089 majority of the stakeholders and community members in Galana feel that irrigation agriculture will reduce water availability for wildlife use in Galana Ranch. While with a mean of 2.9145 majority of the stakeholders and community members neither agree nor disagree that irrigation agriculture will pollute water for wildlife. From the findings, as shown in Table 11, most of the stakeholders and community members in Galana are concerned that irrigation agriculture will negatively affect water available for wildlife in Galana. The majority of the respondents believed that '*irrigation agriculture in Galana will affect both the quality and quality of water available for wildlife'*.

Table 12. Policy and planning

	Policy and Planning				
	N	Minimum	Maximum	Mean	Std. Deviation
Irrigation agriculture will require more stakeholders' engagement in wildlife management	152	1.00	5.00	3.5461	1.58151
Irrigation agriculture will lead to formation of new laws and policies on wildlife.	152	1.00	5.00	3.1513	1.69049
Irrigation agriculture will affect the policy and planning for wildlife in the area.	152	1.00	5.00	3.1513	1.75205
Irrigation agriculture will call for amendments of existing laws in wildlife management.	152	1.00	5.00	3.0132	1.70308
Irrigation agriculture will affect the day to day management of wildlife.	152	1.00	5.00	2.9079	1.69673
Valid N (list wise)	152				

As shown in Table 12, most of the stakeholders and community members in Galana support more stakeholders and community members' engagement on wildlife management matters during land use change to irrigation agriculture in Galana with a mean of 3.5461. The stakeholders and community members believed that public participation is important for the success of irrigation agriculture in Galana.

Table 13. Land use change

Land Use Change					
	N	Minimum	Maximum	Mean	Std. Deviation
Irrigation agriculture will close migratory corridors for wildlife.	152	1.00	5.00	4.2500	1.27248
Irrigation agriculture will reduce range for wildlife.	152	1.00	5.00	4.0395	1.47330
Land preparation will destroy breeding grounds for wildlife.	152	1.00	5.00	3.8026	1.59486
Irrigation agriculture will alter the landscape for wildlife.	152	1.00	5.00	3.7763	1.55771
Fencing will affect the social behavior of wildlife.	152	1.00	5.00	3.5658	1.65049
Valid N (list wise)	152				

As illustrated in Table 13, the majority of the stakeholders and community members in Galana feel that irrigation agriculture will close migratory corridors for wildlife with a response mean of 4.2 on a scale of 1 to 5 where 1 represents strongly disagree while 5 represents strongly agree. The opinion of the majority of the stakeholders was that land use change to irrigation agriculture will generally impact wildlife negatively.

Table 14. Community

Community					
	N	Minimum	Maximum	Mean	Std. Deviation
Irrigation agriculture will create jobs for community members.	152	1.00	5.00	4.7500	.80766
Irrigation agriculture will lead to an increase in the population	152	1.00	5.00	4.6842	.88715

Irrigation agriculture will increase community income.	152	1.00	5.00	4.5987	.98505
Irrigation agriculture will lead to increased human-wildlife conflicts	152	1.00	5.00	3.7303	1.61930
Irrigation agriculture will lead to more social vices	152	1.00	5.00	3.2368	1.76702
Irrigation agriculture will lead to reduced human-wildlife conflicts.	152	1.00	5.00	2.4803	1.70302
Irrigation agriculture will lead to increased poaching.	152	1.00	5.00	1.9276	1.55304
Valid N (listwise)	152				

As illustrated in Table 14 with a mean of 4.7 most of the respondents in Galana feel that irrigation agriculture will create jobs for community members. While a few community members with a mean of 1.97 feel that irrigation agriculture will lead to increased wildlife poaching. Most of the respondents opined that irrigation agriculture will increase community income and reduce wildlife poaching and game meat hunting.

Discussion

Irrigation agriculture in Galana Kulalu Ranch will have both positive and negative effects on the ecosystem in Galana. These will in turn affect wildlife and the entire community both positively and negatively. The following are some of the positive ecological effects of irrigation agriculture in Galana: there will be improved flood moderation for the Galana river waters as the irrigation canals will regulate the flow of water downstream, there will be improved knowledge of local biodiversity since more studies will be done, as result, there will be improved management of the local natural resources, the irrigation infrastructure will improve water availability to community members and wildlife, due to damming of water there will alteration of microclimate of the area, the irrigation project will lead to reduced vulnerabilities to climate change for community members and wildlife as the project will offer options for adaptation such as improved water and food availability, improved wildlife surveillance and improved land use management and reduced poaching activated since the local people will be economically engaged. These findings concur with those of

On the flip side, the following are the negative ecological effects that will arise from irrigation agriculture in Galana: loss of biodiversity due to the reduced range, air pollution as a result of land preparation, soil structure damage due to land tillage, water pollution arising from agrochemicals, the introduction of invasive plant species such as the *Opuntia spp*., increased human-wildlife conflicts due to increased human settlement, Introduction of diseases and pests, introduction of vectors, solid waste management challenges, wildlife migration and breeding patterns will be affected and loss of vegetation cover which will lead to change of aesthetics of the area. To mitigate these negative effects several conservation opportunities can be explored which include; game ranching to complement the conservancy that is already in place, habitat restoration through the greening of developed areas and agroforestry, provision of water to community members, livestock, and wildlife to mitigate human-wildlife conflicts, promotion of aquaculture through introduction of fish in the dams and apiculture.

Conclusion

From the data collected the stakeholder and community perspective is that there is a significant statistical effect of irrigation agriculture on wildlife in Galana Kulalu, Kenya. However, to attain food security and alleviate Kenyans from poverty, irrigation agriculture is the way forward more so in the light of climate change. Continued reliance on rain-fed agriculture is not the way to go since no country in the world has attained food security while relying on natural rain-fed agriculture. The land in Galana can be utilized for both agricultural production and biodiversity conservation through a win-win scientifically informed arrangement. Negative environmental and social costs can be avoided or reduced to an acceptable level by carefully assessing potential problems and implementing cost-effective corrective measures. As a way forward alternatives do exist to mitigate adverse effects of irrigation agriculture development on the ecology and wildlife. Some of them include but are not limited to the following: locating the irrigation project on the side of the ranch where negative ecological effects will be minima; using irrigation systems and technology that decreases the risk of waterlogging, salinization, erosion, and inefficient water use; practicing minimum tillage and using machinery that does not damage the soil as opposed to use of machinery that rips the soil; using treated wastewater through recycling, where appropriate, to make more water available to other users; maintaining flood flows downstream of the dams to ensure that an adequate area is flooded each year, among other reasons, for fishery activities; stakeholder and community engagement in every step of the project and creating a budget for regular environmental monitoring and auditing. The study recommends further studies especially around individual species of wildlife be carried out to establish how irrigation agriculture will impact specific species of wildlife. Further, the study recommends continuous collaboration between ecologists, agricultural experts, policy makers, and community members to mitigate any negative effective effects that may arise.

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