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INTERCONNECTION BETWEEN ECOSYSTEM SERVICES AND LOCAL COMMUNITIES: KNOWLEDGE GAP IDENTIFICATION IN THE AREA OF KAKAMEGA FOREST

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Abstract: *The potential for accelerated loss of ecosystem services exists when the livelihood of the rural poor is heavily reliant on local ecosystems. For an improvement in livelihoods of the rural poor there is need for assessment of key elements of the livelihood framework. This is especially important to Kakamega forest, the last remaining tropical rainforest in Kenya. This paper is a comprehensive literature review aimed at identifying the research gaps in the area of the relationships between local communities and Kakamega forest ecosystem services. We derived the 42 case studies using ROSES framework and used descriptive statistics to analysis the data set. 93% of the case studies analyse provisional ecosystem, 83 % cultural, 55% regulating and 31% supporting ecosystem. We identified 6 research gaps in our interest area. Most used research methodology is the participatory rural methods which involved interviews, key informant interviews, and focus group discussions. The identified research gaps will enable us to develop tools that can be used to assess the livelihood improvement of local forest communities in Kakamega. The comprehensive review is also useful for planning the research in other parts of Kenya and beyond, in order to improve livelihoods of local forest communities.*

Key words: *ecosystem services, livelihoods, local communities, stakeholders, Kakamega forest ecosystem.*

1. Introduction

Ecosystem services (ES) are the benefits that humans gain from ecosystems, and their importance to human well-being is becoming more widely acknowledged [34]. Even though the idea is relevant to both wealthy and developing economies, it is especially pertinent in developing nations like Kenya where most local

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communities rely on these services for their livelihoods [94]. Kenya has Gross Domestic Product (GDP) of USD 110.3 billion in 2021 [25]. There is a 5% growth in Kenia GDP over the past 6 year [71]. The major contributors in 2015 are agriculture with 30%, industry with 14.8% and services with 62.5% [71]. The major exports are tea, horticultural crops, and coffee. The country is a major tourist destination for its big mammals "The big Five" which include African lion, African leopard, African elephant, cape buffalo, and black rhinoceros. They can be seen in the various national parks and game reserves in the country which include Tsavo, Maasai Mara, Amboseli, and Nairobi [71]. Forests in Kenya provide a wide range of ES that support growth of the economy. For instance the montane forest regulates approximately 75% of Kenya's water resources, which is vital for other sector of the economy like agriculture, fisheries, electricity, water, and tourism [38]. The forest also provides wood fuel which contribute approximately 75% of the country energy requirement [71]. Since most forest products are consumed for food or exchanged in informal markets, the forestry sector's economic contribution to Kenya is mostly unreported [89]. NTFP plays a significant role in the Kenya economy contributing approximately USD40 million annually according to a report by Vomigal Limited [40]. Approximately 60% of NTFP (USD 16 million) come from grazing and bush meat hunting, 17.5% (USD 5.1 million) come from the fibre and 16% (USD 4.4 million) from honey [52]. A national study done for charcoal production by Energy for Sustainable Development Africa estimated an annual production of 1.6 million tons [42], with the economic value in 2005 estimated at USD 881 million. However, there is a ban on charcoal production in Kenya imposed on 2018 to halt destruction of forest. This led to establishment of informal markets for charcoal trade and the economic value could still be the same or higher. In Kenya, the ecotourism and community-based tourism industries are expanding, currently making up 12% of the Eastern Africa tourism market [42, 52].

Many policy officials are unaware of ES' importance to local economies and livelihoods and lack a thorough understanding of them [8, 47]. This leads to the need to conduct more research on ES and its nexus with the local communities. Increasing population and globalization induces the demand for ES [14, 84]. Mainstream decision-makers are less inclined to incorporate environmental preservation into development planning due to their prioritization of short-term growth and lack of consideration for environmental concerns [16]. Users of resources won't take action to address the degradation of ES in their resource management choices unless these services are assessed and their worth is acknowledged [10, 62]. Consequently, ES assessments need to be promoted more to support decision-making, particularly in developing countries [26, 50]. Therefore, evaluation of ecosystems and their services as well as nexus with the local communities is crucial for developing effective policy responses to environmental degradation [21].

Kakamega forest is in an area of high population density of 700 inhabitants per square kilometre with an average household size of 5 people, within a high potential farmland [43]. Since the early 1900's the forest has faced numerous

challenges from mining, wood extraction, and lately local use [90]. Change in management led to a halt in mining and illegal logging in some parts of the indigenous forest. However, with the significant strides made that led to success in addressing the challenges. There is still evidence of degradation and deforestation due to fringe communities' interaction [69]. Wood fuel, a provisioning ES, is mostly extracted by the local community for subsistence and commercial use due to expensive alternative fuel source, and low alternative income source. Even with improved management of the forest the increasing population will exacerbate forest reliance [58]. The local communities also depend on Kakamega forest for other ES that complement their livelihood i.e., pole wood, pastures, medicinal extracts, and wild honey [73]. They also carry out cultural rituals in remote areas of the forest, including male circumcision practices. Kenya has started down a gradual route to integrate ES into national debate and fill in knowledge and research gaps in how they can improve livelihoods [52]. Nevertheless, aside from a few studies on governance regimes' impact on land use and land cover change on forest structure [49], climate change effects on forest dependent communities [77], impact of community-based conservation association on household income, and forest ecosystems services [46] and perception of the households on different ES as well as on management of a forest in Kenya[3] [72], there is little knowledge of ES and its nexus with local communities as well as benefits to human wellbeing in Kakamega Forest for various wealth groups[4]. To facilitate local decision-making, it is crucial to assess ES at precise locations within a smaller spatial range. This paper is a comprehensive literature review aimed at identifying the research gaps in the area of the relationships between local communities and Kakamega forest ecosystem services. We shortly present the relevant country and local context to identify knowledge gaps, identify topics approached in the literature relative to the relationship between local communities and ES.

2. Methodological Frame

2.1. Kakamega Forest and Local Communities

Kenya's western region is home to Kakamega Forest Ecosystem (KFE) and is located between the longitudes of 34°40′00′′ and 35°9′30′′ East and the latitudes of 0°29′30′′ and 0°3′00′′ North. KFE is the only remaining tropical rainforest in Kenya (Figure 1). KFE is in Kakamega county which has a high population dependency on the forest. Kakamega County has 433,207 households with a population density of 700 inhabitants per square kilometre. The population is 1,861,322 with an average household size of 5 (total of 5 members in each household) according to the 2019 Kenya Population and Housing Census [43]. KFE lies in different sub-counties and its boundaries overlap with adjacent sub-counties [45]. For this article, preference was given to households that fall within the livelihood dependence zone i.e., 2 km from the official boundary.

[3] More case studies done in Kakamega are described in section 3.

[4] More identified research gaps are detailed in section 3 after each identified topic tackled in literature is described.

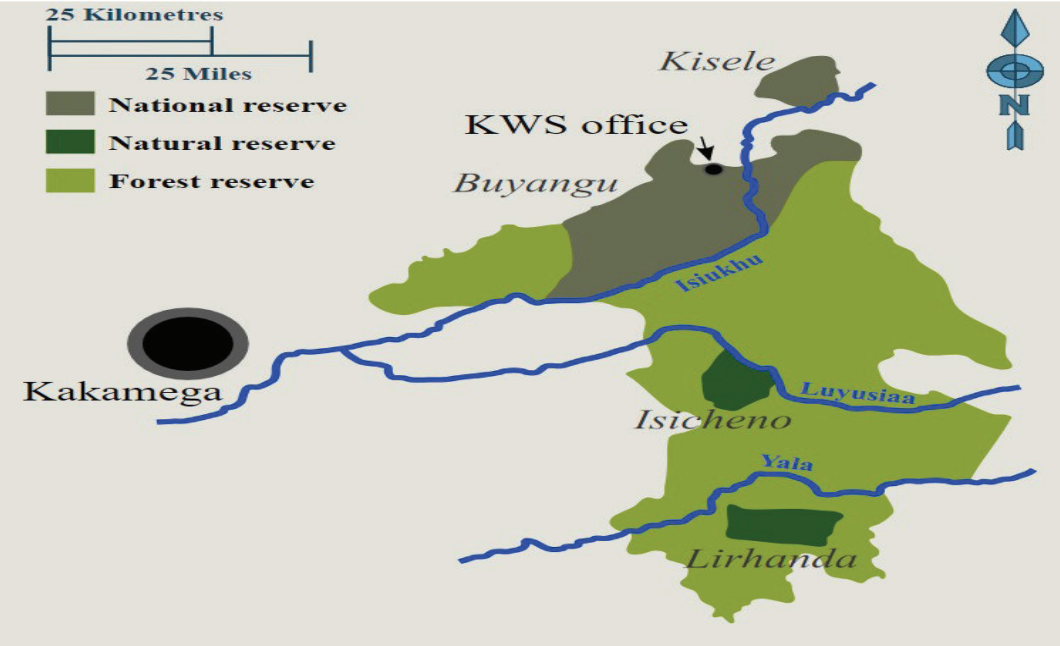

Fig. 1. *Map of KFE [23]*

KFE is divided into five management sectors to enable decentralization and ensure presence in administration and management throughout the whole ecosystem. Two government institutions are mandated to manage the forest, they include Kenya Forest Service (KFS) and Kenya Wildlife Service (KWS). KWS oversees the management of two sectors through a Warden in charge (Practice command and control management regime[5]) [45], and KFS manages the other three sectors through Zonal Forest Managers (Practice participatory forest management regime[6]) [45].

Zonation of forest resource use is intended to balance the primary objective of protecting the Kakamega forest ecology and other resource values with the restriction of use by community members and tourists [45]. As a result, the KFE is divided into 4 resource use zone namely, *core zone*, with the aim of protecting Yala Nature Reserve with a non-extraction indigenous forest, to build a single block of forest in Malava Forest, and to offer a significant natural forest zone for the preservation of flora and fauna [39].*The protection zone* is an area already under KFS and KWS management, includes Isecheno, Kakamega National Reserve, Kisere Forest, and Yala River Nature Reserves, the area is also characterized by low historical disturbance and natural forest [45]. *Livelihood support zone* comprise of forest communities living 2 km from the forest boundary, and the

[5] Area under centralized government management and community is excluded in management.

[6] Local communities are involved in livelihood activities like bee keeping, silk moth farming and ecotourism. As well as participating in decision making process.

area is targeted for sustainable livelihood programs to minimize pressure on forest resources [45]. *Potential utilization zones* are forest areas that are close to local communities and act as a buffer for the forest reserves. They are mostly dominated by bushlands and grazing land. The zone's purpose is to improve sustainable use of forest resources, support local livelihoods, and maintain the remainder of the forest ecosystem while regenerating degraded forest patches [45]. The map of KFE can be seen in Figure 1.

The KFE spans two administrative regions of Vihiga county and Kakamega county. The region is located between 1500 and 1700 meters above sea level, receives 2000 mm of rain on average each year, and the highest temperature is 20.8°C [13].

2.2. Data collection and Analysis

2.2.1. The Web of Science Data Base

The Web of Science data base (https://www.webofscience.com/) was used to derive peer reviewed articles between 2013-2023 containing the terms "ecosystem services" and "local community" in the abstract, title or keywords. Google Scholar data base (https://scholar.google.com/) was also used to search for articles containing our keywords in the title. To obtain our target articles we used Reporting standards for Systematic Evidence Syntheses (ROSES). ROSES is a flow diagram and proforma used in a systematic review and maps in the field of environmental management and conservation [28]. The first search from the Web of Science database presented 1760 articles and 10 more articles from Google Scholar. At the screening stage the exclusion criteria were presence of duplicates, exclusion of other case studies not focusing on forest ES at abstract screening, exclusion of closed accessed case studies at full text, exclusion of case studies not in English at full text screening and exclusion of grey literature and conference papers. At the critical appraisal and synthesis stage we removed review papers. 550 duplicates were removed. 1100 articles were removed after abstract screening. Then 89 articles retrieved at full text. 42 articles left after full text qualitative and quantitative synthesis. Some of the benefits of using ROSES structure compared to PRISMA is its increased reporting details levels by providing additional methodological guidance and points to hence clarity to the readers and authors. Additionally, ROSES is specifically adopted to a variety of synthesis methods commonly used in the field of environmental research so that qualitative and narrative research benefit from such forms [28]. In Figure 2 there ROSES employed in extraction of the articles.

2.2.2. Case Study Methodology

The identified case studies were categorized using spatial scale (Global, other, Africa, Kenya, Kakamega). *Global* scale involves case studies covering more than one continent. *Other* scale involves case studies in Latin America, Europe, Asia, and North America. *Africa* involves case studies in countries in Africa (mostly focusing on specific forest within the country). *Kenya* scale involve case studies focusing other forest ecosystem than Kakamega Forest.

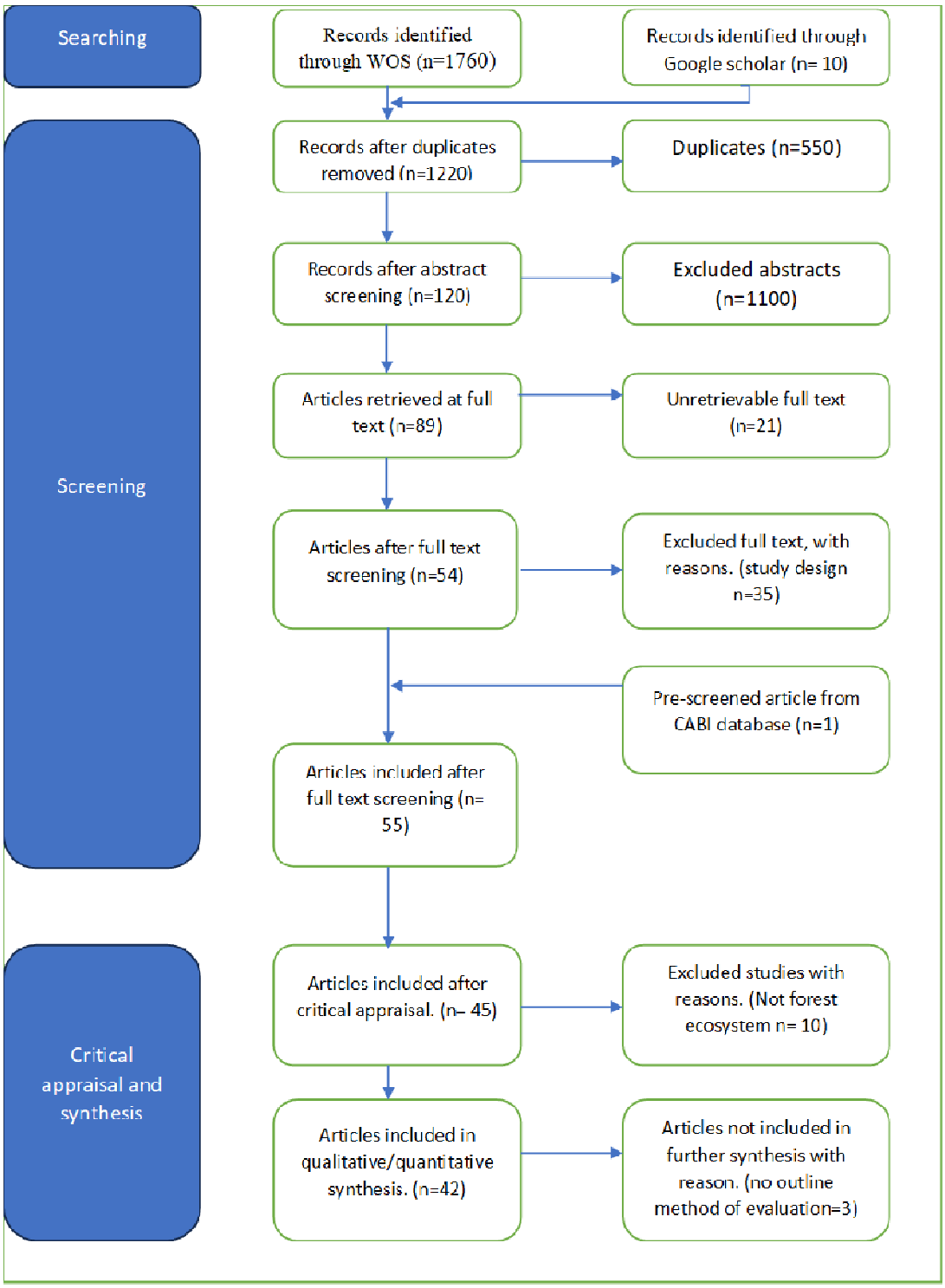

Fig. 2. *ROSES structure employed to retrieve the analysed research articles*

Kakamega scale involves focusing on KFE. We used Scoones et al. [81] key elements of livelihood framework. They divide the key element of livelihood into 5 categories:

- *The vulnerability aspect* involves contextual analysis of conditions and trends of assessment of policy selling. It includes elements like history, demography, and social differentiation;
- *Assets* involves analysis of livelihood resources and includes elements like natural capital, social capital, human capital, and economic capital;
- *Policy and institution context* involves analysis of institutional influence on access to livelihood resources. It includes elements like non-governmental organisations (NGO's), governmental organisation, and community development institutions;
- *Livelihood strategy* involves analysis of livelihood strategy portfolios. It includes elements like agricultural intensification/extensification, livelihood diversity, and migration;
- *Outcome* involves analysis of outcome and trade-offs. It includes element like income and wealth, wellbeing and health, food security, sustainable management of resources, Poverty, Vulnerability, degradation of natural resource.

We used this key element of livelihood to categorize the data in Excel. Then we used descriptive statistics (percentages) to determine the frequency of each key element against spatial scale.

2.2.3. Methodology for Research Methods Used in determining the Relationship Between Local Community and ES

For the research methods used in regarding local community and ES, we used nine categories. This include the questionnaires, willingness to pay, Household survey, regression analysis, focus group discussion (FGD), Interview, GIS, participatory techniques (other) this include pebble distribution, direct observation, other include propensity score, Social Values for Ecosystem Services (SolVES), Sen's capability approach, avoided cost method, collaborative mapping, Index System Evaluation Method of Human Wellbeing, Equivalence Factor Evaluation Method of ES, SWOT and AHP, spatial analysis (INEGI), Difference-in-Differences (DiD) method, mitigative expenditure and discrete choice experiment. We then did a count of each method and determined the frequency.

3. Results and Discussions. The Relationship Between ES and Local Communities in the Literature

3.1. Forest Income and Dependency

There are a lot of research done on the nexus between ES and local communities since Millennium Ecosystem Assessment (MEA) [50]. Most of the research addresses the benefits provided by the forest and its contribution to rural livelihoods with a specific focus on forest income and dependency. An example can be found in Angelsen's research [5], a global comparative analysis of environmental income from 24 developing nations. The study indicates that forest

contributes 22.2% (forest income 21.1%, 1.1% forest plantation) and non-forest environmental income contributes 6.4% to household average annual income. This contribution of forest to household income is confirmed by Andrews et al. [4] research in Tanzania where it was at 27%. Angelsen et al. [5] found that forest income is the main contributor to environmental income but non forest income also plays an important role in rural livelihoods and this outcome aligns with other findings from environmental income studies [9, 54]. In majority of the sampled case studies, we found that most of the households used provisioning ES like wood fuel and poles as building materials for both subsistence and commercial use. Example can be found in countries like Bangladesh, Kenya, and Bhutan respectively [3, 77, 93], where wood fuel and poles were mostly extracted from the forest for both commercial and subsistence use. In Tanzania the sale of wood fuel is the primary source of forest income, followed by wood goods and timber harvesting. However, the demand for NTFP is low due to sufficient intrahousehold production [4]. Different forms of provisioning ES are used for either cash or subsistence use and vary across geographical locations depending on the local community's needs. An example can be Bangladesh [3] where different forms of forest provisioning services (wood fuel, broom grass, bamboo) are used for cash revenue. The lower income households in the area used a wide variety of provisioning services to generate monetary income. Wood fuel, food, and broom grass were the three most significant forest income provisioning services used by low-income households. The fact that these were used less for cash income in the high and moderate wealth groups shows how little they relied on these sources. These materials are crucial cash sources for low-income people. This outcome contrasts with Bangladesh research [56] which show more bamboo was used in poor households than in wealthy households. 93% (Figure 3) of our analysed case studies mentioned provisioning ES. This indicated that most of the research done relating to local communities concentrates more on the provisioning of ES. This could be due to the local communities identifying more with provisioning ES because of their tangible nature and value.

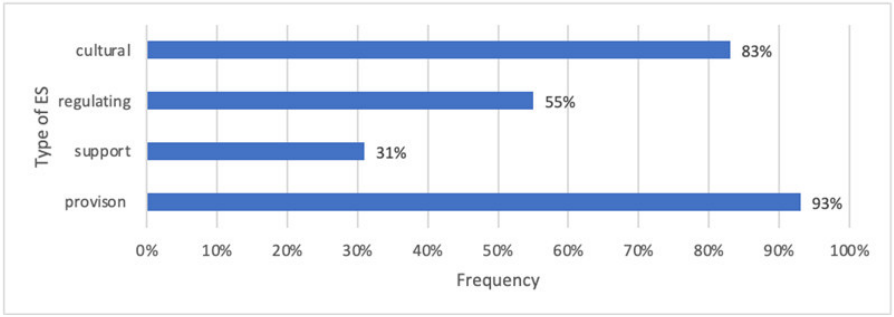

Fig. 3. *ES analysed in the case studies across spatial scale and their frequency*

Household income from provisioning ES varies within the wealth group of the local communities. Angelsen et al. [5] showed disaggregated income data by wealth

quartile. Households in the two lowest quintiles rely significantly more on the forest for subsistence than do households in the highest quintile. This is also seen in Kenya (Maasai Mara) and Tanzania. (Serengeti) [36]. Where in Tanzania forest reliance was 81% on average for the poorest quartiles, mainly due to negative crop failure induced by drought, in Kenya highest income quartile had minimal reliance on forest income with less than 10%. Regarding subsistence use across the wealth groups, Angelsen's research [5] found that the comparative Kuznets Ratio for forest and non- forest environmental income is 0.58, meaning that 86% of the non-forest environmental revenue for the typical household in the sample is in the form of subsistence uses (i.e., this income share is nearly twice as high for the two bottom quintiles compared to the top quintile). As a result, compared to forest resources, most non-forest environmental resources seem to be more readily available to the poor. In general, high-income share doesn't take the households out of poverty but its absolute income does. This is seen in Angelsen et al. [5] research where the results showed that the environmental income of the highest income quintile is almost five times more than that of the lowest income quintile. This finding concurs with findings in Tanzania [4].

There are various socio-economic determinants of household income which vary depending on spatial scale. In Angelsen et al. [5] global research, the determinants for environmental income include young households head, large households, (contrast to [48] case study findings in Ethiopia), and less educated households. In Kenya and Tanzania, age and education level of the household head had a negative correlation with environmental income [36]. Regarding forest dependency, our interest area of KFE shows a high demand for wood fuel to satisfy the increasing population. Low livelihood diversity practiced in the area with minimal income exacerbates more pressure on the forest resource [41]. There are various determinants that influence households' dependency on forest ecosystem. This socio-economic and demographic determinants of dependency on forest ecosystem vary across different geographical locations. An example can be given in China case study where the findings pointed out that less healthy, low education, lower economic status are indicated by asset index, and older households have the strongest indicator of dependency [76]. In Chisinau in Moldova the highest dependency was found in low-income households due to the high price of wood fuel which has an estimated share 18.8% of the household income [87] and in Tanzania case study of Pemba the findings indicated that the age of the household head, level of education, market integration are negatively correlated with forest dependency [4].

Assets are crucial in determining the best livelihood strategies [20]. 74% of the analysed case studies (Table 1) involved analysis of at least one of the four asset types (natural, human, economic and social). Livestock and agricultural assets are important as they are indicators of wealth accumulation and, at site level, have a positive correlation with forest and environmental income [5], indicating its complementary with the livelihood strategies. In Tanzania and Kenya case studies, crop land size had a positive correlation with environmental income [36]. This suggests that more agricultural

land coincides with lower relative and absolute forest income at site level and a trade off at landscape use level as more agricultural land leads to less forest cover, leading to difficulty in management of forest ecosystems. This is confirmed by a case study in Zimbabwe where there was increase in agricultural land by 7% from 2007 - 2017 causing conservational threat to a National Park [60].

In conclusion, forest ecosystems contribute to household income for rural livelihoods, and this can't be ignored during policy design. In spite of the importance of such studies, - there are no studies done on the dependency of local communities in the interest area – KFE, this being an important knowledge gap: household's income of the wealth groups (high- and low-income households) and forest reliance. There is the need to explore the socio-economic and demographic factors that influence dependency, as well as the factors influence between the wealth groups. This would help in policy making with regards to the relevance government authority in providing extension service to the livelihood strategy that support majority of the local community's livelihood.

3.2. Shocks, Safety Nets and Seasonal Gap Filling Among Local Communities

Shocks refer to unexpected events or disruptions that can have detrimental impacts on local forest communities. These shocks can be natural disasters like floods, wildfires or droughts, or they can be socio-economic crises such as economic downturns or political conflicts [6]. Local forest communities are often vulnerable to these shocks due to their reliance on forest resources for their livelihoods and the limited access they may have to alternative income sources [98]. Safety nets are mechanisms and support systems put in place to protect and assist local forest communities in times of shocks or crises. Safety nets can take various forms, including social safety nets, insurance programs, community-based organizations, or government interventions. These safety nets aim to provide financial, social, and environmental support to individuals and communities, helping them cope with shocks and maintain their well-being [59]. Seasonal gap filling is an essential aspect of supporting local forest communities. According to Nemans-Neuman et al. [63] livelihoods often exhibit seasonality, with periods of high productivity and income followed by lean seasons. During lean seasons, when resources may be scarce, it becomes critical to fill the gaps to ensure food security and sustainable income. This can be achieved through strategies such as storing surplus resources, engaging in off-farm activities, or implementing sustainable harvesting practices that promote resource regeneration. 55% of our analysed case studies include vulnerability (shocks, safety nets, and seasonal gaping) (Table 1). Wunder's global research [96] classified shocks into two categories: idiosyncratic (illnesses and deaths) or covariate (crop failures). His analysis challenges some established wisdom which examined the importance of forests as safety nets in response to shock. They discovered that the highest-ranking extractive approach used as a reaction to a shock was hardly one in ten households. The results further revealed that forest extraction ranked lower than factors such as labour redistribution to other areas, support from extra-

household sources, sale of assets, or decreased consumption. In Pemba Tanzania, research revealed that households used forests as a form of insurance against shocks, particularly droughts, but the significance of forests as a safety net depends on the household's access to alternative insurance mechanisms [4].

The second hypothesis Wunder [96] tested was the response to different shock types. The outcome revealed that people use a variety of methods to get outside help when they experienced idiosyncratic shocks, with only minimal increased usage of the forest (6 - 8%). This was less practical in the event of covariate shocks because consumption was frequently decreased, and forest extraction was used twice as frequently (14%). In Kakamega Kenya households' response to covariate shock like drought increased extraction of wood fuel from the forest for commercial use. Other responses include change in livelihood strategy from large herds of livestock to poultry farming [77].

In the third hypothesis, Wunder research [96] determined which village and household characteristics determine them to turn to forest. The results show that households hit by covariate shocks (price instabilities, climatic events) and being asset holding poor (education, land ownership, social capital, and physical capital but to a certain extent) are more likely to turn to forest. But this doesn't imply that most poor households would most likely respond to shock by forest extraction but depends on a variety of factors like pre recognized patterns of forest extraction and forest income diversification. Wunder [96] noted that combination of asset holdings and specialization strategies, along with other variable clusters like demography, infrastructure, institutional and location characteristics, might help explain extractive shock responses. An example in Zimbabwe where the key informant interviews (KII) revealed that lack of irrigation equipment's and infrastructure like bridges was an impediment to establishing a successful agricultural undertaking [60].

The fourth hypothesis Wunder [96] tested was if forests play an important role in seasonal gap filling. Their results were not aligned with the conventional option that forest income is the primary seasonal gap filler to substitute for income short falls of households (agricultural off season). A quarter of forest income indicated a positive correlation with crop income and total income, this excludes forest income from being a gap filler. However, their findings also indicated a negative correlation between wage income and crop income, this can be explained by the households having temporary employment between agricultural harvest [96].

Wunder et al. [96] findings are from a global comparative analysis of shocks and safety nets. However, there is need for an intra site case study analysis to determine what kinds of shocks triggers specific forest related reaction in KFE area. The identified knowledge gap is to find out if KFE is a safety net to shocks and act as a seasonal gap filler, which will further explore the livelihood strategies before shock and aftershock, the availability of insurance mechanism and households' response to different shock types. The filling of the knowledge would help in management plan preparation for KFE, specifically for zonation of the forest resources. (livelihood support zone).

3.3. ES Perception, and Land Use Supporting Well-Being of Local Communities

Understanding perception of the local community regarding ES plays a vital role, particularly when evaluating the type of ecosystem that locals perceive to contribute to their well-being [85]. 45% of the analysed case studies dealt with well-being. An example is research in Bangladesh addressing the relative importance (cultural and regulating) and benefits (provisioning) of ES to households across the three identified wealth groups [3]. The results indicate that the provisioning ES importance dependents on its use (cash or subsistence). This aligns with other outcome from China [31] where provisioning ES (timber, tea, rice) importance depended on the livelihood need (cash or subsistence). The perceived importance of ES varies across spatial scale of the forests and depends on the needs of the local forest communities. In most of the analysed case studies we found that forest communities place more importance on the provisioning ES followed by regulating ES. This is due to their value being tangible compared to other ES. An example is in Ethiopia where most of the respondents placed more importance on provisioning ES (fresh water) with 78% and regulating ES (climate and air regulation) with 63% compared to cultural and supporting ES [51]. In Tanzania similar studies indicate 67% importance on provisioning ES followed by regulating ES at 53% [66].

Regarding perceived importance of the ES across wealth groups, Ahammad et al. [3] research found that wood fuel (provisioning ES) was the most used for subsistence irrespective wealth group, as fuel wood is the primary source of energy in the landscape. This outcome aligns with findings from Nigeria and Nepal respectively, where wood fuel was the primary good households place more importance among the provisioning ES [1, 11]. The results also indicate that the low- and middle-income people rely slightly more on forest wood fuel to meet their energy needs and deal with fuel shortages. Wood fuel gathering is a vital alternative source for low-income people to maintain their livelihoods during the year's lean seasons because they have limited land for farming and face greater food shortages. Regarding cultural ES across the wealth groups, in Bangladesh Chittagong Hill Tracts region, high- and low-wealth households have slightly higher perceptions of the significance of aesthetic and spiritual services [39]. However, Mensah's research in South Africa [53], revealed that households' appreciation of the cultural elements of forests had no significant influence by wealth conditions.

Regarding the perceived benefits of forest ES this vary from different local communities depending on their needs. Ahammad et al. [3] investigated indirect benefits of forests for regulating (regulating air quality, crop pollination, freshwater purification, soil fertility, soil protection, and pest controls) and cultural (aesthetic and spiritual) services. Their results indicated that water purification and supply was an essential service and greatly appreciated across the wealth group in Bangladesh. Their findings regarding locals' awareness and knowledge of the importance of forests in maintaining watersheds were consistent with those of another research conducted in Bangladesh Chittagong Hill Tracts [15,

32], where the locals take most of their drinking water throughout the year from lakes, springs, and streams, and they perceive that the health of the watershed is dependent on good forest condition. In Mt. Marsabit Kenya, the local communities perceived cultural benefit (aesthetic) and provisioning benefit (fodder, water, and wood fuel) as the most important benefits received from the forest reserve [72]. In Germany [74] forest benefits include provisioning (mushroom, wood fuel, fruits) and cultural ES (walking, educational purpose). In Spain [24] - case study of Nacimiento and Sierra Morena regarding perception of high influence stakeholders and low influence stakeholders - the results indicated that perceived benefit of low influence stakeholders was higher in both areas, for provision ES (food) and cultural ES compared to high influence stakeholders. The local communities place value on the benefits they derive from the forest and what they are willing to pay (WTP) for these benefits vary depending on the category of the ES. In Ghana the households were willing to pay USD 1.45 per month for every household near Mole National Park for moderate or high improvement in haunting access, water quality, wildlife habitat, and ecotourism [68]. In our interest area of KFE the respondent were willing to pay USD 25.7 per year for 50% reduction in soil erosion, USD 4.6 per year for a 20% increase in water quantity during dry season [17].

Socio-economic variables are an essential component in determining household perception and WTP for ES. They influence how the local households perceive benefits from forest ecosystems. An example is seen in Ghana where age, level of education, and household size had a positive correlation with WTP, while occupation, gender, income, and residential status was insignificant to households WTP [68]. This outcome contrasted with Kenyan case study [17] where income had a positive correlation with WTP. Regarding ES perception, the socio-economic variables varied across the forest ecosystems in the analysed case studies. For example in Nepal, where location, age, caste[7] and involvement in forest community had an influence on the household's perception on the ES [44]. In Nigeria household size, age, income level, gender, education level influenced local communities' perception of ES [1]. Factors like education, gender, origin, age, personal needs, cultural traditions, access to ES, land ownership, spatial patterns, and household income were found to influence respondents' perceptions of ES in Dominican Republic, Kenya, and Bhutan respectively [27, 72, 93].

Understanding the perspective of forest stakeholders is crucial to ensure effective forest management. This perspective will help tackle challenges experienced in most forest ecosystems like resource exploitation, deforestation, forest encroachment, conflicts within communities, governance etc. For instance, in Bangladesh research [88] highlighted several key factors contributing to the success of community-based forest management, including the active participation of indigenous communities, the establishment of rules and regulations, and the recognition and support from external stakeholders and authorities. This is contrary to findings in Kenya in Kakamega and Marsabit respectively [49, 72] where community-

[7] Hindu society hereditary classes.

based forest management was not successful, and some of the challenges experienced by local communities involved in forest management was deforestation and over exploitation of resources. In the Democratic Republic of Congo, the ES professionals expressed their perception on the constraints and opportunities required to safeguard ES and livelihoods. They mentioned establishment of protected area as strategy to safeguard ES, with 75% agreement. PES as local livelihood contributor had 64% agreement [95].

Land use plays a crucial role in meeting various well-being requirements by ensuring that ES are accessible at local, regional, and global levels. However, altering land use can lead to enhancing certain aspects of well-being, like the economy, while simultaneously causing a decline in multiple essential ecosystem functions which are vital for sustaining community well-being [78]. Gaining a deeper comprehension of the connection between people's well-being and ES is crucial for the sustainable utilization and management of diverse land resources. For example research in Bangladesh [2] indicates ecosystems' contributions to fundamental well-being, including suitable shelter, the capacity to relieve ecological stress, source energy, spiritual and cultural benefits, cultural usable water, and access to traditional healthcare. Similar well-being requirements were observed in South Africa and revealed a particular usage pattern for ES among households [30]. Ahammad's research [2] pointed out that people chose safe housing, which revealed their ongoing demand for building materials like bamboo and timber. This outcome raises a delicate balance scenario indicating that changes to forest areas have an impact on rural people's well-being [19, 33]. Because they have less secure access to forest resources for gathering NTFP and construction timber, such as bamboo. This is more evident in China where the decline in the well-being linked to natural ecological resources was notable. The substantial expansion of croplands and developed areas has caused an imbalance in the ES and abnormal growth in the structure of human well-being [92]. Also, in Wuyishan, China, provisioning ES (timber and rice) were perceived the highest to improve social welling being among the local communities [31]. Other ES like regulating and supporting ES contribute to human well-being based on their perceived importance to local communities. These ES influence local communities by enabling them increase food quantity and prevent food insecurity as well as improve their livelihoods. In Bangladesh [2] community preference for ecological stress reduction (maintaining soil fertility and soil erosion protection) indicates the indirect contribution of the ecosystem in providing farm productivity for subsistence use long term. However, in China social well-being was not affected by regulating ES [31], while in India [78] the research results indicated that provisioning ES are associated with food and nutrition security, domestic water supply, housing, and energy needs; cultural services are connected to gender equality; regulating services are associated with sanitation and hygiene, as well as exposure and resilience to shocks and lastly, supporting services are linked to agricultural assets. All contributing to well-being of households in India. ES preference in supporting well-being is greatly influenced by factors such as

management context and forest lands and other natural resources ownership rights. In Bangladesh [2] people who lacked secure property rights in the framework of state ownership chose forests and swidden agricultural land to meet their demands for several aspects of well-being, including enough food, income, nutrition, space for livestock to graze, and access to water. Those who had completely secure land rights stopped relying on swidden farmed areas and used a variety of land uses to maintain their well-being.

There are socio-economic variables that influence land use delivery of the essential ES supporting well-being of local communities. Understanding this variable is essential in forest management to sustain the livelihoods of the local communities. In Kenya's Mau Forest Miller et al. [55] researched how socio-economic variable like the historical and legal structures, opportunities for market entry, social connections, and the conditions of the area, influence land use, thus, affecting well-being of the local communities in Kedowa and Kuresoi. Miller et al. [55] discovered that those without access to their own wells depend on neighbouring wells and streams, which is dependent on their interpersonal ties. Regarding historical and legal structure, after Kenya gained independence, land was distributed to the locals in large parcels based on social class. The lands in Kuresoi are more fertile, bigger and have better access to water than in Kedowa. Hence the haves got land in Kuresoi and the have nots in Kedowa. Also, in Kenya in Njuguna and Mburu [64] the ownership of a secure land tenure (title deed) influenced households livelihood strategy from crop farming or livestock keeping. Other factors like distance from the water and access to credit had a positive and negative correlation respectively between households' probability of practicing livestock rearing. In Marsabit Kenya distance from the forest had a negative correlation with livestock rearing [72].

Different land use preferences supporting well-being are site specific. In Bangladesh [2] forest was highly valued for meeting the well-being need of safe shelter, traditional healing, ecological stress reduction, wood fuel, livestock food source, water provision. Besides forests, another valued land use was fruit orchards for safe shelter, adequate water provision, minimization of ecological stress, cultural and spiritual benefits, and nutrition. Swidden farming was preferred for providing wood fuel and food. Land use change over time affects well-being differently due to various social, economic, and policy factors. For instance, in China [92] the population's actions led to a significant increase in the size of cultivated and urban areas, resulting in the destruction of forests, water ecosystems, and grasslands over 10-year period. This resulted in a 120.79% increase in basic material well-being, 33.75% decrease in security well-being, 10.2% decrease in social relations well-being, 29.37% increase in health well-being, 65.62% increase in education and cultural well-being, and a 1.06 to 1.23 increase in freedom well-being. Also, different livelihood strategies affect the well-being requirements of local communities differently. In China [31] the researchers concentrated on social and material well-being and their satisfaction level across different livelihood strategies among the local communities. Their results showed that respondents involved in various agricultural activities experienced a

proportional change between their material and spiritual well-being. Individuals not involved in agriculture experienced significantly greater contentment with their material well-being. On the contrary, those involved in forestry reported a relatively elevated level of satisfaction regarding their spiritual well-being.

In conclusion, perceived ES, preferred land use supporting well-being, land use ownership rights, management type of the land use, and livelihood strategies influencing well-being, are important to understand the local community's link with the ES. A blended management approach for forest and agricultural land use strategies to maximize ES values, as more than one land use supports well-being. This is important as ES should be in the fore front of policies regarding land uses and forest livelihoods as a guide for local and regional natural resource management. This shaded light on the knowledge gap in the area of KFE: relative benefits (provisioning), importance (regulating, supporting and cultural), and factors influencing households' choice across wealth groups. Another research objective to be considered would be to evaluate the KFE household's preferred land use supporting their well-being, with specific attention on the significance of land ownership and the socio-economic factors influencing well-being. Fulling this knowledge gap would help in policy making regarding which management type is best suited for the blended landscape which encompasses a variety of land use supporting well-being of the local community.

3.4. PES and Local Communities

Researchers have reached varied and sometimes contradictory findings regarding PES and its potential to improve livelihoods. For instance, certain researchers have determined that PES has the potential to alleviate poverty by providing financial assistance to impoverished households and safeguarding their means of livelihood [97]. Research conducted in East Africa's' Malawi and Ethiopia demonstrated that rural households with greater reliance on forest resources, especially those belonging to the poorest segment of society, would experience significant negative impacts on their livelihoods due PES, one of the impacts discovered being the reduction in the availability of forest resources for locals [37, 48]. One factor behind the differing conclusions was the oversight of the diverse range of stakeholders and the changing nature of the impacts of PES. In China [91] researchers examined the effects of a regional PES program on participants and non-participants in rural households. They investigated how different types of households are impacted economically and socially by PES. There is a noticeable contrast in the amount of natural assets, such as cropland and forestland, between individuals who partake in the PES program and those who do not. Additionally, the existing disparity in natural assets between nonparticipants and participants was due to PES. This aligned with Fan's [22] results where the correlation between credibility[8] and the

[8] Tool used to assess and enhance the trustworthiness and reliability of stakeholders' commitments and actions, with the aim of

total livelihood capital and natural capital of PES participant's full-time herders is substantial and inversely related. This contrasted with Segura-Millán and Perez-Verdin [82] findings where they observed no significant variations in the extent of primary forest cover (checking for leakage: deforestation) between individuals involved in PES and those who were not. In terms of physical assets that improved due to PES, in Wang's research [91] the authors established the infrastructure for producing fruits which consisted of various facilities, such as methane-generation facilities, forest roads, and reservoirs. This contrasted with [22] results - no correlation between credibility and physical assets. Regarding human capital, the participants in PES in Wang et al. [91] research experienced significant improvements in their human resources, particularly in terms of agricultural knowledge, skills, and entrepreneurial abilities. There was an improvement in human capital (agricultural knowledge, skills) in other parts of the world: in Kenya, Peru, and Mexico respectively [75, 82, 94].

Supporting indigenous and local communities' endeavours through PES initiatives is, however, important in preserving their abilities, which will ultimately benefit both current and future members of the global population [86]. In proper PES design cases, opportunities such as employment, personal growth in terms of emotions, spirituality, cultural values, skills, and experiences persist due to the existence of traditional estates [79]. The way individuals connect with their local natural surroundings defines their sense of self, their belief systems, cultural customs, and traditions, all of which influence the land through specific responsibilities and management practices [80]. Relationships between people and their lands, as well as among individuals from different tribes or clans within a particular region (involving the sharing of knowledge and land management practices, as well as the exchange of resources obtained from the land) are inevitably influenced by local values, as well as the geographical and climatic characteristics of the area [79]. Effects of PES schemes are diverse and, in some cases, undermines indigenous institutions. An example can be seen in Peru's [75] National Forest Conservation Program (NFCP) a state PES scheme: local conservation systems, such as the minga, an age-old Amazonian practice of collaborative assistance and communal work for sustaining livelihoods, have been gradually weakened. This has resulted in communities being compelled to substitute these systems with the pursuit of commodity production and the establishment of employer-employee dynamics.

PES schemes have the potential of improving the livelihood of participant local communities. But this improvement in the livelihood of the local communities depends on the PES. Therefore, PES design and implementation require proper assessment of the ES being traded in the PES, transaction type, spatial and temporal scale, and actors involved in PES, as well as the perception of the actors involved in PES implementation to determine the factors that influence PES success [70]. Filling the knowledge gap would help policymakers on the specific criteria that would result to a successful PES implementation. Which ultimately benefit the local community.

conserving nature and sustaining the livelihoods of Chinese herders in the context of grassland ES [91].

3.5. Landscape Use, Landscape Change, and Climate Change

Most of the landscape change in developing nations like Kenya and Zimbabwe consist mainly on conversion of forest land to agricultural land. While in other, more developed nations like China landscape change consist mainly on conversion of forestland to urban area and agricultural lands. In Musakwa's [60] research in Zimbabwe's landscape had change over the 20 years period (1999 - 2019). Increased settlement in the area was a key driver for change in landscape as this induced the establishment of social amenities in the area to satisfy the increasing population. Growing agricultural activities in the area were identified also as a driver for landscape change. This is also the case of or interest area - Kakamega in Kenya [69] in a 20-year period (2000 - 2020) where anthropogenic drivers like conversion of natural forest to agricultural land had changed the landscape. In China [92] there was a significant increase in the size of cultivated and urban areas, resulting in the occupation or destruction of forests and grasslands over 10-year period. These landscape changes led to a decline in the delivery of the forest ES at the detriment of the local communities. In Zimbabwe and Kenya respectively [60, 67] overgrazing was cited as a key issue by the respondents, who linked it to soil erosion and a reduction in soil quality that also affected ES like organic matter decomposition and soil formation. In some cases, landscape change has been caused by wildlife causing human-wildlife conflict. An example in Zimbabwe [60], according to KII, a huge number of large herbivores (about 11,000 elephants) destroyed the vegetation because they exceeded the national park's carrying capacity.

Climate change can disrupt ecosystems, leading to the loss of biodiversity, habitat degradation, and reduced availability of essential resources. In Gonarezhou national park in Zimbabwe [60] the research found that the households engaged in farming activities primarily for subsistence use. These agricultural practices heavily relied on rainfall, making them vulnerable to the effects of climate change, a common situation in many drylands in southern Africa [60]. The survey revealed that the average household size of 60% of the respondents was over five individuals, straining their modest income. Furthermore, 69% of the families earned less than $100 per month, significantly below the poverty threshold of $1.90 per person per day. This suggests that households are highly vulnerable to the impacts of climate change due to limited resources available to cope with its effects. This is also the case in Kakamega [77] where households are vulnerable to climate change and have insufficient resources to survive.

Climate change leads to variability in the average annual rainfall and temperature that affect the local communities depending on rain fed agriculture. This affects their livelihood diversity strategy to adapt to the climate. The combined effects of climate change and landscape change pose significant challenges for the sustainability and resilience of ecosystems and the services they provide. As landscapes transform and climate conditions shift, ecosystems may struggle to adapt, leading to disruptions in the delivery of essential services upon which human well-being depends. In Kakamega

Kenya [77] there was a temperature increase of 0.037°C/year for the highest temperatures from 1980 – 2015. And a decrease of 0.068 mm/year of rainfall from 1923 -2015. In Kakamega's forest community there has been already significant reduction in the production of common crops (maize, sugarcane, and vegetables) over the past few years [58]. This finding is aligned to previous studies done in the area where the farms recorded decline in crop production over the years [7, 57]. Regarding climate change's effects on the livestock in Kakamega by Saalu et al. research [77], the population of Kakamega rear livestock (chicken, cattle, sheep, goats, and pigs) as the majority rear 1-3 animals. Most respondents (87%) had reduced the size of their herd by selling some of their animals because of their farms' inability to grow pastureland owing to protracted drought spells. To minimize risk, most of the respondents' transition to chicken rearing. The respondents that have livestock registered a reduction in milk production from the livestock due to lack of enough pasture during drought. This forces the farmers to feed the livestock crop residue (sugarcane residue and maize stalks) which is much cheaper than purchasing pasture. This outcome resonates with Mutibvu et al. [61] findings that livestock are being fed crop residues during drought. These results in low milk production and some of the farmers abandon livestock husbandry. This is also seen in Zimbabwe [60] case study of Gonarezhou where there was a reduction on crop and livestock production. However, most of the locals resorted to poaching game and harvesting natural resources for survival.

Research done on ES and its link with land use change and climate change is very relevant for our area of interest - KFE, especially the impact of the climate change on the livelihood as Kenya currently being hit with the worse drought between March and June 2023 [35]. The identified knowledge gap in the interest area of KFE is to determine possible households' response to climate change and its impact on livelihood (focus on livelihood diversification strategy). A specific objective would be to determine local communities' response to natural disaster in terms of their livelihood diversification strategies (labour emigration, off-farm enterprises, agriculture diversification (hybrid crops))[9] and preferred land use during this period. Filling the knowledge gap would help policymaker how to appropriately respond to help the local community once a natural disaster like drought hit.

3.6. ES and Forest Management

The relationship between ES, local communities, and forest management is mutually beneficial. Local communities rely on forest ES for their well-being, while their active involvement in forest management promotes sustainable practices and ensures the preservation of these services for future generations. 71% (Table 1) of our analysed case studies focused on sustainable management. In Marsabit Kenya [72] only 6% of the population participated in the implementation of guidelines for the management of the forest. It's believed that better information dissemination and management plan simplicity, tailored to

[9] [77] research in Kakamega didn't focus on other livelihood diversification strategies.

laymen, may increase community involvement [29]. Family size and education level were positively and significantly related to levels of participation in conservation and forest management [28]. This result aligns with Lambini's research [46] in Trans Nzoia Kenya where they found a positive propensity score between family size and education level to forest management. This could be because forest resources like fodder and firewood are more in demand in households with larger families. The knowledge and information flow process are accelerated by education, allowing the educated local community to take part in management. According to earlier studies in Nepal, Haiti, and Ethiopia respectively [12, 18, 86] households with larger families are engaged in community forest management at a higher rate, whereas those without a formal education exhibited lower levels of engagement. Nevertheless, age is strongly and negatively linked with involvement in the forest management program. This outcome aligns with findings from [65] who said that involvement in Kenyan forest management was negatively impacted by age. This might be because the elderly are unable to engage in activities demanding physical effort. The community's lack of involvement in forest management, despite their recognition that the forest is overexploited and the ES are in danger owing to degradation, may be explained by their focus on the provisioning ES like fuel wood, which they directly benefit from.

Forest management involves the sustainable use, conservation, and restoration of forest ecosystems [83]. It aims to balance ecological, economic, and social factors. Effective forest management requires the active participation and engagement of local communities [46]. Different forest management regimes influence the perception of local communities regarding the regime's effectiveness and its impact on the forest state. For instance, Mbuvi's research [49] determined the influence of three management regimes in Kenya. The forests managed by the community experienced a significant increase in the rate of forest degradation. The forest managed under command and control showed significant improvement in its condition. This positive change is credited to the management approach that prohibits the utilization of forest resources for consumption purposes. Forest under participatory forest management experienced improved forest management. This is due to the neighbouring local communities benefiting from the project's interventions at these sites which serves as an incentive for participating in forest management. Mbuvi's research [49] also indicated that in community regime, most respondents did not see a reduction in forest size, while more than half of the respondents in command and control and participatory forest management regime felt that there was a reduction in forest size. Mbuvi's research [49] revealed that community forest management is no longer capable of efficiently managing forests. These induce the need to incorporate regulated access. Additionally, the regime could benefit from the inclusion of some aspects of command and control or partnership with government stakeholders as in the case of participatory forest management. This contrasts with other research findings in other parts of the world in Nepal and Bangladesh respectively [12, 83] where

the community-based forest management sufficiently managed the forest.

Regarding the link between ES and management of forest resources the identified two knowledge gaps which include: the main objective would be to determine the impact of government institution's management on livelihood and its effectiveness in implementing its mandate (ES focus). As specific objectives include: *(i)* determine the effectiveness of forest institutions (KFS and KWS) in charge of managing the natural resources in implementing their mandate in KFE, and *(ii)* To determine the impact of participants and non-participants of participatory forest management on their livelihoods in KFE. Filling the identified knowledge gap would help policymakers to determine the effectiveness of participatory forest management with regards to improving the livelihood of local communities and determine if they are being involved in the decision-making process of the KFE management.

Table 1

Summary of the analysed case studies against key elements of livelihood framework

	Key elements of livelihood framework																				
	Vulnerability context			Assets				Policy & institution context			Livelihood strategy			Outcome							
Spatial scale	Hist	Demo	SD	N	E	H	S	NGO	Govt	CDI	AI / AE	LD	M	I & W	WB & H	FS	SMR	P	V	C	DN
Global (3 CS)	1	2	2	2	2	2	2	2	3	2	1	1	1	2	1	2	1	3	2	0	0
Africa (10 CS)	1	8	8	10	7	8	5	3	7	5	5	5	2	6	5	3	7	3	5	5	9
Kenya (6 CS)	2	6	3	6	6	5	5	0	5	3	1	3	0	5	2	2	4	4	3	3	4
Kakamega (4 CS)	3	1	1	4	2	0	2	1	2	2	1	1	0	2	0	2	3	1	2	2	3
Other (19 CS)	6	14	11	18	14	13	11	4	12	14	11	11	1	3	11	6	15	6	11	6	13
Frequency [%] (Total 42)	31	74	60	95	74	67	60	24	69	62	45	50	10	43	45	36	71	40	55	38	69

Note: CS – case studies; Hist-history, Demo-demography, SD-social differentiation, N-natural, E-Economic, H-human, S-social, NGO-Nongovernmental organization-government organization, CDI- community development institution, AI/AE- Agricultural intensification/Agricultural extensification, LD- livelihood diversification, M- Migration, I&W-income and wealth, WB&H- wellbeing and health, FS- food security, SMR- sustainable management of resources, P- Poverty, V- Vulnerability, DN- degradation of natural resource, other- Countries outside Africa.

In Table 1 we summarized the key elements of the livelihood framework according to Scoones [81] key elements of livelihood framework against our case analysed case studies from different spatial scales. For each of the case studies we looked to see if the authors addressed any of the sub key elements of the livelihood framework and indicated the score on the table. Then we proceeded to check the spatial scale of the study area. After which we proceeded to get the frequency of each sub key elements.

3.7. Ecosystem and Local Communities Research Methodology

Most of the case studies we examined that involves changes in land cover and land use prefer to utilize geographical information systems (GIS) and remote sensing. 19% of the case studies used GIS in their methodology (Figure 4). Most of the research centred on well- being used rural participatory methods like interviews (household, KII) which contributed to 38% of our analysed cases. Other participatory methods used included pebble distribution methods this contributed to 12% of the analysed case studies. Research centred on climate change mostly used focus group discussion (FGD) which contributed to 7% of the analysed case studies. Research on socio-economic conditions of the local forest communities mostly collected their data using questionnaires and household survey which represents 12 and 17% respectively of the analysed cases studies. And research focused on household income collected their data using questionnaires. And analysed the data using the Kuznets Ratio (KR) to determine the income inequality, this contributed to 17% of the analysed case studies as other.

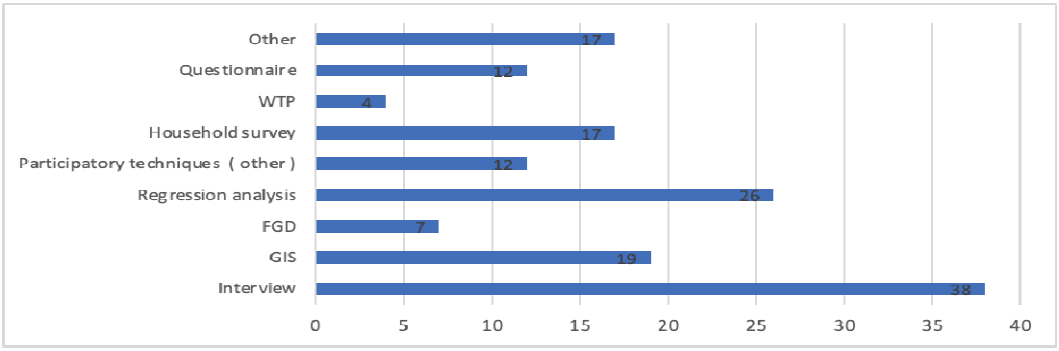

Fig. 4. *Frequency of the methods in the case studies*

4. Conclusion

The various case studies we analysed focused on the four different types of ES with 39 case studies dealing with provision ES (93%), 13 case studies with supporting ES (31%), 23 case studies regulating ES (55%), and 35 case studies cultural ES (83%) as seen in Figure 3. Most of the case studies dealt with different issues regarding key elements of the livelihood

framework and the nexus between local communities and the ES.

The identified knowledge gap in our interest area – KFE – as a conclusion raising from the analysed case studies, are (formulated as tentative research objectives):

a) description the income distribution of the wealth groups (high- and low-income households) and socio-economic factors influencing forest reliance;
b) finding out if KFE is a safety net to shocks and act as a seasonal gap filler; investigate the livelihood strategies before shock (ex-ante) and aftershock (ex-post) and households' response to different types of shocks, and the availability of insurance mechanism;
c) examination of the relative benefits (provisioning), importance (regulating, supporting and cultural), and factors influencing households' choice across wealth groups;
d) evaluation of the KFE household's preferred land use supporting their well-being;
e) finding out the households' response to climate change and its impact on livelihood: focus on livelihood diversification strategy;
f) describing the impact of government institution's management on livelihood and its effectiveness in implementing its mandate (ES focus).

The identified knowledge gaps should be used to enable a better understanding of the relationship between ES and the local community. From this knowledge gaps we can form tools that can be used to improve the livelihood of local communities, thus reducing dependency on the forest ecosystem. The perception of the local communities is equally important in design of the management of KFE.

The case studies used a variety of methodology, most of them got their primary data in the households using participatory rural appraisal methodologies, which involved face to face interview, KII, group discussion, Pebble distribution method and direct observation. For land use land cover change most of the case studies used remote sensing and GIS. Others include damage cost, WTP, Discrete choice experiment, Mitigative expenditure.

The most important limitation of our study was that we didn't classify the specific identified type of ES according to the four categories across the spatial scale according to Millennium Ecosystem Assessment. This would have enabled a better cross-sectional analysis of the identified specific ES.

From our analysis with the established knowledge gaps identified and the various methodologies used across these key areas, we can establish various tools that can be used to address the livelihoods of the local forest community in our interest area of Kakamega forest. The tentative method framework includes participatory rural methods to acquire primary data. Based on these tentative objectives and methodological framework, the future research will address chapter 5 of the national forest programs of the country [8] - the achievement of the SDG goals at country level by address issues of food security through livelihood diversification strategies. Improving forest management of Kakamega forest with the identified needs of the stakeholders (local communities, government institutions, community forest associations and NGO's)

can be afterwards incorporated in the management strategy. The identified tools can be replicated or modified to be used in other forests in the country and beyond.

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