Taylor & Francis
Taylor & Francis Group

International Journal of River Basin Management

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/trbm20

A perspective of sustainable livelihood framework in analysis of sustainability of rural community livelihoods: evidence from Migori River watershed in Kenya

Stephen Balaka Opiyo, Godwin Opinde & Sammy Letema

INTERNATIONAL JOURNAL OF RIVER BASIN MANAGEMENT
https://doi.org/10.1080/15715124.2023.2216019

Taylor & Francis
Taylor & Francis Group

RESEARCH ARTICLE

A perspective of sustainable livelihood framework in analysis of sustainability of rural community livelihoods: evidence from Migori River watershed in Kenya

Stephen Balaka Opiyo, Godwin Opinde and Sammy Letema

Department of Spatial and Environmental Planning, Kenyatta University, Nairobi, Kenya

ABSTRACT

Evaluation of livelihood sustainability in ecologically sensitive areas, impoverished regions, and disaster-stricken zones is critical for understanding sustainability challenges and administering poverty-relief interventions. This paper assesses the sustainability of rural households' livelihoods in the Migori River watershed in Kenya by constructing a livelihood sustainability index (LSI). A cross-sectional survey design was used to collect data from 318 randomly selected households from the upstream, midstream, and downstream watershed zones. The LSI was constructed using the UK Department for International Development (DFID) methodology based on the five livelihood capitals, and one-way ANOVA was used to test for significant differences between watershed zones. The results of the analysis show that although the livelihoods of all the three watershed zones are moderately sustainable with no significant variations (at $p < 0.05$) between the zones, the livelihoods of midstream households are most sustainable followed by the upstream households and then downstream. The social (ranging from 0.64 to 0.69), physical (ranging from 0.60 to 0.67) and natural (ranging from 0.60 to 0.64) capitals registered relatively high index values across the watershed zones unlike the human (ranging 0.55–0.65) and financial (ranging from 0.44 to 0.57) capitals that recorded relatively low index values; which implies that human and the financial capitals are least possessed assets in the watershed. Therefore this paper recommends increasing the natural capital through sustained conservation of natural resources, increasing human capital by providing skills training to household on alternative livelihood options, and increasing access to financial capital by strengthening rural entrepreneurship. The paper suggests the usage of LSI by policy-makers as a practical tool to quantify the livelihood capital endowment of rural communities to help in prioritizing watershed management programs and the development of interventions aimed at a specific livelihood asset. It may also help policy-makers in project monitoring and evaluation, where it provides feedback critical for continual project improvement.

ARTICLE HISTORY
Received 29 June 2022
Accepted 16 May 2023

KEYWORDS
Sustainable livelihood framework; livelihood capital assessment; livelihood sustainability index; watershed development

Introduction

Background

Rural communities engage in a variety of activities to meet their basic needs (Kedir, 2015), depending on their access to productive resources (DFID, 2000). These activities constitute their livelihoods; strategies and means of earning a living (Wang et al., 2015). Since the 1990s, studies on rural livelihoods have grown exponentially and been accorded significant importance in the efforts for rural poverty reduction (Singgalen et al., 2019). As the field evolved, researchers began to incorporate the perspectives of sustainability and even social-political justice (Costa, 2001), leading to the emergence of the concept of sustainable livelihood. This concept was initially put forward in 1987 by the Brundtland Commission on Environment and Development as a means of connecting environmental and socio-economic concerns in a cohesive, policy-relevant framework (Sati & Vangchhia, 2016). It was later adopted in 1992 by the UNCED. From that point on, much attention was given to the definition and analysis of livelihood sustainability by reseachers leading to the development of several analysis frameworks (Liang et al., 2012; Fang et al., 2014). One such framework is the Sustainable Livelihood Framework (SLF).

The SLF was developed by the UK Department for International Development (DFID, 2000), and has been widely adopted by researchers as an effective method for understanding household livelihoods and solving rural poverty problems (Yin et al., 2020). The framework expects interplay of assets, vulnerability context, coping/adaptation strategies, and the structure and process of endogenous and exogenous factors creating sustainable livelihood outcomes (Scoones, 2009). The vulnerability context includes both natural and man-made factors that can affect people's livelihoods, such as climate change, conflicts, and economic shocks; livelihood assets are the resources and capabilities people have at their disposal; structures and processes refer to the formal and informal rules and regulations that shape people's access and use of their assets; livelihood strategies include the different ways in which people cope with and respond to the challenges they face, including diversification, migration, and entrepreneurship; and livelihood outcomes focus on the ultimate goal of sustainable livelihoods, including improvements in income, health, education, and social networks (Scoones, 2009; Morse & McNamara, 2013). Of these various components of SLF, the most complex is the portfolio of assets out of which individuals/people construct their living (Kedir, 2015).

CONTACT Stephen Balaka Opiyo stevebalaka@gmail.com

The asset pentagon, consisting of five types of assets/capitals (natural, financial, human, physical, and social) that are deemed to underpin livelihoods at the level of the individual, household, and village, is at the core of the framework (Kedir, 2015). Natural Capital refers to the stock of natural resources like land, water and forestry, from which ecological goods and services that sustain livelihoods are generated (Scoones, 2009). Financial Capital encompasses all economic instruments and services employed by individuals or households to pursue multiple livelihood choices (Morse & McNamara, 2013). Human Capital refers to the knowledge base, skills set, labor capacity, and healthfulness that collectively allow individuals to seek various livelihood choices and achieve their livelihood goals (Kedir, 2015). Physical Capital describes the primary infrastructural facilities (like transport system, water supply, health care and telecommunications) and production instruments (like farm machinery and household goods) required to sustain livelihoods (Makhetha, 2010). Social Capital describes relationships of trust that enhance cooperation, lower transaction costs, and may serve as the foundation for unstructured safety nets among the impoverished (Altasseb, 2021).

These capitals have equal importance in the life of rural households as they determine the living gained by the individual or household (Yang et al., 2020), which is why the evaluation of the total livelihood capital endowment is used as a measure of the sustainability of rural households (Pandey et al., 2017c; Baffoe & Matsuda, 2018; Abbassi et al., 2020). This approach has gained much attention in the last couple of decades (Fang et al., 2014), and has been widely used by various world organizations (including, the World Bank, FAO, DFID, and UNDP) to study the socio-economic status of rural communities in developing countries (Ansoms & McKay, 2010; Abbassi et al., 2020; Huang et al., 2021). This study applies sustainable livelihood approach in the form of sustainable livelihood index to measure the total livelihood capital endowment of rural communities in the Migori River watershed. The livelihood situation of various watershed zones with varying environmental and socio-economic backgrounds is also compared. The findings of the study may assist relevant authorities to better target the local needs and prioritize their development policies.

Over the years, high population density (430 inhabitants per square kilometer) and recurrent environmental disasters including erosion, droughts, storm flows, and floods in the Migori River watershed, Kenya have adversely impacted livelihood opportunities, exacerbating poverty levels and driving households into chronic poverty (KNBS, 2019; Onyango et al., 2021; Opiyo et al., 2022a). The recognition of this situation and its potential to cause further resource degradation in this watershed by relevant government authorities has greatly increased in the last few years, with various rural development programs expected to be implemented to eradicate poverty among the communities in these areas. However, before such rural development programs can be implemented more generally in the watershed to improve the livelihood status of the communities, it is necessary to identify general priorities for development and the nature and types of policies that can be pursued to improve community livelihoods. In this context, it is important to understand the households' livelihood capitals of rural communities and the factors that lie behind their livelihood choices. This is where the main contribution of the present study lies.

Literature review: approaches and indices for livelihood sustainability analysis

Various approaches based on the Sustainable Livelihoods Framework (SLF) have been utilized to develop indices for comprehending diverse aspects related to the sustainability of rural community livelihoods. Quantification of the livelihood asset portfolio of households has emerged as the most widely used approach to comprehend the socio-economic status of rural communities in developing countries, with a multitude of indices based on this approach developed and applied worldwide to evaluate different aspects of livelihoods (Baffoe & Matsuda; Abbassi et al., 2020). For instance, Jansen et al. (2006) study implemented an index involving the quantification of households' asset portfolio to understand livelihood strategies of rural hillside areas in Honduras. Meanwhile, Berchoux and Hutton (2019) utilizing a quantitative indicator-based conceptualization of livelihood capitals at both community and household levels, showed that household physical capital is positively associated with household financial and social capitals but negatively associated with household natural capital. In Vietnam, Huang et al. (2021) applied a livelihood capital evaluation indicator system to understand the rural households' capital endowment in tourism regions and the factors that impact their livelihood choices. The findings indicated that households with more natural capital are less likely to choose livelihoods other than agriculture livelihood. In evaluating the factors that affect the sources of livelihoods of sweet potato and paddy growers in the Belagavi district of India, Jaganathan et al. (2019) quantified the livelihood capitals using the rural livelihood sustainable index. In Pakistan, Abbassi et al. (2020) constructed various asset indices to identify the endowment of livelihood assets and to assess their role in the adoption of livelihood strategies in the district Bhimber. The study pointed out that human capital has the strongest positive role to enable households to enter into more rewarding livelihood strategies. While these indices provided critical insights into the socio-economic status of the affected communities, their sole reliance on livelihood assets quantification may oversimplify the realities and nuances of rural communities' socio-economic status. As SLF shows, livelihoods are multidimensional in nature and are influenced by a wide range of factors beyond asset quantification, including access to markets, institutions, and socio-cultural dynamics. Neglecting these dimensions may limit comprehensiveness and applicability of the findings.

Indices based on the vulnerability context of the Sustainable Livelihoods Framework (SLF) have been developed to comprehensively assess multiple aspects of rural community livelihood sustainability, with the Livelihood Vulnerability Index (LVI) by Hahn et al. (2009) being a prominent example. The Livelihood Vulnerability Index (LVI) is an indicator-based tool that has been commonly used to evaluate the vulnerability of community/regional livelihoods to climate change impacts. The LVI is a composite index of specific components mapped onto the three IPCC contributing factors to vulnerability; exposure, sensitivity, and adaptive capacity (Hahn et al., 2009). In its first application in two villages in Mozambique, the developer established that the livelihood of one village was more confined by a physical limitation (water resources) whereas the other had extreme vulnerabilities in its socio-demography. The LVI provides a comprehensive assessment of livelihood vulnerability by incorporating multiple dimensions. It considers various aspects such as social, economic, and environmental factors, allowing for a more holistic understanding of vulnerability. Involving local communities and stakeholders in the process ensures that the index reflects their perspectives, priorities, and experiences, increasing its relevance and accuracy. On the flipside, the LVI, as a static index, may not fully capture the temporal dynamics of vulnerability. Vulnerability is often dynamic, influenced by factors such as seasonal variations, shocks, and long-term trends. The index may not adequately capture these temporal dynamics, limiting its ability to provide a nuanced understanding of vulnerability over time.

Another approach used by other studies is to explore the linkages between livelihoods and poverty through the use of indices. For instance, Ansom and Mckay (2010) study adopted a factor and cluster analysis approach to identifying how different livelihood profiles in rural Rwanda based upon asset portfolios differ with respect to the incidence of poverty and livelihood strategies. The study profiled seven household groups based on poverty dimensions of aggregate wealth, human resources, natural resources, quality of location, the centrality of location, and association networks; and respective poverty alleviation policies. Similarly, Berchoux et al. (2020) used a place-based model which identified 5 community types in rural Indian regions; exurban, agro-industrial, rainfed agriculture, irrigated agriculture, and resource periphery by clustering 3 types of community capitals (natural, social, and physical). Another Berchoux et al. (2019b) study in the same Indian region used a Rapid Rural Appraisal (RRA) approach to characterize the collective effects of two levels of livelihood capitals (household capitals and community capitals) on precarious agricultural employment as a measure of chronic rural poverty. The study demonstrated that common-pool resources and private assets do not have the same effect on agricultural livelihoods. Generally, these indices have been designed to deal with the fundamental needs of the poor, especially to solve food scarcity and starvation.

In understanding the socio-economic status and livelihood strategies of rural communities, the current study has embraced the widely accepted approach of quantifying the livelihood asset portfolio of households using an index, despite its discussed weaknesses. By expanding the types and number of variables or indicators evaluated through the index, the study attempts to overcome some of the limitations associated with the narrow focus on quantifiable assets. By incorporating additional dimensions such as access to markets, institutions, and socio-cultural factors, the study intends to provide a more comprehensive understanding of the sustainability of rural livelihoods. This expanded approach will allow for a more nuanced analysis of the socio-economic status and sustainability of rural communities, enabling a deeper exploration of the challenges, opportunities, and potential pathways for improving livelihood outcomes. Additionally, this approach simplifies the reporting on various complex aspects of livelihoods in a non-technical fashion that is easily understood by professionals, decision-makers, and the general public alike, making it easier to pinpoint the factors that contribute to or hinder the sustainability of rural livelihoods and prioritize watershed management programs and the development of interventions aimed at specific livelihood assets.

Methods

Overview of Migori River watershed

The Migori River watershed (Figure 1), hereafter referred to as the watershed, is located within Migori County in the Western Kenya region and covers approximately 2,597km^2 of land area. The entire watershed is found at an altitude of 1500 m above sea level. It enjoys an inland equatorial climate that is heavily influenced by its proximity to Lake Victoria. It receives mean annual rainfall in the range of 700 mm to 1800 mm with two wet seasons and two dry seasons. Average temperatures in the region range from 13^{0}C to 24^{0}C depending on the seasons. The major stream in the watershed, Migori River, originates from Chepalungu Forest in Emuria-Dikiri Sub-county of Narok County, from where it flows 70 km through Migori County and eventually empties into the Lake Victoria. Along its course, the Migori River is fed by several tributaries.

The watershed is generally classified into three regions/zones (JICA, 2014): the upstream (majorly covering Kuria West and East Sub-counties), the midstream (majorly covering Suna East and West Sub-counties), and the downstream (majorly covering Nyatike Sub-county), as illustrated in Figure 1. This classification/demarcation, as originally conducted by JICA (2014), is based on geographical characteristics whereby the three segments show distinct differences in channel geometry, typical microfacies, grain size, and geological process, of which, the channel geometry evolves from high-sinuosity upstream into moderate – low-sinuosity midstream and then into slight-sinuosity and even partially straight downstream. The upstream, midstream and downstream zones cover land areas of 1061.78, 914.36, and 622.23 km^2, respectively. The upstream zone of the Migori River watershed is mainly made up of highlands, hills and protected forest blocks; the midstream zone is generally gently sloping compared to the upstream region; and the downstream zone is a semi-arid region characterized by relatively slow water flow velocity and a lot of lateral erosion. In terms of land use/land cover, the upstream is dominated by extensive agricultural and deforestation practices, the midstream zone is mainly dominated by urbanization and agriculture, while the downstream region is dominated by mining and urban development activities.

Data collection process and analysis

A descriptive cross-sectional survey was conducted in the Migori River watershed between January and February 2022, covering households in the three watershed zones: upstream (majorly covering Kuria West and East Sub-counties), midstream (majorly covering Suna East and West Sub-counties), and downstream (majorly covering Nyatike Sub-county). The total sample size for the study was determined based on Fisher's formula:

$$n = \frac{\mathrm{NZ2P}(1-\mathrm{P})}{d2\ (N-1)\ +\ Z2\ P(1-P)}$$

Where n = required sample size, Z = 95% confidence interval

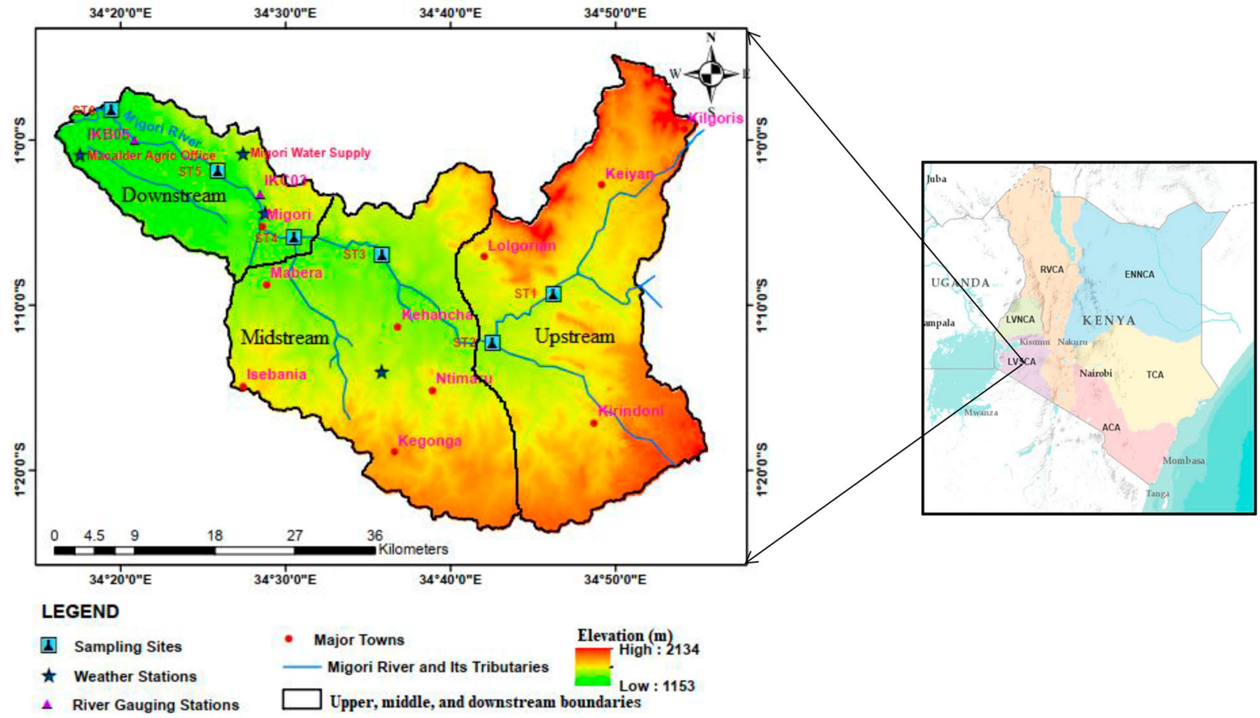

Figure 1. Location map of Migori River watershed, Kenya.

under the normal curve that is 1.96, $p = 0.5$ (proportion of the population to be included in the sample that is 50%), N = size of population (153,954 total no. of households in the watershed drawn from the five sub-counties), d = Margin of error or degree of accuracy (0.05). From this equation, a total sample size of 384 households was determined for the survey, which when split equally among the three zones would result in a sample size of 128 households per zone. The actual sample size per zone was however, reduced to 106 households in consideration of the financial constraints, available time resources, unexpected extreme weather events occurring during the planned sampling period, and inaccessibility of certain households in steep mountainous regions. The study employed equal sample sizes for the three watershed zones rather than unequal sample sizes (proportionally-distributed sample sizes) to avoid the two practical issues/problems that often occur when performing one-way ANOVA with unequal sample sizes: reduced statistical power, and reduced robustness to unequal variance (Parra-Frutos, 2013). The statistical power of a test that compares groups, that is the probability that a test will detect some effect when there actually is one, is highest when each group has an equal sample size (Parra-Frutos, 2013). Literature has shown that the greater the differences in sample sizes, the lower the statistical power of one-way ANOVA, which is why researchers typically want equal sample sizes so that they maximize statistical power and thus a greater probability of detecting true differences (Parra-Frutos, 2013; Shingala & Rajyaguru, 2015; Glen, 2022). Concerning robustness to unequal variance, studies show that unequal sample sizes can lead to unequal variances between samples, which affects the assumption of equal variances in tests like ANOVA (Rusticus & Lovato, 2014; Grace-Martin, 2021). Thus, having both unequal sample sizes and variances dramatically affects statistical power and type I error rates therefore making the results of one-way ANOVA hard to trust (Rusticus & Lovato, 2014).

The selection of the 106 respondent households per each watershed zone was obtained through a multi-stage sampling. In the first stage, administrative units called *divisions* within the various sub-counties located in the respective zones formed the clusters. In the second stage, sampled villages were purposively drawn from the randomly-selected clusters based on their proximity to the river, whereby those with households within 2–5 km from the river were chosen as they are the ones whose livelihoods are closely linked to the ecosystem functioning of the river system. In the third stage, a simple random sampling technique was used to select respondent households from within the chosen villages. Prior to the beginning of household survey activities, village elders and local administrative officials were consulted to explain the purpose of the study, understand the local livelihood realities (which helped in developing indicators and questionnaire items), and obtain permission to visit the selected households.

Household survey data was collected using interviewer-administered semi-structured questionnaires. The household questionnaires consisted of various questions designed to get information on indicators for the five livelihood capitals – natural, financial, human, physical, and social – outlined in Table 1. To ensure reliability of the questionnaire, we adopted a test re-test method in pre-testing whereby a repeat pre-test was conducted after one week among 35 household heads from Awendo Sub-county of Migori County (an area that was not included in the actual data collection for the main study), and Cohen's kappa statistic was used to measure the level of agreement of the results from the two pre-tests. Kappa coefficients were computed for categorical variables and intra-class correlation coefficients for continuous variables. Since the Kappa coefficients obtained after comparison were above 0.78 and intra-class coefficients ranged between 0.95 and 1.00, indicating a moderate to excellent reliability of the questionnaire based on the criteria by Landis and Koch

Table 1. Indicators for livelihood capital of rural households and their index measurement.

Livelihood Capital	Indicators	Source	Measurement Categories and Weighting
Natural Capital	Land holding size	Mumuni and Oladele (2016)	In acres
	Land fertility level	Mumuni and Oladele (2016)	Low = 0.33; moderate = 0.66; & high = 1
	Annual production of the principal staple food crop	Siraw et al. (2020)	In Kilograms
	Commercial agriculture (cash crops)	Siraw et al. (2020)	Yes = 1 and No = 0
	Livestock possession size	Siraw et al. (2020)	No. of heads
	Access to grazing pasture	Saini et al. (2014)	Yes = 1 and No = 0
	Distance to portable water	Siraw et al. (2020)	Walking duration (in minutes)
	Water quality of household drinking water point	Li et al. (2020)	Low = 0.33,moderate = 0.66 & high = 1
	Access to tangible forest resources	Ahmed et al. (2021)	Yes = 1 and No = 0
	Access to fishery resources	Ahmed et al. (2021)	Yes = 1 and No = 0
Human Capital	Educational attainment of household head	Siraw et al. (2020)	No formal education = 0; primary = 0.33; secondary = 0.66; tertiary (college/university) = 1
	Watershed conservation and development training	Siraw et al. (2020)	Yes = 1 and No = 0
	Labor force size	Li et al. (2020)	No. of family laborers (healthy adults)
	Technical skill level of laborers	Mumuni and Oladele (2016)	Low = 0.33,moderate = 0.66 & high = 1
	Daily nutritional intake level	Gupta and Sharma (2017)	Low (<3 meals per day) = 0.33; normal (3 meals per day) = 0.66; & high (> 3 meals per day) = 1
	General health status of the household	Created for this study	Low (half of HH members suffer from chronic illnesses) = 0.33; moderate (few HH members suffer from chronic illnesses) = 0.66; & high (no HH members suffer chronic illnesses) = 1
	Distance to the nearest medical facility Hahn et al. (2009)	Walking duration (in minutes)	
Financial Capital	Participation in off-farm activities	Siraw et al. (2020)	Yes = 1 and No = 0
	Participation in non-farm activities	Siraw et al. (2020)	Yes = 1 and No = 0
	Household monthly income	Siraw et al. (2020)	Amount in Kshs.
	Access to credit/loan services from lending institutions	Saini et al. (2014)	Yes = 1 and No = 0
	Ownership of savings accounts in financial institutions	Saini et al. (2014)	Yes = 1 and No = 0
	Annual household savings	Siraw et al. (2020)	Amount in Kshs.
	The financial value of available livestock	Li et al. (2020)	Amount in Kshs.
	The financial value of current standing crop	Li et al. (2020)	Amount in Kshs.
Physical Capital	Ownership of any transport means (bicycle, motorcycle or car)	Saini et al. (2014)	Yes = 1 and No = 0
	Ownership of any functioning communication devices (cell phone, radio, or TV)	Siraw et al. (2020)	Yes = 1 and No = 0
	House roof type	Siraw et al. (2020)	Iron roofing = 1 and Grass-thatch = 0
	Housing quality	Li et al. (2020)	Hut = 0.33, mud-walled house = 0.66 & brick-walled house = 1
	Possession of sanitary toilet	Abbassi et al. (2020)	Yes = 1 and No = 0
	Household cooking fuel	Chen et al. (2013)	Crop straws/cow dung = 0.25; Fire wood/charcoal = 0.5; LPG gas = 0.75; Electrical power = 1
	Household light source	Chen et al. (2013)	Candle = 0.25; Kerosene = 0.5; Solar power = 0.75; Electricity = 1
	Ownership of full farm equipment	Siraw et al. (2020)	Yes = 1 and No = 0
	Ownership of irrigation equipment (e.g. water pumps)	Mumuni and Oladele (2016)	Yes = 1 and No = 0
	Fertilizer use	Siraw et al. (2020)	Yes = 1 and No = 0
	Herbicides/pesticides use	Siraw et al. (2020)	Yes = 1 and No = 0
	Compost manure application	Siraw et al. (2020)	Yes = 1 and No = 0
	Improved seeds use	Siraw et al. (2020)	Yes = 1 and No = 0
	Possession of furniture (table, chair, bed, etc.)	Siraw et al. (2020)	Yes = 1 and No = 0
	Possession of a silo/storage facilities	Mumuni and Oladele (2016)	Yes = 1 and No = 0
Social Capital	Mutual trust and reliability of relatives	Ahmed et al. (2021)	High = 1 and Low = 0
	Support from the local administration	Siraw et al. (2020)	Yes = 1 and No = 0
	Relationship with neighbors (neigbouring communities)	Ahmed et al. (2021)	Worst = 0.25; Bad = 0.5; Good = 0.75; Very good = 1
	Extent of trust on community social relations	Gupta and Sharma (2017)	Low = 0.33,moderate = 0.66 & high = 1
	Membership in social organizations	Siraw et al. (2020)	Yes = 1 and No = 0
	Membership in WRUA/CFA	Siraw et al. (2020)	Yes = 1 and No = 0
	Participation in community barazas	Saini et al. (2014)	Yes = 1 and No = 0

(1977), all the questions were retained. To ensure validity, the questionnaire was shared and discussed with experts from relevant government departments/agencies, and the study supervisors. The feedback obtained from these experts and pre-testing results were used to make necessary adjustments in the questionnaire including eliminating inadequacies, irrelevance and ambiguities to ensure the questions were able to test what was intended.

During the exercise, the household questionnaires were administered to household heads (or other senior members of the selected households) by trained research assistants at the respondents' houses and farms, upon obtaining verbal consent. Cultural norms dictated that the male be interviewed as the head of the household unless absent then the spouse, or the next responsible adult (over 18 years of age) family member who understands the family and area well.

Each interview lasted about 35 min on average. The collected datasets were cleaned, edited, coded, and organized in MS Excel, and data analysis performed using SPSS version 24.0. The outputs are presented in tables and figures.

Livelihood sustainability index (LSI) calculation

Analysis of the sustainability of household livelihoods in the three zones of the Migori River watershed was conducted based on LSI developed by DFID. Since LSI uses indicators to measure the livelihood assets, a set of indicators under each livelihood asset (natural capital, financial capital, human capital, physical capital, and social capital) were developed based on the realities of livelihood conditions in the watershed as identified through reconnaissance field survey, and a thorough literature review to determine the functional linkages. The indicators considered under each livelihood capital, their sources, and their scales of measurement are shown in Table 1.

In creating an index that could capture all livelihood assets of the watershed households, different scaling and indexing approaches were used to make them comparable and enable purposeful interpretation. All the indicators were evaluated using rating scale methods with varying weights: for example, low, moderate, and high were interpreted as 0.33, 0.66, and 1 respectively; and two answer questions (yes or no responses) were weighted Yes = 1 and No = 0 (Table 1).

This weightage approach was based on the Muangkaew and Shivakoti (2005) indexing, where critical values are chosen to represent different degrees. The rest of the indicators were quantified in various measurement units that were suitable for them (Table 1).

To analyze the LSI for each of the three watershed zones, five major steps were followed. First, the weighting for each of the indicators with assigned weights was calculated depending on the design features of the questionnaire to obtain single values as follows: for example, indicators with two answer choices (Yes and No), the final indicator value (I) = Yes% x 1 + No% x 0; indicators with three answer choices e.g. erosion level (high, moderate, and low), the final indicator value (I) = High% x 1 + Moderate% x 0.66 + Low% x 0.33; and the same procedure was followed for indicators with four or more answer choices. Indicators without assigned weights such as those in the form of counts or ratios or averages, for example annual income, remain with their original values.

Secondly, since each indicator is measured on a different scale, standardization was necessary before the calculation of the livelihood indices (Phanxay et al., 2015). Therefore, the values of all the indicators were standardized to a scale between 0 and 1 using equation (1).

$$X_i = \left\{ \frac{S_z - S_{min}}{S_{max} - S_{min}} \right\} \tag{1}$$

where, X_i is the standardized value of the indicator; S_z is the actual value of the same indicator; and S_{min} and S_{max} are the minimum and maximum values, respectively, of the same indicator.

Third, after standardization of all indicators, the indicators under each livelihood capital were averaged using Equation (3) to obtain the value of each type of livelihood capital for the respective watershed zones.

$$LC = \left\{ \frac{\sum_{i=1}^{n} X_i}{n} \right\} \tag{2}$$

where, LC is the value of one of the five types of livelihood capitals (natural capital, financial capital, human capital, physical capital, and social capital) for each watershed zone; X_i is the standardized value of the indicator, that makes up each type of livelihood capital; and n is the total number of indicators in each type of livelihood capital.

Fourth, the overall livelihood asset score for each watershed zone was then calculated by averaging the values of the five livelihood capitals as follows:

$$LA = \left\{ \frac{NC + FC + HC + PC + SC}{5} \right\} \tag{3}$$

where, LA represents the livelihood asset score for each watershed zone; NC, FC, HC, PC, and SC are the respective values for natural capital, financial capital, human capital, physical capital, and social capital. In order to compare the mean differences in access to livelihood capital assets of the three watershed zones, the group comparison method using one-way ANOVA was applied following Donohue and Biggs (2015) and Siraw et al. (2020). The livelihood asset pentagon was drawn to illustrate the level of access to the capital assets among the watershed zones.

Finally, the LA scores for each watershed zone were transformed into percentages (by multiplying by 100) to generate the livelihood sustainability index which was then meaningfully interpreted using the rating scale system applied by Etana et al. (2021). This LSI scale ranges from 0% (Least sustainability) to 100% (Highest sustainability), and livelihood sustainability is classified as low (when LSI ranges from 0–33%), medium/moderate (when LSI ranges from 34–66%), and high (when LSI ranges from 67–100%).

Results and discussion

Household livelihood capitals

Natural capital

Natural capital describes the stock of natural resources from which ecological goods and services that sustain livelihoods are generated (Scoones, 2009). The study evaluated households' natural capitals using indicators that represent households' crop production, livestock production and access to land resources, grazing pastures, water resources, forest resources, and fishery resources (Table 2). The average households land holding size in the watershed zones was 2.91 acres; the highest size (3.02 acres) was at the downstream whereas the lowest one (2.76 acres) was at the upstream (Table 2). However, the variation in household land holding size among the three watershed zones was not statistically significant (Table 7). Based on farmers' responses (Table 2), soil fertility level was moderate in the two watershed zones (upstream and midstream) and high in the downstream. Generally, land fertility in the watershed zones was moderate, and the ANOVA statistical test confirmed that the difference in land fertility level among the watershed zones was not statistically significant ($p < 0.05$). This is in line with the findings of Shiluli et al. (2021) which showed that about 42% of farming households in this watershed experience soil fertility problems. The average households' annual production of the principal staple food crop (maize) in the watershed zones was 787kgs; the highest average annual maize production was observed at midstream (967kgs) while the lowest one (558kgs) was in the downstream (Table 2). However, this variation in households' average annual maize production among the three watershed zones was not statistically significant (Table 2). The current maize production estimates seem to be consistent with the 900Kgs (10 bags) average households' annual production reported for Migori County by Nyamohanga (2018). Further, the household survey revealed that three-quarters (75.49%) of respondents are not engaged in commercial agriculture, which should be an extra source of income for households. A comparison of the three watershed zones showed that commercial agriculture uptake in the upstream zone was significantly higher ($p < 0.05$; Table 7). In the other two watershed zones (midstream and downstream), about 21–22% of households are engaged in commercial agriculture. This finding is consistent with the conclusions of Otieno et al. (2013) that indicate that uptake of commercial agriculture is low in this region compared to other regions of Western Kenya.

The average number of livestock owned by the watershed households was 5.73 TLU (Table 2). The households in the upstream owned a greater number of livestock than the other two watershed zones (midstream and downstream) which had the almost same number of livestock possession (Table 2); however, this difference was not statistically significant ($p < 0.05$; Table 7). The ownership of large livestock sizes among the watershed households can be attributed to the availability of grazing pastures; as 100% of the upstream households, 95.18% of the downstream households, and 78.21% of the midstream households indicated that they have access to grazing pastures (Table 2). These findings are consistent with the previous studies by Makalle et al. (2008) and Yamane et al. (2015) which generally reported high livestock ownership in Western Kenya due to the high availability of pasture lands.

For water access, households have to walk for 15.23 min on average to reach their portable water source with significant differences between watershed zones ($p < 0.05$; Table 7). At the watershed level, the average distance traveled by households to reach a portable water source was 19.52, 13.27, and 12.91 min at the upstream, midstream, and downstream zones respectively (Table 2). These distances imply that the majority – if not all of the watershed households have no household-level water point. Moreover, the water quality of water sources utilized by watershed households was perceived to be high in the upstream, moderate in the midstream, and low at the downstream (Table 2). Perceptions on water quality was based on the respondents' observations and interactions with the resource, with classifications of low, moderate and high based on the three organoleptic properties (Doria, 2010), namely smell, taste and transparency. The variations in perceived water quality among the zones was found to be statistically significant by the ANOVA test ($p < 0.05$; Table 7). These perceptions on water quality is consistent with the results of limnological evaluation of Migori River, the primary drinking water source for the community, which indicated that the river's water condition is 'poor' due to physical impurities and bacteriological contaminants and that upstream has better water condition that gradually decreases toward the downstream (Opiyo et al., 2022b).

The majority of respondents (84.9%) had access to tangible forest resources with a significant difference between watershed zones ($p < 0.05$). Results (Table 2) indicate that 100%, 96.2% and 58.5% of the upstream, downstream and midstream households respectively had access to tangible forest resources (such as fuel wood, timber, medicinal substances, honey, and fruits). A study by Magige (2018) indicates that the upstream region (Kuria and Trans Mara sub-counties) has more gazetted forest blocks; the downstream region (Nyatike sub-county) has more households with private forest plantations due to non-governmental organization's efforts to curb the drought situation, and the midstream region (Suna sub-county) has more farms compared to the three zones which might be the reason for less forest coverage. Regarding access to fisheries resources, it was observed that a greater proportion of the downstream households (88.7%) were fishing or trading in fish resources compared with the upstream (52.8%) and midstream (32.1%); however, this difference was not statistically significant ($p < 0.05$; Table 7). The downstream region has the greatest proportion of fisher folks majorly because it is dominated by the Luo ethnic group who are historically known to be fisher folks and it is close to Lake Victoria hence greater access to fishery resources and opportunities.

Table 2. Survey responses on natural capital indicators.

		Watershed zones			
Indicators	Responses	Upstream	Downstream	Midstream	Total
Land holding size	In acres	2.76	2.99	2.98	2.91
Land fertility level	Low (%)	0.00	5.95	4.76	3.56
	Moderate (%)	98.82	35.72	88.10	74.31
	High (%)	1.18	58.33	7.14	22.12
Annual production of the principal staple food crop	In Kilograms	846	558	957	787
Commercial agriculture (cash crops)	Yes (%)	29.41	22.62	21.43	24.51
	No (%)	70.59	77.38	78.57	75.49
Livestock possession size (TLU)	TLU	6.34	5.33	5.53	5.73
Access to grazing pasture	Yes (%)	100.00	95.18	78.21	91.10
	No (%)	0.00	4.82	21.79	8.90
Distance to portable water	Minutes	19.52	12.92	13.27	15.24
Water quality of household drinking water point	Low (%)	6.60	51.90	43.46	26.17
	Moderate (%)	17.90	37.30	48.10	64.15
	High (%)	75.50	10.80	8.44	9.68
Access to tangible forest resources	Yes (%)	100.00	96.20	58.50	84.90
	No (%)	0.00	3.80	41.50	15.10
Access to fishery resources	Yes (%)	52.80	88.70	32.10	57.90
	No (%)	47.20	11.30	67.90	42.10

The overall measure of the natural capital showed that households in two watershed zones (upstream and downstream) have better access to natural capital compared to the midstream zone (Table 7). ANOVA test indicated that the variation in natural capital index between the three watershed zones was statistically significant ($p < 0.05$; Table 7). The limited access to tangible forest resources and fishery resources by the majority of households in the midstream could probably be some of the major reasons for low natural capital in that zone. The natural capital endowment of midstream households could improve to sustainable levels with policy measures that provide greater access to forest and fishery products. Policies could, for example, give financial and technical assistance to households to encourage the adoption of agroforestry on the available modest land sizes offering high returns and for the development of community-managed fishponds.

Although the natural capital endowment among the watershed households remains generally high (Table 7), its sustainability is still threatened by small household land holding sizes, relatively-low soil quality, and extremely-high dependence of the rural households on subsistence food production. Given the limited natural resource base of rural Kenya, it seems unrealistic for policy-makers to enhance access to land. However, poverty eradication policies could focus on enhancing access to soil improvement inputs (such as fertilizers, manure, etc.) to improve agricultural output, and enhancing incentives to encourage the adoption of commercial agricultural practices with higher rates of return. Nevertheless, the watershed households will need to be engaged in income-generating activities outside the agricultural sector. Therefore policies for enhancing incentives to engage in off-farm enterprises/employment should be considered by policymakers. Noteworthy, the natural capital is highly vulnerability to changes occasioned by climate variability and the occurrence of natural disasters like earthquakes, floods, and wildfires (Soulineyadeth, 2014); hence policies for greater resilience of the available natural resources against these factors are warranted (Morse & McNamara, 2013).

Human capital

This capital represents the quantity of physical capability as well as the intellectual quality of labor resources (like knowledge and skills) that allows people to profit from economic opportunities (Oduro et al., 2015; Khuzwayo, 2016). The study explored households' human capital by employing metrics that measure households' knowledge, skill level, and access to information (Table 3). The study evaluated the respondent's level of educational attainment as an indicator that represents their knowledge and skillset level and about 23% of the household heads had post-secondary education (college or university), while 25.5% had attained secondary education, another 23% had primary education and 28% had no formal education (Table 3). At the watershed level, the mean educational attainment index was higher at the upstream (0.53) compared to the midstream (0.47) and the downstream (0.44); however, ANOVA confirmed that variation was not statistically significant at $p < 0.05$ (Table 7). This implies that access to education in the watershed is relatively similar, which contrasts with the Kenya 2019 Census (KNBS, 2019) results which show that the Suna Sub-county (midstream) has higher educational attainment among household heads, followed by Nyatike Sub-county (downstream) and then Kuria Sub-county (upstream). The reason for this disparity could be attributed to the study concentrating around the watershed boundaries, which usually don't follow administrative boundaries that are normally used in census. Generally, access to education in Migori County under which the watershed is located has been previously reported to be at par with the national average (UNICEF, 2017). Community-based training has been proven to be valuable in transmitting technical knowledge aimed at enhancing livelihoods to protect fragile ecosystems like watersheds (Palanisami & Kumar, 2009). Over three-quarters of household heads in the upstream and the downstream zones had received various watershed conservation and development training compared to about 63% of household heads in the midstream zone (Table 3), with significant differences between watershed zones (Table 7). An interview with one of the community leaders revealed that these trainings are offered by various conservation groups (water resource users associations and community forest associations) which are sponsored and have been trained by various NGOs and county government departments. The insights obtained from such trainings have the potential to greatly improve household livelihoods while also enhancing watershed conservation (Siraw et al., 2020).

Table 3. Survey responses on human capital indicators.

Indicators	Responses	Watershed zones			
		Upstream	Downstream	Midstream	Total
Educational attainment of household head	No formal education (%)	20.80	26.40	36.80	28.00
	Primary (%)	26.40	30.20	12.30	23.00
	Secondary (%)	26.40	26.40	23.60	25.50
	Tertiary (%)	26.40	17.00	27.40	23.60
Watershed conservation or development training	Yes (%)	86.80	90.60	63.20	80.20
	No (%)	13.20	9.40	36.80	19.80
Family labor force size (household healthy adults)	Count	3.76	3.69	3.80	3.75
Technical skill level of laborers	Low (%)	9.40	14.20	21.70	15.10
	Moderate (%)	54.70	30.20	67.00	50.60
	High (%)	35.80	55.70	11.30	34.30
Daily nutritional intake level	Low (%)	0.00	23.60	24.50	16.00
	Normal (%)	98.10	66.00	72.60	78.90
	High (%)	1.90	10.40	2.80	5.00
General health status of the household	Low (%)	1.90	27.40	16.00	15.10
	Moderate (%)	33.00	52.80	67.90	51.30
	High (%)	65.10	19.80	16.00	33.60
Distance to the nearest medical facility	Minutes	21.37	11.68	30.44	21.16

The average households' labor force size (number of adult working family members) in the watershed zones was 3.74 persons (Table 3). At the watershed level, the mean family labor force index was higher at the midstream (0.56) compared to the upstream (0.44) and the downstream (0.34); however, ANOVA confirmed that variation was not statistically significant (Table 7). The technical skill level of households' labor force was moderate in the two watershed zones (upstream and midstream) and high in the downstream (Table 3). However, ANOVA found no significant difference in the technical skill level of family laborers among the watershed zones ($p < 0.05$; Table 7). The majority of households in the watershed had a normal level of daily nutritional intake; 98.1% of the upstream households, 72.6% of the midstream households, and 66% of the downstream households reportedly take 3 meals a day. Unfortunately, about a quarter of households in both the midstream and the downstream zones reportedly had low daily nutritional intake levels (i.e. less than 3 meals a day). This variation in daily nutritional intake was found to be statistically significant ($p < 0.05$; Table 7). This can be attributed to the erratic precipitation patterns in the lower parts of Migori County coupled with high drought prevalence (Ayugi et al., 2016), all of which contribute to reduced agricultural productivity.

In terms of households' health status (Table 3), about 84% of households in the watershed had better health status (51.3% moderate and 33.6% high health status). At the watershed level, over half of the households at the midstream and the downstream had moderate health status (less than half of the household members suffer from chronic illnesses) while two-thirds of households in the upstream had high health status (no household member suffering from chronic illnesses); however, this variation was not statistically significant (Table 7). The survey further revealed that the average distance traveled by households to reach the nearest medical facility was 30.44, 21.37, and 11.68 min at the midstream, upstream, and downstream watershed zones respectively (Table 3), with ANOVA, indicating significant differences between watershed zones ($p < 0.05$; Table 7).

The overall human capital index was higher in the upstream zone than in the midstream and downstream zones (both of which had nearly similar index values) (Table 7). However, this difference was not statistically significant (Table 7). The lower human capital index at the two watershed zones was due to lower levels of health status and longer distances to health facilities as compared to the households in the upstream zone. Improved quality and availability of public health centers could work to upgrade the human capital endowment of these two zones to be at par with that of the upstream zone.

Of the five livelihood capitals, the results showed that human capital is the second least possessed asset by the rural households in the watershed. This should gravely concern policy-makers because human capital is crucial in supporting other livelihood assets (Shah et al., 2013), and therefore to attain a positive livelihood outcome, it is vital to have adequate human capital (Altasseb, 2021). Enhanced access to better education, information, innovations, training, and good health and nutrition can all help to increase this type of capital (Hautala, 2013; Khuzwayo, 2016). While improved access to education might only benefit the next generation of household heads in the long term (because it's not practical to formally educate or re-educate the current household heads in the watershed), providing skills training to household heads on alternative livelihood options might help enhance human capital in both short and long terms. The households in the watershed have the potential for benefitting from these trainings, given their already considerable access to trainings offered by various conservation groups as revealed by the results. Policymakers could draw lessons from the already existing watershed conservation trainings to help formulate strategies that incentivize greater and more effective participation in the skillset trainings. The ILO (2014) intimates that poverty is intimately linked to poor education and insufficient skills; as a result, the availability and quality of education, as well as skill acquisition, must be prioritized in rural communities.

Financial capital

There are two key sources of financial capital: accessible stocks, such as bank savings, hard cash, credit supplies, or liquid assets such as farm equipment and cattle that aren't tied to liabilities and are not reliant on third parties; and continuous inflows of income, such as wages, salaries, retirement benefits, or any other government transfers, as well as remittances that are largely dependent on third parties, and must be reliable (Alhassan, 2010; Morse & McNamara, 2013). The study employed 8 indicators to measure the financial capital in the watershed zones (Table 4). The average monthly income of households in the watershed zones was approximated to be 10,856 Kshs. The upstream (Kshs 12,566) had the highest monthly household's income, followed by the midstream (Kshs 11,785), while the downstream (Kshs 8,216) had the lowest. This difference in annual mean households' income among the watershed zones was found to be statistically significant (Table 7). Based on the household survey responses (Table 4), the average financial value of the current standing crop was highest in the midstream (Kshs 74,074) followed by the upstream (Kshs 56,158) and lowest at the upstream (Kshs 43,621), and ANOVA showed that this variation between watershed zones was statistically significant (Table 7). On the other hand, the average financial value of available livestock was greater at the upstream than at the midstream and the upstream (both of which had nearly similar amounts), and ANOVA showed that this variation between watershed zones was not statistically significant (Table 7). The average annual household savings was greater in the midstream (Kshs 91,583) compared to the downstream (Kshs 87,500) and the upstream (Kshs 47,564), and ANOVA showed this variation between watershed zones was statistically significant (Table 7). Access to credit services and savings services was highest at the downstream (59.4% and 63.2% respectively), followed by the midstream (52.8% and 51.9% respectively), and lowest at the upstream (36.8% and 36.8% respectively). The study found that the variation in both access to credit services and access to savings services among watershed zones was not statistically significant at $p < 0.05$ (Table 7).

Apart from crop production, the high annual income and annual saving levels observed among the watershed zones were supported by participation in non-farm activities rather than off-farm activities, as results show that 66.7 and 45.3 percent of watershed households, respectively, engage in these income-generating activities (Table 4). Evidently, participation in non-farm activities was highest in the downstream and lowest in the upstream (Table 4) with

Table 4. Survey responses on financial capital indicators.

Indicators	Responses	Watershed zones Upstream	Downstream	Midstream	Total
Participation in off-farm activities	Yes (%)	32.10	64.20	39.60	45.30
	No (%)	67.90	35.80	60.40	54.7
Participation in non-farm activities	Yes (%)	55.70	76.40	67.90	66.70
	No (%)	44.30	23.60	32.10	33.30
Household monthly income	Amount in Kshs.	12566.04	8216.98	11785.38	10856.13
Access to credit/loan services	Yes (%)	36.80	59.40	52.80	49.70
	No (%)	63.20	40.60	47.20	50.30
Ownership of savings accounts in financial institutions	Yes (%)	36.80	63.20	51.90	50.60
	No (%)	63.20	36.80	48.10	49.40
Annual household savings	Amount in Kshs.	47564.10	87500.00	91583.64	75549.25
The financial value of available livestock	Amount in Kshs.	206187.00	136857.00	139917.00	160987.00
The financial value of the current standing crop	Amount in Kshs.	56158.30	43621.21	74074.23	57951.25

significant statistical differences between watershed zones (Table 7). High participation in non-farm activities in the downstream zone could be due to the thriving gold mining business there which its residents participate in. On the other hand, participation in off-farm activities was generally low in both the upstream and the midstream and only higher among households in the downstream zone, and the difference between watershed zones was not statistically significant at $p < 0.05$ (Table 7).

The financial capital measurement revealed that the midstream and the downstream had better financial endowment compared to the upstream zone. The overall financial capital index was highest at the midstream (0.57), followed by the downstream (0.52), while lowest at the upstream (0.44) (Table 7). The variation in mean household financial capital between the watershed zones was found to be statistically significant (Table 7). The financial capital index was generally low across the watershed zones, which is a reflection of the depth of household poverty (Alhassan, 2010).

In comparison to the other livelihood assets, the results of the study indicated that financial capital is the least possessed asset by the rural households in the Migori River watershed hence a major contributor to the chronic poverty conditions. This is consistent with previous studies that concluded that this capital, which has the potential to replace other capitals, is the least accessible asset for the poor, and therefore its inadequacy in a household is a factor that reflects the depth of household poverty (Alhassan, 2010; Chirau, 2012). Studies show that financial capital is the most preferred form of capital since it can be quickly converted to other capital or employed directly in purchasing household consumption (Scoones, 2009; Alhassan, 2010; Chirau, 2012). Improving access to the financial safety net for watershed households would require policies that especially focus on strengthening rural entrepreneurship and better access to insurance and credit facilities. Policymakers could capitalize on the considerable social capital that these households already hold to achieve these objectives. About 91% to 95% of the surveyed households participate in some form of association (Table 6). Therefore, there's a potential to improve access to off-farm small-scale enterprises/employment through collective action. Associations could facilitate access to start-up credit and networks could provide households with outlets for their products and services as well as opportunities for finding non-agricultural employment. The livelihoods of the households could be enhanced with policy measures that provide a lever to the initiatives taken by the associations themselves. For instance, policies could provide financial and technical assistance to associations to encourage the adoption of new techniques that could increase household farm and livestock production for the market, and for the development of off-farm entrepreneurial activities. Additionally, appropriate policies could encourage associations to form cooperatives within which they are active agents as this will improve their positions in price negotiations which in turn may promote a more entrepreneurial spirit amongst farmers.

Physical capital

This capital comprises primary infrastructure and production instruments required to sustain livelihoods (Makhetha, 2010). The infrastructural components include cost-effective transport system, safe residential buildings, sufficient hygiene and clean water supply, clean and economical energy, health care facilities, and accessible telecommunication systems while production equipment includes farm machinery, commodities, and household goods, etc. (Morse & McNamara, 2013; Khuzwayo, 2016). In measuring the household's physical capital in the watershed zones, the study used several indicators (Table 5). From the results (Table 5), about three-quarters of respondents (78.49%) in the watershed owned iron-roofed houses with no statistically significant differences ($p < 0.05$) between watershed zones (Table 7). A large proportion of the houses owned by the respondents, that is over 70% in each watershed zone, were mud-walled (Table 5), with no statistically significant differences ($p < 0.05$) between watershed zones (Table 7). Nearly all of the sampled households (95.28%) possessed furniture (chairs, tables, and beds) that was adequate for their household needs, and no statistically significant differences ($p < 0.05$) was found between watershed zones (Table 7). All households (100%) owned food storage facilities, with no significant difference across the watershed zones (Table 5). Over 90% of households in each of the three watershed zones possessed a sanitary latrine, and the variation across the watershed zone was not significantly different ($p < 0.05$). In over half of the watershed households (55%), firewood was the main source of cooking energy. Firewood was utilized by 74.5% of the upstream households, 49.1% of the midstream households, and 41.5% of the downstream households; however, the variation across the watershed was not statistically significant (Table 7). The dominant source of light in the upstream and the midstream was solar power utilized by 53.8% and 60.4% respectively, whereas in the downstream it was kerosene which was utilized by close to half of the sampled households (46.6%). The variations in the utilization of various sources of light across watershed zones were found to be statistically significant (Table 7).

Table 5. Survey responses on physical capital indicators.

Indicators	Responses	Watershed zones			
		Upstream	Downstream	Midstream	Total
Ownership of any transport means (bicycle, motorcycle, or car)	Yes (%)	14.40	10.40	25.50	15.40
	No (%)	85.60	89.60	74.50	84.60
Ownership of any functioning communication devices	Yes (%)	91.50	88.70	87.70	89.30
	No (%)	8.50	11.30	12.30	10.70
House roof type	Iron roofing (%)	81.10	67.37	94.00	78.49
	Grass-thatch (%)	18.90	32.63	6.00	21.51
Housing quality	Hut (%)	17.50	7.50	10.90	5.30
	Mud-walled house (%)	64.80	72.60	77.20	71.10
	Brick-walled house (%)	17.70	29.90	11.90	23.60
Possession of sanitary toilet	Yes (%)	96.20	90.60	95.30	94.00
	No (%)	3.80	9.40	4.70	6.00
Household cooking fuel	Crop straws/cow dung (%)	0.00	18.90	14.20	11.00
	Fire wood/charcoal (%)	74.50	41.50	49.10	55.00
	LPG gas (%)	25.50	4.70	8.50	12.90
	Electrical power (%)	0.00	34.90	28.30	21.10
Household light source	Candle (%)	1.90	3.90	2.37	5.19
	Kerosene (%)	37.50	46.60	31.53	36.60
	Electricity (%)	6.80	8.10	5.70	11.01
	Solar Power (%)	53.80	41.40	60.40	47.20
Ownership of full farm equipment	Yes (%)	84.91	41.12	61.32	61.94
	No (%)	15.09	58.88	38.68	38.06
Ownership of irrigation equipment (e.g. water pumps)	Yes (%)	18.87	26.42	14.75	33.33
	No (%)	81.13	73.58	85.25	66.70
Fertilizer use	Yes (%)	58.10	42.62	65.29	44.96
	No (%)	41.90	57.38	34.71	55.04
Herbicides/pesticides use	Yes (%)	31.41	23.81	34.52	39.41
	No (%)	68.59	76.19	65.48	60.59
Compost manure application	Yes (%)	67.82	39.62	55.71	43.77
	No (%)	32.18	60.38	44.29	56.23
Improved seeds use	Yes (%)	65.84	79.76	57.95	66.73
	No (%)	35.16	20.24	42.05	33.27
Possession of furniture (table, chair, bed, etc.)	Yes (%)	99.06	86.79	100.00	95.28
	No (%)	0.94	13.21	0	4.72
Possession of silos/storage facilities	Yes (%)	100	100	100	100
	No (%)	0	0	0	0

Since access to information is an important part of livelihood, the survey revealed that over 80% of households in each of the three watershed zones had at least one functional communication device (such as radio, TV, and phones). However, the study found no significant variation in ownership of a functional communication device among the watershed zones (Table 5). Less than one-fifth households in each watershed zone, owned some type of transport means (bicycle, motorcycle, car, or ox-drawn cart), and there was a statistically significant difference among the watershed zones (Table 7).

About 61% had full farm equipment (implements used to cultivate crops) with no significant differences among watershed zones. Only a third of the study respondents owned irrigation equipment (especially water pumps) for pumping water from the rivers/streams to the adjacent farms, and the majority of these respondents (84.9%) were located in the upstream, followed by the midstream and finally the downstream (Table 5). A significant difference ($p < 0.05$) across the watershed zones in terms of ownership of irrigation equipment was revealed by the ANOVA test (Table 7). As illustrated in Table 5, over two-fifths of the respondents (44.96%) utilize fertilizers (such as Urea, DAP) to boost the fertility of their farms. The percentage of households who utilize chemical fertilizers was significantly higher in the midstream (65.29%) in comparison to households in the upstream (58.15%) and the downstream (42.62%) (Table 5). Although these estimates are a bit lower than the estimates provided by Shiluli et al. (2021) which show that 86% of households in the entire Migori County are using fertilizers, they still show high usage which could be attributed to the moderate soil fertility level reported by the respondents. The majority of the respondents, over three-fifth of the households, had used improved seeds, and there were significant differences between watershed zones ($p < 0.05$; Table 7).

Therefore there seems to be less dependence on local seeds among the watershed farmers, which is consistent with the conclusions of Shiluli et al. (2021) that most farmers in the region are increasingly taking up fertilizing. Contrarily, only a few households (about two-fifth of the total sample) reportedly apply herbicides/pesticides to their croplands, and there was no significant difference between watershed zones ($p < 0.05$; Table 7). The proportion of households using herbicides/pesticides on their farms was relatively similar among the three watershed zones (Table 5). In the last planting season of 2021, close to a half of the watershed households (43.77%) reportedly prepared and applied compost manure on at least one part of their farm to boost soil fertility, but the level of utilization significantly varied ($p < 0.05$) among watershed zones (Table 7). This implies that manure application is also a key soil management strategy in the watershed.

The overall physical capital index showed that the upstream and the midstream had the same level of households' access to physical capital, which was a little higher than the level of access at the downstream. But, the variation in physical capital index between the watershed zones was not statistically significant at $p < 0.05$ (Table 7). The ownership of full farm equipment and the usage of herbicides/pesticides or fertilizers by a large number of households in the upstream and midstream compared to the downstream could probably be some of the major reasons for low physical capital in the downstream zone. Therefore, policies focusing on enhancing access to farm equipment (especially irrigation equipment like water pumps) and chemical farm inputs (especially fertilizers and pesticides) could be implemented to improve the physical capital endowment of households in the downstream zone. The provision of communal irrigation equipment for pumping water from the rivers/streams to the adjacent farms may help increase agricultural output in this drought-stricken zone.

Physical capital endowment among the households in the study area was relatively higher in comparison to the other livelihood assets (Table 7), generally making it one of the two most possessed in the watershed. This offers great potential for livelihood improvement in the watershed because physical capital (just like human capital) is one of the two most important elements for poverty alleviation due to its capacity to spur production (Sen, 2003; Kamaghe et al., 2014). There is, however, a crucial physical capital factor for this watershed that remains a challenge to sustainability; high dependence on firewood and kerosene for cooking and lighting purposes, respectively. Destruction of forests for firewood and extraction and burning of petroleum products like kerosene are triggers for climate change which is a threat to future livelihoods (and lives). Hence, relevant policy-makers may need to concentrate on enhancing incentives for rural households to adopt alternative renewable energy sources for cooking and lighting. Another key threat to physical capital sustainability is the extremely low ownership of some type of transport means among households. Given the limited financial resource base of rural Kenya, it seems unrealistic for policy-makers to enhance access to household ownership of transport means. However, as a first step, rural poverty eradication policies could focus on improving road infrastructure networks to facilitate household access to local markets through public service vehicles. Better linkages to the trade chain could facilitate access to production inputs and outputs and could spur a more market-oriented production mode. Improved infrastructure lowers production costs and increases investment in both agro-based and other sectors (Altasseb, 2021).

Social capital

This is developed through social networks and connectedness (that enhance their trust and ability to collaborate and increase their access to a broader range of organizations); membership and participation in a formal organization operating under a system of mutually agreed rules and regulations; and relationships of trust that enhance cooperation, lower transaction costs, and may serve as the foundation for unstructured safety nets among the impoverished (DFID, 2002; Altasseb, 2021). The study employed 7 indicators to measure the social capital in the watershed zones (Table 6). The study findings revealed a high level of households' membership (91% to 95%) in various social organizations. These organizations play a critical role in establishing and strengthening bonds of social obligation, reciprocity, solidarity, and mutual assistance, all of which play a key role, particularly during shocks, hardships, and periodicity (Morse & McNamara, 2013). Participation in social organizations seems to be lowest in the downstream (91.5%) and highest in the midstream (95.6%), but there was no statistically significant difference across the three zones. On the other hand, households' membership in conservation groups (WRUAs and CFAs) was lower in all three watershed zones. The highest membership was observed at the midstream (37.2%) and the lowest was observed at the upstream (17%), and the difference in household's membership in conservation groups between the watershed zones was statistically significant at $p < 0.05$ (Table 7). Participation in community barazas was generally high in all the watershed zones, with over 80% of households in each zone reportedly participating in these barazas (Table 6).

Participation in barazas was higher in the midstream (92.5%) as compared to the downstream (87.7%) and the upstream (81.5%), and ANOVA showed no significant difference in barazas participation across the watershed zones. The level of trust in community social relations was generally high in the upstream and midstream as reported by 97.2% of households respectively while in the downstream it was reported to be moderate (47.2%). However, no significant difference was observed between the three watershed zones. In the upstream and the downstream, the majority of households (81.2% and 90.6% respectively) indicated high mutual trust and reliability of relatives while in the midstream the level of mutual trust and reliability of relatives was equally rated high and low by the households; ANOVA confirmed that significant difference ($p < 0.05$) exist between the watershed zones. Concerning the relationship with neighbors, both the downstream (0.81) and the midstream (0.84) recorded high index scores compared to the extremely low score recorded by the upstream (0.59), with no

Table 6. Survey responses on social capital indicators.

Indicators	Responses	Watershed zones			
		Upstream	Downstream	Midstream	Total
Mutual trust and reliability of relatives	High (%)	81.20	90.60	49.10	79.90
	Low (%)	18.80	9.40	50.90	20.10
Support from local administration	Yes (%)	14.29	9.40	48.10	20.11
	No (%)	85.71	90.60	51.90	79.89
Relationship with neighbors	Bad (%)	43.10	2.80	9.40	10.90
	Good (%)	34.70	49.10	28	31.10
	Very good (%)	22.20	48.10	62.60	58.00
Extent of trust on community social relations	Low (%)	0.00	10.40	6.60	5.70
	Moderate (%)	2.80	2.80	47.20	17.60
	High (%)	97.20	86.80	46.20	76.70
Membership of social organizations	Yes (%)	93.84	91.50	95.30	95.60
	No (%)	6.16	8.50	4.70	4.40
Membership of WRUA/CFA	Yes (%)	17.00	29.60	37.20	31.34
	No (%)	83.00	70.40	62.80	68.66
Participation in community barazas	Yes (%)	81.50	87.70	92.50	83.40
	No (%)	18.50	12.30	7.50	16.60

Table 7. Mean index of indicators and comparisons of significant differences between watershed zones.

	Mean Index		One-way ANOVA		
Indicators	Upstream	Downstream	Midstream	F Value	*p*
Land holding size	0.19	0.25	0.24	0.113	0.894
Land fertility level	0.66	0.84	0.67	2.112	0.595
Annual production of principal staple food crop	0.57	0.42	0.54	0.142	0.069
Commercial agriculture (cash crops)	0.29	0.23	0.21	3.182	0.018*
Livestock possession size (TLU)	0.87	0.73	0.76	0.547	0.948
Access to grazing pasture	1.00	0.95	0.78	0.294	0.911
Distance to portable water	0.40	0.29	0.30	4.191	0.006*
Water quality of household water point	0.89	0.53	0.55	3.566	0.024*
Access to tangible forest resources	1.00	0.96	0.59	6.418	0.002*
Access to fishery resources	0.53	0.89	0.32	1.263	0.318
Natural Capital	**0.64**	**0.61**	**0.50**	**7.101**	**0.031***
Educational attainment of household head	0.53	0.44	0.47	0.445	0.086
Watershed conservation and development training	0.87	0.91	0.63	13.201	0.019*
Labor force size	0.44	0.34	0.56	0.366	0.071
Technical skill level of laborers	0.75	0.80	0.63	0.092	0.913
Daily nutritional intake level	0.67	0.62	0.59	7.724	0.000*
General health status of the household	0.88	0.64	0.66	3.192	0.087
Distance to nearest medical facility	0.42	0.30	0.33	0.183	0.007*
Human Capital	**0.65**	**0.58**	**0.55**	**0.742**	**0.459**
Participation in off-farm activities	0.37	0.64	0.40	0.571	0.579
Participation in non-farm activities	0.56	0.76	0.68	3.144	0.032*
Household monthly income	0.15	0.09	0.14	5.392	0.002*
Access to credit/loan services	0.47	0.59	0.53	2.084	0.920
Ownership of savings account	0.37	0.63	0.52	0.393	0.684
Annual household savings	0.09	0.10	0.25	8.659	0.013*
Financial value of available livestock	0.82	0.73	0.96	0.114	0.893
Financial value of current standing crop	0.69	0.60	1.07	2.573	0.001*
Financial Capital	**0.44**	**0.52**	**0.57**	**13.097**	**0.008***
Ownership of any transport means	0.14	0.10	0.26	3.141	0.000*
Ownership of any functioning communication devices	0.92	0.89	0.88	0.382	0.537
House roof type	0.81	0.67	0.94	2.160	0.154
Housing quality	0.66	0.70	0.66	0.307	0.633
Possession of sanitary toilet	0.96	0.81	0.95	2.056	0.096
Household cooking fuel	0.56	0.64	0.63	1.526	0.374
Household light source	0.78	0.72	0.81	21.023	0.026*
Ownership of full farm equipment	0.85	0.41	0.61	0.683	0.524
Ownership of irrigation equipment	0.19	0.26	0.15	4.496	0.022*
Fertilizer use	0.58	0.43	0.65	6.256	0.041*
Herbicides/pesticides use	0.31	0.26	0.35	0.123	0.885
Compost manure application	0.68	0.50	0.56	10.152	0.015*
Improved seeds use	0.66	0.80	0.58	9.156	0.001*
Possession of furniture (table, chair, bed, etc.)	0.99	0.87	1.00	0.336	0.605
Possession of silo/storage facilities	1.00	1.00	1.00	0.847	0.053
Physical Capital	**0.67**	**0.60**	**0.67**	**2.322**	**0.197**
Mutual trust and reliability of relatives	0.81	0.91	0.49	9.495	0.033*
Support from local administration	0.14	0.09	0.48	3.067	0.034*
Relationship with neighbors	0.59	0.81	0.84	0.194	0.826
Extent of trust on community social relations	0.99	0.92	0.80	0.210	0.931
Membership of social organizations	0.94	0.92	0.95	1.753	0.217
Membership of WRUA/CFA	0.17	0.30	0.37	5.735	0.0425*
Participation in community barazas	0.82	0.88	0.93	0.724	0.076
Social Capital	**0.64**	**0.69**	**0.69**	**2.013**	**0.987**
LSI	**0.61**	**0.60**	**0.62**	**0.396**	**0.714**

Note: * indicates significant difference ($p < 0.05$).

significant difference between the three watershed zones (Table 7). This implies that the upstream and the midstream communities enjoy better relationships with other neighboring communities as compared to the upstream which usually faces the challenge of cattle rustling by the neighbouring communities. Lastly, very few households in

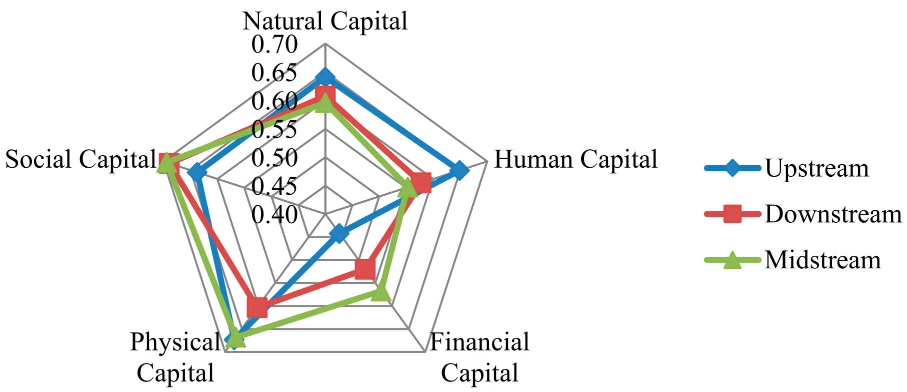

Figure 2. Livelihood capital variations across watershed zones.

the upstream (14.29%) and downstream (9.4%) reported that they got sufficient support from the local government administration (county government) in various activities including the enforcement of laws and implementation of community development programs. This was however different from the midstream where almost half of the households (48.1%) reported that they got support from the local administration. The study noticed a significant variation ($p < 0.05$) in the access to local administration's assistance among the watershed zones (Table 7).

The social capital index of the watershed households was generally high among the watershed households. The downstream and the midstream both had the same social capital index, which was higher than the one for the upstream (Table 7). The variation in the social capital index between the watershed zones was not statistically significant at $p < 0.05$ (Table 7). The low social capital of the upstream is attributable to the low support from local administration and the negative relationship with neighbors as observed in the study. It should be noted that the Kuria tribe which occupies the entire upstream section has been historically marginalized due to their small population and unique socio-cultural practices, and this not only denies them equitable access to governmental support but also breeds animosity between them and the neighboring communities especially the Maasai who frequently steal their cattle herds. Therefore, policies are needed to curb this marginalization.

Generally, in comparison to the other livelihood assets, the study results indicated that social capital is the most possessed asset by the rural households in the Migori River, which is commendable since the access and management of other types of capital are directly influenced by the social capital (Chirau, 2012). People can use social capital to obtain loans, childcare, meals, housing, and information about jobs and opportunities through mobilizing relationships of cooperation and reciprocity that exist within and across households, close relatives, and communities (Chirau, 2012; Hautala, 2013). Many households in most countryside settings, peri-urban, and occasionally metropolitan communities are often interconnected by bonds of social obligation, reciprocity, solidarity, and mutual assistance, all of which play a key role, particularly during shocks, hardships, and periodicity (Morse & McNamara, 2013).

Livelihood sustainability index (LSI)

The SLI for each watershed zone was determined based on the individual indices for the five livelihood capitals (natural capital, human capital, financial capital, physical capital, and social capital). The distribution of the individual scores for the five livelihood capitals among the three watershed zones is shown in a spider diagram (Figure 2) with a scale ranging from 0 (least livelihood asset level) to 1 (most livelihood asset level). Aggregated values of the livelihood assets for the entire watershed, shows that social capital had the highest index values (ranging from 0.64 to 0.69), and physical capital had moderately high index values (ranging from 0.60 to 0.67), followed by natural capitals (0.60–0.64). Human capital (0.55–0.65) and financial capital (0.44–0.57) recorded relatively low index values, which imply that they were the least possessed assets by the rural households in the watershed. The low levels of financial and human capitals could potentially hinder the watershed households from respectively developing the necessary infrastructure and increasing farm or non-farm productivity; as a result, achieving livelihood diversification becomes more challenging.

The LSI estimates for the upstream, midstream, and downstream were 0.61, 0.62, and 0.60, respectively, with no significant differences across the watershed zones. On the rating criteria, these values indicate that the livelihoods of all the three watershed zones are moderate sustainability. Even though there were no substantial variations between watershed zones, the total LSI was highest in the midstream zone and lowest in the downstream zone, indicating that the livelihoods of midstream households are the more sustainable followed by the midstream households and the downstream households (Table 7). The livelihoods of upstream and midstream zones are most sustainable (because they possess high physical, social, and natural capitals) while the livelihoods of the downstream are least sustainable probably because they are prone to natural disasters like floods and droughts. Moderate sustainability level suggests that household heads within the watershed have limited access to natural resources (especially quality and adequate land), formal education, income-generating opportunities, credit services, and physical property.

Generally, the overall LSI (0.61) calculated for this study is slightly higher than the LSI values of 0.43–0.52 for rural households from three conserved micro-watersheds in the northwestern highlands of Ethiopia (Siraw et al., 2020), 0.357–0.503 for rural households in agro-ecological zones of Central Ethiopia (Etana et al., 2021), and 0.4143-0.5704 for rural households in tourism destinations of Wuhan area in China (Li et al., 2020). It was however, considerably higher than the LSI values of 0.12–0.29 computed for farming households in southern China (Wang et al., 2016), and 0.337 for the livelihoods of floating fishermen in the riverine system of Bangladesh (Ahmed et al., 2021).

Conclusions and recommendations

The livelihoods of the three watershed zones are moderately sustainable with no significant variations between the zones. However, the midstream zone had relatively high sustainability index because of high endowment of physical, social, and financial capitals; whereas the downstream zone has relatively low sustainability index attributed to the low endowment of financial and physical capitals. Human and financial capitals are the least possessed assets by the rural households in the watershed. Increasing the sustainability level of watershed households would require improvement in endowment of natural, human and financial capitals in the area. Therefore this paper recommends increasing the natural capital through sustained conservation of natural resources to ensure continuous supply of ecological goods and services; increasing human capital by providing skills training to household on alternative livelihood options; and increasing access to financial capital by strengthening rural entrepreneurship through provision of community-based entrepreneurial and technical trainings.

This research has successfully demonstrated that livelihood sustainability index is a practical tool that can be applied by policymakers and development organizations to quantify the livelihood capital endowment of rural communities to help in the prioritization of watershed management programs and interventions measures as well as in monitoring of intervention measures.

Acknowledgments

The authors would like to thank DAAD for financing this study. The authors also wish to the research assistants for their assistance in coordinating the fieldwork for this research.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

Authors would like to thank DAAD for the financial support of this research given to the first author under a Ph.D. scholarship.

Conflicts of interest

The authors declare no conflict of interest.

Author contributions

All authors contributed to the study's conception and design. Material preparation, data collection, and analysis were performed by Mr. Stephen Balaka Opiyo under the close supervision of Prof. Sammy Letema and Dr. Godwin Opinde. The first draft of the manuscript was written by Mr. Stephen Balaka Opiyo. Prof. Sammy Letema and Dr. Godwin Opinde critically reviewed the manuscript and contributed intellectual content. All authors read and approved the final manuscript.

ORCID

Stephen Balaka Opiyo http://orcid.org/0000-0003-3157-5192
Godwin Opinde http://orcid.org/0000-0002-7442-4100
Sammy Letema http://orcid.org/0000-0002-8766-0022

References

Abbassi, F. A., Ullah, A., Hashmi, M. S., Hussain, K., & Akhter, N. (2020). The role of livelihood assets' endowment in the adoption of rural livelihood strategies: An intra-regional comparison of district bhimber, AJ&K. *Sarhad Journal of Agriculture*, *36*(1), 258–271.

Ahmed, M., Saha, S. M., Hossain, M. E., Khan, M. A., & Prodhan, M. H. (2021). Assessment of livelihood and food poverty status of the floating fishermen in riverine system of Bangladesh. *Social Sciences & Humanities Open*, *4*(1), 100219. https://doi.org/10.1016/j.ssaho.2021.100219

Alhassan, A. A. (2010). *An assessment of rural livelihood systems in selected communities in the northern region of Ghana (master's thesis.* Kwame Nkrumah University).

Altasseb, H. G. (2021). Livelihoods and Survival Strategies among the Migrant Shoe-Shinning Children: A Case Study at Arada Sub-City, Addis Ababa (Master's thesis, Addis Ababa University).

Ansoms, A., & McKay, A. (2010). A quantitative analysis of poverty and livelihood profiles: The case of rural Rwanda. *Food Policy*, *35*(6), 584–598. https://doi.org/10.1016/j.foodpol.2010.06.006

Ayugi, B. O., Wen, W., & Chepkemoi, D. (2016). Analysis of spatial and temporal patterns of rainfall variations over Kenya. *Studies*, *6*(11).

Baffoe, G., & Matsuda, H. (2018). An empirical assessment of rural livelihood assets from gender perspective: Evidence from Ghana. *Sustainability Science*, *13*(3), 815–828. https://doi.org/10.1007/s11625-017-0483-8

Berchoux, T., & Hutton, C. W. (2019). Spatial associations between household and community livelihood capitals in rural territories: An example from the mahanadi delta, India. *Applied Geography*, *103*, 98–111. https://doi.org/10.1016/j.apgeog.2019.01.002

Berchoux, T., Watmough, G. R., Amoako Johnson, F., Hutton, C. W., & Atkinson, P. M. (2020). Collective influence of household and community capitals on agricultural employment as a measure of rural poverty in the mahanadi delta, India. *Ambio*, *49*(1), 281–298. https://doi.org/10.1007/s13280-019-01150-9

Berchoux, T., Watmough, G. R., Hutton, C. W., & Atkinson, P. M. (2019). Agricultural shocks and drivers of livelihood precariousness across Indian rural communities. *Landscape and Urban Planning*, *189*, 307–319. https://doi.org/10.1016/j.landurbplan.2019.04.014

Chen, H., Zhu, T., Krott, M., Calvo, J. F., Ganesh, S. P., & Makoto, I. (2013). Measurement and evaluation of livelihood assets in sustainable forest commons governance. *Land use Policy*, *30*(1), 908–914. https://doi.org/10.1016/j.landusepol.2012.06.009

Chirau, T. (2012). *Understanding livelihood strategies of urban women traders: a case of Magaba, Harare in Zimbabwe* (Masters dissertation), Rhodes University, Zimbabwe.

Costa, C. (2001). An emerging tourism planning paradigm? A comparative analysis between town and tourism planning. *International Journal of Tourism Research*, *3*(6), 425–441. https://doi.org/10.1002/jtr.277

DFID. (2000). Sustainable livelihoods guidance sheets. Deptt. for Int. Dev. London, UK. Retrieved on August 9, 2021, from www.livelihood.org/info/info guidancesheets.html.

DFID. (2002). *Linking poverty reduction and environmental management – policy challenges and opportunities*. Department for International Development.

Donohue, C., & Biggs, E. (2015). Monitoring socio-environmental change for sustainable development: Developing a multidimensional livelihoods index (MLI). *Applied Geography*, *62*, 391–403. https://doi.org/10.1016/j.apgeog.2015.05.006

Doria, M. F. (2010). Factors influencing public perception of drinking water quality. *Water Policy*, *12*(1), 1–19. https://doi.org/10.2166/wp.2009.051

Etana, D., Snelder, D. J., van Wesenbeeck, C. F., & de Cock Buning, T. (2021). The impact of adaptation to climate change and variability on the livelihood of smallholder farmers in central Ethiopia. *Sustainability*, *13*(12), 6790. https://doi.org/10.3390/su13126790

Fang, Y. P., Fan, J., Shen, M. Y., & Song, M. Q. (2014). Sensitivity of livelihood strategy to livelihood capital in mountain areas: Empirical analysis based on different settlements in the upper reaches of the minjiang river, China. *Ecological Indicators*, *38*, 225–235. https://doi.org/10.1016/j.ecolind.2013.11.007

Glen, S. (2022). "Unequal Sample Sizes" From StatisticsHowTo.com: Elementary Statistics for the rest of us! Retrieved on November 9, 2022, from https://www.statisticshowto.com/unequal-sample-sizes/.

Grace-Martin, K. (2021). When unequal sample sizes are and are not a problem in ANOVA. Retrieved on November 9, 2022, from https://www.theanalysisfactor.com/when-unequal-sample-sizes-are-and-are-not-a-problem-in-anova/.

Gupta, A. K., & Sharma, M. L. (2017). Sustainable livelihood system of the tribes in chhattisgarh state of India: A tribe's perspective analysis. *Asian Journal of Agricultural Extension, Economics & Sociology*, *16*(4), 1–13. https://doi.org/10.9734/AJAEES/2017/31812

Hahn, M. B., Riederer, A. M., & Foster, S. O. (2009). The livelihood vulnerability index: A pragmatic approach to assessing risks from climate variability and change—A case study in Mozambique. *Global Environmental Change*, *19*(1), 74–88. https://doi.org/10.1016/j.gloenvcha.2008.11.002

Hautala, K. R. (2013). *A Sustainable Livelihoods Analysis of Small-Scale Farmers in M'muock, Cameroon: Local Realities and Structural Constraints (Master's thesis.* University of Oslo).

Huang, L., Yang, L., Tuyến, N. T., Colmekcioglu, N., & Liu, J. (2021). Factors influencing the livelihood strategy choices of rural households in tourist destinations. *Journal of Sustainable Tourism*, *30*(4), 875–896.

ILO. (2014). Skills for Rural Employment and Development: Policy Brief. Retrieved on August 9, 2021, from http://www.ilo.org/wcmsp5/groups/public/—ed_emp/ ifp_skills/documents/publication/wcms_237240.pdf.

Jaganathan, D., Immanuel, S., More, S. J., & Sivakumar, P. S. (2019). Assessment of livelihood capitals of sweet potato and paddy growers in karnataka. *Indian Research Journal of Extension Education*, *19*(4), 43–48.

Jansen, H. G., Pender, J., Damon, A., Wielemaker, W., & Schipper, R. (2006). Policies for sustainable development in the hillside areas of Honduras: A quantitative livelihoods approach. *Agricultural Economics*, *34*(2), 141–153. https://doi.org/10.1111/j.1574-0864.2006.00114.x

Japan International Cooperation Agency (JICA). (2014). The Project on the Development of the National Water Master Plan 2030, Volume - II Main Report (1/2).

Kamaghe, A. A., Mlozi, R. S. M., & Johansen, M. V. (2014). Assessment of livelihoods of smallholder pig keepers in mbeya rural and mbozi districts, mbeya region, Tanzania. *International Journal of Agricultural Research*, *3*(12), 260–267.

Kedir, K. B. (2015). *Livelihoods and coping strategies of rural households in abela lida peasant association of shebedino district, southern Ethiopia (master's thesis*. University of South Africa).

Khuzwayo, H. A. (2016). *A sustainable livelihood approach to poverty reduction: Participatory experiences of women involved in art and craft cooperative in bhambayi, Kwa zulu natal (master's thesis*. University of KwaZulu-Natal).

KNBS. (2019). 2019 Kenya Population and Housing Census: Volume IV. https://s3-eu-west-1.amazonaws.com/s3.sourceafrica.net/documents/119795/VOLUME-IV-KPHC-2019.pdf.

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, *33*(1), 159–174. https://doi.org/10.2307/2529310

Li, H., Nijkamp, P., Xie, X., & Liu, J. (2020). A new livelihood sustainability index for rural revitalization assessment—A modelling study on smart tourism specialization in China. *Sustainability*, *12*(8), 3148. https://doi.org/10.3390/su12083148

Liang, Y., Li, S., Feldman, M. W., & Daily, G. C. (2012). Does household composition matter? The impact of the grain for green program on rural livelihoods in China. *Ecological Economics*, *75*, 152–160. https://doi.org/10.1016/j.ecolecon.2012.01.019

Magige, J. M. (2018). Impacts of Tobacco Farming on forest cover in Bukira West/Bukira East location, Migori country, Kenya [MSc Thesis]. Kenyatta University.

Makalle, A. M., Obando, J., & Bamutaze, Y. (2008). Effects of land use practices on livelihoods in the transboundary sub-catchments of the lake Victoria basin. *African Journal of Environmental Science and Technology*, *2*(10), 309–317.

Makhetha, P. (2010). Exploring the livelihood strategies employed by street trading selling vegetables and fruits along Noord Street (Master's thesis), University of the Witwatersrand).

Morse, S., & McNamara, N. (2013). The theory behind the sustainable livelihood approach. In *Sustainable livelihood approach* (pp. 15–60). Springer.

Muangkaew, T., & Shivakoti, P. G. (2005). Effect of livelihood assets on rice productivity: A case study of rice based farming in southern Thailand. *ISSAAS Journal*, *11*(2), 63–83.

Mumuni, E., & Oladele, O. I. (2016). Access to livelihood capitals and propensity for entrepreneurship amongst rice farmers in Ghana. *Agriculture & Food Security*, *5*(1), 1–11. https://doi.org/10.1186/s40066-015-0049-x

Nyamohanga, P. W. (2018). *Factors influencing maize crop production among small-scale farmers in kuria east Sub-county, migori county, Kenya (master's thesis*. Egerton University).

Oduro, C. Y., Adamtey, R., & Ocloo, K. (2015). Urban growth and livelihood transformations on the fringes of African cities: A case study of changing livelihoods in peri-urban Accra. *Environment and Natural Resources Research*, *5*(2), 81–98. https://doi.org/10.5539/enrr.v5n2p81

Onyango, D. O., Ikporukpo, C. O., Taiwo, J. O., & Opiyo, S. B. (2021). Monitoring the extent and impacts of watershed urban development in the lake Victoria basin, Kenya, using a combination of population dynamics, remote sensing and GIS techniques. *Environmental & Socio-Economic Studies*, *9*(2), 11–25. https://doi.org/10.2478/environ-2021-0007

Opiyo, S. B., Opinde, G., & Letema, S. (2022a). Dynamics and drivers of land use and land cover changes in migori river watershed, western Kenya region. *Watershed Ecology and the Environment*, *4*, 219–232. https://doi.org/10.1016/j.wsee.2022.11.008

Opiyo, S. B., Opinde, G., & Letema, S. (2022b). Spatio-seasonal variations in water quality status of migori river in Kenya and associated household health risk implications: An application of a multidimensional water quality index approach. *International Journal of River Basin Management*, 1–12. https://doi.org/10.1080/15715124.2022.2138409

Otieno, A. C., Mugalavai, V., & Kamau, E. H. (2013). A study on impact of climate change on the food and nutrition security in children of small scale farmer households of migori area. *Global Journal of Biology, Agriculture and Health Sciences*, *2*(1), 67–71.

Palanisami, K., & Kumar, D. S. (2009). Impacts of watershed development programmes: Experiences and evidences from tamil nadu. *Agricultural Economics Research Review*, *22*(conf), 387–396.

Pandey, R., Jha, S. K., Alatalo, J. M., Archie, K. M., & Gupta, A. K. (2017). Sustainable livelihood framework-based indicators for assessing climate change vulnerability and adaptation for himalayan communities. *Ecological Indicators*, *79*, 338–346. https://doi.org/10.1016/j.ecolind.2017.03.047

Parra-Frutos, I. (2013). Testing homogeneity of variances with unequal sample sizes. *Computational Statistics*, *28*(3), 1269–1297. https://doi.org/10.1007/s00180-012-0353-x

Phanxay, I., Isao, H., & Satoshi, Y. (2015). Access to livelihood assets under the influence of a climate event in upland northern laos. *Geographical Review of Japan Series B*, *87*(2), 131–145. https://doi.org/10.4157/geogrevjapanb.87.131

Rusticus, S. A., & Lovato, C. Y. (2014). Impact of sample size and variability on the power and type I error rates of equivalence tests: A simulation study. *Practical Assessment, Research, and Evaluation*, *19*(1), 11.

Saini, M., Mala, N. R., & Joshi, P. K. (2014). Measurement of the impacts of watershed management programme on livelihoods of a watershed community. *International Journal of Development Research*, *4*(3), 511–514.

Sati, V. P., & Vangchhia, L. (2016). *A sustainable livelihood approach to poverty reduction: An empirical analysis of mizoram, the eastern extension of the himalaya*. Springer.

Scoones, I. (2009). Livelihoods perspectives and rural development. *The Journal of Peasant Studies*, *36*(1), 171–196. https://doi.org/10.1080/03066150902820503

Sen, B. (2003). Drivers of escape and descent: Changing household fortunes in rural Bangladesh. *World Development*, *31*(3), 513–534. https://doi.org/10.1016/S0305-750X(02)00217-6

Shah, K. U., Dulal, H. B., Johnson, C., & Baptiste, A. (2013). Understanding livelihood vulnerability to climate change: Applying the livelihood vulnerability index in Trinidad and Tobago. *Geoforum; Journal of Physical, Human, and Regional Geosciences*, *47*, 125–137. https://doi.org/10.1016/j.geoforum.2013.04.004

Shiluli, M., Mogaka, J., Nyaga, J., Kinuthia, R., Njoroge, J., Kidula, N., Öborn, I., Duncan, A., & Hammond, J. (2021). LegumeSELECT: A baseline characterisation of four selected sites in Kisii and Migori counties of western Kenya. ILRI Project Report. Nairobi, Kenya: ILRI.

Shingala, M. C., & Rajyaguru, A. (2015). Comparison of post hoc tests for unequal variance. *International Journal of New Technologies in Science and Engineering*, *2*(5), 22–33.

Singgalen, Y. A., Sasongko, G., & Wiloso, P. G. (2019). Ritual capital for rural livelihood and sustainable tourism development in Indonesia. *Jurnal Manajemen Hutan Tropika*, *25*(2), 115–115. https://doi.org/10.7226/jtfm.25.2.115

Siraw, Z., Bewket, W., & Adnew Degefu, M. (2020). Assessment of livelihood benefits of community-based watershed development in northwestern highlands of Ethiopia. *International Journal of River Basin Management*, *18*(4), 395–405. https://doi.org/10.1080/15715124.2018.1505733

Soulineyadeth, S. (2014). Impact of Unexploded Ordnance (UXO) on Rural Communities' Livelihoods in Xiengkhouang Province, Lao PDR. Retrieved on August 9, 2021, from http://researcharchive.vuw.ac.nz/xmlui/bitstream/handle/10063/3670/thesis.pdf?sequence=2.

UNICEF. (2017). Migori Social Sector Budget Brief (2013-14 to 2015-16). Retrieved on August 9, 2021, from https://www.unicef.org/esa/media/876/file/UNICEF-Kenya-2017-Migori-Budget-Brief.pdf.

Wang, F., Yang, D., Wang, C., & Zhang, X. (2015). The effect of payments for ecosystem services programs on the relationship of livelihood capital and livelihood strategy among rural communities in northwestern China. *Sustainability*, *7*(7), 9628–9648. https://doi.org/10.3390/su7079628

Wang, C., Zhang, Y., Yang, Y., Yang, Q., Kush, J., Xu, Y., & Xu, L. (2016). Assessment of sustainable livelihoods of different farmers in hilly red soil erosion areas of southern China. *Ecological Indicators*, *64*, 123–131. https://doi.org/10.1016/j.ecolind.2015.12.036

Yamane, Y., Asanuma, S., & Umenura, K. (2015). Influence of livestock farming on vegetation in a degraded soil area on the east coast of lake Victoria in western Kenya: A case study of jimo east Sub-location in nyando Sub-county. *Journal of Environmental Protection*, *6*(8), 85–101. https://doi.org/10.4236/jep.2015.68075

Yang, Y., Wu, F., Zhang, Q., Hong, J., & Dong, C. (2020). Is it sustainable to implement a regional payment for ecosystem service programme for 10 years? An empirical analysis from the perspective of household livelihoods. *Ecological Economics*, *176*, 106746. https://doi.org/10.1016/j.ecolecon.2020.106746

Yin, S., Yang, X., & Chen, J. (2020). Adaptive behavior of farmers' livelihoods in the context of human-environment system changes. *Habitat International*, *100*, 102185. https://doi.org/10.1016/j.habitatint.2020.102185