Effects of variation in local governance on community attitudes, ecological outcomes and ecosystem services in Mt. Kenya forest

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Abstract

Many countries in the tropics have decentralised forest management to incorporate local communities in decision making, referred to as community-based forest management (CBFM). A paradigm shift from state control, CBFM has been receiving considerable attention in conservation due to success in restoring degraded forestlands. However, successful forest outcomes are largely inferred from comparisons with other governance regimes e.g. state management. Effective governance is a prerequisite for positive conservation outcomes but little attention has been paid on local governance and in particular variability of local governance between local communities and its effect on forest outcomes. Additionally, CBFM provides insufficient benefits, particularly economic benefits, yet sufficient net benefits are crucial for winning support of local communities. Using a globally relevant CBFM programme, this thesis examines variation in local governance between communities and its effects on ecological outcomes. Factors influencing communities' attitudes towards forest conservation and ecosystem service preferences important for locals' livelihoods and well-being are examined. Local governance at grassroot community institutions – community forest associations (CFAs) was assessed qualitatively from CFAs documentation and quantitatively from respondents' perceptions of CFAs governance using principles of good governance. Forest structure and outcomes were examined in CFAs plots through ground measurement of forest parameters, field observation and in-depth interviews. Local attitudes, livelihoods, ecosystem services and preferences, PFM processes and activities were examined through a combination of mixed methods in social research. Strongly-governed CFAs plots had better forest outcomes; species diversity, carbon biomass and lower forest disturbance than weakly-governed plots. Further local's attitudes were influenced by strong governance, higher economic benefits and capacity building. CBFM provided multiple ecosystem services with contrasting perceptions to preferred ecosystem services influenced by socio-demographic factors. Co-management programmes must devise mechanisms for strengthening governance and offer sustainable solutions for enhancing flow of benefits (economic and non-economic) to improve conservation effectiveness.

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Chapter 1

Introduction

Vegetation in Mt. Kenya forest

1. Introduction

1.1. Forest resources

Globally, forests are among the most biologically rich ecosystems on earth (FAO, 2010; Kohl et al., 2015) covering 31 percent of total land area (FAO, 2010). They are valuable natural resources providing vital ecosystem services and associated benefits at multiple scales; social, ecological and economic benefits at local, national and global levels. In the tropics, they play a crucial role in contributing to the well-being of local communities especially forest-dependent rural households in different ways. They support current consumption, act as a safety net during periods of crisis (e.g. drought), provide regular cash income and potentially offer a pathway out of poverty for poor forest-dependent households (FAO, 2010; Sunderlin et al., 2005; Angelsen & Wunder, 2003). Consequently, forests have been shown to contribute a significant proportion of income to local communities in the tropics, approximately 21-28 percent of total household income (Angelsen et al., 2014; Vedeld et al., 2007), with rural poor households relying more heavily on forests for subsistence needs (e.g. fuel wood, wild foods, medicinal herbs) than wealthy households. Chao (2012) estimates that forests contributes directly to the livelihoods of half a billion indigenous people and 1.3 billion forest-dependent people around the world, a figure close to FAO (2014) estimates — 1.6 billion people dependent of forests.

Forests make significant contributions to national economies of many countries, hence supporting progress towards realisation of sustainable development goals (SDGs) (e.g. nutrition and health, food security, education). Their contribution to economic development is enormous with wood and manufactured forest products adding more than US$ 450 billion to the world economy annually (Kohl et al., 2015). Approximately 40 percent of amount generated annually is from developing countries (FAO, 2014c), with officially-reported monetary contributions of forests to developing world economies exceeding $250 billion — more than twice the value of total development assistance (Agrawal et al., 2013). In many countries in the tropics, forest sector ranks among the highest revenue and employment regenerating sectors e.g. Gabon, Swaziland, Solomon Islands (FAO, 2014c), with forest-based employment providing 49 million jobs especially in rural areas (FAO, 2014c). Globally, 13.2 million people are employed in the formal sector with an additional 41 million people in the informal sector (FAO, 2014b).

Furthermore, forest ecosystems support ecological processes (e.g. air purification, soil fertility, nutrient cycling, pollination etc..) important for sustaining humans and wildlife and reduce risks of natural disasters such as floods and landslides (World Bank 2008; FAO 2014) especially in vulnerable communities. They continue to be vital carbon sinks supporting global climate change mitigation with FAO (2015) estimating that forests stored on average 2.1 Gt CO_2 yr^{-1} during the period 2011–2015. Thus, forests provide a wide range of benefits and their efficient management is critical for sustainable flow of these benefits for communities' well-being, economic development and biodiversity conservation.

In the tropics, forest resources are increasingly being threatened by unsustainable land use practices, population growth, anthropogenic activities and competing land uses (e.g. agriculture, urbanisation and infrastructure development (Popradit et al., 2015 Poffenberger, 2006; FAO, 2014b; MEA, 2005). For instance, 3.9 million hectares of natural forests have been cleared — approximately the size of Switzerland — between 2001-2011 in eight countries[1] majoring in the production of four commodities; palm oil, beef, soy and wood products (Henders et al., 2015). These land use changes and other anthropogenic activities such as illegal logging increases greenhouse gas emissions, threatens ecosystem functioning and biodiversity there in (Carlson et al., 2013; Alroy, 2017; Barlow et al., 2016).

Although conversion of forests to other land uses (e.g. agriculture, dams' construction) has increased food production and other services (e.g. shelter and water, raw materials) critical for human well-being and economic development, ecosystem fragmentation and degradation could have global implication on biodiversity conservation, ecosystem functioning and human well-being. To forest-dependent communities whose survival depends on a wide range of timber and non-timber forest products, declining resources and ecosystem services present increasing threats to their livelihoods and well-being (MEA, 2005; Sunderlin et al., 2005). This is because poor rural households living on the edges and adjacent to forest areas are often politically weak and powerless (Sunderlin et al., 2005), with limited options for livelihoods and diversification strategies (e.g. access to land, capital, and skills). Thus, forest fragmentation and degradation pose serious threats to their well-being which can aggravate poverty levels and vulnerability of already marginalised communities.

1.2. Forest governance and management

1.2.1. Top-down approach

Throughout the last decade, attention has been focused on the dilemma of forest resources in the tropics faced with increased anthropogenic activities, deforestation and declining biodiversity (Keenan et al., 2015; Barlow et al., 2016). Tropical forests hold the highest

[1] Brazil, Indonesia, Papua New Guinea, Bolivia, Malaysia, Argentina, Paraguay and Democratic Republic of Congo

level of biodiversity (NAS, 1988; Naughton-Treves et al., 2005) and increased deforestation and degradation at levels beyond capacity to recover or withstand imbalances can threaten biodiversity and pose serious risks to species of conservation concern. To counter this threat, strict protectionist approach through command and control, and significant resources — financial, human and capital (Naughton-Treves et al., 2005; Bruner et al., 2004) were deployed to protect tropical forests from exploitation and anthropogenic activities. The World Bank, for instance, spent on average, US$ 275 million annually supporting protected areas in the tropics over a 20-year period between 1988 to 2008 (Hickey & Pimm, 2011), while national governments provided additional support amounting to between US$1.2 and 2.6 billion per year (Molnar et al., 2004). The rationale being that human activities in tropical forests are incompatible with conservation of biodiversity (Brandon et al., 1998; Kubo & Bambang, 2010) especially in strict IUCN protected areas (PAs) categories; I−4 prohibiting human use or activity (IUCN, 2013).

Increasing number of biodiversity hotspots (Myers et al., 2000; Brooks et al., 2006) and expansion of protected areas (PAs) which have increased tremendously over the years (Brockington et al., 2006), currently at 238,432 designated terrestrial PAs covering 15% of the world's land (UNEP-WCMC & IUCN, 2019) are some of the measures taken to protect and maintain forest resources and biodiversity therein. In the tropics, forest PAs cover 26% of global land area (Morales-hidalgo et al., 2015), which is projected to increase as many countries strive to achieve 2020 Aichi biodiversity targets aimed at increasing and effectively managing PAs (CBD, 2010). As a result, evidence shows some PAs have succeeded in realizing conservation objectives by mitigating anthropogenic activities such as illegal logging, encroachment and grazing (e.g. Laurance et al., 2012; Geldmann et al., 2013). This is especially where PAs' management have adopted co-management arrangements with local communities promoting social and economic empowerment through inclusive participation and sustainable resource use (Oldekop et al., 2016; de Koning et al., 2017).

In the last decade, while creation and expansion of PAs continued and increased exponentially over time, with many states striving to place 10 percent of their land area under protection following the 1982 World Parks Congress in Bali (IUCN, 1982; Miller, 1984) little attention was being paid on the well-being of local communities. Increased expansion of PAs was in conflict with the needs of local communities (Agrawal & Redford, 2009; Schwartzman et al., 2000; Brockington & Schmidt-soltau, 2004). Evictions of local and indigenous communities to pave way for establishment of PAs also displaced their livelihoods confining them to marginal areas with limited potential (DeGeorges & Reilly, 2009). As a result, displaced rural livelihoods caused considerable environmental problems (Brockington et al., 2006) arising from illegal activities and scarcity of resources both within and outside PAs respectively.

With burgeoning population, increasing demand for forest resources (Defries et al., 2010; FAO, 2011) in the midst of scarce resources in locals' communal or own lands, top-down forest management has been dominated by increased tension, conflicts and non-compliance to established rules e.g. illegal activities, killing of wildlife and encroachment (Kideghesho et al., 2007; Weladji & Tchamba, 2003). Such illegal activities threaten biodiversity and conservation efforts, and command and control became increasingly costly and difficult to implement in the midst of constrained budgets (Bruner et al., 2004; Wilkie et al., 2001; James et al.,1999) and lack of community support essential for successful conservation outcomes (Brooks et al., 2013; Wells & Mcshane, 2004). Thus, the command and control approach fell short of expectations with forest PAs failing to meet mandate of protecting biodiversity, with reported high deforestation and degradation, and threats to critical species of conservation within and outside PAs (Hill et al., 2015; Laurance et al., 2012; Wilkie et al., 2011; Hansen et al., 2013).

Criticisms that PAs have failed (or may fail) in protecting biodiversity (Locke & Dearden, 2005; Watson et al., 2014) coupled with social justice agenda in recognition of community rights (Martin et al., 2016) witnessed increased calls for reconciling local needs with biodiversity conservation. Consequently, sustainable development has been promoted in many countries to meet the needs of current generations while protecting integrity of natural resources in meeting needs of future generations (WCED, 1987). Since 1987, increased interest in integrating environment and development, addressing rural poverty and local needs, and inclusivity in social and economic growth (IUCN, 1982; UNCED, 1992) has led to signing and ratification of internationally recognised frameworks for promoting sustainable development. Among these include recognition of indigenous people's rights, public participation in decision making, and fair and equitable sharing of benefits from resources as a prerequisite for achieving sustainable development (UNECE, 1998; UNCED, 1992; IUCN, 2007; CBD, 2004). Commitment by many states in abiding to the frameworks and mechanisms for achieving global sustainable development goals — MDGs and SDGs — (UN, 2000; 2015) has witnessed increased legal reforms in many countries. Currently, conservation strategies for natural resources such as forests recognise rights of local communities in community-based natural resource management (CBNRM) approach in many countries in the tropics. This approach represents new paradigm shift from centralised state control characterised by strict exclusion of local communities to co-management approaches recognising local community needs and participation in biodiversity conservation.

Increased recognition of the importance of functioning ecosystems (e.g. healthy forests) and contributions to human well-being has been a driving force for promoting biodiversity conservation and sustainable use of natural resources such as forests. Well-managed ecosystems provide crucial benefits important for human well-being and conservation purposes (MEA, 2005; Summers et al., 2012). The Millennium Ecosystem Assessment (MEA) demonstrates close linkages between ecosystems, human well-being and possible drivers — direct and indirect — that may affect changes to ecosystems and the services they provide, thereby affecting human well-being (MEA, 2005). Ecosystem services are benefits people obtain from nature and MEA categorised these into; provisioning (e.g. food, water, timber, medicinal herbs); regulating (e.g. soil erosion and floods control, air purification, pollination, water quality); cultural (e.g. education, aesthetic, recreational, religious/spiritual benefits); and supporting services (e.g. habitat, nutrient cycling) important for human well-being.

Humans are part of ecosystems and increased human interactions with other natural ecosystems fuelled by industrial revolution and technological advancement has transformed and changed ecosystems at a fast rate. Although their transformation has contributed to improvements in human well-being and economic development (MEA, 2005), their interference with ecological functions cause adverse socio-environmental impacts e.g. resource conflicts, increased rural income inequality, greenhouse gas emissions (Ceddia, 2019; Pearson et al., 2014; Whitworth et al., 2018). These socio-environmental impacts negatively affect human well-being, in particular poor and vulnerable groups in society, and is an impediment in achieving global development goals (MEA, 2005). To improve quality of degraded ecosystems, management practises incorporating local needs, sustainable utilisation of resources and sound management of natural resources are crucial for ensuring constant supply of ecosystem services for human well-being and biodiversity conservation.

1.2.2 Decentralisation in forest management

Many states have engaged in policies of institutionalising popular participation for decentralising forest management (FAO, 2015; RRI, 2012; Ribot, 2002) with significant changes being made in management practices. By 1990, over 50 countries had establishment legal frameworks and or adopted policy amendments incorporating local communities in sustainable forest management while others were in the process of review (FAO 1999). These policies advocate for inclusive decision making and participation of local communities in forest conservation with the aims of improving forest conditions, empowering communities and providing sustainable livelihoods for poverty reduction (Charnley & Poe, 2007; Maryudi et al., 2012). In many countries, local communities living near and adjacent to forest resources are increasingly being recognised as key stakeholders in forest conservation, commonly referred to as community based forest management (CBFM). These collaboration initiatives between local communities and government(s) has witnessed a notable increase in forest area under community ownership and or control with almost one-third of the world's forest area being under some form of CBFM initiatives (Gilmour, 2016).

Community based forest management (CBFM), a paradigm shift from the conventional control and command approach, promotes participation and collaboration in forest management between local communities, government(s) and may include other stakeholders such as non-government organisations (NGOs), donors and private sector. To improve quality of forest ecosystems and encourage participation, local communities have been (are being) granted rights and incentives, including; tenure, decision making/management, user rights and expanded capacity (skills and knowledge) in managing forest resources (e.g. Larson & Dahal, 2012; Cronkleton et al., 2012; Essougong et al., 2019). Incentives for participating local communities encourages sustainable utilisation of forest resources (i.e. permitted, e.g. timber/posts, fuel wood, fodder/grazing, income generating activities, etc.) to improve the welfare of local communities. The CBFM approach is based on the assumption that reconciling conservation and local needs by supporting livelihoods and activities benefiting communities economically would lead to winning local support, counter biodiversity threats (Salafsky & Wollenberg, 2000; Wells & Mcshane, 2004), thus advancing conservation goals. However, in some instances, increased economic incentives/benefits combined with little enforcement and monitoring may accelerate more rapid resource extraction and exploitation (Salafsky & Wollenberg, 2000; Barrett et al., 2001).

Strengthening local institutions, governance, and provision of defined benefits[2] that can empower local communities to govern their forest resources has been shown to be effective in achieving conservation objectives (Pagdee et al., 2006; Oldekop et al., 2010; Ribot, 2002). Over the years, the importance of local communities and strong institutions characterised by good

[2] Benefits should be well known to local communities and secured through long-term agreements. Local communities should be able to seek restitution for compensation if benefits and other rights are abrogated unfairly

governance practices in forest management while balancing competing demands, needs and interests of different users and actors has been increasingly acknowledged (e.g. MEA, 2005; CBD, 2004;World Bank, 2009). Local communities can add their own rules and regulations, forming local institutions — rules-in-use (Gibson et al., 2000) complementing existing national frameworks in resource management. Thus, institutions are formal and informal political and social structures designed to assist in efficient resource management but they can also play a major role in their mismanagement (Ostrom, 1990). Since local institutions guide daily use and consumption of natural resources (Gibson et al., 2000), they consist of decision making structures providing guidance to local communities on their interaction with natural resources.

Strong local institutions comprising of formal and informal systems of resource control are essential for effective community conservation initiatives (Barrett et al., 2001). Local communities have shown in the past and increasingly today to be efficient in long-term and sustainable management of forest resources when granted autonomy and decision making rights (e.g. Ostrom, 1990; Persha et al., 2011; Murali et al., 2002; Chhatre & Agrawal, 2009), hence the importance of strengthening local institutions for biodiversity conservation. Close proximity to forest resources equips communities with more knowledge on their surrounding including forest users and uses, making monitoring easier and cost effective (Andersson et al., 2014). Where local communities share common interest(s) in a resource, e.g. benefits or for the good of society, inclusive decision making for organising formal or informal local systems of control can enhance the likelihood of rule compliance (Andrade & Rhodes, 2012) thus, overcoming resource exploitation and also influencing the distribution and sharing of benefits from local resources (Agrawal & Benson, 2011).

Strong local organisation and fair representation of local communities in decision making can enhance collective responsibility, sense of belonging and psychological ownership, hence, motivating them in enforcing access restrictions and or control (Barrett et al., 2001) for efficient forest management. Under common-pool resources such as forests, decision making rights yield more power as holders of these rights have authority to participate in decision making to set rules to determine how, when and whether harvesting in a resource may occur (Schlager & Ostrom, 1992), and can modify factors to reduce deforestation to improve the condition of resource systems (Gibson et al., 2000). Thus, strengthening local institutions by granting autonomy in decision making rights to local communities are central to effective biodiversity conservation (Agrawal 2001; Ostrom 1990) and conservation success in achieved where resource access is restricted by strong local systems (Chan et al., 2007; Barrett et al., 2001).

1.3. Economic and social incentives

Incentives, perceived or received influence people's motivations to engage in conservation behaviours (Ruiz-Mallén et al., 2015; Reddy et al., 2017). Incentives can be economic and or social in nature and are integrated into conservation programmes aimed at promoting behaviours for maintaining biodiversity by using resources sustainably (Ferraro & Kiss, 2002) especially in developing countries. Actions of local communities can be shaped by perceived incentives and benefits received from natural resources and as a result, such perceptions may influence direction and intensity of their behaviours towards natural resources (Asah et al., 2014). Further, behaviour of local communities in conservation is conditioned by economic benefits, for instance, if consequences and costs for engaging in economically attractive activities e.g. illegal logging are insignificant compared to returns generated from such activities, then conservation is likely to be compromised as benefits provided to local communities may not be an inducement to stop threats to natural resources such as forests (Nick Salafsky & Wollenberg, 2000). Capital assets (e.g. land, skills, equipment) also significantly determine benefits received especially from resource exploitation and as such wealthy individuals or households have been shown to receive more benefits than their poor counterparts Parajuli et al., 2015 Local institutions; human-crafted rules and norms (Ostrom, 1990), and well-designed incentives (economic and non-economic) best suited for local context are mechanisms that can be used to promote conservation behaviours to enhance sustainable utilisation and management of natural resources.

Economic benefits enhance local engagement and provide motivation for participation in biodiversity conservation (McClenachan et al., 2015; Yang et al., 2015). However, conservation based on economic inducements requires significant flow of benefits, large enough to also spread throughout the community (Barrett et al., 2001) to ward off illegal activities from those left out from benefits (e.g. Oyono et al., 2006). Some scholars point out that, economic benefits must be sufficient to outweigh local costs incurred in conservation for net benefits to be realised (Leimona, 2009; Dickman et al., 2011), with costs equitably distributed among ecosystem service beneficiaries — locally and globally (Chan et al., 2007; Barrett et al., 2001). The basic "law of behaviour is that higher incentives lead to more effort and higher behaviour" with significant effect on performance (Gneezy et al., 2011), implying that high net benefits lead to more effort in participation and pro-conservation behaviour in conservation. Failure to provide significant economic incentives can undermine conservation efforts, generating apathy and resentment towards conservation initiatives (e.g. Samndong & Vatn, 2012; Ansong and Røskaft 2011).

Economic benefits have largely dominated in designing incentives for motivation and behavioural interventions in conservation programmes (Ferraro & Kiss, 2002; Leduc & Hussey, 2019). As a result, conservation programs assume that poor households have fixed income targets and do not pursue additional opportunities beyond those targets (Barrett et al., 2001). Further, economic benefits have a higher degree of flexibility and can be converted to local goods and services (Leimona, 2009) to meet immediate and basic needs However, little economic benefits from conservation coupled with short term nature of benefits (e.g. Martin et al., 2014; Spiteri & Nepal, 2006) are major challenges for sustaining conservation efforts amongst local communities. Well-designed conservation programmes that establish direct links with biodiversity conservation and livelihood practices are more likely to achieve social, economic and ecological success (Oldekop et al., 2016; Brown, 2002). Suich (2013) demonstrates that conservation success is more likely where greater economic benefits to local people make significant impact on their welfare, and benefits are sustainable (Salafsky et al., 2001), otherwise unsustainable benefits may hinder long-term conservation efforts. On the contrary, some scholars point out that biodiversity conservation should be the ultimate goal (McCauley, 2006) as external interventions such as economic benefits and rewards to promote participation and pro-social behaviour may “crowd out” any intrinsic motivation to perform a task, including participation in conservation (Frey, 1993; Bénabou & Tirole, 2003).

Non-economic incentives such as social benefits (e.g. transparency, confidence, self-esteem, greater decision-making power, revenue sharing, improved social services) have often been ignored as inducements for motivation (Fehr & Falk, 2002), particularly in conservation. However, such non-economic social benefits can be linked to long term productive capacity, conservation success and social capital building (Pretty, 2003; García-amado et al., 2013). Social benefits such as skills and knowledge acquired from training(s) can redirect labor and capital away from degrading ecosystems, diversity livelihoods and income generating activities such as nature based entreprises, thus achieving ‘win–win’ scenarios (Ferraro, 2001; García-amado et al., 2013). For instance, butterfly farming in Arabuko-sokoke forest generated cumulative community earnings exceeding US$130,000 from 1994 to 2001, with significant positive effects on both livelihoods and attitudes (Gordon & Ayiemba, 2003). Although building social capital and changing peoples’ attitude in the midst of urgent livelihood needs (& conservation results) can take long to develop (Ferraro, 2001; Pretty, 2003), they are pragmatic in reinforcing intrinsic value-based attitudes, pro-conservation behaviours and ethical morals for long-term biodiversity conservation (McCauley, 2006).

1.4. Community based forest management outcomes

Community based forest management studies document mixed outcomes (e.g. Porter-Bolland et al., 2012; Pelletier et al., 2016). Where success is reported, it is usually connected to forest conditions and cover. Evidence for creating and promoting sustainable livelihoods including community empowerment is limited. Studies reporting forest conditions show improved forest outcomes; reduced human activities (e.g. cut stumps, charcoal burning), high growth and regeneration, recovery of wildlife populations, high tree and basal area density (e.g. Gautam et al. 2002; Pandit and Bevilacqua 2011; Lund et al. 2014; Lambrick et al., 2014). While the evidence provides useful findings on role of local communities and co-management initiatives in achieving conservation objectives, considerable research effort for majority of studies is devoted to comparing the effectiveness of different governance categories, that is, state, private and community/indigenous forest management. Schleicher et al., (2017), for instance, in a study in the Amazon examined performance of state PAs on deforestation and degradation in relation to indigenous territories (ITs), civil society and private conservation concessions (CCs), reporting that CCs and ITs were more effective in reducing deforestation, degradation than state PAs. Further, Wright et al., (2016) using matching techniques found that community forests with active engagement of local communities had more stable forest cover that state managed forests in Peru. However, there is variability in performance in each category of governance in biodiversity conservation e.g. successful and unsuccessful community forests or PAs (e.g. Barnes et al., 2017), and gaps exist in understanding conditions under which governance regimes promote or hinder effective forest conservation. Additionally, inconclusive findings emanating from contradictory results/studies in forest conservation fails to validate which management regime is effective in sustainable forest management. For instance, some studies shows that community forests and PAs permitting sustainable use of resources are more effective in stemming deforestation and linked with better forest outcomes (Ferraro et al., 2013; Blackman, 2015). Yet, other studies demonstrate the opposite; strict protected areas are associated with better forest outcomes than sustainable use areas (Nolte et al., 2013). This implies that although findings are useful in conservation agenda, governance regime may not be a suitable indicator for measuring and explaining differences in conservation outcomes and thus need to pay greater attention to other factors influencing conservation outcomes.

Recognizing that effective governance is a prerequisite for successful management of forest resources (PROFOR, 2012), many scholars call for more attention and research on how different governance arrangements affect conservation outcomes (e.g. Brockington et al., 2018; Agrawal et al., 2008). Local communities have demonstrated their capacity to successfully manage their forest resources sustainably (Zimmerman et al., 2001; Andersson et al., 2014) although some communities are better at developing innovative governance structures for achieving conservation objectives while others not (Ostrom, 1990; Barrett et al., 2001). In this regard, little understanding exists on why governance effectiveness varies across communities operating under similar CBFM governance framework, and how variability of local governance influences outcomes. Using a globally relevant CBFM programme in Kenya, this study sought to address this research gap to improve our understanding on effectiveness of governance quality in delivering conservation objectives, social outcomes and engendering favourable attitudes amongst local communities in CBFM.

Local's attitudes and perceptions towards biodiversity conservation are shaped by impacts — both positive and negative — of conservation activities (Nsonsi et al., 2017). These attitudes and perceptions can affect success of biodiversity conservation. For instance, negative attitudes can hamper conservation efforts leading to illegal activities, over exploitation of resources and increased poaching activities (Hazzah et al., 2013; Infield & Namara, 2001; Travers et al., 2019). An assessment of conservation attitudes towards forest management amongst local communities is important for devising mechanisms to foster favourable attitudes or enhance these perceptions and win support of local communities. Previous studies shows locals attitudes towards biodiversity conservation are influenced by different social-demographic e.g. as income, wealth, education, (Angula et al. 2018; Hazzah et al. 2013). As local communities comprise of diverse populations, success of any community conservation initiative will largely depend on the ability to devise programmes reflecting heterogenous needs and expectations of local communities. In regards to conservation benefits, economic benefits to local communities are crucial inducements for motivating local communities and generating favourable attitudes towards conservation (Adhikari et al., 2016; Dewu & Røskaft, 2017). However, value of economic incentives matter with low economic benefits often linked to less favourable or negative attitudes and reduced participation in conservation activities (e.g. Störmer et al., 2019; Ansong & Røskaft, 2011; Jim & Steve, 2002). On the contrary, evidence from CBFM studies shows little economic incentives tricking to local communities (e.g Porter-Bolland et al., 2012; Parajuli et al., 2015; Mutune & Lund, 2016), yet communities continue partipating with increased engagement and participation associated with better forest conditions (e.g. Wright et al., 2016; Persha et al., 2011). Literature is limited on the effect of social benefits including non-economic benefits (e.g. rulemaking autonomy, participation, transparency, empowerment, training) on local's attitudes towards forest management. Therefore, this study addresses this gap by examining influence of both economic and non-economic benefits on communities' attitudes towards forest conservation.

Forests provide a broad range of ecosystem goods and services vital for supporting livelihoods and well-being of local communities. Studies examining livelihood benefits provided through CBFM to local communities give more prominence to a single type of ecosystem service, particularly provisioning services, often assessed in monetary terms (Lakerveld et al., 2015; Matiku et al., 2013; Ameha et al., 2014). This despite the fact that non-monetary benefits play a crucial role in fulfilling communities' well-being as well as in ecosystem service agenda (Daniel et al., 2012; Chan et al., 2012), yet excluded in ecosystem assessments. This is attributed to prominent focus given to economic assessment of ecosystem services traded in the market and challenges encountered in the assessment of non-monetary benefits (Small et al., 2017). Nevertheless, economic assessment of ecosystem services does not capture broad spectrum of benefits local communities perceive as important for their well-being. Thus, gaps exist in understanding the social dimension of forest ecosystem services in fulfilling communities' well-being. Identifying preference(s) in ecosystem services is important to identify priorities and contrasting preferences in ecosystem services in order to make informed decisions and better policy formulation to ensure sustained flow of ecosystem services beneficial for local communities and for conservation purposes.

Therefore, this study assessed the following objectives;

a) Impact of local governance and benefits on local communities' attitude towards sustainable forest management
b) Variation in local governance and its effect on forest conditions and outcomes
c) Role of community based forest management in delivering ecosystem services and livelihoods for human well-being.

This research seeks evidence for improving effective management of forest resources under co-management initiatives emphasising role of local governance quality on conservation and social outcomes especially in the tropics where large populations are dependent on forest ecosystems. In doing so, this study aims to enhance our understanding on governance quality of local institutions and its effectiveness in forest conservation, social outcomes and community attitudes towards sustainable forest management. This is important in order to identify governance strengths and weaknesses promoting or curtailing CBFM programmes and its outcomes. This research uses a globally relevant CBFM programme that comprises of local communities spanning a range of governance strength (quality) with an aim of devising mechanisms for strengthening local governance for successful outcomes in co-management initiatives such as CBFM.

1.5. Historical overview of forest management in Kenya

1.5.1. Importance of forest resources in Kenya

Forests in Kenya cover vast climatic regions and are categorised in to; coastal, dry zone, montane and western rain forests (Wass, 1995). Kenya's closed canopy forests constitute less than 2% of total land area (DRSRS and KFWG, 2006; Wass, 1995). However, despite low forest cover, they provide goods and services important to local communities' and economic development. The large and wide range of species they harbour especially bird species and large mammals rank the country the second highest in species richness for these groups among African countries (World Resource Institute et al., 2007), and thus are crucial in biodiversity conservation. Approximately 50, 40, 30 and 35 percent of all woody plants, large mammals, birds and butterflies respectively are found in forests (Wass, 1995) and further provide habitat for a significant number of endemic species found nowhere else in the world (World Resource Institute et al., 2007) and species of conservation importance; endangered, threatened and vulnerable species e.g. *Loxodonta africana, Piliocolobus rufomitratus, Equus grevyi, Tragelaphus eurycerus* (IUCN, 2015).

Contribution of forests in supporting locals' livelihoods is enormous especially to forest-dependent rural households who rely on forests for their sustenance, with forests contributing approximately 70 per cent of cash income to forest adjacent households in Kenya (UNEP, 2009; Wass, 1995). Local communities benefit from multiple ecosystem goods and services; timber (e.g. timber, poles), non-timber forest products (e.g. fuel wood, fodder) and other services (e.g. pollination, soil fertility) supporting essential livelihood and well-being components such as agriculture, culture, religious and spiritual nourishment. Additionally, forestry is a key sector in Kenya's economy contributing about 1.3 percent of Kenya's gross domestic product (GDP) to the national economy per year — Ksh 9.9 billion (US$ 141 million) (World Resource Institute et al., 2007).

1.5.2. Threats to forest resources

Most Forests in Kenya are mainly concentrated in areas of high agricultural potential (e.g. Mt. Kenya, Mau Forest Complex) which are the most densely populated areas in Kenya (DRSRS and KFWG, 2006) due to their conducive environment for agricultural activities and urban settlements. The forests and adjacent areas suffer from increased threats from urbanisation, population pressure and competing land uses (e.g. agriculture, settlements and infrastructure development – e.g. the authorised Itare dam in Mau forest complex). With an annual growth rate of 2.8 percent (UNEP, 2009), Kenya's population growth has increased tremendously, from just eight million in 1960s to approximately 21 and 28 million people in 1989 and 1999 respectively (GoK, 2002). This is further projected to increase to 46 million people in 2019 census (KNBS, 2019), further placing a heavy strain on forest resources. Further, anthropogenic activities, corruption and mismanagement has decimated forest resources (Morjaria, 2012; FAO, 2005; KFS, 2010). For instance, with an original forest cover of 6.8 million ha of closed canopy indigenous forests[3], only 1.24 million ha of this is remaining in the country (Wass, 1995).

Moreover, forest fires, invasive species, pests and diseases have also been a threat to forest resources (KFS, 2010). Aggravating the risk of forest fires are human activities carried out in forests requiring use of fires such as charcoal burning, honey harvesting, bush meat roasting and fires to drive away animals (e.g. elephants) in farms located inside or near forests. As a result, key forested areas such as Mt. Kenya forest and Mau Forest Complex have experienced wildfires caused by human activities (KFS, 2010), often the most leading cause of forest fires in many countries (Santín & Doerr, 2016). In Kenya, a tremendous increase in forest fires has been recorded with an average annual outbreak of 78 fires (GoK, 2013; FAO, 2000) threatening ecosystems and loss of biodiversity.

1.5.3. Forest management during colonial period (1895-1962)

In Kenya and most of sub-Saharan Africa countries, *de facto* traditional conservation practices regulated resource management before colonisation (DeGeorges & Reilly, 2009). Formal forest management coincided with colonisation and traditional systems have been gradually phased out due to shift to western forest management, introduction of strong markets, industrialisation, increasing population and transformation of society towards modernity (e.g. formal education) (Ayiemba et al., 2014; Wass, 1995; DeGeorges & Reilly, 2009).

[3] Indigenous forests refer to Kenya's natural forests composed of indigenous species only (Wass, 1995).

The enactment of the East African Forestry Regulations and creation of a Forest Department (FD) in 1902 conferred control and management of forests to FD, and thereafter gazettement of indigenous forest land into protected areas (PAs) commenced (Wass, 1995). The 1902 regulations were revised severally in to Forest Ordinances of 1911, 1915, 1916 and 1941 expanding the earlier regulations by restricting entry into gazetted forests, charging of forest products (e.g. fuel wood), defining offenses and imposing fines and penalties for infractions (Ayiemba et al., 2014; Castro, 1991).

Forceful eviction of indigenous communities continued throughout the colonial period and by 1940, government-controlled forest area had increased to 1,050,000 ha (Wass, 1995). The gazettement of forests during the colonial period was meant to: protect forests from destructive indigenous land use practices; prevent European settlers from obtaining private ownership; and generate revenue for the FD through the sale of timber and minor forest products (Castro, 1991; Ayiemba et al., 2014). Evictions confined local communities into crowded native reserves with limited resources which failed to sustain their livelihoods. The aftermath was depletion, degradation and scarcity of resources within the native reserves (Wass, 1995; Ayiemba et al., 2014) prompting eventual encroachment into gazetted forests to obtain subsistence materials for use and consumption (e.g. bush meat, fuel wood, timber). Restricting access to large areas of forests limited local communities options for eking out a living triggering conflicts and increased hostilities between the colonial government and livid communities unwilling to surrender their forest land which has persisted up to date e.g. Ogiek community (Yeoman, 1993; Claridge, 2017).

1.5.4. Forest management after independence (1963 — current)

The Kenyan government inherited the top-down colonial system of forest management which lasted for four decades until 2005. After independence, the Forest Act, Chapter 385 of the Laws of Kenya of 1942, revised in 1982, 1992 and 2005 provided legal framework for forest management in Kenya. Gazettement of new government-controlled forests and forceful eviction of indigenous communities continued after independence and by 1990 government protected forests had increased to 1,930,000 ha (Wass, 1995). Despite increased gazettement of forests, this period witnessed unprecedented increase in deforestation rates and over-exploitation of forest resources. Wass, (1995) points out that, after independence, the country was losing approximately 5,000 ha of forests annually attributed to illegal activities and mismanagement. High demand for forest products (e.g. fuel wood, timber) and illegal activities diminished forest supplies faster than they could be replenished (Castro, 1991). Additionally, increasing population pressure and an estimated 3 million forest-adjacent people living within 5 kms of forest boundary (Mogaka et al., 2001; Wass, 1995) sustained more pressure through exploitation of forest products to meet livelihood needs.

Mismanagement of forest resources and corruption like in many other countries in the tropics; Africa, Asia and South America (e.g. Laurance et al., 2012; Sundström, 2016) also contributed significantly to dwindling forest resources. Weak forest laws and abuse of power by political elites accelerated forest mismanagement. For instance, Section 4 of the Forest Act, Chapter 385 conferred powers to the Minister to gazette any unalienated land as government forest land, but the same Act gave the Minister authority to degazette forest land – forest excision via publication of a Gazette Notice, 28 days prior to excision (Wass, 1995). Discretionary powers granted to Minister created a vacuum in favour of forest excisions for both political and private vested interests. Wass (1995) criticised the excision process; lack of legally defined procedures for handling objections, short period notice (28 days), lack of provision for environmental impact assessments (EIAs) and excisions carried out not in the interest of the public.

Ministers exercised this authority frequently, especially during forth coming general elections (Morjaria, 2012; Klopp, 2012). Large areas of forests were lost through legal process of forest excisions — de-gazettement of forest land (Klopp, 2012; Morjaria, 2012), with the country losing approximately 6.5 percent of its forest cover or around 241,000 ha between 1990 and 2010 (FAO, 2010). A big percentage of this loss was driven mainly by forest excisions triggered by political motives for agriculture/settlements, private gain and public use (FAO, 2014; Wass, 1995). For instance, the Nyayo tea zones[4] were used as a conduit through which forest land was illegally allocated to well-connected individuals and political elites (Klopp, 2012), with approximately 11,000 ha of forest land cleared for the tea zones (GoK, 1994). Further, forests were used as a campaigning tool by the government in power then (from 1978-2002) for voter allegiance and support during national elections, with forest excisions accelerating towards electioneering period (Morjaria 2012). Morjaria, for instance, shows that between 1993-2002, approximately 117,853.83 ha of forest land was lost through excision, with large areas excised in loyal and swing districts (now counties) supporting or alleging support to the government in power.

[4] Agricultural tea farming established by Presidential Order in 1986 and Act of Parliament in 1988 to pave way for tea farming to act as a physical buffer zone between communities' villages/agricultural land and protected area forests, and also to provide alternative source of income and employment (GoK, 1994; Wass, 1995).

Since the beginning of forest excisions in Kenya, approximately 220,000 ha of forest land — representing 13% of Kenya's total gazetted forest reserves — was degazetted (GoK, 1994; Wass, 1995) into settlements and agricultural farms in key water catchment areas including Mt. Kenya forest and Mau forest complex. Coupled with competing land uses (e.g. Nyayo tea zones, urbanisation, infrastructure development), anthropogenic activities and population pressure, forest cover declined to approximately 3 percent (UNEP, 2001; UNEP, 2009). As a result, adverse environmental impacts; dry river beds, delayed and in-adequate rains, prolonged drought (Gathaara, 1999; UNEP, 2001; Daily Nation, 1999; Morgan, 2009 — *"Kenya's heart stops pumping*"), threatened key ecosystem services critical for Kenya's economy, livelihoods of local communities and biodiversity conservation.

With a view of enhancing forest regeneration and conditions, a strategic plan for forest resource development — the Kenya Forest Master Plan, KFMP — in 1994 was prepared (GoK, 1994). The Master Plan assessed forest management in the country including legal and institutional weaknesses and recommended various turn around strategies including decentralisation, co-management with local communities and development of a new law to reflect the proposed changes (GoK, 1994). The KFMP key objectives aimed at contributing to environmental conservation and enhancing the role of forestry sector in socio-economic development through increased contribution to economic growth, income and employment generation. After ten years since development of the KFMP, a new Forest Act was enacted in 2005 (GoK, 2005). The new Forest Act also paved the way for establishment of a state corporation – the Kenya Forest Service, KFS — (GoK, 2005), that succeeded the Forest Department, and whose enhanced mandate include development of forest sector and sustainable management of forest resources through sound harvesting and utilisation practises for economic development.

1.5.5. Community based forest management

Community based forest management has been more recent in Kenya and other countries in Africa e.g. Tanzania, Uganda compared to countries in Southeast Asia, which started in the 80's. Enactment of a new Forest Act in Kenya in 2005 legalised implementation of CBFM commonly referred to as participatory forest management (PFM). The Act and the subsequent amendment in 2016 recognises local communities living near and adjacent to forest resources as key stakeholders in sustainable forest management (GoK, 2005; 2016). The Act mandates communities to form and register community forest associations (CFAs) — with Registrar of Societies — in order to collaborate with KFS in forest conservation. Before registration and approval of CFAs, CFAs management plans and constitution is mandatory which outlines; use of forest resources, activities, methods of monitoring, protecting and enforcing, financial regulations, membership and election of officials (GoK, 2016). CFA is a voluntary association composed of community members living within 5 km of forest boundaries. As of 2014, a total of 97 CFAs had prepared management plans covering approximately 1,031,460 ha of forests nationally (Ayiemba et al., 2014).

The Forest Act gives CFAs control in; conservation and management of forests under their jurisdiction, assisting KFS in enforcing forest regulations especially on illegal harvesting of forest produce, helping in firefighting and other activities necessary for sound management of forest resources. In return for participation, communities have usufruct rights to permitted forest products and activities including; harvesting of subsistence products (e.g. medicinal herbs, fuel wood, fodder), bee keeping, timber harvesting, plantation establishment and livelihood improvement scheme (PELIS) and other benefits as may be agreed from time to time (GoK, 2005; 2016). PELIS is a programme where CFA members are allocated a half-acre farming plot to plant and nurture tree seedlings while practising crop farming in clear-felled plantations for a period of three years after which they are required to vacate the plots to allow young saplings to mature. This is one of the main incentives for communities' participation in PFM.

Kenya's forests are still owned by the state but some control and authority (e.g. decision making, conflict management, fundraising, negotiating with KFS and initiating forest activities) has been relegated to local communities through CFAs (Mogoi et al., 2012; Koech et al., 2009). CFAs are guided by the Forest Act in managing forests at their jurisdiction but they can also craft formal and informal rules restricting access and controlling use of forest products. Some CFAs have established extensive governance structures including operational rules such as access, use, taxation, sanctions, benefit sharing, monitoring and enforcement, meeting procedures and responsibilities. They are headed by CFA officials working in close collaboration with KFS in guiding conservation activities. Devolved power is mainly concentrated on forest conservation, protection and low value subsistence benefits such as fuel wood, fodder/grazing, bee keeping (*see* Mutune & Lund, 2016; Chomba et al., 2015) with little control on perceived high value benefits e.g. timber harvesting. Further, access to subsistence benefits is subject to taxation fees determined solely by KFS with additional charges levied by some CFAs for revenue generation.

High-value benefits such as timber harvesting and PELIS are subject to more restrictive terms and conditions, and further approval from KFS and tendering committee is needed.

Although CFAs can express interest and place bids for timber harvesting like other established saw millers in the country, lack of skills and prohibitive costs including expensive equipment and high capital investment has disqualified majority of CFAs from the lucrative venture (Mogoi et al., 2012; Ayiemba et al., 2014). Indeed, lack of local capacity, absence of technical expertise and low levels of financial capability cuts across many local communities in the tropics such as Uganda, Nepal, Indonesia and Bolivia (Ribot et al., 2006). In Kenya, the Forest Act mandates KFS to "promote the empowerment of associations and communities in the control and management of forests" (GoK, 2016), and one way is by granting a percentage of forest concessions/timber harvesting or revenues (Lawry, 1990) and strengthening institutional governance in order to encourage participation in conservation activities. However, KFS has done little to empower, facilitate and grant timber harvesting rights and concessions to CFAs. In contrast, in countries such as Nepal and Cameroon, communities have been granted rights to exploit timber resulting to wealth creation and rural development (Anup et al., 2015; Rai et al., 2016). Further, while some CFAs bid and win small contracts for silvicultural activities (e.g. thinning, pruning), many outsource works to private sector due to lack of capacity and technical expertise in silvicultural practices (Koech et al., 2009).

Burdened by increasing exclusion from decision making in timber harvesting and concessions in community controlled forest sites and lack of benefit sharing mechanisms between local communities and state as outlined in the Forest Act, CFAs and the National Alliance of Community Forest Association (NACOFA) – a community alliance advocating for community recognition and rights in natural resource management – has instituted several legal proceedings against KFS and the Government of Kenya in the past (e.g. judicial review case no. 285 of 2012, environment and land case no. 273 of 2013 to challenge exclusion of CFAs in decision making and timber harvesting and concessions in community controlled state forests including; Mt. Kenya, North Rift, Aberdare, Mt. Elgon and Lembus forests among other forests (Kenya Law, 2013) – (*see Appendix 1 for complains against KFS*). Although the court(s) ruled in favour of CFAs and NACOFA in all suit cases restraining KFS from granting timber harvesting and concessions to individuals or private enterprises, and to recognise CFAs as key stakeholders in further deliberations (Kenya Law, 2013), question remains as to whether KFS and the state will honour the court case(s) recognising communities in decision making in timber revenues, thus ceding a share/percentage of key revenue stream at the expense of socio-economic development interests.

1.6. Study site description

1.6.1. Mt. Kenya forest

Mt. Kenya Forest Reserve is both a Forest Reserve and a National Park covering 2,130.82 km^2 and 715 km^2 respectively and under joint jurisdiction of both KFS and KWS (KFS, 2010; KWS, 2010). It is a protected area (PA) gazetted in 1949 through legal notice No. 69 of 6th June 1949. The Forest Reserve is an important biodiversity hotspot harbouring wide variety of species of plants and animals. For instance, 880 plant species belonging to 479 genera in 146 families have been recorded below 3200m altitude in the forest (KWS, 2010). Due to its remarkable biodiversity, ecosystems and natural landscapes, it was designated as a Man and Biosphere Reserve in 1978 and a World Heritage Site (WHS) in 1997 (KWS 2010). The forest is an important bird and biodiversity area (IBA) providing refuge to a significant number of species of conservation concern[5] (Bennun & Njoroge, 1999; IUCN, 2015).

It is a critical and valuable resource being one of the five[6] water catchment areas in the country providing numerous benefits; material and ecological to both local populations and the country for economic development. For instance, the forest provides livelihood benefits (e.g. fuel wood, fodder, medicinal herbs) for approximately 520,000 households (Wass, 1995) living adjacent to the forest. Further, approximately 50 percent of Kenya's population rely on water originating from the forest and provides 70 percent of the country's hydroelectric power (KWS, 2010). Emerton (1997) demonstrated economic significance of the forest with an estimated value in excess of Ksh. 2 billion (1 US $ = ~ Ksh. 100) although pundits have increasingly criticised commodification of nature and valuation methods in non-monetized services (e.g. Mccauley, 2006).

Mt. Kenya Forest Reserve suffers from intense human pressures and threats (KWS, 2010; DRSRS and KFWG, 2006) as the forest is surrounded by densely populated areas with small land holdings (Emerton 1997), hence increasing demand for forest products and commercial interests (e.g. water abstraction and bottling). Furthermore, forest excision process degazetted 6,360.5 ha for settlement (KFS, 2010) and the forest is more prone to further encroachment and illegal activities exacerbating over-exploitation of forest products. For instance, findings of an

[5] Examples include; African elephant (Loxodonta Africana — Vulnerable), Grevy's Zebra (Equus grevyi — Endangered), Mountain Bongo (Tragelaphus eurycerus — Near Threatened), Sykes monkey (Cercopithecus mitis — Decreasing), Abbott's starling (Cinnyricinclus femoralis — Vulnerable), Macronyx sharpie — Endangered, Turdoides hindei — Vulnerable; Cisticola Aberdare — Endangered, and Cinnyricinclus femoralis — Vulnerable).

[6] Others include Aberdare's, Mau Complex, Mt. Elgon and Chereng'ani Hills forests all providing most of the water supplies needs in the country and supporting major sectors of the country's economy.

aerial survey conducted in 1999 by Kenya Wildlife Service (KWS) in collaboration with the United Nations Environmental Programme (UNEP) revealed extensive destruction to Mount Kenya forest; a total of 5,631 ha of forests destroyed, marijuana (*Canabis sativa*) cultivation extended to 200 hectares in the forest, over 6,700 Camphor (*Ocotea usambarensis*) trees destroyed through illegal logging out of a total of 14,662 indigenous trees cut and 2,465 charcoal kilns recorded (Gathaara, 1999). Mogaka et al., (2005) notes that maintaining one kiln requires approximately three mature indigenous trees each week, indicating more than 7,000 indigenous trees may have been cut per week to support recorded kilns. As a result, increased exploitation and forest destruction led to a legal review through Legal Notice No. 93 of 24 July 2000 placing the entire Mt. Kenya Forest Reserve under the management of KWS; the forest reserve is currently under joint management of KWS and KFS.

Implementation of CBFM in Mt. Kenya forest like other forests in Kenya is aimed at curbing anthropogenic activities, reducing deforestation and rehabilitating degraded forest areas in collaboration with local communities. Although great strides have been made in conserving the forest, new threats and persistent pressures (e.g. illegal logging, over-exploitation, expanding settlements, agricultural intensification, and water abstraction through legalised activities such as PELIS) are threatening functioning of ecological processes thereby diminishing important ecosystem services for both local communities and biodiversity conservation. For instance, reduced water volume and dry river beds (*see* Mungai, 2018 "*Irony of dry Mt. Kenya rivers despite rainfall*") affects key economic sectors at the local and national level, and water supply needs for the citizenry. Reduced water volume significantly affects water availability for domestic, agricultural and industrial activities and can trigger conflicts related to water shortage/scarcity and stress.

1.6.2. Climate, vegetation and soils

Climate of the montane forest and adjacent areas is strongly influenced by altitude with great variation in altitude (m above sea level) ranging from 1,500 m in the lower zones to the two highest peaks; Batian (5,199 m) and Nelion (5,188 m) within the National Park (KWS, 2010). Average mean temperatures within Mt. Kenya environs is 11.5°C but fluctuates greatly from a low of 7.5°C (at 4,200 metres) to a high of 20°C (KFS, 2010) with temperatures decreasing by 0.6°C for each 100m increase in altitude (KWS, 2010). Rainfall pattern is bimodal with maximum rains falling during March to June and short rains from October to November. Rainfall ranges from 900 mm yr^{-1} to 2,300mm yr^{-1} with highest rainfall experienced on the Windward side (south eastern slopes) while little rainfall falls on the Leeward side (north side of the mountain)

(Camberlin et al., 2016; KWS, 2010). Altitudes receiving more rainfall fall between 2,700m – 3,100m, while precipitation falls as snow or hail above 4,500m (KWS, 2010).

Vegetation is divided into five management zones namely; Moorland between altitude 3000m and 3500m; pure bamboo between 2550m and 2650m; mixed bamboo with indigenous trees which extends from 2500m to 3200m; indigenous natural forest starting at 2400m down to 2000m and plantation forest zones between 2200m and 2400m (*Table 1.1*). Some of the indigenous trees in the forest include; Camphor (*Ocotea usambarensis);* Cedar (*Juniperus procera*); Meru Oak (*Vitex Keniensis*), Croton (*Croton macrostachyus*); Podo (*Podocarpus latifoli*us); Wild Olive (*Olea europaea) and East* Africana Rosewood (*Hagenia abyssinica.).* Main commercial tree species planted in the plantation zone include; Cypress, Pines, and Eucalyptus.

Table 1.1. Distribution of vegetation types in Mt Kenya forest

County/ Zone	Indigenous forest (ha)	Plantation (ha)	Bush land (ha)	Grass land (ha)	Bamboo (ha)	Moorland/ Others (ha)	Total
Nyeri	33,659	9,937	2,726	5,776	12,141	169	64,408
Kirinyaga	13,246	1,248	5,350	398	10,120	4	30,366
Meru Central	55,790	5,521	7,129	12,340	4,070	0	84,850
Meru South	28,873	230	2,300	570	5,800	1,600	39,373
Embu	7,748	474	257	2,497	6,837	445	18,258
Total	**139,316**	**17,410**	**17,762**	**21,581**	**38,968**	**2,218**	**237,255**

Source: KWS (2010)

Soils are categorised into four broad groups and are significantly influenced by environmental parameters (KWS, 2010; KFS, 2010). On the steep high altitude, above 4000m asl soils are shallow and consist of stony dark loam soils with high organic matter and low bulk density (e.g. Leptosols, Regosols and Greysols) (KFS, 2010). The upper slopes between 2400 and 4000m asl consist of dark surface horizons and low bulk density soils but rich in organic matter, including Regosols, Histosols and Andosols. In the lower slopes below 2600m, soil type is influenced by amount of rainfall received in the area ranging from intensively red soils with considerable amount of clay (e.g. Nitisols, Cambisols and Andosols) to dark top horizons soils with high proportions of clay minerals (e.g. Phaeozems, Planosols and Vertisols) (KFS, 2010). Thus, soil type within Mt. Kenya forest region is greatly determined by climatic factors and altitude and thus influencing vegetation types.

1.6.3. Local communities and economic activities

Three ethnic communities reside near and adjacent to the forest; *Kikuyu* surrounding the Nyeri and Kirinyaga forest block; *Embu* on Embu block and *Meru* community on the Meru South and Meru Central blocks. The three communities belong to the Central highlands Bantu linguistic group with similar cultural practices and closely related languages — *Kikuyu, Kiembu and Kimeru*. Further, intermarriages are common amongst the three communities. They primarily engage in agricultural and dairy farming taking advantage of conducive environment including rich fertile soils, sufficient rainfall and nearby markets for farm produce. They grow crops such as maize, beans, peas, sweet potatoes, arrow roots and vegetables including cabbages, kales, spinach and carrots. Cash crops grown include tea and coffee (GoK, 2010; KFS, 2010). Tourism also contributes significantly to the local and national economy (GoK, 2012) with key attraction sites and activities; mountain climbing, wildlife viewing, cultural and historical heritage, fishing, site-seeing and canoeing attracting both domestic and international tourists.

1.7. Methodology justification

This study adopted a mixed methods approach in data collection, combining elements of quantitative and qualitative methods. Being an interdisciplinary research exploring multifaceted interplay between socio-economic issues, institutional governance and ecological conditions, mixed methods supported data collection and integration of socio-economic and ecological data, providing a deep understanding of complex socio-ecological systems in Mt. Kenya forest. This was achieved through use of multiple data sources (survey, in-depth interviews, focus group discussions, participant observation, forest inventory) which supported data triangulation and corroboration, increasing scientific rigor of the study and thus, strengthening validity of results (White et al., 2005; Salkind, 2010).

Mixed methods approach is increasingly being used in conservation research to gain a broader understanding of phenomenon being investigated, thus, overcoming inflexibility and bias inherent of using a single method (McKim, 2017; Creswell, 2014; Johnson et al., 2007). Lund et al., (2014) for instance, applied a mixed method approach to assess effects of decentralisation on conservation impact of two forests in Tanzania using forest inventory and adopted management practises. The authors conducted qualitative interviews to assess forest management practices which they linked to biophysical evidence of forest inventory measurements. Lonn et al., (2018) used a similar approach and assessed forest cover changes from 2000 to 2012 using local people's perceptions and published global maps to evaluate effectiveness of community-based programme in Cambodia. Therefore, quantitative and qualitative methods complement one another and are used in conservation research to gather more nuanced and complete information about conservation management practises, socio-economic and ecological information, and to explicitly understand people's perceptions, values, preferences and attitudes (Sutherland et al., 2014; Creswell, 2014), that may be key to enhancing conservation strategies and solving conservation challenges.

Qualitative methods (e.g. in-depth interviews, focus group discussions, participant observation) are essential in gaining ecological and socio-economic information on specific conservation issues (Young et al., 2018). These methods are used in filling knowledge gaps and broaden understanding, particularly if complex behaviours are to be investigated (Reddy et al., 2017; Minichiello et al., 2008). For instance, qualitative methods are widely used in conservation research to discuss personal experiences and perceptions about a specific topic, attitudes, beliefs, motivations and or conservation practices (Nyumba et al.,2018; Bennett, 2016), which may prove difficult to assess using quantitative methods. A combination of qualitative methods comprising of in-depth interviews, focus group discussions and participant observation were used in this study to explicitly assess ecosystem service values and preferences, local attitudes, perceptions of governance and implementation, and socio-economic impacts of PFM. Qualitative approaches adopted in this thesis such as in-depth interviews and focus group discussions allowed for open-ended questions and probing leading to nuanced understanding and rich narrative descriptions (Bennett, 2016) of PFM impact, perceptions/beliefs, experiences and preferences which were central in establishing how these shape locals' behaviours in conservation. For instance, respondents' opinions and perceptions on whether CFAs governance structures promoted transparency, accountability, inclusivity in decision making and equity (in-equity) in benefit sharing were key in understanding local's behaviours in conservation such as compliance to by-laws or proliferation of illegal activities such as tree debarking and logging.

In-depth interviews are important for gathering information on natural resource management approaches (Sutherland et al., 2018). The interviews can be used to collect data on communities' preferences, perceptions, attitudes, and socio-cultural experiences derived from their interaction and relationship with immediate surroundings (Nyumba et al., 2018; Bennett, 2016). These experiences and peoples' perception can contribute to sound decision making to support conservation initiatives. For instance, individuals or local groups who believe that a conservation programme is infringing on their right to food security and livelihood benefits may develop negative attitudes and actively oppose conservation (e.g. Shibia, 2010; Hazzah at al., 2013; Hariohay et al., Røskaft, 2018). This can be captured better through narrative interviews of experiences and perceptions of local communities which in turn can lead to changes in decisions addressing both conservation and local needs.

Efforts to improve conservation decisions has witnessed extensive application of focus group discussions with a small number of participants in order to explore in-depth insights and understanding of conservation programmes such as CBFM through narrative discussions and descriptions of people's perspectives on social-economic, ecological and conservation issues/impacts (e.g. Nsonsi et al., 2017; Andersson et al., 2014; Soe & Yeo-Chang, 2019). Two separate focus group discussions (one for CFA and the other for non-CFA respondents) comprising of between 12-14 participants enabled relaxed and in-depth discussions on PFM programme; impacts (socio-economic and ecological), benefits, ecosystem service preferences, governance structures (lack of), socio-cultural experiences before and after PFM, challenges and preferred future scenario.

Using a list of questions to guide discussions, group discussions with a smaller number of participants provided better understanding of PFM and benefitted from complex personal experiences, perceptions and motivations (lack of) (Nyumba et al., 2018; Morgan, 2002) of selected participants, thus, broadening understanding and aiding data triangulation from other sources (surveys and observation) providing strong evidence to improve social and ecological outcomes. Decisions to improve conservation outcomes rely on good evidence, with qualitative methods providing deep insights of the messy and complex social–ecological contexts within which conservation occurs (Adams & Sandbrook, 2013), thus, supporting sound evidence for better decision making.

Quantitative methods are important techniques for data collection and are used to quantify and describe patterns, make connections and explore relationships amongst variables (White et al., 2005). They are essential in presenting facts in a precise form and are widely used in research to enhance research objectivity and support generalisation of study findings beyond scope of study under investigation (Creswell, 2014). Quantitative methods used in this study include use of a survey and measurement of ecological parameters on sampled respondents and Mt. Kenya forest CFA sites' respectively. Survey administration supported data collection on socio-economic variables, governance and management practises, respondents' attitude towards PFM, participation, preferences and values, and skills acquired through PFM. Data collected provided quantitative description of socio-economic, ecological and conservation practises, which supported comparisons between groups (CFA groups and sites) and assessment of relationships amongst variables (e.g. local governance and attitudes). Surveys are increasingly used in conservation research as suitable tools for gathering data and are used in rating (e.g. using a Likert scale), ranking, quantifying human behaviour, and comparing (e.g. between groups, sites or countries) quantitative indicators of perceptions of social, attitudinal, ecological, governance, and management considerations (Quintas-Soriano et al., 2018; Oteros-Rozas et al., 2014; Bennett, 2016; Amano et al., 2018; Mollick et al., 2018). For instance, Andersson et al., (2014) used a survey to assess and compare community perceptions of forest cover change, vegetation diversity and density, and institutional governance between forest user groups in Bolivia. Thus, quantitative methods are vital in assessing biodiversity and human-environment relationships critical for understanding perceptions and impacts of change for sound decision making.

Piloting of survey questionnaires was done to minimise potential bias from outsider perceptions (interviewers), to gauge completion time and kind of responses received against expectation. Additionally, piloting provided an opportunity for respondents to seek clarification where needed and thus, supported review of the questionnaire by incorporating issues identified and removing duplicate questions or questions which did not add new information. Questions were ordered in a logical manner, related topics classified or grouped together, moving from one topic to another and keeping the flow of questions in a chronological manner, thus avoiding mixing topical issues which can affect nature of respondents' answers through errors (National Research Council, 2013). Further, to establish rapport with respondents, the first early questions were designed to be answered with much ease (e.g. education, household size) (Creswell, 2014; Patton, 2002) thus, avoiding difficult or sensitive questions which might provoke respondents at an early stage of interviewing.

Quantitative methods also enabled collection of forest inventory data through measurement of forest stand structure attributes (e.g. diameter at breast height) and disturbance levels in terms of number and size of stumps in sampled plots. Data collected supported assessment of links between socio-economic (from survey) and ecological variables, and comparison of forest conditions in CFAs sites. There is increasing evidence that stand structure attributes determine forest conditions and functioning (Ali, 2019; Naidu & Kumar, 2016), with more studies attempting to integrate ecological data with socio-economic parameters for deeper understanding of human-environment relationships and linkages for better decision making. For instance, studies assess forest conditions and growth through measurement of stand attributes (e.g. diameter at breast height, tree height, size and age of stumps) and examine the extent into which environmental benefits and management practises (e.g. rulemaking, enforcement) influence ecological outcomes (e.g. Hayes, 2006; Persha, Agrawal, & Chhatre, 2011; Lund et al., 2014). Similar approach was used in this study supporting better understanding of local governance structures and relationship with socio-economic and ecological outcomes, thus providing a more nuanced understanding of the complex processes under which PFM and by extend community conservation initiatives occurs.

Therefore, qualitative and quantitative methods complement each other and were vital in gaining a clear picture and deeper understanding of PFM processes, impacts and governance structures by examining underlying motivations behind behaviours, preferences and values, attitudes, governance legitimacy and preferred future scenario. This is important in order to provide objective scientific information and evidence (Sutherland, et al., 2004; Pullin et al., 2013) necessary for supporting effective conservation decisions to solve conservation challenges, thus achieving conservation success.

1.8. Thesis structure

This thesis begins with an introduction, setting the context on the importance of forest ecosystems at local and global levels. Past and current forest governance regimes particularly in the tropics are discussed and challenges encountered in each regime (Chapter 1). Subsequent chapters focus on CBFM in sustainable forest management, with Chapter 2 assessing and presenting results on influence of local governance quality, economic and non-economic benefits on local's attitudes towards forest conservation. Chapter 3 presents results on ecological outcomes based on forest structure, carbon storage, tree species richness, diversity and composition in relation to governance quality of local institutions. Chapter 4 shows a wide range of ecosystem services provided through CBFM, social dimension of forests in fulfilling communities' well-being as well as contrasting preferences of ecosystem services amongst social groups in communities. Chapter 5 concludes with a summary and discussion of thesis findings.

1.8. Appendix 1

Table 1.2. Selected list of complains brought against KFS by CFAs under National Alliance of Community Forest Association (NACOFA)

- On the 14th June 2012, the Respondent Kenya Forest Service (KFS), through an advertisement in the Daily Nation newspaper, invited individuals and interested institutions to apply for concessions in state forest plantations, for parcels of between 1,000 – 12,000 hectares each. The opening of bids is scheduled for July 16th, 2012.
- If this process is allowed to proceed, it will result in hundreds of thousands of hectares of forest land being allocated to individuals and companies for a period of 30 years and more. The affected forests are Mt. Kenya, North Rift, Aberdares and Mt. Elgon.
- Parliament is yet to create the laws and regulations to govern the concession of Kenyan Resources to private persons;
- No public consultation was conducted prior to the issuance of the notice;
- Parliament and the Government generally have not enacted the rules and regulations for the equitable sharing of resources;
- The Respondent KFS has not provided the public with any information as to how the decision to issue the notice was arrived at;
- The concessions will in effect pre-empt forthcoming county governments and their citizens from exercising any form of power over these forest resources, as well as deprive them commensurate benefits for a period of 30 years or more.
- Forest stakeholders have been alienated in the decision making process that culminated in KFS publicly soliciting for expressions of interest (EOIs) for concession awards.
- There is a failure to adhere to the Forests Act 2005, which is the core legislation that governs management of forest resources, Section 35(1) of this Act, requires that every state forest, local authority forest and provincial forest be managed in accordance with a management plan. However, management plans for the four targeted forests have not been made public nor been presented publicly as a basis for the KFS' decision to grant concessions in respect of these forests.
- Article 69(1) (a) and (h) of our Constitution, which forest communities expected to deliver long awaited tangible benefits from natural resources, stand in jeopardy.
- Forest communities have undergone many years of frustration as they sought to legalize their entitlement to forest resources.
- They have mobilized millions of shillings to support government led forest management planning, in the hope that this would culminate in access to forest resources. However, this has not been forthcoming. Hence, the communities have turned their focus on Article 69. The KFS move now serves to shatter this last resort.
- The concessions would place these fragile ecosystems in the hands of business people whose main drive is to maximize benefits.
- This is likely to lead to depletion of the national forest cover and deprive the country of the tremendous amenities provided by forests.
- The manner in which the call for the Expression of Interests is articulated accords concession holders the prerogative to determine communities' involvement during the concession period. In actual fact it ambiguously presents the communities' role as providing support to the concession and not to share in the benefits of the concession.
- When concessions are one type of forest utilization regime, they are not necessarily the best when applied exclusively over an entire forest unit. They compromise a variety of other economic uses such as non-timer forest products harvesting, beekeeping, ecotourism, crops production, sustenance of hydrological functions among others.
- Therefore, the implication of concessions is that the variety of economic uses that present opportunities for a bigger number of people will be invalidated.
- The Applicant has protested to the Respondent to no avail
- The Applicant stands to suffer irreparable loss if these orders are not allowed.
- That the actions of the Respondent are oppressive and unconscionable.
- That the said actions of refusal have been taken without consultation or giving the Applicant any hearing despite several letters done to the Respondent.

Source: (Kenya Law, 2013).

1.9. References

Adams, W. M., & Sandbrook, C. (2013). Conservation, evidence and policy. *Oryx*, *47*(3), 329–335. https://doi.org/10.1017/S0030605312001470

Adhikari, S., Kingi, T., & Ganesh, S. (2016). Incentives and community participation in the governance of community forests in Nepal. *Small-Scale Forestry*, *15*(2), 179–197. https://doi.org/10.1007/s11842-015-9316-8

Agrawal, A. (2001). Common property institutions and sustainable governance of resources. *World Development*, *29*(10), 1649–1672. https://doi.org/10.1016/S0305-750X(01)00063-8

Agrawal, A., & Benson, S. C. (2011). Common property theory and resource governance institutions: Strengthening explanations of multiple outcomes. *Environmental Conservation*, *38*(2), 199–210. https://doi.org/10.1017/s0376892910000925

Agrawal, A., Cashore, B., Hardin, R., Shepherd, G., Benson, C., & Miller, D. (2013). *Economic contributions of forests*. *Background paper prepared for the United Nations Forum on Forests. Tenth session 8 -19 April 2013*. Istanbul, Turkey. Retrieved from http://www.un.org/esa/forests/pdf/session_documents/unff10/EcoContrForests.pdf

Agrawal, A., Chhatre, A., & Hardin, R. (2008). Changing governance of the world's forests. *Science*, *320*(1460), 1460–1462. https://doi.org/10.1126/science.1155369

Agrawal, A., & Redford, K. (2009). Conservation and displacement: An overview. *Conservation and Society*, *7*(1), 1–10. https://doi.org/10.4103/0972-4923.54790

Ali, A. (2019). Forest stand structure and functioning: Current knowledge and future challenges. *Ecological Indicators*, *98*, 665–677. https://doi.org/10.1016/j.ecolind.2018.11.017

Alroy, J. (2017). Effects of habitat disturbance on tropical forest biodiversity. *Proceedings of the National Academy of Sciences*, *114*(23), 6056–6061. https://doi.org/10.1073/pnas.1611855114

Amano, T., Székely, T., Sandel, B., Nagy, S., Mundkur, T., Langendoen, T., … Sutherland, J. W. (2018). Successful conservation of global waterbird populations depends on effective governance. *Nature*, *553*(7687), 199–202. https://doi.org/10.1038/nature25139

Ameha, A., Nielsen, O. J., & Larsen, H. O. (2014). Impacts of access and benefit sharing on livelihoods and forest: Case of participatory forest management in Ethiopia. *Ecological Economics*, *97*, 162–171. https://doi.org/10.1016/j.ecolecon.2013.11.011

Andersson, K., Benavides, J. P., & León, R. (2014). Institutional diversity and local forest governance. *Environmental Science and Policy*, *36*, 61–72. https://doi.org/10.1016/j.envsci.2013.07.009

Angelsen, A., Jagger, P., Babigumira, R., Belcher, B., Hogarth, N. J., Bauch, S., … Wunder, S. (2014). Environmental income and rural livelihoods: A global-comparative analysis. *World Development*, *64*, S12–S28. https://doi.org/10.1016/j.worlddev.2014.03.006

Angelsen, A., & Wunder, S. (2003). *Exploring the forest-poverty link: Key concepts, issues and research implications*. *CIFOR Occasion Paper No. 40*. Bogor, Indonesia. https://doi.org/10.1016/S0039-6109(16)32102-8

Angula, N. H., Stuart-Hill, G., Ward, D., Matongo, G., Diggle, W. R., & Naidoo, R. (2018). Local perceptions of trophy hunting on communal lands in Namibia. *Biological Conservation*, *218*, 26–31. https://doi.org/10.1016/j.biocon.2017.11.033

Ansong, M., & Røskaft, E. (2011). Determinants of attitudes of primary stakeholders towards forest conservation management: A case study of Subri Forest Reserve, Ghana. *International Journal of Biodiversity Science, Ecosystem Services & Management*, *7*(2), 98–107. https://doi.org/10.1080/21513732.2011.613411

Anup, C. K., Koirala, I., & Adhikari, N. (2015). Cost-benefit analysis of a community forest in Nepal. *Journal of Sustainable Forestry*, *34*(3), 199–213. https://doi.org/10.1080/10549811.2014.1003074

Asah, T. S., Guerry, D. A., Blahna, J. D., & Lawler, J. J. (2014). Perception, acquisition and use of ecosystem services: Human behavior, and ecosystem management and policy implications. *Ecosystem Services*, *10*, 180–186. https://doi.org/10.1016/j.ecoser.2014.08.003

Ayiemba, W., Mbithi, D., Nahama, E., Kagombe, J., Njuguna, L., Njuguna, L. W., … Mwanzia, J. (2014). Proceedings of the 2nd national PFM conference: Enhancing participatory forest management under the devolved governance structure. July 15-16. Nairobi, Kenya: Kenya Forestry Research Institute.

Barlow, J., Lennox, G. D., Ferreira, J., Berenguer, E., Lees, A. C., Nally, R. Mac, … Gardner, T. A. (2016). Anthropogenic disturbance in tropical forests can double biodiversity loss from deforestation. *Nature*, *535*(7610), 144–147. https://doi.org/10.1038/nature18326

Barnes, M. D., Craigie, I. D., Dudley, N., & Hockings, M. (2017). Understanding local-scale drivers of biodiversity outcomes in terrestrial protected areas. *New York Academy of Sciences*, *1399*(1), 42–

60. https://doi.org/10.1111/nyas.13154

Barrett, B. C., Brandon, K., Gibson, C., & Gjertsen, H. (2001). Conserving tropical biodiversity amid weak institutions. *BioScience*, *51*(6), 497–502. https://doi.org/10.1641/0006-3568(2001)051[0497:ctbawi]2.0.co;2

Bénabou, R., & Tirole, J. (2003). Intrinsic and extrinsic motivation. *Review of Economic Studies*, *70*, 489–520. https://doi.org/https://doi.org/10.1111/1467-937X.00253

Bennett, N. J. (2016). Using perceptions as evidence to improve conservation and environmental management. *Conservation Biology*, *30*(3), 582–592. https://doi.org/10.1111/cobi.12681

Bennun, L., & Njoroge, P. (1999). *Important Bird Areas in Africa and associated islands - Kenya*. Nairobi, Kenya: Nature Kenya.

Blackman, A. (2015). Strict versus mixed-use protected areas: Guatemala's Maya Biosphere Reserve. *Ecological Economics*, *112*, 14–24. https://doi.org/10.1016/j.ecolecon.2015.01.009

Brandon, K., Redford, H. K., & Sanderson, E. S. (Editors). (1998). *Parks in peril: people, politics and protected areas*. Washington D.C: Island Press.

Brockington, D., Adams, M. W., Agarwal, B., Agrawal, A., Büscher, B., Chhatre, A., … Oldekop, A. J. (2018). Working governance for working land. *Science*, *362*(6420), 1257. https://doi.org/10.1126/science.aav8452

Brockington, D., Igoe, J., & Schmidt-soltau, K. (2006). Conservation, human rights and poverty reduction. *Conservation Biology*, *20*(1), 250–252. https://doi.org/10.1111/j.1523-1739.2006.00335.x

Brockington, D., & Schmidt-soltau, K. (2004). The social and environmental impacts of wilderness and development. *Oryx*, *38*(2), 140–142. https://doi.org/10.1017/S0030605304000250

Brooks et al. (2006). Global biodiversity conservation priorities. *Science*, *313*(5783), 58–61. https://doi.org/10.1126/science.1127609

Brooks, J., Waylen, K. A., & Mulder, M. B. (2013). Assessing community-based conservation projects: A systematic review and multilevel analysis of attitudinal, behavioral, ecological, and economic outcomes. *Environmental Evidence*, *2*(1), 1–34. https://doi.org/10.1186/2047-2382-2-2

Brown, K. (2002). Innovations for conservation and development. *The Geographical Journal*, *168*(1), 6–17.

Bruner, G. A., Gullison, E. R., & Balmford, A. (2004). Financial costs and shortfalls of managing and expanding Protected-Area systems in developing countries. *BioScience*, *54*(12), 1119–1126.

Camberlin, P., Boyard-Micheau, J., Philippon, N., Baron, C., Leclerc, C., & Mwongera, C. (2016). Climatic gradients along the windward slopes of Mount Kenya and their implication for crop risks. Part 1: Climate variability. *International Journal of Climatology*, *36*(2), 917–932. https://doi.org/10.1002/joc.4394

Carlson, M. K., Curran, M. L., Asner, P. G., Pittman, A. M., Trigg, N. S., & Marion, J. A. (2013). Carbon emissions from forest conversion by Kalimantan oil palm plantations. *Nature Climate Change*, *3*, 283–287. https://doi.org/10.1038/nclimate1702

Castro, A. P. (1991). The Southern Mount Kenya forest since independence: A social analysis of resource competition. *World Development*, *19*(12), 1695–1704. https://doi.org/10.1016/0305-750X(91)90013-8

Ceddia, M. G. (2019). The impact of income, land, and wealth inequality on agricultural expansion in Latin America. *Proceedings of the National Academy of Sciences*, *116*(7), 2527–2532. https://doi.org/10.1073/pnas.1814894116

Chan, M. A. K., Guerry, D. A., Balvanera, P., Klain, S., Satterfield, T., Basurto, X., … Woodside, U. (2012). Where are cultural and social in ecosystem services? A framework for constructive engagement. *BioScience*, *62*(8), 744–756. https://doi.org/10.1525/bio.2012.62.8.7

Chan, M. A. K., Pringle, M. R., Ranganathan, J., Boggs, L. C., Yvonne, L., Ehrlich, R. P., … Dena, P. (2007). When agendas collide: Human welfare and biological conservation. *Society for Conservation Biology*, *27*(1), 59–68.

Chao, S. (2012). *Forest peoples: Numbers across the world*. *Forest Peoples Programme*. UK: Forest Peoples Programme.

Charnley, S., & Poe, M. R. (2007). Community forestry in theory and practice: Where are we now? *Annual Review of Anthropology*, *36*(1), 301–336. https://doi.org/10.1146/annurev.anthro.35.081705.123143

Chhatre, A., & Agrawal, A. (2009). Trade-offs and synergies between carbon storage and livelihood benefits from forest commons. *Proceedings of the National Academy of Sciences*, *106*(42), 17667–17670. https://doi.org/10.1073/pnas.0905308106

Chomba, S., Treue, T., & Sinclair, F. (2015). The political economy of forest entitlements: Can community based forest management reduce vulnerability at the forest margin? *Forest Policy and Economics*,

58, 37–46. https://doi.org/10.1016/j.forpol.2014.11.011
Claridge, L. (2017). *Victory for Kenya's Ogiek as African Court sets major precedent for indigenous peoples' land rights*. London, UK. Retrieved from https://minorityrights.org/wp-content/uploads/2017/08/MRG_Brief_Ogiek.pdf
Convention on Biological Diversity (CBD). (2004). *Decisions from meetings of the Conference of the Parties: Decision VII/28 Protected Areas (Articles 8 [a] to [e])*. Retrieved from https://www.cbd.int/doc/decisions/cop-07/cop-07-dec-28-en.pdf
Convention on Biological Diversity, (CBD). (2010). Convention on biological diversity (CBD) Aichi biodiversity targets. Retrieved June 10, 2019, from https://www.cbd.int/sp/targets/
Creswell, W. J. (2014). *Research design: Qualitative, quantitative and mixed methods approaches* (4th ed.). California, USA: SAGE Publications, Inc.
Cronkleton, P., Saigal, S., & Pulhin, J. (2012). Co-management in community forestry: How the partial devolution of management rights creates challenges for forest communities. *Conservation and Society*, *10*(2), 91. https://doi.org/10.4103/0972-4923.97481
Daily Nation. (1999, November 7). The endangered forests of Kenya. Retrieved August 15, 2017, from https://www.nation.co.ke/lifestyle/artandculture/1222-381438-5d5x94z/index.html
Daniel, C. T., Muhar, A., Arnberger, A., Aznar, O., Boyd, W. J., Chan, M. A. K., … Spierenburg, M. (2012). Contributions of cultural services to the ecosystem services agenda. *Proceedings of the National Academy of Sciences*, *109*(23), 8812–8819. https://doi.org/10.1073/pnas.1114773109
de Koning, M., Nguyen, T., Lockwood, M., Sengchanthavong, S., & Phommasane, S. (2017). Collaborative governance of Protected Areas: Success factors and prospects for Hin Nam No National Protected Area, Central Laos. *Conservation and Society*, *15*(1), 87–99. https://doi.org/10.4103/0972-4923.201396
Defries, S. R., Rudel, T., Uriarte, M., & Hansen, M. (2010). Deforestation driven by urban population growth and agricultural trade in the twenty-first century. *Nature Geoscience*, *3*, 178–181. https://doi.org/10.1038/ngeo756
DeGeorges, P. A., & Reilly, B. K. (2009). The realities of community based natural resource management and biodiversity conservation in Sub-Saharan Africa. *Sustainability*, *1*(3), 734–788. https://doi.org/10.3390/su1030734
Dickman, J. A., Macdonald, A. E., & Macdonald, W. D. (2011). A review of financial instruments to pay for predator conservation and encourage human-carnivore co-existence. *PNAS*, *108*(34), 13937–13944. https://doi.org/10.1073/pnas.1118014108
DRSRS and KFWG. (2006). *Changes in forest cover in Kenya's five "Water Towers" 2003-2005*. Nairobi, Kenya.
Emerton, L. (1997). *An economic assessment of Mt. Kenya forest: Conservation and management of indigenous forests*. Nairobi, Kenya.
Essougong, U., Foundjem-Tita, D., & Minang, A. P. (2019). Addressing equity in community forestry: Lessons from 20 years of implementation in Cameroon. *Ecology and Society*, *24(1):9*. https://doi.org/10.5751/es-10656-240109
FAO. (1999). *State of the world's forests*. Rome, Italy: Food and Agriculture Organisation.
FAO. (2000). *Kenya's forest resource assessment (FRA)*. Rome, Italy: Food and Agriculture Organisation.
FAO. (2005). *State of the world's forests*. Rome, Italy: Food and Agriculture Organisation.
FAO. (2010). *Global forest resources assessment 2010*. Rome, Italy: Food and Agriculture Organisation.
FAO. (2014a). *Country report: Kenya*. *Global forest resources assessment 2015*. Rome, Italy: Food and Agriculture Organisation.
FAO. (2014b). *State of the world's forests*. Rome, Italy: Food and Agriculture Organisation.
FAO. (2014c). *The state of the world's forest genetic resources*. Rome, Italy: Food and Agriculture Organisation. Retrieved from http://www.fao.org/3/a-i3825e.pdf
FAO. (2015). *Assessment of forests and carbon stocks, 1990–2015*. Rome, Italy: Food and Agriculture Organisation.
Fehr, E., & Falk, A. (2002). Psychological foundations of incentives. *European Economic Review*, *46*, 687–724.
Ferraro, J. P. (2001). Global habitat protection: Limitations of development interventions and a role for conservation performance payments. *Conservation Biology*, *15*(4), 990–1000.
Ferraro, J. P., Hanauer, M. M., Miteva, A. D., Canavire-Bacarreza, G. J., Pattanayak, K. S., & Sims, R. E. K. (2013). More strictly protected areas are not necessarily more protective: Evidence from Bolivia, Costa Rica, Indonesia, and Thailand. *Environmental Research Letters*, *8*(025011), 7pp. https://doi.org/10.1088/1748-9326/8/2/025011
Ferraro, J. P., & Kiss, A. (2002). Direct payments to conserve biodiversity. *Science*, *298*, 1718–1720.

Frey, S. B. (1993). Motivation as a limit to pricing. *Journal of Economic Psychology*, *14*, 635–664.
García-amado, L. R., Pérez, M. R., & García, S. B. (2013). Motivation for conservation: Assessing integrated conservation and development projects and payments for environmental services in La Sepultura Biosphere Reserve, Chiapas, Mexico. *Ecological Economics*, *89*, 92–100. https://doi.org/10.1016/j.ecolecon.2013.02.002
Gathaara, G. (1999). *Aerial survey of the destruction of Mt. Kenya, Imenti and Ngare Ndare Forest Reserves.* Nairobi: Kenya Wildlife Service. Retrieved from http://www.unep.org/dewa/Portals/67/pdf/Mt_Kenya.pdf
Gautam, A. P., Webb, E. L., & Eiumnoh, A. (2002). GIS assessment of land use/land cover changes associated with community forestry implementation in the Middle Hills of Nepal. *Mountain Research and Development*, *22*(1), 63–69.
Geldmann, J., Barnes, M., Coad, L., Craigie, D. I., Hockings, M., & Burgess, D. N. (2013). Effectiveness of terrestrial protected areas in reducing habitat loss and population declines. *Biological Conservation*, *161*, 230–238. https://doi.org/10.1016/j.biocon.2013.02.018
Gibson, C. C., McKean, A. M., & Ostrom, E. (2000). Explaining deforestation: The role of local institutions. In C. C. Gibson, A. M. McKean, & E. Ostrom (Eds.), *People and forests: Communities, institutions and governance*. Cambridge & Massachusetts, London, England: The MIT Press.
Gilmour, D. (2016). *Forty years of community-based forestry: A review of its extent and effectiveness*. Rome, Italy: Food and Agriculture Organisation.
Gneezy, U., Meier, S., & Rey-Biel, P. (2011). When and why incentives (don't) work to modify behavior. *Journal of Economic Perspectives*, *25*(4), 191–210. https://doi.org/10.1257/jep.25.4.191
GoK. (1994). *Kenya forestry masterplan (KFMP)*. Nairobi, Kenya: Government Printer.
GoK. (2002). *Kenya 1999 population and housing census*. Nairobi, Kenya: Government Printer.
GoK. (2005). *Forests Act, 2005*. Nairobi, Kenya: Government Printer.
GoK. (2010). *Agricultural sector development strategy 2010-2020*. Nairobi, Kenya: Government Printer.
GoK. (2012). *Kenya's vision 2030*. Nairobi, Kenya: Government Printer.
GoK. (2013). *National climate change action plan 2013 -2017: Vision 2030*. Nairobi, Kenya: Government Printer.
GoK. (2016). *The forest conservation and management Act*. Nairobi, Kenya: Government Printer.
Gordon, I., & Ayiemba, W. (2003). Harnessing butterfly biodiversity for improving livelihoods and forest conservation: The Kipepeo Project. *Journal of Environment and Development*, *12*(1), 82–98. https://doi.org/10.1177/1070496502250439
Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., … Townshend, J. R. G. (2013). High-resolution global maps of 21st-century forest cover change. *Science*, *342*(6160), 850–853. https://doi.org/10.1126/science.1244693
Hariohay, Malle, K., Fyumagwa, D. R., Kideghesho, R. J., & Røskaft, E. (2018). Awareness and attitudes of local people toward wildlife conservation in the Rungwa Game Reserve in Central Tanzania. *Human Dimensions of Wildlife*, *23*(6), 503–514. https://doi.org/10.1080/10871209.2018.1494866
Hayes, M. T. (2006). Parks, people, and forest protection: An institutional assessment of the effectiveness of Protected Areas. *World Development*, *34*(12), 2064–2075. https://doi.org/10.1016/j.worlddev.2006.03.002
Hazzah, L., Dolrenry, S., Kaplan, D., & Frank, L. (2013). The influence of park access during drought on attitudes toward wildlife and lion killing behaviour in Maasailand, Kenya. *Environmental Conservation*, *40*(3), 266–276. https://doi.org/10.1017/S0376892913000040
Henders, S., Persson, U. M., & Kastner, T. (2015). Trading forests: Land-use change and carbon emissions embodied in production and exports of forest-risk commodities. *Environmental Research Letters*, *10*(12). https://doi.org/10.1088/1748-9326/10/12/125012
Hickey, V., & Pimm, L. S. (2011). How the World Bank funds protected areas. *Conservation Letters*, *4*, 269–277. https://doi.org/10.1111/j.1755-263X.2011.00172.x
Hill, R., Miller, C., Newell, B., Dunlop, M., & Gordon, I. J. (2015). Why biodiversity declines as protected areas increase: the effect of the power of governance regimes on sustainable landscapes. *Sustainability Science*, *10*, 357–369. https://doi.org/10.1007/s11625-015-0288-6
Infield, M., & Namara, A. (2001). Community attitudes, and behaviour towards conservation: An assessment of a community conservation programme around Lake Mburo, National Park, Uganda. *Oryx*, *35*(1), 48–60. https://doi.org/10.1046/j.1365-3008.2001.00151.x
International Union for Conservation of Nature (IUCN). (1982). The world national park congress, 11-22 October 1982, Bali, Indonesia. IUCN.
International Union for Conservation of Nature (IUCN). (2007). *United Nations Declaration on Rights of Indigenous People*. New York, USA: IUCN.

International Union for Conservation of Nature (IUCN). (2013). *Guidelines for applying Protected Area management categories*. Gland, Switzerland: International Union for Conservation of Nature.

International Union for Conservation of Nature (IUCN). (2015). The IUCN red list of threatened species. Version 2015. Retrieved February 16, 2016, from www.iucnredlist.org

James, N. A., Kevin, J. G., & Balmford, A. (1999). Balancing the Earth's accounts. *Nature*, *401*, 323–324.

Jim, C. Y., & Steve, S. W. X. (2002). Stifled stakeholders and subdued participation: Interpreting local responses toward Shimentai Nature Reserve in South China. *Environmental Management*, *30*(3), 327–341. https://doi.org/10.1007/s00267-002-2623-9

Johnson, R. B., Onwuegbuzie, J. A., & Turner, A. L. (2007). Toward a definition of mixed methods research. *Journal of Mixed Methods Research*, *1*(2), 112–133. https://doi.org/10.4324/9780203777176

Keenan, R. J., Reams, G. A., Achard, F., de Freitas, J. V., Grainger, A., & Lindquist, E. (2015). Dynamics of global forest area: Results from the FAO global forest resources assessment 2015. *Forest Ecology and Management*, *352*, 9–20. https://doi.org/10.1016/j.foreco.2015.06.014

Kenya Law. Republic v Kenya Forest Service Ex-parte Clement Kariuki & 2 others eKLR (2013). Retrieved from http://kenyalaw.org/caselaw/cases/view/83362

KFS. (2010). *Mt. Kenya forest reserve management plan 2010-2019*. Nairobi, Kenya: Kenya Forest Service (KFS).

Kideghesho, J. R., Røskaft, E., & Kaltenborn, B. P. (2007). Factors influencing conservation attitudes of local people in Western Serengeti, Tanzania. *Biodiversity and Conservation*, *16*(7), 2213–2230. https://doi.org/10.1007/s10531-006-9132-8

Klopp, J. M. (2012). Deforestation and democratization: Patronage, politics and forests in Kenya. *Journal of Eastern African Studies*, *6*(2), 351–370. https://doi.org/10.1080/17531055.2012.669577

KNBS. (2019). *Economic survey 2019*. Nairobi, Kenya: Government Printer.

Koech, C. K., Ongugo, P. O., Mbuvi, M. T. E., & Maua, J. O. (2009). *Community forest associations in Kenya: Challenges and opportunities*. Nairobi, Kenya: Kenya Forest Research Institute.

Kohl, M., Lasco, R., Cifuentes, M., Jonsson, O., Korhonen, K. T., Mundhenk, P., … Stinson, G. (2015). Changes in forest production, biomass and carbon: Result from the 2015 UN FAO global forest resource assessment. *Forest Ecology and Management*, *352*, 21–34. https://doi.org/10.1016/j.foreco.2015.05.036

Kubo, H., & Bambang, S. (2010). From fence-and-fine to participatory conservation : mechanisms of transformation in conservation. *Biodiversity Conservation*, *19*, 1785–1803. https://doi.org/10.1007/s10531-010-9803-3

KWS. (2010). *Mt. Kenya ecosystem management plan 2010-2020*. Nairobi, Kenya: Kenya Wildlife Service (KWS).

Lakerveld, P. R., Lele, S., Crane, T. A., Fortuin, K. P. J., & Springate-Baginski, O. (2015). The social distribution of provisioning forest ecosystem services: Evidence and insights from Odisha, India. *Ecosystem Services*, *14*, 56–66. https://doi.org/10.1016/j.ecoser.2015.04.001

Lambrick, F. H., Brown, N. D., Lawrence, A., & Bebber, D. P. (2014). Effectiveness of community forestry in prey long forest, Cambodia. *Conservation Biology*, *28*(2), 372–381. https://doi.org/10.1111/cobi.12217

Larson, M. A., & Dahal, R. G. (2012). Forest tenure reform: New resource rights for forest-based communities? *Conservation and Society*, *10*(2), 77. https://doi.org/10.4103/0972-4923.97478

Laurance, F. W., Kakul, T., Tom, M., Wahya, R., & Laurance, G. S. (2012). Defeating the "resource curse": Key priorities for conserving Papua New Guinea's native forests. *Biological Conservation*, *151*, 35–40. https://doi.org/10.1016/j.biocon.2011.10.037

Laurance, W. F., Carolina Useche, D., Rendeiro, J., Kalka, M., Bradshaw, C. J. A., Sloan, S. P., … Zamzani, F. (2012). Averting biodiversity collapse in tropical forest protected areas. *Nature*, *489*(7415), 290–293. https://doi.org/10.1038/nature11318

Lawry, W. S. (1990). Tenure policy toward common property natural resources in Sub-Saharan Africa. *Natural Resources Journal*, *30*, 403–422.

Leduc, O. H. C. A., & Hussey, E. N. (2019). Evaluation of pay-for-release conservation incentives for unintentionally caught threatened species. *Conservation Biology*, *33*(4), 953–961. https://doi.org/10.1111/cobi.13300

Leimona, B. (2009). Can rewards for environmental services benefit the poor? Lessons from Asia. *International Journal of the Commons*, *3*(1), 82–107.

Locke, H., & Dearden, P. (2005). Rethinking protected area categories and the new paradigm. *Environmental Conservation*, *32*(1), 1–10. https://doi.org/10.1017/S0376892905001852

Lonn, P., Mizoue, N., Ota, T., Kajisa, T., & Yoshida, S. (2018). Using forest cover maps and local people's perceptions to evaluate the effectiveness of community-based ecotourism for forest conservation in Chambok (Cambodia). *Environmental Conservation*, 1–7. https://doi.org/10.1017/S0376892918000462

Lund, J. F., Burgess, N. D., Chamshama, S. a. O., Dons, K., Isango, J. a., Kajembe, G. C., … Treue, T. (2014). Mixed method approaches to evaluate conservation impact: Evidence from decentralized forest management in Tanzania. *Environmental Conservation*, *42*(02), 162–170. https://doi.org/10.1017/S0376892914000241

Martin, A., Coolsaet, B., Corbera, E., Dawson, M. N., Fraser, A. J., Lehmann, I., & Rodriguez, I. (2016). Justice and conservation: The need to incorporate recognition. *Biological Conservation*, *197*, 254–261. https://doi.org/10.1016/j.biocon.2016.03.021

Martin, A., Gross-Camp, N., Kebede, B., & McGuire, S. (2014). Measuring effectiveness, efficiency and equity in an experimental Payments for Ecosystem Services trial. *Global Environmental Change*, *28*, 216–226. https://doi.org/10.1016/j.gloenvcha.2014.07.003

Maryudi, A., Devkota, R. R., Schusser, C., Yufanyi, C., Salla, M., Aurenhammer, H., … Krott, M. (2012). Back to basics: Considerations in evaluating the outcomes of community forestry. *Forest Policy and Economics*, *14*(1), 1–5. https://doi.org/10.1016/j.forpol.2011.07.017

Matiku, P., Caleb, M., & Callistus, O. (2013). The impact of participatory forest management on local community livelihoods in the Arabuko-Sokoke forest, Kenya. *Conservation and Society*, *11*(2), 112–129. https://doi.org/10.4103/0972-4923.115724

McCauley, J. D. (2006). Selling out on nature. *Nature*, *443*, 27–28.

McClenachan, L., Lovell, S., & Keaveney, C. (2015). Social benefits of restoring historical ecosystems and fisheries: Alewives in Maine. *Ecology and Society*, *20(2):31*. https://doi.org/10.5751/ES-07585-200231

McKim, A. C. (2017). The value of mixed methods research: A mixed methods study. *Journal of Mixed Methods Research*, *11*(2), 202–222. https://doi.org/10.1177/1558689815607096

Millennium Ecosystem Assessment (MEA). (2005). *Ecosystems and human well-being: Synthesis*. Washington, D.C.: Island Press.

Miller, K. (1984). The Bali action plan: A framework for the future of protected areas. In A. J. McNeely & K. Miller (Eds.), *National parks conservation and development* (pp. 756–764). Washington, D.C.: Smithsonian Institution Press.

Minichiello, V., Aroni, R., & Hays, T. N. (2008). *In-depth interviewing: Principles, techniques, analysis*. Frenchs Forest, Australia: Pearson Education Australia.

Mogaka, H., Gichere, S., Davis, R., & Hirji, R. (2005). *Climate variability and water resources degradation in Kenya: Improving water resources development and management* (No. 69). *World Bank Working Paper*. Washington, D.C. https://doi.org/10.1596/978-0-8213-6517-5

Mogaka, H., Simons, G., Turpie, J., Emerton, L., & Karanja, F. (2001). *Economic aspects of community involvement in sustainable forest management in Eastern and Southern Africa.* Nairobi, Kenya: IUCN — The World Conservation Union, Eastern Africa Regional Office.

Mogoi, J., Obonyo, E., Ongugo, P., Oeba, V., & Mwangi, E. (2012). Communities, property rights and forest decentralisation in Kenya: Early lessons from participatory forestry management. *Conservation and Society*, *10*(2), 182–194. https://doi.org/10.4103/0972-4923.97490

Mollick, S. A., Rahman, K., Khan, N. I., & Sadath, N. (2018). Evaluation of good governance in a participatory forestry program: A case study in Madhupur Sal forests of Bangladesh. *Forest Policy and Economics*, *95*, 123–137. https://doi.org/10.1016/j.forpol.2018.07.014

Molnar, A., Scherr, J. S., & Khare, A. (2004). *Who conserves the world's forests? Community-driven strategies to protect forests and respect rights*. Washington, D.C.: Forest Trends.

Morales-hidalgo, D., Oswalt, N. S., & Somanathan, E. (2015). Status and trends in global primary forest, protected areas, and areas designated for conservation of biodiversity from the Global Forest Resources Assessment 2015. *Forest Ecology and Management*, *352*, 68–77. https://doi.org/10.1016/j.foreco.2015.06.011

Morgan, D. L. (2002). Focus group interviewing. In F. J. Gubrium & A. J. Holstein (Eds.), *Handbook of interviewing research: Context & method* (pp. 141–159). California, USA: Sage Publications Inc.

Morgan, J. (2009). Kenya's heart stops pumping. Retrieved July 12, 2018, from http://news.bbc.co.uk/1/hi/world/africa/8057316.stm

Morjaria, A. (2012). *Electoral competition and deforestation: Evidence from Kenya* (ABCDE 2012). *Working paper prepared for World Bank*. Washington, D.C.

Morris, R. J. (2010). Anthropogenic impacts on tropical forest biodiversity: A network structure and ecosystem functioning perspective. *The Royal Society*, *365*, 3709–3718. https://doi.org/10.1098/rstb.2010.0273

Mungai, A. (2018, August 27). Irony of dry Mt. Kenya rivers despite rainfall. Retrieved February 14, 2019, from https://www.standardmedia.co.ke/article/2001293588/mt-kenya-rivers-run-dry-despite-rainfall

Murali, K. S., Murthy, K. I., & Ravindranath, N. H. (2002). Joint forest management in India and its ecological impacts. *Environmental Management and Health*, *13*(5), 512–528. https://doi.org/10.1108/09566160210441807

Mutune, J. M., & Lund, J. F. (2016). Unpacking the impacts of "participatory" forestry policies: Evidence from Kenya. *Forest Policy and Economics*, *69*, 45–52. https://doi.org/10.1016/j.forpol.2016.03.004

Myers, N., Mittermeier, A. R., Mittermeier, G. C., Fonseca, A. B. G., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature*, *403*, 853–858.

Naidu, M., & Kumar, O. (2016). Tree diversity, stand structure, and community composition of tropical forests in Eastern Ghats of Andhra Pradesh, India. *Journal of Asia-Pacific Biodiversity*, *9*(3), 328–334. https://doi.org/10.1016/j.japb.2016.03.019

National Academy of Sciences (NAS). (1988). *Biodiversity*. Washington, DC: The National Academies Press. https://doi.org/https://doi.org/10.17226/989

National Research Council. (2013). *Nonresponse in social science survey: A research agenda*. (R. Tourangeau & J. T. Plewes, Eds.). Washington, D.C.: The National Academies Press.

Naughton-Treves, L., Holland, M. B., & Brandon, K. (2005). The role of protected areas in conserving biodiversity and sustaining local livelihoods. *Annu. Rev. Environ. Resour.*, *30*, 219–252. https://doi.org/10.1146/annurev.energy.30.050504.164507

Nolte, C., Agrawal, A., Silvius, M. K., & Britaldo, S. S. F. (2013). Governance regime and location influence avoided deforestation success of protected areas in the Brazilian Amazon. *Proceedings of the National Academy of Sciences*, *110*(13), 4956–4961. https://doi.org/10.1073/pnas.1214786110

Nsonsi, F., Heymans, J.-C., Diamouangana, J., & Breuer, T. (2017). Attitudes towards forest elephant conservation around a protected area in northern Congo. *Conservation and Society*, *15*(1), 59–73. https://doi.org/10.4103/0972-4923.201394

Nyumba, O. T., Wilson, K., Derrick, J. C., & Mukherjee, N. (2018). The use of focus group discussion methodology: Insights from two decades of application in conservation. *Methods in Ecology and Evolution*, *9*(1), 20–32. https://doi.org/10.1111/2041-210X.12860

Oldekop, A. J., Bebbington, J. A., Brockington, D., & Preziosi, F. R. (2010). Understanding the lessons and limitations of conservation and development. *Conservation Biology*, *24*(2), 461–469. https://doi.org/10.1111/j.1523-1739.2010.01456.x

Oldekop, J. A., Holmes, G., Harris, W. E., & Evans, K. L. (2016). A global assessment of the social and conservation outcomes of protected areas. *Conservation Biology*, *30*(1), 133–141. https://doi.org/10.1111/cobi.12568

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge, UK: Cambridge University Press.

Oteros-Rozas, E., Martín-López, B., González, J. A., Plieninger, T., López, C. A., & Montes, C. (2014). Socio-cultural valuation of ecosystem services in a transhumance social-ecological network. *Regional Environmental Change*, *14*(4), 1269–1289. https://doi.org/10.1007/s10113-013-0571-y

Oyono, P. R., Ribot, J. C., & Larson, A. M. (2006). *Green and black gold in rural Cameroon: Natural resources for local governance, justice and sustainability*. *Working paper 22*. Washington, D.C.: World Resource Institute.

Pagdee, A., Kim, Y., & Daugherty, P. J. (2006). What makes community forest management successful: A meta-study from community forests throughout the world. *Society & Natural Resources*, *19*(1), 33–52. https://doi.org/10.1080/08941920500323260

Pandit, R., & Bevilacqua, E. (2011). Forest users and environmental impacts of community forestry in the hills of Nepal. *Forest Policy and Economics*, *13*(5), 345–352. https://doi.org/10.1016/j.forpol.2011.03.009

Parajuli, R., Lamichhane, D., & Joshi, O. (2015). Does Nepal's community forestry program improve the rural household economy? A cost–benefit analysis of community forestry user groups in Kaski and Syangja districts of Nepal. *Journal of Forest Research*, *20*(6), 475–483. https://doi.org/10.1007/s10310-015-0501-6

Patton, M. Q. (2002). *Qualitative evaluation and research methods* (3rd ed.). California, USA: SAGE Publications.

Pearson, T. R. H., Brown, S., & Casarim, F. M. (2014). Carbon emissions from tropical forest degradation caused by logging. *Environmental Research Letters*, *9*(3), 1–11. https://doi.org/10.1088/1748-9326/9/3/034017

Pelletier, J., Gélinas, N., & Skutsch, M. (2016). The place of community forest management in the REDD+

landscape. *Forests*, *7*(8), 1–24. https://doi.org/10.3390/f7080170
Persha, L., Agrawal, A., & Chhatre, A. (2011). Social and ecological synergy: Local rule making, forest livelihoods and biodiversity conservation. *Science*, *331*(6024), 1606–1608. https://doi.org/10.1126/science.1199343
Poffenberger, M. (2006). People in the forest: Community forestry experiences from Southeast Asia. *International Journal of Environment and Sustainable Development*, *5*(1), 57–69. https://doi.org/10.1504/IJESD.2006.008683
Popradit, A., Srisatit, T., Kiratiprayoon, S., Yoshimura, J., Ishida, A., Shiyomi, M., … Phromma, I. (2015). Anthropogenic effects on a tropical forest according to the distance from human settlements. *Scientific Reports*, *5*, 1–10. https://doi.org/10.1038/srep14689
Porter-Bolland, L., Ellis, E. a., Guariguata, M. R., Ruiz-Mallén, I., Negrete-Yankelevich, S., & Reyes-García, V. (2012). Community managed forests and forest protected areas: An assessment of their conservation effectiveness across the tropics. *Forest Ecology and Management*, *268*, 6–17. https://doi.org/10.1016/j.foreco.2011.05.034
Pretty, J. (2003). Social capital and the collective management. *Nature*, *302*, 1912–1914.
PROFOR. (2012). *Assessing and monitoring forest governance. A user's guide to a diagnostic tool*. Washington, D.C.: Program on Forests (PROFOR), The World Bank.
PROFOR, & FAO. (2011). *Framework for assessing and monitoring forest governance*. Rome, Italy: The Program On Forests (PROFOR) and Food and Agriculture Organisation.
Pullin, S. A., Sutherland, W., Gardner, T., Kapos, V., & Fa, E. J. (2013). Identifying need, taking action and evaluating success. In W. D. Macdonald & J. K. Wills (Eds.), *Key Topics in Conservation Biology 2* (pp. 3–22). John Wiley & Sons, Ltd.
Quintas-Soriano, C., Brandt, S. J., Running, K., Baxter, V. C., Gibson, M. D., Narducci, J., & Castro, J. A. (2018). Social-ecological systems influence ecosystem service perception: A programme on ecosystem change and society (PECS) analysis. *Ecology and Society*, *23(3):3*. https://doi.org/10.5751/ES-10226-230303
Rai, R. K., Neupane, P., & Dhakal, A. (2016). Is the contribution of community forest users financially efficient? A household level benefit-cost analysis of community forest management in Nepal. *International Journal of the Commons*, *10*(1), 142–157. https://doi.org/10.18352/ijc.594
Reddy, M. S., Montambault, J., Masuda, J. Y., Keenan, E., Butler, W., Fisher, R. J., … Gneezy, A. (2017). Advancing conservation by understanding and influencing human behavior. *Conservation Letters*, *10*(2), 248–256. https://doi.org/10.1111/conl.12252
Ribot, J. (2002). *Democratic decentralization of natural resources: Institutionalizing popular participation*. Washington, D.C.: World Resource Institute.
Ribot, J., Agrawal, A., & Larson, A. (2006). Recentralizing while decentralizing: How national governments reappropriate forest resources. *World Development*, *34*(11), 1864–1886. https://doi.org/10.1016/j.worlddev.2005.11.020
RRI. (2012). *What rights? A comparative analysis of developing countries' national legislation on community and indigenous peoples' forest tenure rights*. Washington, D.C.: Rights and Resources Initiative (RRI).
Ruiz-Mallén, I., Schunko, C., Corbera, E., Rös, M., & Reyes-García, V. (2015). Meanings , drivers , and motivations for community-based conservation in Latin America, *20*(3).
Salafsky, N., Cauley, H., Balachander, G., Cordes, B., Parks, J., Margoluis, C., … Margoluis, R. (2001). A systematic test of an enterprise strategy for community-based biodiversity conservation. *Conservation Biology*, *15*(6), 1585–1595. https://doi.org/10.1046/j.1523-1739.2001.00220.x
Salafsky, N., & Wollenberg, E. (2000). Linking livelihoods and conservation: A conceptual framework and scale for assessing the integration of human needs and biodiversity. *World Development*, *28*(8), 1421–1438.
Salkind, J. N. (2010). *Encyclopedia of research design*. London, UK: SAGE Publications, Inc.
Santín, C., & Doerr, S. H. (2016). Fire effects on soils: The human dimension. *Philosophical Transactions of the Royal Society B*, *371*(20150171). https://doi.org/10.1098/rstb.2015.0171
Schlager, E., & Ostrom, E. (1992). Property-rights regimes and natural resources: A conceptual analysis. *Land Economics*, *68*(3), 249–262.
Schleicher, J., Peres, C. A., Amano, T., Llactayo, W., & Leader-Williams, N. (2017). Conservation performance of different conservation governance regimes in the Peruvian Amazon. *Scientific Reports*, *7*(1), 1–10. https://doi.org/10.1038/s41598-017-10736-w
Schwartzman, S., Moreira, A., & Nepstad, D. (2000). Rethinking tropical forest conservation: Perils in parks. *Conservation Biology*, *14*(5), 1351–1357.
Shibia, M. G. (2010). Determinants of attitudes and perceptions on resource use and management of

Marsabit National Reserve, Kenya. *JournaL of Human Ecology*, *30*(1), 55–62.
Small, N., Munday, M., & Durance, I. (2017). The challenge of valuing ecosystem services that have no material benefits. *Global Environmental Change*, *44*, 57–67. https://doi.org/10.1016/j.gloenvcha.2017.03.005
Soe, K. T., & Yeo-Chang, Y. (2019). Perceptions of forest-dependent communities toward participation in forest conservation: A case study in Bago Yoma, South-Central Myanmar. *Forest Policy and Economics*, *100*, 129–141. https://doi.org/10.1016/j.forpol.2018.11.009
Spiteri, A., & Nepal, K. S. (2006). Incentive-based conservation programs in developing countries: A review of some key issues and suggestions for improvements. *Environmental Management*, *37*(1), 1–14. https://doi.org/10.1007/s00267-004-0311-7
Störmer, N., Weaver, L. C., Stuart-hill, G., Diggle, W. R., & Naidoo, R. (2019). Investigating the effects of community-based conservation on attitudes towards wildlife in Namibia. *Biological Conservation*, *233*, 193–200. https://doi.org/10.1016/j.biocon.2019.02.033
Suich, H. (2013). The effectiveness of economic incentives for sustaining community based natural resource management. *Land Use Policy*, *31*, 441–449. https://doi.org/10.1016/j.landusepol.2012.08.008
Summers, J. K., Smith, L. M., Case, J. L., & Linthurst, R. A. (2012). A review of the elements of human well-being with an emphasis on the contribution of ecosystem services. *Ambio*, *41*, 327–340. https://doi.org/10.1007/s13280-012-0256-7
Sunderlin, W. D., Angelsen, A., Belcher, B., Burgers, P., Nasi, R., Santoso, L., & Wunder, S. (2005). Livelihoods, forests, and conservation in developing countries: An overview. *World Development*, *33*(9), 1383–1402. https://doi.org/10.1016/j.worlddev.2004.10.004
Sundström, A. (2016). Understanding illegality and corruption in forest governance. *Journal of Environmental Management*, *181*, 779–790. https://doi.org/10.1016/j.jenvman.2016.07.020
Sutherland, J. W., Dicks, V. L., Everard, M., & Geneletti, D. (2018). Qualitative methods for ecologists and conservation scientists. *Methods in Ecology and Evolution*, *9*, 7–9. https://doi.org/10.1111/2041-210X.12956
Sutherland, J. W., Gardner, A. T., Haider, L. J., & Dicks, V. L. (2014). How can local and traditional knowledge be effectively incorporated into international assessments? *Oryx*, *48*(1), 1–2. https://doi.org/10.1017/S0030605313001543
Sutherland, J. W., Pullin, S. A., Dolman, M. P., & Knight, M. T. (2004). The need for evidence-based conservation. *Trends in Ecology and Evolution*, *19*(6), 305–308. https://doi.org/10.1016/j.tree.2004.03.018
Travers, H., Archer, J. L., Mwedde, G., Roe, D., Baker, J., Plumptre, J. A., & Rwetsiba, A. (2019). Understanding complex drivers of wildlife crime to design effective conservation interventions. *Conservation Biology*, *0*(0), 1–10. https://doi.org/10.1111/cobi.13330
UN General Assembly. (2015). Transforming our world: The 2030 agenda for sustainable development. Retrieved October 17, 2018, from https://www.refworld.org/docid/57b6e3e44.html
UNEP-WCMC, & IUCN. (2019). Protected planet: The world database on Protected Areas (WDPA). Retrieved August 10, 2019, from https://livereport.protectedplanet.net
United Nations (UN). (1992). United Nations Conference on Environment & Development (UNCED), 3 to 14 June (p. 351). Rio de Janerio, Brazil: United Nations.
United Nations (UN). (2000). *Millennium Development Goals (MDGs)*. New York, USA: UN.
United Nations Economic Commission for Europe (UNECE). (1998). *The UNECE convention on access to information, public participation in decision-making and access to justice in environmental matters*. Geneva, Switzerland: United Nations.
United Nations Environment Programme (UNEP). (2001). *An assessment of the status of the world's remaining closed forests*. Nairobi, Kenya: UNEP/DEWA.
United Nations Environment Programme (UNEP). (2009). *"Kenya: Atlas of our changing environment."* Nairobi, Kenya: UNEP.
Vedeld, P., Angelsen, A., Bojö, J., Sjaastad, E., & Kobugabe Berg, G. (2007). Forest environmental incomes and the rural poor. *Forest Policy and Economics*, *9*, 869–879. https://doi.org/10.1016/j.forpol.2006.05.008
Wass, P. (Ed. . (1995). *Kenya's indigenous forests: Status, management and conservation*. Gland, Switzerland and Cambridge, UK: IUCN.
Watson, E. M. J., Dudley, N., Segan, B. D., & Hockings, M. (2014). The performance and potential of protected areas. *Nature*, *515*, 67–73. https://doi.org/10.1038/nature13947
WCED. (1987). *Our common future, report of the World Commission on Environment and Development (WCED)*. New York: United Nations.

Weladji, B. R., & Tchamba, N. M. (2003). Conflict between people and protected areas within the Bénoué Wildlife Conservation Area, North Cameroon. *Oryx*, *37*(1), 72–79. https://doi.org/10.1017/S0030605303000140

Wells, P. M., & Mcshane, O. T. (2004). Integrating protected area management with local needs and aspirations. *Ambio*, *33*(513–519). https://doi.org/10.1579/0044-7447-33.8.513

White, C. L. P., Jennings, N. V., Renwick, R. A., & Barker, H. L. N. (2005). Questionnaires in ecology: A review of past use and recommendations for best practice. *Journal of Applied Ecology*, *42*, 421–430. https://doi.org/10.1111/j.1365-2664.2005.01032.x

Whitworth, A., Pillco-Huarcaya, R., Downie, R., Villacampa, J., Braunholtz, L. D., & MacLeod, R. (2018). Long lasting impressions: After decades of regeneration rainforest biodiversity remains differentially affected following selective logging and clearance for agriculture. *Global Ecology and Conservation*, *13*(e00375), 1–13. https://doi.org/10.1016/j.gecco.2018.e00375

Wilkie, S. D., Bennett, L. E., Peres, A. C., & Cunningham, A. A. (2011). The empty forest revisited. *New York Academy of Sciences*, *1223*, 120–128. https://doi.org/10.1111/j.1749-6632.2010.05908.x

Wilkie, S. D., Carpenter, F. J., & Zhang, Q. (2001). The under-financing of protected areas in the Congo Basin: So many parks and so little willingness-to-pay. *Biodiversity and Conservation*, *10*, 691–709.

World Bank. (2008). *Forests sourcebook: Practical guidance for sustaining forests in development cooperation*. Washington, D.C.: World Bank.

World Bank. (2009). *Roots for good forest outcomes: An analytical framework for governance reforms*. Washington, D.C.

World Resource Institute; Department of Resource Surveys and Remote Sensing, Ministry of Environment and Natural Resources, Central Bureau of Statistics, Ministry of Planning and National Development, K. and I. L. R. I. (2007). *Nature's benefits in Kenya: An atlas of ecosystems and human well-being*. Washington, D.C. and Nairobi: World Resources Institute (WRI).

Wright, G. D., Andersson, K. P., Gibson, C. C., & Evans, T. P. (2016). Decentralization can help reduce deforestation when user groups engage with local government. *Proceedings of the National Academy of Sciences*, *113*(52), 14958–14963. https://doi.org/10.1073/pnas.1610650114

Yang, H., Harrison, R., Yi, Z. F., Goodale, E., Zhao, M. X., & Xu, J. C. (2015). Changing perceptions of forest value and attitudes toward management of a recently established nature reserve: A case study in southwest China. *Forests*, *6*(9), 3136–3164. https://doi.org/10.3390/f6093136

Yeoman, G. (1993). High altitude forest conservation in relation to the Dorobo people: Kenya past, present and future. *Sabinet African Journals*, *25*, 31–35.

Young, J. C., Rose, D. C., Mumby, H. S., Benitez-Capistros, F., Derrick, C. J., Finch, T., … Mukherjee, N. (2018). A methodological guide to using and reporting on interviews in conservation science research. *Methods in Ecology and Evolution*, *9*(1), 10–19. https://doi.org/10.1111/2041-210X.12828

Zimmerman, B., Peres, C. A., Malcolm, J. R., & Turner, T. (2001). Conservation and development alliances with the Kayapó of south-eastern Amazonia, a tropical forest indigenous people. *Environmental Conservation*, *28*(1), 10–22.

Chapter 2

Impact of local forest governance and benefits on communities' attitude towards conservation of Mt. Kenya forest

PELIS programme — A young plantation intercropped with food crops in Mt. Kenya forest.

2.1. Abstract

Sufficient benefits to communities participating in forest conservation is crucial for promoting positive attitudes to achieve conservation success. However, despite limited economic benefits in community-based forest management programmes, improved restoration and ecological conditions raises pertinent issues on factors influencing positive attitudes amongst local communities. Mixed methods are used to examine effect of local governance, benefits and demographic factors on locals' attitudes towards sustainable forest management in Mt. Kenya forest. Nine community forest association groups (CFAs) were selected and local governance quality assessed from adapted principles of good governance using CFAs documentation. Within each CFA, a survey was administered to 30 randomly selected household heads/representatives (n = 290), in-depth interviews with key informants (n = 14) and two focus group discussions (n = 12) conducted. Using generalised linear mixed model, two separate analyses were carried out relating respondent's attitude to; forest income, socio-demographic factors and CFAs governance assessed at a) respondents' perception and b) institutional level — qualitative assessment of CFAs governance. We show that respondents were more likely to express positive attitude if they received higher economic benefits, were in strongly-governed CFAs and had attended more trainings compared to respondents in weakly-governed CFAs irrespective of income earned. Governance arrangements including; inclusive participation in decision making, democratic elections, rules and enforcement, conflict resolution and transparency in benefit sharing shaped respondents' attitudes towards conservation. These results draw attention to the importance of strong local governance in instilling positive attitudes, thus winning locals' support in efficient management of forest resources.

2.2. Introduction

Increasing global recognition of community-based forest management (CBFM) in the tropics is attributed to its success in improving forest conditions, restoring degraded forest lands and reducing deforestation rates. Local support and participation of communities living in close proximity to forest resources is essential for the success of conservation objectives (Thondhlana & Cundill, 2017; Western et al., 2013) especially when resources for enforcement and protection are limited (e.g. Holmes, 2013; Brockington, 2004). Consequently, communities' aspirations, needs and attitudes need to be considered (Mehta & Heinen, 2001; Hariohay et al., 2018) as their activities can either facilitate or undermine conservation efforts. Economic benefits are increasingly being integrated in community conservation to motivate and sustain community participation in sustainable forest management (e.g. Matiku et al., 2013; Mazunda & Shively, 2015; Ameha et al., 2014; Moktan et al., 2015). Several scholars argue that economic benefits must be sufficient to offset costs of conservation (Suich 2013; Kellert, 2000) in order to engender positive attitudes amongst locals towards biodiversity conservation (Dewu & Røskaft, 2017; Ansong and Røskaft 2011). Ansong and Røskaft for instance, showed that residents deriving benefits from Subri Forest Reserve in Ghana had less support for forest management as they preferred substantial benefits with more economic significance. However, although economic benefits from conservation and specifically CBFM have been shown to be insignificant and largely subsistence in nature (e.g. Charnley & Poe, 2007; Ribot et al., 2010; Bowler et al., 2012), communities' participation continues despite little benefit to their economic welfare. The question therefore remains what nature of benefits influence locals' attitudes towards forest conservation and thus sustained participation in CBFM?. Gross-camp (2017) showed that despite little economic benefits, local communities value strengthened governance; local authority, power and ability to exclude outsiders. Thus, non-economic benefits, such as improved governance, greater decision-making power and empowerment, while difficult to measure (Stronza & Gordillo, 2008), could motivate locals' participation in co-management thus, helping overcome elusive economic benefits from CBFM. However, the influence of local governance on local's attitudes, and how communities' perceptions of local governance shapes their attitudes towards forest conservation, are poorly understood.

Community based forest management emanated from forest reform processes aimed at tacking high rates of deforestation and degradation. In the tropics, forest destruction has been attributed to long-term overexploitation (Poffenberger, 2006), competing land use practices (Lambin & Meyfroidt, 2011; Defries et al., 2010), and poor governance and mismanagement including weak law enforcement, widespread corruption and political patronage (Barr et al., 2014; Klopp, 2012; Morjaria, 2012). Over a 15-year interval, 1980-1995, countries in the tropics had an estimated net loss of 200 million of forest cover (FAO, 1999). Although the rate of forest loss is decreasing, with for instance, Achard et al., (2014), showing a gross loss of tropical forests amounting to 8.0 million ha$^{-yr.}$ in the 1990s and 7.6 million ha$^{-yr.}$ in the 2000s, the region still has higher rates of net forest loss compared to other biomes (FAO, 2015). Recognition of protected areas' (e.g. forests) contribution in meeting society's needs (IUCN, 1982; FAO, 2010) to address rural poverty and social inequality (World Bank, 2008), and new emphasis on engaging a wider range of actors (World Bank 2008; FAO 1999) including local communities further propelled CBFM in many countries. The combination of these factors ushered in a new paradigm shift in forest management that promoted community collaboration, a radical departure from centralised state control characterised by strict protection that had been practised in many countries and that limited communities' access to forests, use and any management responsibility (Tole, 2010). CBFM is now legalised through legal frameworks and policy amendments[7] of forest-related laws in many countries recognising local communities living near and adjacent to forest resources as key stakeholders in sustainable forest management.

Community-based forest management aims to improve the wellbeing of local communities through provision of sustainable livelihoods, empowering them and improving condition and quality of forest resources (Charnley & Poe, 2007; Maryudi et al., 2012). Many countries in the tropics have adopted CBFM which allows sustainable use of forest resources to meet livelihoods of local communities, with approximately 25 percent of tropical forests under community control (Bluffstone et al., 2013). A number of factors including strong local institutions, governance and defined benefits have been identified as paramount for achieving successful conservation and social outcomes in community conservation initiatives (Pagdee et al., 2006; Baynes et al., 2015). Oldekop et al., (2010) for instance in a meta-analysis of 116 published case studies on common resource management regimes showed that strong institutions characterised by presence of rules, enforcement and monitoring were positively associated with better conservation outcomes. Further, benefits (or lack) to local communities can influence human actions (Asah et al., 2014), thus affecting communities' engagement, participation and behaviours in biodiversity conservation. Designing and promoting conservation benefits and incentives, directly or indirectly to local communities is more likely to win the support of communities, thus achieving positive conservation outcomes (Brooks et al., 2013; Oldekop et al., 2016).

Economic incentives from conservation enhance local engagement, provide motivation for participation in biodiversity conservation (McClenachan et al., 2015; Yang et al., 2015), and are essential in fostering favourable attitudes amongst local communities (Mbaiwa & Stronza, 2011; Milupi et al., 2017; Mogaka et al., 2001). These incentives are important in supporting livelihoods of local communities especially cash-constrained households in developing countries. However, CBFM studies show mixed outcomes in sustainable livelihoods for local communities despite evidence of improved forest governance (some areas) and better forest outcomes (e.g. Epstein, 2017; Hayes & Murtinho, 2018; Bowler et al., 2012). Review of studies

[7] FAO (1999) note that by 1990, over 50 countries had adopted policy amendments with others in the process of review with an aim of incorporating local communities in decision making for effective forest conservation.

shows communities frequently receive little economic benefits, largely from low value forest products such as non-timber forest products, e.g. fodder, fuel wood and wild foods (e.g. Ameha et al., 2014; Parajuli et al., 2015; Persha & Meshack, 2015; Mutune & Lund, 2016), which have little impact in improving living standards of local communities. This has been attributed to lack of real institutional reform through actions of state actors that limit transfer of powers to local communities (Agrawal, 2001), with most states retaining significant control on forest ownership and high value benefits e.g. timber, trophy hunting (Anderson et al., 2015). Little economic benefits trickling to local communities have been found to be a major impediment in conservation success (Suich, 2013; Ansong and Røskaft 2011), generating conflicts and demotivating local communities from participation in conservation initiatives (e.g Samndong & Vatn, 2012). Nevertheless, negligible economic benefits from CBFM have not hampered communities' participation in conservation, restoration of degraded forests and successful forest outcomes. Consequently, winning support of local communities may transcend economic benefits as other factors come into play. Salafsky et al., (2001) for instance, in a meta-analysis of 39 community-based projects in Africa showed significant association between non-economic benefits and conservation success in community-based projects.

Non-economic benefits such as strong institutions and governance, and community empowerment on conservation success is widely acknowledged (e.g. Oldekop et al., 2010; Paavola, 2007). However, little information exists on how local governance influences community attitudes towards forest conservation. Most importantly, links between perceptions of local communities on local governance that shapes their attitudes towards forest conservation is limited. These perceptions are important as performance of local governance in delivering conservation outcomes depends on society's needs, acceptance and perceived fit of governing institutions by local communities (Epstein et al., 2015). Acceptance and fit of local governing institutions can be influenced by the appropriateness of rulemaking processes and perceived fairness given local community preferences, needs and expectations (Epstein et al., 2015). Further, perceptions of local people can provide insights in the legitimacy of local governance and the social acceptability of environmental management (Bennett, 2016) and thus, shape local user's attitudes towards governance of resources.

Weakly-governed local institutions characterised by among others non-transparency and exclusion in decision making process may disenfranchise communities leading to reduced support in conservation initiatives. For instance, exclusion of local communities in decision making in the creation of Idodi-Pawaga wildlife management area (WMA) in Tanzania led to low levels of support and satisfaction with the WMA (Kiwango et al., 2018). On the contrary, perceived positive perceptions on local governance may enhance the support of local communities thus enabling long-term success of conservation initiatives (Bennett, 2016; de Koning et al., 2017). Thus, understanding how local governance in CBFM and perceptions of local communities on the same influence local attitudes towards forest conservation when other known motivational factors for conservation particularly economic benefits are partially fulfilled can inform management interventions for improving and strengthening institutional governance for increased participation, legitimacy of institutions and successful outcomes in forest conservation.

Local communities are heterogenous groups comprising of individuals and sub-groups with varying interests, preferences and a range of demographic factors (e.g. age, income/wealth, ethnicity, education level, household size). Demographic factors can shape interaction and participation of participants and thus conservation outcomes (Leisher et al., 2016; La Ferrara, 2002) and have been used widely in past studies to assess influence of local attitudes towards biodiversity conservation; income/economic benefits (Nsonsi et al., 2017; Angula et al., 2018; Kideghesho et al., 2007); gender (Mir et al., 2015; Ray et al., 2016); age (Shibia, 2010); and education (Yang et al., 2015; Hazzah et al., 2013). However, findings differ amongst studies indicating that local attitudes may be influenced by context-specific characteristics and generalising demographic factors could mask the predictive effects of other explanatory variables. In an attempt to capture relevant factors influencing local's attitudes towards forest conservation, relevant socio-demographic variables were also included.

In Kenya, CBFM commonly referred to as Participatory Forest Management (PFM) was formalised through a new forest Act in 2005 (GoK 2005), which introduced PFM as a central pillar in the governance of forest resources in the country (GoK, 2005; Ayiemba et al., 2014). Unlike its precursor, the Forest Act 2005 and the subsequent amendment in 2016 (GoK, 2016a) recognised critical role to be played by forest-adjacent communities in rehabilitating and restoring degraded forests, with aims of increasing tree cover to 10% of total land area, and contributing to poverty reduction through livelihood improvement programmes (MENR, 2007; GoK, 2010). Communities living adjacent to forest resources and within 5 kms radius of forest boundary voluntarily form and register associations referred to as Community Forest Associations (CFAs), prepare and sign management plans and agreements to enter into partnership with Kenya Forest Service (KFS – government agency in charge of forests) in sustainable forest management (GoK, 2005; GoK, 2016). As of 2014, a total of 97 CFAs had prepared management plans covering a total of 1,031,460 ha of forests nationally (Ayiemba et al., 2014). In return, community CFA members receive incentives by accessing forests for material benefits (e.g. PELIS[8] - plantation establishment and livelihood improvement scheme, bee keeping, ecotourism, fuel wood, fodder) to motivate them in collaborative forest management. Consistent with other studies globally, local communities participating in CBFM in Kenya receive meagre economic benefits, mostly subsistence — not sufficient to uplift their standards of living (e.g. Mutune and Lund 2016; Ayiemba et al., 2014; Chomba et al., 2015). Matiku et al., (2013), for instance, in a study in Arabuko-Sokoke forest showed that forest benefits for local communities participating in CBFM were higher compared to non-participants, although the reported net annual household benefits for participants was insignificant — Ksh. 4,609 or US$ 61.45 translating to approximately Ksh. 13 per day or US 0.16 (1 US$ = Ksh.75), which is negligible to even meet daily household basic needs. Thus, CBFM and to an extend PFM in Kenya has not contributed in providing sustainable livelihoods aimed at reducing poverty levels especially to forest-dependent communities living in rural areas.

To understand what type of benefits and factors influence local attitudes towards sustainable forest management, this chapter addresses identified gaps through following questions, a) What is the influence of local governance quality, forest income and socio-demographic factors on local's attitudes towards sustainable forest management? b) How do local's attitudes differ among groups under varying institutional local governance? and c) What local governance elements have been implemented and are effective in conservation of Mt. Kenya forest? Using mixed methods, including quantitative analysis of a large (n = 290) sample of semi-structured interviews for household respondents, in-depth interviews with key informants (n = 14); focus group discussion (n = 12) and participant observation through participation in CFAs activities, we examine governance (using a priori indicators), respondents participation, motivation and attitude towards CBFM across nine replicate communities and local management institutions (CFAs) that differ in governance quality. Findings will contribute to narrowing the gap in understanding local governance elements as they are the least understood and researched drivers vital for successful conservation outcomes (Barnes et al., 2017).

[8] PELIS is a programme where CFA members are allocated a half-acre farming plot to plant and nurture tree seedlings while practising crop farming in clear-felled plantations for a period of three years after which they are required to vacate the plots to allow young saplings to mature. This is one of the main incentives for communities' participation in PFM.

2.3. Methodology

2.3.1. Mt. Kenya forest reserve

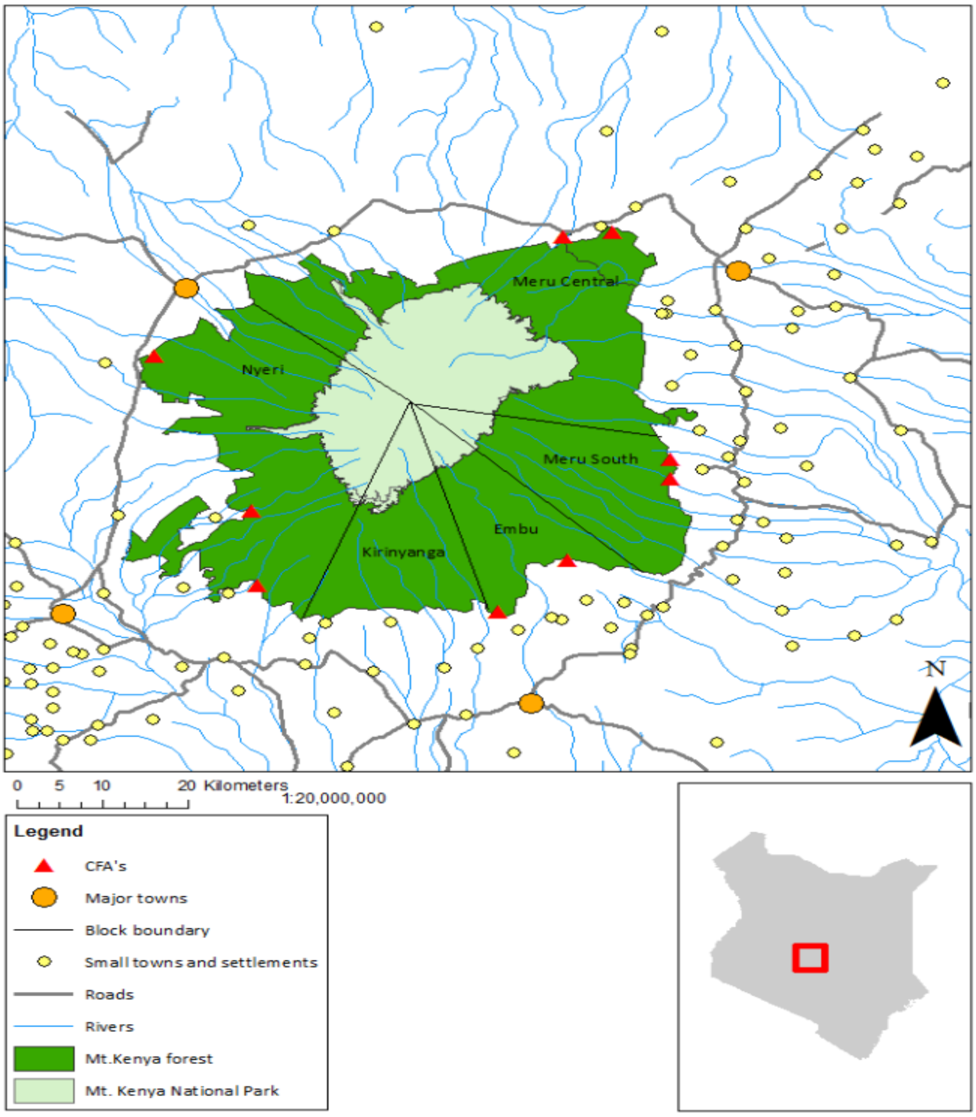

Fig. 2.1. Mt. Kenya forest reserve study site and sampled CFAs within the forest (Source: Author's).

The study was conducted in Mt. Kenya forest reserve in Kenya, located to the east of the Great Rift Valley (Latitude 0'10'S, longitude 37'20'E), covering 213,083 ha. The forest reserve is subdivided into five forest blocks; Nyeri, Kirinyaga, Embu, Meru South and Meru Central (*Fig. 2.1*), with forest stations — manned by Kenya Forest Service staff — and fourteen Community Forest Association (CFAs) groups spread out in the forest. Local communities living within 5 kms radius of forest boundary may voluntarily join CFAs and partner with KFS in sustainable forest management. All CFAs in Mt. Kenya forest were formally established in 2006[9] following enactment of a new national regulatory framework for forest management in 2005 — Forest Act (GoK, 2005). CFAs have management jurisdiction over their forest sites/blocks with clearly defined boundaries based on national survey boundaries and or natural features such as valleys, rivers and streams.

The forest reserve supports high biodiversity (KWS, 2010) and provides a diverse range of socio-economic benefits to the country and local communities living in close proximity who strongly depend on the forest for their livelihoods (Emerton, 1997; KWS, 2010). Native ethnic communities neighbouring the forest are; *Kikuyu*, *Meru* and *Embu* – all of these belong to the Eastern Bantu group and share a similar culture and closely related language. Kikuyu's inhabit areas adjacent to Nyeri and Kirinyaga forest block, Embu natives neighbour Embu forest while Meru natives live in close proximity to Meru central and Meru South forest blocks (*Fig.2.1*). The communities are predominantly farmers taking advantage of the rich fertile soils and high rainfall. They grow crops such as maize, beans, peas, sweet potatoes, arrow roots and other vegetables, as well as livestock keeping. Cash crops grown include fruits, tea and coffee.

2.3.2. Governance quality assessment and sample of CFAs

Prior to data collection, a reconnaissance study gathered information from 14 CFAs in Mt. Kenya forest in March−April 2016. Information on governance structure and systems, activities, livelihoods, benefits and opportunities, challenges and collaboration mechanism with KFS across the CFAs revealed they were at different levels of operation in terms of activity implementation, participation and governance processes. Of these 14 CFAs, nine were selected based on CFA's officials' availability and willingness to participate in the study, to provide documentation, as well as mobilise their members. These include; Gathiuru, Kabaru, Ragati, Kamulu, Ntimaka, Irangi, Chuka, Chogoria and Njukini CFAs.

In each of the nine selected CFAs, local governance quality was assessed using CFAs documentation (e.g. reports, minutes, CFAs constitution and management plans, and Mt. Kenya ecosystem management plan) against four umbrella principles of good governance adapted from (PROFOR & FAO, 2011; UNDP, 2011) (*Table 2.1*). Documentation records are important in assessments as they provide information that may not be directly observable, history or events

[9] Study established that local NGOs (e.g. Green Belt Movement, Kenya Forest Working Group, Forest Action Network) were already working with local communities conducting civic education and mobilising CFAs prior to enactment of the Forest Act 2005 in readiness for collaborative forest management.

occurring prior to beginning of research and provides leads through which appropriate questions are asked (Patton, 2002). In circumstances where information was not clear or lacking (e.g. Chuka, Chogoria, Ntimaka CFAs), clarification was sought from CFA officials and KFS staff.

Qualitative assessment of governance in each CFA was done with the help of various indicators. A scoring criterion was developed for each indicator and qualitative assessment of governance in each CFA was conducted consistently, scoring (qualitatively) across a series of indicators: CFA's accountability and transparency (e.g. elections, income transparency, meetings & events); collective action (e.g. rules and enforcement, monitoring, participation with shared responsibilities); benefits and benefits sharing; and CFA's efficiency (documentation, and up to date records). Mean score across each indicator was calculated and overall mean score for all indicators was used to represent overall governance quality of each CFA; CFAs were then grouped between strong, fair and weak governance (*Table 2.1 & Appendix 2; Table A7-A8*). Strongly governed CFAs were identified and categorised as those with presence of the adapted principles of good governance such as presence and enforcement of rules, regular monitoring, inclusivity in decision making, democratic elections among others. Where rules were absent, rarely enforced and CFAs lacked the adapted indicators of good governance, CFAs were categorised as having weak governance. CFAs under fair governance were those with presence of some of the indicators of good governance, inconsistent and or inadequately executed (*Table 2.1 & Appendix 2; Table A7-A8*).

Table 2.1. Summary of CFAs local governance criteria and assessment (See Appendix 2; Table A7-A8 for more criteria and assessment tabulation)

Governance criteria		NAME OF CFA AND PERFORMANCE OF THE INDICATOR								
	Indicator	**Gathiuru**	**Kabaru**	**Ragati**	**Kamulu**	**Ntimaka**	**Chogoria**	**Chuka**	**Njukini**	**Irangi**
	Ethnic composition	Kikuyu	Kikuyu	Kikuyu	Meru	Meru	Meru	Meru	Embu	Embu
Accountability and transparency	Election of CFA officials	Good	Good	Fair	Fair	Very poor	Very poor	Fair	Fair	Fair
	Voting methods	Good	Good	Poor	Fair	Very poor	Very poor	Fair	Fair	Poor
	Selection of delegates	Fair	Fair	Good	Good	Very poor	Very poor	Poor	Poor	Poor
	Presiding officer(s) attendance	Fair	Fair	Fair	Fair	Very poor	Very poor	Poor	Fair	Fair
	AGM held yearly as per constitution	Good	Good	Fair	Good	Poor	Poor	Fair	Fair	Fair
	Income & expenditure reports	Good	Good	Poor	Good	Poor	Poor	Poor	Good	Poor
	Frequency of meetings for members	Good	Good	Fair	Good	Poor	Very poor	Poor	Fair	Poor
Efficiency (documentation & maintenance of records)	Constitution	Good	Good	Fair	Good	Fair	Fair	Fair	Fair	Fair
	Membership list	Good	Good	Fair	Fair	Poor	Poor	Poor	Fair	Poor
Participation & collective action	Participation (decision making & duty roaster)	Good	Good	Fair	Good	Fair	Very poor	Fair	Fair	Fair
	Monitoring & Patrolling (security)	Good	Good	Fair	Good	Fair	Poor	Poor	Fair	Poor
	Rule of law & Enforcement	Good	Good	Fair	Good	Fair	Poor	Poor	Fair	Poor
Benefit sharing	Forest products	Good	Good	Good	Good	Good	Very poor	Very poor	Good	Very poor
	Plots for farming	Fair	Fair	Fair	Fair	Fair	N/A	Poor	Fair	Poor
	Sum total	**53**	**53**	**42**	**51**	**31**	**20**	**32**	**43**	**32**
	Mean score	3.8	3.8	3.0	3.6	2.2	1.5	2.3	3.1	2.3
	Mean score round off	4	4	3	4	2	2	2	3	2
	Governance quality/category	Strong/ Good	Strong/ Good	Fair	Strong/ Good	Weak/ Poor	Weak/ Poor	Weak/ Poor	Fair	Weak/ Poor

2.3.3. Field data collection

Data were gathered from August 2016 to mid-January 2017. Research permits were provided from the Kenyan National Commission for Science, Technology and Innovation (NACOSTI), Kenya Forest Service (KFS) and four county governments (Nyeri, Chuka, Meru and Embu) whose jurisdiction falls under Mt. Kenya forest study sites. Ethical approval for research was granted by the University of East Anglia, United Kingdom.

The study used mixed methods incorporating elements of both qualitative and quantitative approaches (Creswell, 2014; Johnson et al., 2007). These encompassed survey and in-depth interviews, participant observation as well as secondary data from CFAs documentation (e.g. minutes, reports, constitution, management plans). The mixed method approach allows the combination of methods (e.g. observation, interviewing and use of documents) from different data sources to allow cross validation and strengthening of evidence, thus overcoming limitations of using only one method (Patton, 2002; Schoonenboom & Johnson, 2017). The mixed methods approach has been used in studies to evaluate conservation impact (e.g. Lund et al., 2014; Baral & Stern, 2011) and assessment of people's attitudes towards biodiversity conservation (e.g. Nsonsi et al., 2017; Macura et al., 2011) and provides a holistic approach for collecting wide range of data including socio-economic and ecological data.

Semi-structured questionnaire-based interviews were conducted with approximately 30 randomly selected CFA household-head members or spouses (each representing a household) from each of the 9 sampled CFAs (total n = 290). Members were randomly selected using CFA membership registers; where these were outdated (i.e. Chogoria, Chuka, Irangi, and Ntimaka), members selected using the available register were cross-checked with minutes of meetings attended in the past one year and confirmed with CFA officials if they were bona fide members[10]. Data were gathered on each respondent on; socio-demographic characteristics; livelihood opportunities and income from forest; PFM implementation process and activities; respondents' attitude towards PFM; capacity building initiatives; challenges encountered in forest conservation; possible solutions and perceptions of local governance structure and systems. Respondent's perceptions on CFAs governance quality were assessed using five indicator variables (decision making; elections participation; income & expenditure transparency and

[10] CFAs are community membership institutions with subscription and annual renewal fees for membership differing amongst the CFAs.

accountability; CFAs efficiency in conflict resolution and capacity building assessed by number of trainings respondents attended). In assessing individuals' perceptions of CFAs governance quality, we considered that individual characteristics (e.g. education, age, preferences) could ultimately influence or shape their attitudes towards PFM. To assess CFA member's attitudes towards PFM, respondents were asked their relative agreement (on a five-point Likert scale, ranging from strongly disagree to strongly agree) with the statement: '*since PFM started in this area, I have positive attitude towards sustainable forest management'*. The Likert scale is an ordered scale data ascribing quantitative value to qualitative data which respondents choose one option that best suits their opinion (Heck & Thomas, 2012) and is commonly used to measure respondent's attitudes or satisfaction to a particular statement or product.

To enrich and validate semi-structured interviews, in-depth interviews and focus group discussions were carried out. Seven key informants represented by KFS staff, CFA officials and national administration and seven CFA members from selected CFAs participated in in-depth interviews. Further, twelve participants from the nine CFAs identified during semi-structured interviews based on their knowledge of PFM participated in a focus group discussion to elicit more information and detailed understanding of PFM programme and implementation, livelihood benefits & opportunities, motivations for members support (or lack of), socio-economic and ecological changes due to PFM, leadership and institutional governance and challenges encountered and possible solutions. A questionnaire guide was used during in-depth interviews but also included some CFA-specific questions arising from survey interviews and or observations from specific CFAs forest sites and activities. Furthermore, the lead researcher participated in some CFAs activities (e.g. tree planting, meetings, election of officials, work plan preparation and forest patrols) enabling observation and cross-validation of data. Such participant observation is important in data collection as it enables an outsider to detect insiders feelings and theoretical truths in realities of daily human life (Boije, 2010), and to learn about the activities of the people under study in a natural setting through observing and participating in those activities (Kawulich, 2005; Robinson et al., 2007).

2.4. Data analysis

2.4.1 Quantitative data

We first examined respondents' attitudes towards PFM (response variable). Attitude scores in Likert categories were merged following (MacNeil & Cinner, 2013) to mitigate low frequencies in some categories. The five-point Likert scale attitude scores were merged as follows; strongly disagree (N=13); disagree (N=9); neutral (N=19); agree (N=75) and strongly agree (N=168) was collapsed to 3 categories: negative (scored as 0; combining strongly disagree and disagree, N=22); neutral (scored 1, N=19); and positive (scored 2, combining agree and strongly agree categories, N=243). Further, CFAs local governance categorised into three groups: strong, N=3, fair, N=2 and weak, N=4 were merged to two groups; Weak = 0 and Strong = 1 by merging 'strong' and 'fair' categories.

Table 2.2. Summary of predictor variables used in analysis (N = 284)

Variable name	Description	Type of data
PFM income	Household revenue generated from forest products and related activities for one year grouped into two categories (Low = < Ksh. 184, High = > Ksh. 184)	Categorical
Training	Total number of trainings attended by respondent since joining CFA membership and facilitated through PFM	Continuous
Formal education (years)	Number of years spent schooling	Continuous
Individual's response perceptions on CFA's local governance		
Decision making	Respondent participation in decision making (No = 0, Yes = 1)	Categorical
Financial transparency & accountability	CFA's committee is transparent and accountable through sharing of financial reports, i.e. income and expenditure reports (No = 0, Yes = 1)	Categorical
Conflict Resolution	CFA's committee is efficient in resolving disputes and conflicts within CFAs (Disagree = 0, Agree =1)	Categorical
Researcher's qualitative assessment of local governance at CFAs level		
CFAs governance quality	CFAs local governance assessed qualitatively using governance indicators adapted from PROFOR & FAO, 2011; UNDP, 2011). CFAs local governance grouped in three groups: strong, fair and weak and merged to two groups; Weak = 0, Strong = 1).	Categorical

The following predictor variables were used to determine factors influencing respondent's attitudes;

1. PFM income – respondents' household revenue per year earned from sale of forest products and related activities and categorised into two levels; 'low income' defined as income below average income calculated from total PFM income and 'high income' defined as income above average income earned).
2. Number of PFM-related trainings attended by the individual respondent (continuous).
3. Formal years of schooling (continuous).
4. CFA's local governance assessed at; a) institutional level, that is CFAs' level (a single score for all respondents in that CFA) and b) respondent's level; respondent's perception on CFAs governance assessed from four indicators of good governance including;

- Participation in decision making (categorical at two levels)
- Participation in CFA's elections[11] (categorical at two levels)
- CFA's income and expenditure accountability (categorical at two levels)
- CFA's committee efficiency in conflict resolution (categorical at two levels - assessed in five-point Likert scale categories and collapsed into two categories: disagree (scored 0; combining strongly disagree N=13; disagree N=21; neutral N=26, pooled N = 60); and agree (scored 1; combining agree N=94, and strongly agree N=130, pooled N=224) (*Table 2.2*).

Two generalised linear mixed models (GLMMs) were carried out, that allow the inclusion of both fixed and random effects to simple and complex hierarchical modelling approaches (Field, 2009; Grueber et al., 2011). Respondents' attitude towards PFM (response variable) was related to a) individual's perceptions of CFAs local governance, PFM income, number of trainings attended and education level – analysis 1 and; b) local governance assessed at institutional level — CFAs, PFM income, number of trainings attended and education level — analysis 2. CFA site was included in both models as a random factor to account for grouping of individual respondents from the nine CFA sites and control for non-independence of members in groups (Zuur & Ieno, 2016) (Equation 1). Continuous variables were transformed and standardised around the mean using the scale function in R, to improve model performance and facilitate interpretation of the relative strength of parameter estimates (Grueber et al., 2011; Field, 2009).

Equation 1

Analysis 1 = Respondent's Attitude ~ PFM income + trainings attended + years schooling + respondent's perception on CFAs responses on local governance[12]+ (1 | CFA site)

Analysis 2 = Respondent's Attitude ~ PFM income + trainings attended + years schooling + overall CFA's governance quality+ (1 | CFA site)[13].

Ordinal logistic regression was used to examine factors influencing respondents attitudes towards PFM (assessed on the merged Likert scale: negative, neutral, positive) using the "ordinal package" (Christensen, 2015) in R software version 3.4.3 (R Core Team, 2018).

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[11] Participation in elections was removed from quantitative analysis as not all members participate in elections in some CFAs. Representative delegates are chosen to participate in election of CFA officials. However, it is included in qualitative analysis.

[12] Assessed from members responses on decision making participation, CFA's efficiency in conflict resolution, financial transparency and accountability, and trainings attended

[13] Qualitative assessment using governance indicators adapted from PROFOR & FAO, 2011; UNDP, 2011.

Ordinal logistic regression uses a proportional odds model where parameter estimates of predictors (β) represents the increase associated with a one-unit increase in *X,* in the log odds of the response variable falling into lower categories (against being in the higher category), while holding all other *X* variables constant (Heck & Thomas, 2012). The reference category for the response variable was positive attitude coded as '2' against neutral '1' and negative '0' attitude. Preliminary analysis confirmed the multicollinearity assumption was met, assessed using variance inflation factor (VIF), (Field, 2009) which were less than 10 for all variables with the highest value being 5.441 (analysis 1) & 5.024 (analysis 2).

Regression coefficients (β) in ordinal logistic regression model will have a sign that is the opposite of what is expected in an ordinary linear regression models and may be confusing to interpret (Hox, 2010; Powers & Xie, 1999). Therefore, parameter estimate coefficients (β) were multiplied by -1 to restore the direction of the regression coefficients such that positive coefficients increase the likelihood of being in the highest category and negative coefficients decrease it[14] (Hox, 2010; Long 1997). To ease interpretation, parameter coefficients (β) scaled in terms of log odds – that are difficult to interpret (Hox, 2010) - were converted into odds ratios (OR) calculated as the exponent of the log odds (e^{β}), thus providing an indicator of change in odds resulting from a unit change in the predictor (Hox, 2010; Agresti, 2013). Thus, in this study, an OR of <1 or >1 indicates that the odds of expressing positive attitude towards PFM (being in the higher category) decreased or increased, respectively, with each unit increase of the relevant predictor variable.

For both Analysis 1 & 2, the best fitting model(s) were examined using the dredge function in the MuMin package (Barton, 2018), for each candidate model calculating Akaike Weights (w_i) – that represent the ratio of ΔAICc values for the whole set of candidate models and provides a measure of the relative strength of evidence for each model (Burnham & Anderson, 2002). Due to uncertainty in choosing the best model for inference when the Akaike weights (w_i) of the top-ranked model(s) is less than 0.9 (Grueber et al., 2011; Burnham & Anderson, 2002), model averaging was performed based on 95% cumulative confidence models set (Grueber et al., 2011; Burnham & Anderson, 2002; 2011). The relative importance of each

[14] Some software programs (such as IBM SPSS) automatically multiply linear predictors' β by –1 to restore the signs of regression coefficients to the direction they would have in a standard linear regression (Hox, 2010) pg. 146), unlike R software used in this analysis. Same analysis done using IBM SPSS software confirmed differences in direction of the regression coefficients.

variable (RVI) on the model(s) was assessed using summed Akaike weights (w_i) from all model combinations where the variable was present. The higher the RVI value, the more important the variable relative to other variables (Burnham & Anderson, 2002). However, the RVI of predictors with poor explanatory power may not be close to zero (Boughey et al., 2011) and it may be difficult distinguishing predictors influencing respondents' attitude towards PFM. Therefore, in order to determine the direction and magnitude of effect of each predictor variable, 95% confidence intervals (CI) of model averaged coefficients were also assessed; variables were considered to be supported if the CI did not overlap zero (Grueber et al., 2011).

2.4.2. Qualitative data

Qualitative data from in-depth interviews were transcribed into written form and analysed using computer aided qualitative data analysis (CAQDA) software – NVivo 11 (Patton, 2002). Data coding was done through grounded theory which is a powerful qualitative data analysis tool that allows development of codes, categories and defining of relationships between categories from data (Charmaz, 2006). Line by line transcripts were read, assigning codes to quotations or smaller segments of transcribed data (Creswell, 2007; 2014). The next step involved grouping related or similar codes into one broad theme in an attempt to understand patterns and relationships emerging from data collected. Finally, data were presented by describing relationships and links from broad themes or patterns formed.

2.5. Results

2.5.1. Quantitative data

Respondent's profile

After data cleaning, data for 284 respondents were used in analysis of which a slight majority (56.3%, n =160) were female and mean household size was 4.5 people. The mean age of respondents was 48.5 years (sd =13.9), with youth (aged 18-35 years[15]) comprising a minority (17.6%), middle aged (36-45 years) respondents 29.9%, those between 46-55 years 21.5% and those over 55 years comprising 31.0%. More than half of respondents (63%) had attained primary level qualification comprising of 8 years of formal schooling while 37% had proceeded beyond primary school level (secondary and tertiary). Mean attitude towards PFM for respondents in strong governed CFAs was 1.89 (sd = 0.41), was greater, (Man-Whitney test $p < 0.001$) than that of respondents in weak governed CFAs, 1.53 (sd = 0.71).

[15] In Kenya, a youth is defined as an individual between the age of 18 and 35 years (GoK, 2010).

The 95% cumulative set of GLMM models examining respondents' attitude towards PFM comprised of 15 (out of 64 candidate models examining six predictors) and 3 (out of 16 models of four predictors) models for analysis 1 and 2 respectively; details of the top 10 models in each set are shown in Appendix 2; Table A2 & A3. In analysis 1, whether an individual respondent expressed positive attitude towards PFM was strongly and positively associated with PFM income, number of trainings attended and CFA's efficiency in conflict resolution. Further, analysis 2 showed similar results, with respondent's positive attitude towards PFM again strongly and positively associated with PFM income and number of trainings attended (*Fig. 2.2B & Appendix 2; Table A5*). In analysis 1 (using respondent's perception of CFAs governance), decision making participation has a moderate influence on respondents' attitude towards PFM (95% confidence intervals close to zero margin), similar findings found in analysis 2, with CFAs governance quality also having a moderate influence on respondent's attitudes. However, there was no evidence that CFAs financial transparency and years spent schooling influenced respondents' attitudes towards PFM (*Fig. 2.2A & 2.2B*). Model averaged results in both analysis 1 and 2 shows that revenue earned from PFM (PFM income) had the strongest effect in influencing individual respondent's attitude towards PFM (*Appendix 2; Table A4 & A5*), with respondent's likelihood of expressing a positive attitude towards PFM increasing with greater PFM income. Specifically, the probability of expressing positive attitude for members in high income category (earning more than Ksh. 184 per year) versus those in low-income category (Ksh. < 184) is 5.686 and 6.098 times greater (analysis I & 2 respectively) than the combined probabilities of respondents expressing neutral and negative attitude towards PFM (*Appendix 2; Table A4 & A5*).

Respondents who attended greater number of trainings related to PFM were more likely to express a positive attitude towards PFM compared to members who had attended fewer or no trainings, with one additional training attendance being associated with 2.239 and 2.484 times (analysis 1 and 2 respectively) greater probability of expressing a positive attitude towards PFM. From survey results, the majority of trained members and thus more skills in forest conservation were from strongly-governed CFAs with 56.7 % (n = 161); Gathiuru (24.4%; N=23), Kabaru (13.8%; N=13), Njukini (11.7%, N=11) and Kamulu (12.7%; N=12), in comparison to 43.3% (n= 123) from weakly-governed CFAs with little training; Chuka (9.5%; N=9), Irangi (4.2%; N= 4), and Ntimaka (1%; N=1).

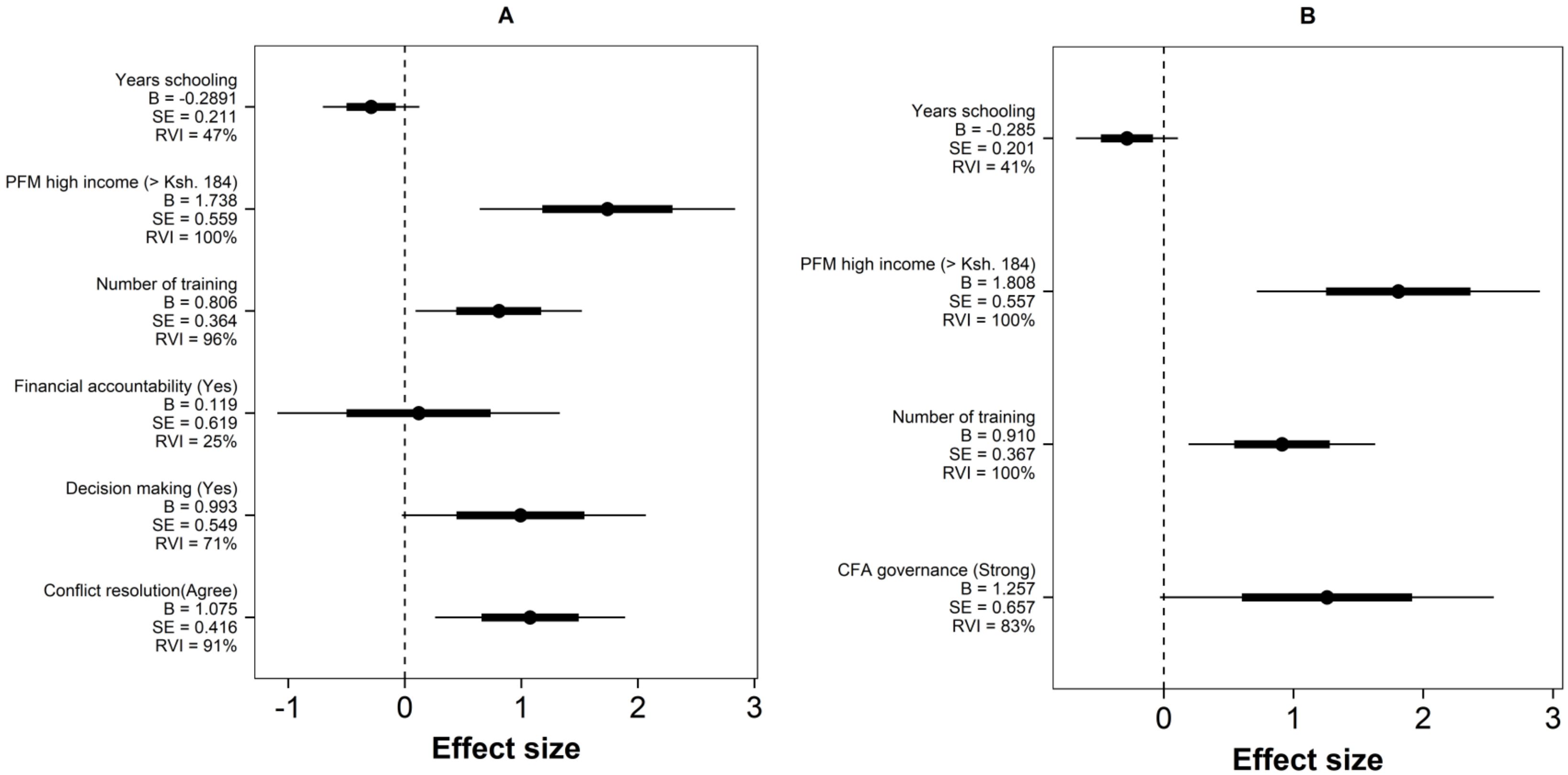

Fig 2.2. Model averaging across 95% cumulative set of candidate models relating respondents' attitude to PFM on; PFM income, number of trainings attended, years spent schooling and CFA's governance assessed at respondent's level (conflict resolution, decision making participation, financial accountability) (A), and PFM income, number of trainings attended, years spent schooling and CFA's governance assessed at CFA's level (B). Showing effect sizes (circles), standard errors - SE (thick lines), 95% confidence intervals (thin lines), parameter estimates (B) and relative variable importance (RVI).

Respondents who reported participating in decision making were more likely to express positive attitude towards PFM than those reporting not taking part (analysis 1). In particular, the probability of expressing positive attitude towards PFM for respondents' participating in decision making versus those who did not was 2.699 times higher than the combined probabilities of those expressing neutral and negative attitude. Furthermore, CFAs efficiency in conflict resolution was also an important predictor for respondents' attitude towards PFM (analysis 1). The odds of expressing positive attitude for respondents' reporting CFA committee was efficient in conflict resolution versus those who disagreed is 2.930 times higher than combined probabilities of respondents reporting neutral and negative attitude towards PFM.

CFAs level governance had a moderate effect on respondent's attitude towards PFM (analysis 2). Respondents in CFAs categorised with strong governance were likely to express positive attitude towards PFM compared to respondents in weakly-governed CFAs (*Fig. 2.2B & Appendix 2; Table A5*). In particular, probability of expressing a positive attitude for respondents in strongly-governed CFAs compared to those in weakly-governed CFAs is 3.52 times greater than the combined probabilities of respondents having neutral and negative attitude towards PFM (*Appendix 2; Table A4 & A5*). CFAs categorised with strong governance had presence of good governance indicators including; rules and enforcement, monitoring, transparency in benefits sharing, regular meetings, participation in decision making and activities, democratic elections and updated documentation e.g. CFAs constitution. Including other socio-demographic variables identified in the literature as important predictors for local attitudes towards forest biodiversity conservation (age, gender, household size) gave similar results (*Appendix 2; Table A6*).

2.5.2. Qualitative data (In-depth interviews and focus group discussions)

Key broad themes emerged from qualitative data analysis including benefits, opportunities and distribution, governance issues such as election of CFAs officials, decision making, conflicts and resolution, rules and enforcement, which ultimately shaped respondent's attitudes towards PFM and thus their engagement in forest conservation. These findings are presented below using evidence from the study.

a) Decision making and transparency

In strongly-governed CFAs (Gathiuru, Kabaru, Kamulu, Njukini), members were engaged frequently in CFAs' activities which enabled more awareness and understanding of CFAs roles in forest conservation, and members were kept abreast with new changes and activities. This was made possible through bi-monthly meetings and annual events (e.g. yearly work plan, annual general meeting — AGM) organised as per CFAs by-laws and constitution. For instance, during data collection in 2016-2017, Gathiuru, Kabaru, Njukini[16] and Kamulu CFAs had operational by-laws, up-to date constitution and yearly work-plans in place discussed and agreed on by majority of members. CFAs by-laws consist of groups objectives, rules and regulations on; forest products permitted, levies and fees, nature of products to be harvested specifically dead fallen wood, harvesting frequency, mode of transportation (vehicles and motorcycles are prohibited in some sites), fines and sanctions for breaches, authorised activities, frequency of meetings as well as communication channels. The majority of respondents interviewed reported decisions were largely made through consensus, CFAs by-laws and constitution were drafted and passed by a majority of members and thus internalised their contents as witnessed and observed in Kamulu and Gathiuru CFAs elections[17]. For instance, in Gathiuru CFA, a member contesting for secretary's position during CFA elections was barred from vying by other members (in attendance) as the member had been implicated in illegal timber harvesting contrary to by-laws on leadership and integrity. Additionally, to ensure fairness and transparency, representatives from provincial administration, KFS and registrar of societies attended Kamulu CFA elections while provincial administration and KFS representatives attended Gathiuru elections.

Fig. 2.3. Secret ballot elections in Gathiuru CFA to choose CFA officials.

[16] Lead researcher attended a yearly work-plan preparation meeting for Njukini CFA in 2016
[17] Lead researcher attended and observed elections in Gathiuru and Kamulu CFAs during data collection.

This is in line with Forest Act regulations which mandates KFS forest station manager(s) to be a member of CFA committees in guiding and overseeing CFA activities. (GoK, 2016; 2005; MENR, 2007).

Successful implementation of forest activities in strongly-governed CFAs was achieved through effective planning where CFA members were involved in all stages. The level of inclusion, transparency and accountability generated favourable attitudes motivating members to actively participate in PFM programmes like tree planting and nursery management, seed collection, construction of fire breaks and firefighting, forest patrols and monitoring; "*I am watering the young seedlings to prevent withering because it is very hot…I come here two days in a week in the morning and then go back to do household chores"* (CFA female member).

Fig. 2.4. Tree nursery in Kamulu CFA.

Respondents emphasised that participation in decision making and preparation of yearly work plans led to effective implementation of activities as they were fully aware of their responsibilities. When asked about prioritising work at the tree nursery over household chores, a CFA member reported that these were collective decisions discussed and agreed by a majority of members; "*yes, this is what we agreed…and if you don't do the work, there are fines we passed to ensure that people who don't turn up pay…If I am very busy to come here, I look for a friend to do the work for me. I also help other members if they are unable to come"* (CFA female member).

By contrast, in CFAs categorised with weak governance (Chuka, Chogoria, Irangi and Ntimaka), decisions were unilaterally made by KFS staff in consultation with CFAs officials. Engagement and inclusion of members was limited and interviews revealed that they were informed on what to do after decisions were made. Additionally, work-plans and CFA by-rules were non-existent, and CFAs operated with outdated constitution[18] prepared during initial stages of CFAs formation more than 10 years ago. Lack of inclusive participation in decision making, especially on issues affecting their livelihoods (e.g. increase of forest products levies in Ntimaka CFA) and planning of CFAs activities, led to disenfranchised members generating discontent which further affected their participation. Further, CFAs activities and meetings were planned on an ad hoc basis (especially during rainy season), and members did not have a sense of obligation and duty to undertake forest activities due to exclusion from activity planning. This was evidenced through observations at CFAs sites with abandoned tree nurseries, withered and dried seedlings, with some overgrown as transplanting was delayed due to low levels of participation in forest activities; "*the tree nursery in this CFA was one time ranked one of the best in Mt. Kenya region, all members were very active…community members used to even get tree seedlings for free. Now it has deteriorated to a very bad state. People lost morale to volunteer and all tree seedlings dried…all frustrations came from the officials…. poor leadership, non-transparency and conflicts* (CFA male member).

Fig. 2.5. An overgrown and abandoned tree nursery in Irangi forest block.

[18] It was established that CFAs constitutions were haphazardly prepared by selected representatives more than 10 years ago to guide CFA formation and registration and were not in line with current CFAs activities/operations. However, CFAs officials promised to update their constitution and other documents to align with current issues and experiences in their respective CFAs.

In-depth interviews with CFA officials from weakly-governed CFAs corroborated lack of members inclusivity in decision making process and planning of CFAs activities. For instance, in Chuka CFA, access to the Chuka forest block by members and the wider community for harvesting of forest products such as fuelwood, fodder and 'salty water'[19] was temporary banned by officials due to wanton and illegal activities in the forest;

INT: *I have been informed of a total ban on access or collection of firewood in this forest. How did you conclude that the ban should be executed, and did you involve members*?

CFA official: *We are the ones (referring to officials) who decided to have the ban until they come back and say that they are ready to manage the forest well….*

In weakly-governed CFAs, non-transparency and accountability in choosing CFAs officials during elections generated frequently conflicts and strong resentment between two opposing camps. One group yearned for change in leadership and governance through transparent and fair elections while another group loyal to current officials (and perceived to benefit more from the forest by other members) resisted attempts for leadership change. In Ntimaka and Chogoria CFAs, elections had never been held since CFA formation (10 years ago by time of study) contrary to CFAs' constitution to conduct elections at least every three years[20]. In Chuka CFA, elections were held albeit late but reported by interviewed respondents as not free, fair or credible as the same officials have been voted back in office since 2006. In-depth interviews revealed systemic entrenchment of patronage networks where delegates loyal to CFAs leadership were chosen as representatives to participate in elections which ensured the same officials were voted in office in every election held. This was corroborated through in-depth interviews with KFS forest station manager in charge of Chuka forest who, despite being a member of the CFA committee, (GoK, 2005; MENR, 2007) was neither aware of the date, and venue of elections nor informed prior to elections like many other CFA members not selected as delegates. Furthermore, in-depth interviews with CFA officials confirmed non-transparency in organising and conducting elections as previously reported by respondents and KFS staff;

INT: "*And what happens during elections if there is more than one candidate interested in one position, let's say Secretary's position?*

CFA official: *Mhhh.. let me be truthful on that, we have never encountered such in our CFA. Our members 'love us'*

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[19] Salty water from a spring in Chuka forest is believed to contain medicinal properties, consumed by locals and sold by women in the local market

[20] CFAs constitution stipulates elections to be held to choose CFA officials and period varies among CFAs, ranging between every three to four years.

so much and we have never had a situation where more than two members were interested in vying for the same position…… I have never witnessed that here, it has never happened, but I have witnessed in other groups".

Failure to hold elections (credible) was perceived by interviewed respondents to be associated with officials' own interests to maintain a grip on power and continue benefitting from forest benefits and opportunities that come with such positions; "*the officials especially the Chairman and the Secretary make their own decisions…they use the forest to enrich themselves…sometimes you only see lorries coming to carry timber and members don't really know what happens*" (CFA male member). The conflict of interest in CFAs leadership and forest conservation generated conflicts and negative attitudes leading to membership withdrawal and reduced participation. In some instances, some respondents reported that themselves, other CFA members and the wider community engaged in anti-conservation behaviour including illegal logging and tree debarking as observed in Chuka and Chogoria forests so as 'to benefit from the forest the same way as the officials'; "*we are allowed to collect dry wood, what happens is that people go and remove the bark of trees to fasten their drying…. And then they go back after some time to cut down the trees. If you meet that person, you can't ask him/her anything because he/she is carrying dry wood"* (CFA male member). Widespread forest destruction, especially in Chuka forest block, necessitated a temporary ban on forest access and product harvesting imposed by CFAs officials and KFS staff in the year 2016, although the Forest Act 2016 legalised forest access and harvesting of permitted benefits. Similarly, illegal activities were also observed in Chogoria, Irangi and Ntimaka CFA forest blocks.

Fig. 2.6. Tree debarking to fasten drying and illegal logging in Chuka forest block.

Conflicts and resolution mechanisms

Conflicts were reported in all CFAs especially on human-wildlife conflicts but others were more pronounced in Chuka, Ntimaka and Chogoria CFAs — all categorised as weakly-governed. Benefit-sharing challenges, embezzlement of CFA funds and power struggles between members and officials in weakly-governed CFAs were commonly characterised by frequent and prolonged conflicts; *"you know members don't even know what happens in this CFA…even when sponsors come and give some little money to facilitate activities like tree planting, nobody knows how much was received, how it was spent…. because the officials just decide what to do…so, for now we need credible elections"* (CFA female member). Perceived high value benefits permitted in Chuka (timber harvesting and PELIS) and Ntimaka CFAs (PELIS) generated sufficient funds to support CFAs activities but the majority of respondents interviewed were not aware of revenue streams, the amount generated or how funds were utilised. Respondents reported mismanagement and elite capture by CFAs officials. These findings were corroborated during in-depth interviews with CFAs officials where timber harvesting was done and facilitated by officials without involvement of members or following laid down procedures as outlined in Forest Act 2016; *"members tell us that myself (Secretary) and the Chairman we find how to raise money and pay KFS for the timber block, harvest timber and if we get a profit, they request us to do a development activity for them. Like now we are harvesting in Kiang'ondu in Chuka forest (*timber harvesting was ongoing in 2016 during data collection*), they requested us that when we get a profit, of like Ksh. 100,000, we use the money to launch the management plan"* (CFA official).
This was in contrast to standard procedures followed by strongly-governed CFAs such as Gathiuru and Njukini where all CFA members contributed towards payment of timber harvesting blocks to KFS, and revenue generated ploughed back to support conservation activities e.g. monitoring and or utilised in activities benefiting the wider community as per members agreement (e.g. construction of eco-camp in Njukini CFA, school bursary for needy pupils/students and construction of a dam in Gathiuru CFA).

Embezzlement of CFA funds, poor leadership and lack of transparency in decision making, benefits sharing and election of officials were major triggers of conflicts in weakly-governed CFAs. Conflicts were exacerbated by lack of internal dispute resolution mechanisms with aggrieved members seeking arbitration and intervention from external arbitrators e.g. courts, provincial administration. External arbitrators such as courts take long to settle disputes and frequent and prolonged conflicts were reported as a major cause for membership withdrawals, reduced participation and animosity within CFAs, which ultimately undermined conservation initiatives. On the contrary, strongly-governed CFAs (Gathiuru, Kamulu and

Kabaru) had well-established conflict resolution committees composed of members trained in dispute resolution and were responsible for handling internal disputes within CFAs.

Benefits and other opportunities

Benefits from Mt. Kenya forest appeared to be an important motivating factor for respondent's participation and support of PFM activities. Further, perceived value of benefits received was associated with participation in PFM programmes with respondents receiving high value benefits committed to forest conservation as observed and reported during in-depth interviews. PELIS and timber harvesting were perceived as high value benefits attributed to high returns generated. Benefits permitted in each CFA are in line with management plans and agreements approved by KFS. PELIS was permitted in several CFAs such as Gathiuru, Kabaru, Kamulu, Njukini, Ntimaka, Ragati, Irangi, Chuka but timber harvesting was only permitted in three CFAs – Gathiuru, Njukini and Chuka (by time of study), while other CFAs were in the process of application for authorisation. It was established that although timber harvesting is lucrative, it is capital intensive and out of reach for majority of CFAs who compete with well-established saw milling companies, yet CFAs carry out most of the conservation work.

In strongly-governed CFAs (Gathiuru, Kamulu, Kabaru, Njukini, Ragati), benefit sharing and distribution was guided through established CFAs by-rules. For instance, PELIS plots for farming were allocated through ballot voting and members benefitting from initial allocation were not allowed to participate in subsequent allocations. Similarly, training opportunities followed the same procedure with members who never participated in training receiving priority in future training opportunities. Further, revenue generated from membership subscription, products fees permit, PELIS plots and timber harvesting in strongly-governed CFAs were used to support conservation initiatives (e.g. forest patrols & monitoring, scouts patrol uniform, training members), members welfare (soft loans to members) and establishment of initiatives benefiting wider community. Members equipped with wide ranging skills (e.g. tree nursery management; conservation farming; livelihood diversification including bee keeping, rabbit, poultry and goat keeping, and potato and greenhouse farming; *chamas* - table banking; human-wildlife; leadership; conflict management; scouting and monitoring) reported to using skills acquired to conserve the forest, their immediate environment in villages as well as in establishing livelihood diversification programmes for income generation, hence contributing to sustainable forest management by reducing pressure off the forest.

Transparency in CFAs funds utilisation and benefit sharing through established procedures in strongly-governed CFAs enhanced members confidence in CFA's leadership, thereby strengthening relationships, co-operation, social cohesion and mutual trust. This generated favourable attitudes with members participating more as observed in CFAs sites. "*before I joined this CFA, we used to sleep hungry and sometimes I used to borrow food from neighbours…. I live in a rented house and I have no land. But now since joining, I was allocated a half-acre plot where I farm... I harvest a lot of beans and potatoes, and I sell the surplus…. that's why I come here every week in forest activities…I want to work hard and save some money to buy a piece of land to build my home"* (CFA female member). This is in contrast to respondents in CFAs permitted to undertake high value benefits but embroiled in poor leadership, non-transparency and accountability (e.g. Ntimaka, Chuka) with distribution of benefits skewed in favour of loyal members and officials without any transparent procedures for benefit sharing. This was reported especially in PELIS programme, perceived as more beneficial by CFA members, officials and KFS staff where more than two farming plots per person were allocated to officials and loyal members in Chuka and Ntimaka CFAs while others had none.

Plantation establishment and livelihood improvement scheme (PELIS) as an incentive for CFA members was abused by both officials and members who sold or rented out plots to other interested community members with fees ranging from Ksh. 20,000 to 40,000 (1US$ = ~ Ksh. 100). For instance, undeserving respondents in Ntimaka CFA holding large parcels of unutilised land (in one instance, respondent owned 15 acres of land allocated through past government settlement scheme) were beneficiaries of PELIS plots and sold these to other parties. Similarly, in Chuka CFA, allocation of plots to non-members and non-residents was stopped through a court process lodged by area member of parliament (MP) after complaints from both the CFA and community members. Although members in Chuka, Chogoria, Irangi and Ntimaka are well versed and informed on good leadership and governance qualities, including problems afflicting their CFAs and solutions needed to bring change, they are faced with myriad challenges especially influence from current leadership and local politics. Members reported solution to persistent problems was by having good leadership and governance which could only be realised by conducting free, fair and credible elections, and where all members participated to elect credible and accountable officials.

2.6. Discussion

Study findings provide significant insights on local's attitudes towards sustainable forest conservation. Strong local governance and higher economic benefits are closely intertwined, reinforcing each other in influencing respondent's attitudes towards PFM. Significant differences were found in local's attitudes towards PFM with respondents earning higher forest incomes and in strongly-governed CFAs expressing more favourable attitude towards forest conservation compared to respondents in weakly-governed CFAs irrespective of level of income earned. Findings are consistent with reviews showing that defined benefits[21] and local autonomy in designing clear and enforceable rules (Pagdee et al., 2006; Agrawal and Angelsen 2009) through institutions that fit local context are crucial for successful CBFM outcomes. Local communities are more likely to support conservation initiatives and participate actively if they directly benefit from conservation with significant economic benefits (Ansong & Røskaft, 2011) and distribution of the benefits should be seen as fair and transparent by participants involved. Study results challenges findings that communities' value local autonomy, power and ability to exclude outsiders despite receiving meagre benefits (Gross-camp, 2017). Respondents attitudes towards PFM and hence motivation to participate in forest conservation were shaped by receipt of perceived high value benefits (e.g. PELIS, timber harvesting), transparency and accountability in benefits sharing enabled through strong governance mechanisms (e.g. inclusive engagement and participation in decision making). By assessing CFAs governance quality and perceptions of respondents based on indicators of good governance to examine locals attitudes towards forest conservation, this study contributes to a growing literature on local governance in sustainable forest management (e.g. Kisingo et al., 2016; Mollick et al., 2018; Maraseni et al., 2019).

Inclusive decision-making and activity planning in strongly-governed CFAs (Gathiuru, Kamulu, Ragati, Njukini and Kabaru) engendered positive attitudes towards PFM and thus collective participation and responsibility as respondents internalised contents agreed by majority of members. Further, procedures established (e.g. ballot allocation of farming plots) through inclusive participation of members guided sharing of benefits and because these were agreed by majority of members, distribution or allocation of benefits was perceived as fair and thus accepted by members. Luintel et al., (2017) in a study in Nepal documented similar findings where community user groups with better institutional governance ensured equity in benefit sharing through established benefit sharing mechanisms. Transparency in decision making and communication is crucial in maintaining trust, involvement and achievement of project goals (De Vente et al., 2016) as found in strongly governed CFAs with members kept abreast of new and on-going activities through regular meetings. Field observations at these CFA sites revealed

[21] Benefits should be well known to local communities and secured through long-term agreements. Local communities should be able to seek restitution for compensation if benefits and other rights are abrogated unfairly.

active participation of members in conservation activities evidenced through well managed tree nurseries, big turnout in events (e.g. meetings, elections) and PFM activities such as tree nursery preparation, seed collection and tree planting. These findings are in line with (Prokopy, 2005; Lauer et al., 2018) who demonstrated that engagement and residents control on project process and in decision making leads to significant high levels of satisfaction and hence more participation. Further, presence of monitoring committees in strongly-governed CFAs conducting random inspection of harvested forest products ensured conformity to CFAs/forest regulations by both CFA members and wider community.

Transparent decision-making process in strongly-governed CFAs was associated with favourable attitudes towards PFM leading to high level of rule compliance in forest products harvesting. For instance, at the CFA sites, locals crafted rules about how forest resources and other benefits were to be harvested. Rules encompassed nature of products to be harvested, frequency of harvesting, mode of transportation, sanctions for infractions and authorised activities. Members conformed to rules by collecting dead fallen wood during specific days of the week and using permitted mode of transportation (e.g. donkeys). CFA members showed high level of understanding and awareness of CFAs by-rules and constitution arising from their participation in rulemaking. For instance, there was high likelihood of compliance and enforcement of sanctions as evidenced in Gathiuru during CFA elections in 2016 where a member was barred (by members in attendance) from vying for CFA's secretary position since he had been implicated in illegal timber harvesting. According to members present, the candidate had failed credibility and integrity test as per CFA by-laws and constitution expected from all CFA members. Thus, CFA members demonstrated high standards of leadership qualities, transparency and accountability important for efficient forest management. This corroborates (Hayes et al., 2015) findings that communities who craft new rules and apply their rules are more likely to be organized and have internal monitoring and enforcement mechanisms. Similarly, decisions made by incorporating communities' views or through participation offers better chance of service delivery and can contribute significantly to forest conservation (Fischer, 2000) and rule compliance (Andrade & Rhodes, 2012).

In weakly governed CFAs (Chuka, Ntimaka, Irangi, Chogoria), lack of transparency in decision making, elections, funds management and engagement of members in planning of activities led to negative attitudes demotivating members from participation in forest conservation. Exclusion of communities in decision making processes in protected areas conservation and management is a determinant for negative attitudes (Silori, 2007; Kiwango et al., 2018). Kiwango et al., for instance, showed that low level of communities' participation in decision making (e.g. assembly meetings, election of officials,) in creation of Idodi-Pawaga wildlife management area (WMA) in Tanzania led to low levels of satisfaction with the WMA. Additionally, non-accountability and perceived in-equity in benefits sharing and abuse of PELIS system through sale of plots to third parties contrary to CFA Act 2016 led to allocation of plots to some wealthy individuals (owning large idle parcels of land) thus limiting incentives meant to genuine CFA members participating in forest conservation. Perceived in-equity in benefits in weakly governed CFAs triggered frequent conflicts and resentment negatively affecting respondent's participation in forest conservation. This was evidenced through abandoned tree nurseries, withered and dead seedlings. An individual's decision to join a group is determined by expected net benefits from participation (La Ferrara, 2002) and if this is curtailed through unfair distribution or marginalisation, then locals may harbour negative attitudes, reduce their participation and may engage in illegal activities as observed in Chuka, Chogoria and Irangi CFAs (e.g. fresh cut stumps, debarked trees[22], hidden logs and overharvesting of forest products). People are less likely to co-operate in circumstances of perceived unfairness, damaging relationships and aggravating conflicts which counteract expected conservation outcomes (Noordwijk & Leimona, 2010). Perception of unfairness in decision making and financial benefits has been shown to lead to retaliation through forest destruction by aggrieved parties in Cameroon (Oyono et al., 2006).

Poor governance characterised by lack of transparency and accountability in conducting elections to choose CFA officials in weakly-governed CFAs negatively affected members' attitude towards PFM. Ribot et al., (2010) notes that elections with open candidature and universal voting rights are important and necessary mechanisms for enhancing accountability but these have been grossly violated by officials in Chogoria, Chuka, Irangi and Ntimaka CFAs. KFS forest station manager(s) in these CFAs is a member of CFA committee mandated to guide and oversee CFAs activities (GoK, 2016) including facilitating transparent and fair elections in line with CFAs constitution. However, collusion between officials and KFS staff has entrenched non-accountability with a degree of success due to vested interests. Since CFAs establishment ten years ago, positions for officials in Chuka, Chogoria, Ntimaka and Irangi CFAs have been held by same people who have succeeded in monopolising decision-making. For instance, temporary ban of forest access withdrawing harvesting rights and arbitrary review of forest products levies

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[22] The Forest Act 2005; 2016 allows communities to collect dry wood for fuel wood and debarking of trees is meant to fasten drying of mature trees, thus concealing illegal cutting where community members cut and disguise such wood as dry wood.

in Chuka and Ntimaka CFAs respectively without community engagement. An essential component for accountability is through conducting free and credible elections and in the absence of these, CFAs officials in weakly-governed CFAs cannot be downwardly accountable to their constituents (Ribot, 2004), which emerged as a trigger for conflicts. Additionally, withdrawal of access rights can lead to tenure insecurity which is a significant driver of deforestation and degradation (Seymour et al., 2014) as community members seek illegal and informal arrangements to access forest products thus undermining conservation efforts.

Governance issues if not addressed can lead to internal conflicts (Ojha et al., 2009; Cousins & Kepe, 2004; Samndong & Vatn, 2012) undermining group's social cohesion, motivation and harbouring negative attitudes towards forest conservation. In situations where conflicts exist, it is difficult to get people to cooperate (Skutsch, 2000) as observed in Chuka, Chogoria, Ntimaka and Irangi CFAs. Although Van Laerhoven & Andersson, (2013) demonstrates that good forestry outcomes correlate positively with occurrence of conflicts, these should be resolved amicably, efficiently and in shortest time possible, but lack of internal dispute resolution mechanisms in weakly-governed CFAs has hampered speedy conflict resolution. Prolonged and unresolved conflicts may escalate and undermine trust, confidence and groups conservation efforts with contending parties competing against each other for use of resources, and may ultimately result in environmental collapse (Skutsch, 2000).

Internal conflicts were reported in all CFAs under study especially on illegal harvesting, increased levies for forest products, crop raiding by both wildlife and livestock[23], default on membership renewal and benefits/opportunities (e.g. sub-letting or lease of farming plots to outsiders), but were more pronounced in weakly-governed CFAs such as Chuka, Chogoria and Ntimaka. Mogoi et al., (2012) reported similar findings where 71% of forest user groups under study (16 CFAs in 11 forests in Kenya) experienced internal conflicts. Our findings show that CFAs' efficiency in conflict resolution is positively and strongly associated with positive attitude towards PFM, indicating increased efficiency in conflict resolution can enhance collective management by strengthening co-operation and networking (Pretty, 2003) among community members there by overcoming threats to forest conservation. Conflicts within resource user groups are both inherent and necessary components of common pool resource self-governance arrangements (Van Laerhoven & Andersson, 2013), but if not addressed can confound collective action and jeopardise the very same resource being conserved.

[23] Conflicts on human-wildlife were reported in all CFA sites but more pronounced on CFAs where PELIS is permitted.

Conflict resolution strategies and thus efficiency in handling disputes are key in managing disputes and these varied significantly between strongly and weakly governed CFAs. Conflict resolution committee(s) in strongly-governed CFAs composed of members trained in conflict resolution and management handles internal disputes with majority of respondents interviewed, 62.5% (n = 140) expressing great satisfaction with committee's efficiency in conflict resolution. In contrast, fewer respondents, 37.5% (n = 84) from weakly-governed CFAs expressed satisfaction with dispute resolution in their CFAs. Conflict resolution mechanisms are among principles important for effective community forest management (Ribot, 2004; Ostrom, 1999). Community groups should have rapid access to low-cost local arenas for resolving conflicts among users and between users (Milupi et al., 2017) as demonstrated in strongly-governed CFAs. However, conflicts in weakly governed CFAs were mostly handled and resolved through external arbitrators including representatives of the national administration (e.g. Chiefs, Members of Parliament) and the local law courts, which may take a longer period, thus undermining groups' social cohesion and conservation efforts. In Chuka CFA, for instance three court cases were filed at the local courts relating to non-transparency in CFA elections, benefits sharing and exclusion of communities in major decisions affecting them (fencing of Chuka forest block).

New skills and knowledge acquired through capacity building initiatives such as training had a positive and strong association with member's attitude towards PFM. Respondents equipped with more skills by attending greater number of trainings were more likely to report positive attitude towards PFM. Majority of members trained on PFM issues were from strongly-governed CFAs such as Gathiuru, Kabaru, Kamulu and Njukini with at least one training attended by respondents (mean 0.87, sd =1.27) compared to no training or fewer respondents trained (mean 0.41, sd = 0.91) from weakly-governed CFAs such as Chuka, Ntimaka and Irangi. Training equipped respondents with wide ranging skills in forest conservation and livelihood diversification (greenhouse farming, rabbit, poultry keeping and soap making) enhancing their attitude to actively participate in forest conservation. Sinclair et al., (2011) found that promoting learning through new skills and knowledge led to significant changes in participant's attitudes towards conservation of Arabuko-sokoke forest with participants engaging, speaking out for conservation and questioning local cultural norms.

Participant observation in meetings organised in strongly-governed CFAs e.g. Gathiuru, Kabaru and Njukini showed members expressing their ideas and opinions clearly and confidently indicating members comprehension of forest (and biodiversity) conservation issues from broad knowledge base on the subject matter. Where participants freely make statements and participate in discussion and decision making, the process leads to win-win and sustainable solutions that achieve its original goals and facilitate learning between participants (De Vente et al., 2016). Members equipped with skills on; livelihood diversification strategies, tree nursery management, conservation farming, *chamas* (table banking) and human-wildlife conflict among others reported to using skills in forest conservation, greening their immediate environment in villages as well as income generation from livelihood diversification programmes. Economic success is most likely when projects invests in capacity building (Brooks et al., 2013) with revenue generated in strongly governed CFAs used for conservation and society's welfare by providing basic social services (e.g. dam construction, trainings, school bursary, soft loans). Similar social services and infrastructure development from community conservation has been reported in Nepal with higher levels of group capacity linked to greater participation and implementation success in forest outcomes (Mehta & Heinen, 2001). Capacity development at both individual and institutional levels is directly linked to generating success in people's attitudes and behaviours as well as ecological and economic outcomes (Brooks et al., 2013; Sterling et al., 2017). As a result, capacity building enhances community's ability to deal collectively with conservation issues by either protecting resources or solving environmental problems (such as illegal logging, degradation) and can contribute to a sense of social togetherness (Fischer, 2017). Therefore, training of CFA members is crucial for enhancing positive attitude towards forest management and also in building confidence and relationships important for conservation success.

2.6.1. Conclusion

This study has provided insights on effect of strong governance and higher economic benefits on local attitudes towards forest conservation as a basis for improving community conservation initiatives. Strong governance and institutions are needed to respond to conservation and local communities needs through sustainable use of resources and diversification of livelihoods. Increased engagement of local communities through inclusive decision making and planning of conservation goals can boost morale and engender positive attitudes towards forest conservation. Local communities depend on forests for their livelihoods and will participate to conserve a resource that provides benefits for their well-being. Providing access to sustainable utilisation of forest products as well providing income diversification opportunities can reduce pressure on forests and win the support of local communities. Strengthening capacity building and providing income diversification strategies with greater economic benefits linked to forest conservation such as timber, eco-lodges can greatly improve relationships and create harmony between communities and forest resources. Further regular engagement with local communities can enhance transparency and accountability in decision making and benefit sharing, thus improving perceptions of fairness and equity amongst local communities. This can build trust, enhance relationships and create opportunities for co-operation and networking, diffusing tensions as well as providing a platform for accountability. Empowerment of local communities is essential in order to build strong structures through inclusive processes that develop mechanisms (e.g. democratic elections, harvesting rules) widely accepted in communities and best suited for local context. Additionally, such structures should include fast, low-cost and efficient conflict settlement mechanisms for ameliorating conflicts within the shortest time, in order to avert escalation that could jeopardise conservation efforts. Government agencies and other stakeholders working in close collaboration with local communities should integrate and promote good governance in co-management initiatives while also enhancing communities' capacity to engage in income diversification strategies (e.g. establishment of eco-camps, employment, timber harvesting) linked to sustainable forest management.

2.7. Appendix 2

Table A1. Governance indicators used in the assessment of CFAs local governance

Principles of good governance	Indicators of good governance	Perception of CFAs governance assessed at individual level	Qualitative assessment of local governance assessed at CFAs level
Accountability and transparency	Election of CFA officials	√	√
	Voting methods		√
	Selection of delegates		√
	Presiding officer's attendance		√
	Annual general meetings		√
	Financial transparency & accountability	√	√
	Frequently organised meetings		√
Collective action and participation	Activity implementation (duty roaster)		√
	Decision making (Inclusive/consensus)	√	√
	Monitoring and patrolling		√
	Rule of law and enforcement		√
	Conflict resolution	√	√
Benefits and benefits sharing	Benefits and benefits sharing	√	√
Efficiency in documentation and maintenance of records/database			√

Table A2. Analysis 1- Results of generalized linear mixed model relating members attitude to six predictor variables; PFM income, number of trainings attended, years schooling and respondents' responses of local governance quality assessed from; CFA's efficiency in conflict resolution, decision making participation, and CFA's financial accountability. Shown are models' degrees of freedom (df), Log likelihood (logLink), AICc, ΔAICc and Akaike model weights (w_i) for the top 10 models. All models include the intercept

Model	df	logLink	AICc	ΔAICc	Akaike weights
Conflict resolution + PFM Income + training + decision making	7	-119.779	254.0	0.00	0.210
Conflict resolution + PFM Income + training + decision making + schooling	8	-118.746	254.0	0.05	0.204
Conflict resolution + PFM Income + training	6	-121.444	255.2	1.23	0.113
Conflict resolution + PFM Income + training + schooling	7	-120.693	255.8	1.83	0.084
Conflict resolution + PFM income + training + decision making + accountability	8	-119.771	256.1	2.10	0.073
Conflict resolution + PFM Income + training + decision making + accountability + schooling	9	-118.711	256.1	2.12	0.073
Conflict resolution + PFM Income + training + accountability	7	-121.443	257.3	3.33	0.040
Conflict resolution + PFM Income + training + accountability + schooling	8	-120.689	257.9	3.94	0.029
Decision making + PFM Income + training	6	-122.969	258.2	4.28	0.025
Decision making + PFM Income + training + schooling	7	-121.950	258.3	4.34	0.024

Table A3. Analysis 2- Results of generalized linear mixed model relating members attitude to four predictor variables; PFM income, number of trainings attended, post primary schooling and governance quality assessed at CFAs level. Shown are models' degrees of freedom (df), Log likelihood (logLink), AICc, ΔAICc and Akaike model weights (w_i) for the top 10 models

Model	df	logLink	AICc	ΔAICc	Akaike weight (w_i)
CFA governance quality + PFM Income + training	6	-122.958	258.2	0.00	0.372
CFA governance quality + PFM Income + training + schooling	7	-121.948	258.3	0.08	0.357
PFM income + training	5	-124.936	260.1	1.87	0.146
PFM income + training + schooling	6	-124.265	260.8	2.61	0.101
CFA governance quality + PFM Income	5	-127.813	265.8	7.62	0.008
CFA governance quality + PFM Income + schooling	6	-126.788	265.9	7.66	0.008
CFA governance quality + training	5	-129.035	268.3	10.07	0.002
PFM income	4	-130.571	269.3	11.06	0.001
CFA governance quality + training + schooling	6	-128.596	269.5	11.27	0.001
CFA governance quality + training + schooling	5	-130.043	270.3	12.08	0.001

Table A4. Summary results after model averaging of analysis 1 of models within 95% cumulative set: Importance and effect of each parameter on members' attitude towards participatory forest management (PFM)

Parameter	Estimate-β (SE-conditional)	Confidence Interval	z Value	Odds ratio	Relative Variable Importance[24]
Intercept for attitude					
Positive/Negative	0.828(0.501)	(-1.811, 0.155)	1.652		
Negative/Neutral	1.869(0.525)	(-2.899, 0.839)	3.557		
Conflict resolution (Agree)	1.075(0.416)	(0.259, 1.891)	2.582	2.930	0.91
Decision making (Yes)	0.993(0.549)	(-0.082, 2.068)	1.809	2.699	0.71
Financial transparency (Yes)	0.119(0.619)	(-1.094, 1.331)	0.192	1.126	0.25
PFM high income (Ksh)	1.738(0.559)	(0.642, 2.834)	3.109	5.686	1.00
(> Ksh.184)					
Training	0.806(0.364)	(0.092, 1.520)	2.212	2.239	0.96
Years schooling	-0.289(0.211)	(-0.703, 0.125)	1.369	0.750	0.47

The table shows estimates of effect sizes, standard errors, confidence interval at 95%, z value, odds ratios and relative importance of each parameter*. Dependent variable- Attitude; reference category: Positive attitude. Conflict resolution, decision making, financial transparency and PFM income are comparisons to reference levels in each category.*

Table A5. Summary results after model averaging of analysis 2 of models within 95% cumulative set: Importance and effect of each parameter on members' attitude towards participatory forest management (PFM)

Parameter	Estimate-β (SE-conditional)	Confidence Interval	z Value	Odds ratio	Relative Variable Importance
Intercept for attitude					
Positive/Negative	1.178(0.499)	(0.200, 2.155)	2.362		
Negative/Neutral	2.186(0.523)	(1.161, 3.211)	4.178		
CFA governance (Strong)	1.257(0.657)	(-0.029, 2.544)	1.915	3.515	0.83
PFM high income (Ksh)	1.808(0.557)	(0.717, 2.899)	3.248	6.098	1.00
(> Ksh.184)					
Training	0.910(0.367)	(0.190, 1.630)	2.478	2.484	1.00
Years schooling	-0.285(0.201)	(-0.678, 0.108)	1.419	0.752	0.41

The table shows estimates of effect sizes, standard errors, confidence interval at 95%, z value, odds ratios and relative importance of each parameter*. Dependent variable- Attitude; reference category: Positive attitude. Conflict resolution, decision making, financial transparency and PFM income are comparisons to reference levels in each category.*

[24] Relative importance values are the sum of Akaike weights of a variable across all models in the set where the variable occurs. Larger values indicate that the variable is more important relative to the other variables and appears in more and better supported models, while low values indicate that the variable is less important and is in fewer models with less support from the data (Burnham & Anderson, 2002).

Table A6. Summary results after model averaging including all demographic factors for models within 95% cumulative set: Importance and effect of each parameter on members' attitude towards participatory forest management (PFM)

Parameter	Estimate-β (SE-conditional)	Confidence Interval	z Value	Relative Variable Importance[25]
Intercept for attitude				
Positive/Negative	0.838(0.518)	(-1.853, 0.177)	1.618	
Negative/Neutral	1.885(0.542)	(-2.947, -0.823)	3.478	
Conflict resolution (Agree)	1.059(0.419)	(0.237, 1.881)	2.525	0.90
Decision making (Yes)	1.020(0.553)	(-0.035, 2.103)	1.845	0.72
Financial transparency (Yes)	0.147(0.624)	(-1.075, 1.370)	0.236	0.26
PFM high income (Ksh) (> Ksh.184)	1.708(0.565)	(0.602, 2.815)	3.026	1.00
Training	0.812(0.365)	(0.097, 1.527)	2.226	0.95
Years schooling	-0.342(0.226)	(-0.786, 0.102)	1.511	0.54
Age (years)	-0.236(0.219)	(-0.664, 0.192)	1.081	0.39
Gender (male)	0.229(0.415)	(-0.584, 1.042)	0.552	0.28
Household size	-0.019(0.199)	(0.408, 0.370)	0.095	0.25

The table shows estimates of effect sizes, standard errors, confidence interval at 95%, z value, odds ratios and relative importance of each parameter. *Dependent variable- Attitude; reference category: Positive attitude. Conflict resolution, decision making, financial* transparency *and PFM income are comparisons to reference levels in each category.*

[25] Relative importance values are the sum of Akaike weights of a variable across all models in the set where the variable occurs. Larger values indicate that the variable is more important relative to the other variables and appears in more and better supported models, while low values indicate that the variable is less important and is in fewer models with less support from the data (Burnham & Anderson, 2002).

CFAs local governance assessment

Table A7. Local governance indicator ranking criteria (ranking: 4 = good; 3 = fair; 2 = poor; 1 = very poor)

GOVERNANCE CRITERIA		RANKING CRITERIA			
Accountability and transparency	**Indicator**	**4**	**3**	**2**	**1**
	Election of CFA officials held as per the constitution	Yes, elections held as per constitution	Yes, elections held but not as per constitution (delayed)	Yes, elections held once since CFA formation	-Elections never held since formation (i.e. officials just appointed to steer the registration of CFA pending elections
	Voting methods in elections	Secret ballot	Majoritarian	Queuing (to stand in line behind the candidate members support	No elections. Appointment/selection (done by a few people)
	Selection of delegates in elections	All CFA members vote as delegates	Delegates selected by CFA members themselves	Delegates selected by CFA officials	Appointment/selection of CFA officials (done by a few people) No elections
	Presiding officer (Forester and representative from the ministry of social services)	Both attend	One attends	None attends	Elections never done
	Annual General Meeting (AGM) held every year as per the constitution	Held every year	Held when it suits the CFA (e.g. to apply for funding or when forced my ministry of social services	Never held	
	Income and expenditure reports shared with members	Reports shared	Shared only when requested	Not shared at all	
	Constitution shared with members in AGM	Constitution shared	Constitution shared only when requested	Constitution not shared at all	
	Frequency of meetings to update members on CFA activities	Monthly meetings	After every 3 months	Meeting held when it suits the CFA	No meetings

Cont:

GOVERNANCE CRITERIA		**RANKING CRITERIA**			
	Indicator	**4**	**3**	**2**	**1**
Collective action	Rule of law & enforcement (e.g. access and harvesting rules, fines & sanctions)	Rules in place and fully enforced	Rules in place and partially enforced	Rules in place and not enforced	No rules in place
	A year duty roaster for all members on participation (what to do, who to do and when (e.g. tree planting & tendering, tree nursery management, etc.)	A yearly duty roaster and progress report of the activities undertaken; members attended	Duty roaster planned mostly during rainy season	Duty roasted planned on *ad hoc* basis or when it is necessary and suits the CFA	No duty roaster
	Monitoring & patrolling (security)	Done throughout the year	Not regular. Done mostly when threats to forests are detected or discovered	Never done	
Benefits & benefit sharing	Equity & inclusivity in benefits				
	Forest products	All members access/harvest allowed forest products (mostly subsistence) as long as they pay the required fees/permit	Some members access/harvest allowed forest products (mostly subsistence) without paying the required fees/permit	Some members bribe to harvest more/extra forest products (mostly subsistence)	Some members bribe or have special connections with the authority to harvest banned products (e.g. timber, poles/posts, hunting)
	Plots allocation for farming	Secret ballot allocation of plots and members aware of the total number of plots	Secret ballot allocation of plots and members not aware of the total number of plots	No secret ballot allocation of plots and members not aware of the total number of plots	
CFAs efficiency (documentation & updated records	Constitution	Constitution & updated	Constitution and not updated	No constitution	
	Membership list	Membership list updated every year	Membership updated only when it suits the CFA	Membership list never updated since CFA formation	No membership list

Table A8. CFA's local governance assessment

Governance Criteria	**Name of CFA and performance of the governance indicator**									
	Indicators	**Gathiuru**	**Kabaru**	**Ragati**	**Kamulu**	**Ntimaka**	**Chogoria**	**Chuka**	**Njukini**	**Irangi**
Accountability and transparency	Election of CFA officials held as per constitution	Elections held as per constitution	Elections held as per constitution	Elections held but delayed	Elections delayed by postponing date	No elections held since formation (7 years ago). Members selected to register the CFA still serving as officials	No elections held since formation (10 years ago). Members selected to register the CFA still serving as officials	Elections held but delayed	Elections held but delayed	Elections held but delayed
		4	4	3	3	1	1	3	3	3
	Voting methods in CFAs elections	Secret ballot Observed elections during field work	Secret ballot	Voting by queuing	Majoritarian Observed elections during field work	Appointment/ selection (No elections)	Appointment / selection (No elections)	Majoritarian	Majoritarian	Voting by queuing
		4	4	2	3	1	1	3	3	2
	Selection of delegates	Delegates selected by CFA members themselves	Delegates selected by CFA members themselves	All CFA members attending vote as delegates	All CFA members attending vote as delegates	Appointment/ selection of CFA officials	Appointment/ selection of CFA officials	Delegates selected by CFA officials	Delegates selected by CFA officials	Delegates selected by CFA officials
		3	3	4	4	1	1	2	2	2
	Presiding officer(s) attending	Forester attended	Forester attended	Forester attended	Social services representativ e	Elections never done	Elections never done	None	Forester	Forester
		3	3	3	3	1	1	2	3	3

Governance criteria	**Indicators**	**Gathiuru**	**Kabaru**	**Ragati**	**Kamulu**	**Ntimaka**	**Chogoria**	**Chuka**	**Njukini**	**Irangi**
	AGM Held every year as per the constitution	AGM held every year as per the constitution	AGM held every year as per the constitution	AGM not held as per constituti on but when it suits the CFA	AGM held every year as per the constitution	AGM never held	AGM never held	AGM not held as per constitution but when it suits the CFA	AGM not held as per constitution but when it suits the CFA	AGM not held as per constitution but when it suits the CFA
		4	4	3	4	2	2	3	3	3
	Income and expenditure reports shared with members	Reports shared	Reports shared	Not shared at all	Reports shared	Not shared at all	Not shared at all	Not shared at all	Reports shared	Not shared at all
		4	4	2	4	2	2	2	4	2
	Frequency of meetings	Monthly	Monthly	After every 3 Months	Monthly	Meeting held when it suits CFA officials	No meetings	Meeting held when it suits CFA officials	After every 3 Months	Meeting held when it suits CFA
		4	4	3	4	2	1	2	3	2
Collective action	Rule of law & Enforcement (e.g. access and harvesting rules, fines & sanctions)	Rules in place and fully enforced	Rules in place and fully enforced	Rules in place and partially enforced	Rules in place and fully enforced	Rules in place and partially enforced	Rules in place and not enforced	Rules in place and not enforced	Rules in place and partially enforced	Rules in place and not enforced
		4	4	3	4	3	2	2	3	2

Governance criteria	Indicators	Gathiuru	Kabaru	Ragati	Kamulu	Ntimaka	Chogoria	Chuka	Njukini	Irangi
	Participation A year duty roaster for all members on what to do, who to do & when (e.g. tree planting & tendering, tree nursery management, etc.	A year duty roaster for all members to participate in forest activities	A year duty roaster for all members to participate in forest activities	Duty roaster planned mostly during rainy season for members to participate in forest activities	A year duty roaster for all members to participate in forest activities	Duty roaster planned mostly during rainy season for members to participate in forest activities	No duty roaster	Duty roaster planned mostly during rainy season for members to participate in forest activities	Duty roaster planned mostly during rainy season for members to participate in forest activities	Duty roaster planned mostly during rainy season for member s to participa te in forest activities
		4	4	3	4	3	1	3	3	3
	Monitoring & Patrolling by members (security)	Done throughout the year	Done throughout the year	Done only partially (when CFA plans to do it)	Done throughout the year	Done only partially (when CFA plans to do it)	Never done	Never done	Done only partially (when CFA plans to do it)	Never done
		4	4	3	4	3	2	2	3	2
benefits and benefit sharing	Equity & inclusivity in benefits									
	Forest products	All members access the benefits (allowed) so long as they pay the	All members access the benefits (allowed) so long as they pay	All members access the benefits (allowed) so long as they pay	All members access the benefits (allowed) so long as they pay the	All members access the benefits (allowed) so long as they pay the	Some members bribe or have special connections with the authority to	Some members bribe or have special connections with the authority to harvest banned products (e.g. timber, poles/posts, hunting)	All members access the benefits (allowed) so long as they pay the	Some member s harvest banned products through collusion

		required fees/permit	the required fees/permit	the required fees/permit	required fees/permit	required fees/permit	harvest banned products (e.g. timber, poles/posts, hunting)		required fees/permit	with officials (e.g. timber, poles/posts
		4	4	4	4	4	1	1	4	1
	Plots allocation for farming	Secret ballot allocation of plots but members not aware of the total number of plots	Secret ballot allocation of plots but members not aware of the total number of plots	Secret ballot allocation of plots but members not aware of the total number of plots	Secret ballot allocation of plots and members not aware of the total number of plots	Secret ballot allocation of plots and members not aware of the total number of plots	**N/A**	No secret ballot allocation of plots and members not aware of the total number of plots (plots given to groups of people to farm together)	Secret ballot allocation of plots but members not aware of the total number of plots	No secret ballot allocation of plots and members not aware of the total number of plots (
		3	3	3	3	3		2	3	2
CFA efficiency Documentation & updated records	Constitution	Updated	Updated	Not updated	Updated	Not updated	Not updated	Not updated	Not updated	Not updated
		4	4	3	4	3	3	3	3	3
	Membership list	Membership list updated every year	Membership list updated every year	Membership updated only when it suits the CFA	Membership updated only when it suits the CFA	Membership list never updated	Membership list never updated	Membership list never updated	Membership updated only when it suits the CFA	Membership list never updated
		4	4	3	3	2	2	2	3	2

References

Achard, F., Beuchle, R., Mayaux, P., Stibig, H.-J., Bodart, C., Brink, A., … Simonetti, D. (2014). Determination of tropical deforestation rates and related carbon losses from 1990 to 2010. *Global Change Biology*, *20*(8), 2540–2554. https://doi.org/10.1111/gcb.12605

Agrawal, A. (2001). Common property institutions and sustainable governance of resources. *World Development*, *29*(10), 1649–1672. https://doi.org/10.1016/S0305-750X(01)00063-8

Agrawal, A., & Angelsen, A. (2009). Using community forest management to achieve REDD+ goals. In A. Angelsen (Ed.), *Realising REDD+: National strategy and policy options* (pp. 201–212). Bogor, Indonesia: Center for International Forestry Research.

Agresti, A. (2013). *Categorical data analysis* (3rd ed.). Canada: John Wiley & Sons.

Ameha, A., Nielsen, O. J., & Larsen, H. O. (2014). Impacts of access and benefit sharing on livelihoods and forest: Case of participatory forest management in Ethiopia. *Ecological Economics*, *97*, 162–171. https://doi.org/10.1016/j.ecolecon.2013.11.011

Anderson, J., Mehta, S., Epelu, E., & Cohen, B. (2015). Managing leftovers: Does community forestry increase secure and equitable access to valuable resources for the rural poor? *Forest Policy and Economics*, *58*, 47–55. https://doi.org/10.1016/j.forpol.2014.12.004

Andrade, G. S. M., & Rhodes, J. R. (2012). Protected areas and local communities. *Ecology and Society*, *17(4):14*. https://doi.org/http://dx.doi. org/10.5751/ES-05216-170414

Angula, N. H., Stuart-Hill, G., Ward, D., Matongo, G., Diggle, W. R., & Naidoo, R. (2018). Local perceptions of trophy hunting on communal lands in Namibia. *Biological Conservation*, *218*, 26–31. https://doi.org/10.1016/j.biocon.2017.11.033

Ansong, M., & Røskaft, E. (2011). Determinants of attitudes of primary stakeholders towards forest conservation management: A case study of Subri Forest Reserve, Ghana. *International Journal of Biodiversity Science, Ecosystem Services & Management*, *7*(2), 98–107. https://doi.org/10.1080/21513732.2011.613411

Asah, T. S., Guerry, D. A., Blahna, J. D., & Lawler, J. J. (2014). Perception, acquisition and use of ecosystem services: Human behavior, and ecosystem management and policy implications. *Ecosystem Services*, *10*, 180–186. https://doi.org/10.1016/j.ecoser.2014.08.003

Ayiemba, W., Mbithi, D., Nahama, E., Kagombe, J., Njuguna, L., Njuguna, L. W., … Mwanzia, J. (2014). Proceedings of the 2nd national PFM conference: Enhancing participatory forest management under the devolved governance structure. July 15-16. Nairobi, Kenya: Kenya Forestry Research Institute.

Baral, N., & Stern, J. M. (2011). A comparative study of two community-based conservation models in Nepal. *Biodiversity and Conservation*, *20*, 2407–2426. https://doi.org/10.1007/s10531-011-9993-3

Barnes, M. D., Craigie, I. D., Dudley, N., & Hockings, M. (2017). Understanding local-scale drivers of biodiversity outcomes in terrestrial protected areas. *New York Academy of Sciences*, *1399*(1), 42–60. https://doi.org/10.1111/nyas.13154

Barr, C., Barney, K., & Laird, A. S. (2014). Governance failures and the fragmentation of tropical forests. In J. C. Kettle & P. L. Koh (Eds.), *Global forest fragmentation* (pp. 132–157). Oxford, UK: CABI.

Barton, K. (2018). *MuMIn: Multi-Model Inference*. R package version 1.40.4. Retrieved from http://www.cran.r-project.org/package=MuMIn

Baynes, J., Herbohn, J., Smith, C., Fisher, R., & Bray, D. (2015). Key factors which influence the success of community forestry in developing countries. *Global Environmental Change*, *35*, 226–238. https://doi.org/10.1016/j.gloenvcha.2015.09.011

Bennett, N. J. (2016). Using perceptions as evidence to improve conservation and environmental management. *Conservation Biology*, *30*(3), 582–592. https://doi.org/10.1111/cobi.12681

Bluffstone, R., Robinson, E., & Guthiga, P. (2013). REDD+ and community-controlled forests in low-income countries: Any hope for a linkage? *Ecological Economics*, *87*, 43–52. https://doi.org/10.1016/j.ecolecon.2012.12.004

Boije, H. (2010). *Analysis in qualitative research*. London, UK: SAGE.

Boughey, K. L., Lake, I. R., Haysom, K. A., & Dolman, P. M. (2011). Effects of landscape-scale broadleaved woodland configuration and extent on roost location for six bat species across the UK. *Biological Conservation*, *144*(9), 2300–2310. https://doi.org/10.1016/j.biocon.2011.06.008

Bowler, D. E., Buyung-Ali, L. M., Healey, J. R., Jones, J. P. G., Knight, T. M., & Pullin, A. S. (2012). Does community forest management provide global environmental benefits and improve local welfare? *Frontiers in Ecology and the Environment*, *10*(1), 29–36. https://doi.org/10.1890/110040

Brockington, D. (2004). Community conservation, inequality and injustice. Myths of power in Protected Area management. *Conservation and Society*, *2*(2), 411–432.

Brooks, J., Waylen, K. A., & Mulder, M. B. (2013). Assessing community-based conservation projects: A systematic review and multilevel analysis of attitudinal, behavioral, ecological, and economic outcomes. *Environmental Evidence*, *2*(1), 1–34. https://doi.org/10.1186/2047-2382-2-2

Burnham, K., & Anderson, D. (2002). *Model selection and multimodel inference: A practical information-theoretic approach* (2nd ed.). New York, USA: Springer-Verlag New York, Inc.

Burnham, K. P., Anderson, D. R., & Huyvaert, K. P. (2011). AIC model selection and multimodel inference in behavioral ecology: Some background, observations and comparisons. *Behavioral Ecology and Sociobiology*, *65*(1), 23–35. https://doi.org/10.1007/s00265-010-1029-6

Charmaz, K. (2006). *Constructing grounded theory: A practical guide through qualitative analysis*. London, UK: SAGE Publications.

Charnley, S., & Poe, M. R. (2007). Community forestry in theory and practice: Where are we now? *Annual Review of Anthropology*, *36*(1), 301–336. https://doi.org/10.1146/annurev.anthro.35.081705.123143

Chomba, S., Treue, T., & Sinclair, F. (2015). The political economy of forest entitlements: Can community based forest management reduce vulnerability at the forest margin? *Forest Policy and Economics*, *58*, 37–46. https://doi.org/10.1016/j.forpol.2014.11.011

Christensen, R. H. B. (2015). *Ordinal - Regression models for ordinal data*. R package version 2015. Retrieved from http://www.cran.r-project.org/package=ordinal

Cousins, B., & Kepe, T. (2004). Decentralisation when land and resource rights are deeply contested: A case study of the Mkambati eco-tourism project on the wild coast of South Africa. *European Journal of Development Research*, *16*(1), 41–54. https://doi.org/10.1080/09578810410001688725

Creswell, W. J. (2007). *Qualitative inquiry and research design: Choosing among five approaches* (2nd ed.). California, USA: SAGE Publications, Inc.

Creswell, W. J. (2014). *Research design: Qualitative, quantitative and mixed methods approaches* (4th ed.). California, USA: SAGE Publications, Inc.

de Koning, M., Nguyen, T., Lockwood, M., Sengchanthavong, S., & Phommasane, S. (2017). Collaborative governance of Protected Areas: Success factors and prospects for Hin Nam No National Protected Area, Central Laos. *Conservation and Society*, *15*(1), 87–99. https://doi.org/10.4103/0972-4923.201396

De Vente, J., Reed, M. S., Stringer, L., Valente, S., & Newig, J. (2016). How does the context and design of participatory decision-making processes affect their outcomes? Evidence from sustainable land management in global drylands. *Ecology and Society*, *21(2):24*. https://doi.org/10.5751/ES-08053-210224

Defries, S. R., Rudel, T., Uriarte, M., & Hansen, M. (2010). Deforestation driven by urban population growth and agricultural trade in the twenty-first century. *Nature Geoscience*, *3*, 178–181. https://doi.org/10.1038/ngeo756

Dewu, S., & Røskaft, E. (2017). Community attitudes towards protected areas: Insights from Ghana. *Oryx*, *52*(3), 1–8. https://doi.org/10.1017/S0030605316001101

Emerton, L. (1997). *An economic assessment of Mt. Kenya forest: Conservation and management of indigenous forests*. Nairobi, Kenya.

Epstein, G. (2017). Local rulemaking, enforcement and compliance in state-owned forest commons. *Ecological Economics*, *131*, 312–321. https://doi.org/10.1016/j.ecolecon.2016.09.012

Epstein, G., Pittman, J., Alexander, M. S., Berdej, S., Dyck, T., Kreitmair, U., … Armitage, D. (2015). Institutional fit and the sustainability of social-ecological systems. *Current Opinion in Environmental Sustainability*, *14*, 34–40. https://doi.org/10.1016/j.cosust.2015.03.005

FAO. (1999). *State of the world's forests*. Rome, Italy: Food and Agriculture Organisation.

FAO. (2010). *Global forest resources assessment 2010*. Rome, Italy: Food and Agriculture Organisation.

FAO. (2015). *Global forest resources assessment 2015*. Rome, Italy: Food and Agriculture Organisation.

Field, A. (2009). *Discovering statistics using IBM SPSS statistics* (3rd ed.). London, UK: SAGE Publications.

Fischer, F. (2000). *Citizens, experts , and the Environment*. London, UK: Duke University Press.

Fischer, F. (2017). *Climate crisis and the democratic prospect: Participatory governance and sustainable Communities*. Oxford, UK: Oxford University Press.

GoK. (2005). *Forests Act, 2005*. Nairobi, Kenya: Government Printer.

GoK. (2010). *The constitution of Kenya*. Nairobi, Kenya: Government Printer.

GoK. (2016). *The forest conservation and management Act*. Nairobi, Kenya: Government Printer.

Gross-camp, N. (2017). Tanzania ' s community forests: Their impact on human well-being and persistence in spite of the lack of benefits. *Ecology and Society*, *22(1):37*. https://doi.org/https://doi.org/https://doi.org/10.5751/ES-09124-220137

Grueber, C. E., Nakagawa, S., Laws, R. J., & Jamieson, I. G. (2011). Multimodel inference in ecology and evolution: Challenges and solutions. *Journal of Evolutionary Biology*, *24*(4), 699–711.

https://doi.org/10.1111/j.1420-9101.2010.02210.x

Hariohay, Malle, K., Fyumagwa, D. R., Kideghesho, R. J., & Røskaft, E. (2018). Awareness and attitudes of local people toward wildlife conservation in the Rungwa Game Reserve in Central Tanzania. *Human Dimensions of Wildlife*, *23*(6), 503–514. https://doi.org/10.1080/10871209.2018.1494866

Hayes, T., & Murtinho, F. (2018). Communal governance, equity and payment for ecosystem services. *Land Use Policy*, *79*, 123–136. https://doi.org/10.1016/j.landusepol.2018.08.001

Hayes, T., Murtinho, F., & Wolff, H. (2015). An institutional analysis of payment for environmental services on collectively managed lands in Ecuador. *Ecological Economics*, *118*, 81–89. https://doi.org/10.1016/j.ecolecon.2015.07.017

Hazzah, L., Dolrenry, S., Kaplan, D., & Frank, L. (2013). The influence of park access during drought on attitudes toward wildlife and lion killing behaviour in Maasailand, Kenya. *Environmental Conservation*, *40*(3), 266–276. https://doi.org/10.1017/S0376892913000040

Heck, H. R., & Thomas, S. (2012). *Multilevel modelling of categorical outcomes using IBM SPSS*. New York, USA: Routledge.

Holmes, G. (2013). Exploring the relationship between local support and the success of Protected Areas. *Conservation and Society*, *11*(1), 72–82. https://doi.org/10.4103/0972-4923.110940

Hox J. Joop. (2010). *Multilevel analysis: Techniques and applications* (Second edi). New York, USA: Routledge.

International Union for Conservation of Nature (IUCN). (1982). The world national park congress, 11-22 October 1982, Bali, Indonesia. IUCN.

Johnson, R. B., Onwuegbuzie, J. A., & Turner, A. L. (2007). Toward a definition of mixed methods research. *Journal of Mixed Methods Research*, *1*(2), 112–133. https://doi.org/10.4324/9780203777176

Kawulich, B. B. (2005). Participant observation as a data collection method. *Forum: Qualitative Social Research*, *6*(2, Art. 43).

Kellert, S. R. ., Mehta, J. N. ., Ebbin, S. A. ., & Lichtenfeld, L. L. (2000). Community natural resource management: Promise, rhetoric, and reality. *Society & Natural Resources*, *13*, 705–715. https://doi.org/10.1080/089419200750035575

Kideghesho, J. R., Røskaft, E., & Kaltenborn, B. P. (2007). Factors influencing conservation attitudes of local people in Western Serengeti, Tanzania. *Biodiversity and Conservation*, *16*(7), 2213–2230. https://doi.org/10.1007/s10531-006-9132-8

Kisingo, A., Rollins, R., Murray, G., Dearden, P., & Clarke, M. (2016). Evaluating 'good governance': The development of a quantitative tool in the Greater Serengeti Ecosystem. *Journal of Environmental Management*, *181*, 749–755. https://doi.org/10.1016/j.jenvman.2016.08.002

Kiwango, W. A., Komakech, H. C., Tarimo, T. M. C., & Martz, L. (2018). Levels of community participation and satisfaction with decentralized wildlife management in Idodi-Pawaga Wildlife Management Area, Tanzania. *International Journal of Sustainable Development and World Ecology*, *25*(3), 238–248. https://doi.org/10.1080/13504509.2017.1378750

Klopp, J. M. (2012). Deforestation and democratization: Patronage, politics and forests in Kenya. *Journal of Eastern African Studies*, *6*(2), 351–370. https://doi.org/10.1080/17531055.2012.669577

KWS. (2010). *Mt. Kenya ecosystem management plan 2010-2020*. Nairobi, Kenya: Kenya Wildlife Service (KWS).

La Ferrara, E. (2002). Inequality and group participation: Theory and evidence from rural Tanzania. *Journal of Public Economics*, *85*(2), 235–273. https://doi.org/10.1016/S0047-2727(01)00102-5

Lambin, E. F., & Meyfroidt, P. (2011). Global land use change, economic globalization, and the looming land scarcity. *Proceedings of the National Academy of Sciences*, *108*(9), 3465–3472. https://doi.org/10.1073/pnas.1100480108

Lauer, F. I., Metcalf, A. L., Metcalf, E. C., & Mohr, J. J. (2018). Public engagement in social-ecological systems management: An application of social justice theory. *Society & Natural Resources*, *31*(1), 4–20. https://doi.org/10.1080/08941920.2017.1364456

Leisher, C., Temsah, G., Booker, F., Day, M., Samberg, L., Prosnitz, D., … Wilkie, D. (2016). Does the gender composition of forest and fishery management groups affect resource governance and conservation outcomes? A systematic map. *Environmental Evidence*, *5*(6), 1–10. https://doi.org/10.1186/s13750-016-0057-8

Long, J. S. (1997). *Regression models for categorical and limited dependent variables*. California, USA: SAGE Publications, Inc.

Luintel, H., Bluffstone, A. R., Scheller, M. R., & Adhikari, B. (2017). The effect of the Nepal community forestry program on equity in benefit sharing. *Journal of Environment and Development*, *26*(3), 297–321. https://doi.org/10.1177/1070496517707305

Lund, J. F., Burgess, N. D., Chamshama, S. a. O., Dons, K., Isango, J. a., Kajembe, G. C., … Treue, T. (2014). Mixed method approaches to evaluate conservation impact: Evidence from decentralized forest management in Tanzania. *Environmental Conservation*, *42*(02), 162–170. https://doi.org/10.1017/S0376892914000241

MacNeil, A. M., & Cinner, J. E. (2013). Hierarchical livelihood outcomes among co-managed fisheries. *Global Environmental Change*, *23*(6), 1393–1401. https://doi.org/10.1016/j.gloenvcha.2013.04.003

Macura, B., Zorondo-rodríguez, F., Grau-satorras, M., Demps, K., Laval, M., Garcia, C. A., & Reyes-garcía, V. (2011). Local community attitudes toward forests outside Protected Areas in India. Impact of legal awareness, trust and participation . *Ecology and Society*, *16(3):10*.

Maraseni, T. N., Bhattarai, N., Karky, B. S., Cadman, T., Timalsina, N., Bhandari, T. S., … Poudel, M. (2019). An assessment of governance quality for community-based forest management systems in Asia: Prioritisation of governance indicators at various scales. *Land Use Policy*, *81*, 750–761. https://doi.org/10.1016/j.landusepol.2018.11.044

Maryudi, A., Devkota, R. R., Schusser, C., Yufanyi, C., Salla, M., Aurenhammer, H., … Krott, M. (2012). Back to basics: Considerations in evaluating the outcomes of community forestry. *Forest Policy and Economics*, *14*(1), 1–5. https://doi.org/10.1016/j.forpol.2011.07.017

Matiku, P., Caleb, M., & Callistus, O. (2013). The impact of participatory forest management on local community livelihoods in the Arabuko-Sokoke forest, Kenya. *Conservation and Society*, *11*(2), 112–129. https://doi.org/10.4103/0972-4923.115724

Mazunda, J., & Shively, G. (2015). Measuring the forest and income impacts of forest user group participation under Malawi's forest co-management program. *Ecological Economics*, *119*, 262–273. https://doi.org/10.1016/j.ecolecon.2015.09.016

Mbaiwa, E. J., & Stronza, L. A. (2011). Changes in resident attitudes towards tourism development and conservation in the Okavango Delta, Botswana. *Journal of Environmental Management*, *92*, 1950–1959. https://doi.org/10.1016/j.jenvman.2011.03.009

McClenachan, L., Lovell, S., & Keaveney, C. (2015). Social benefits of restoring historical ecosystems and fisheries: Alewives in Maine. *Ecology and Society*, *20(2):31*. https://doi.org/10.5751/ES-07585-200231

Mehta, J. N., & Heinen, J. T. (2001). Does community-based conservation shape favorable attitudes among locals? An empirical study from Nepal. *Environmental Management*, *28*(2), 165–177. https://doi.org/10.1007/s002670010215

Milupi, I. ., Somers, M. ., & Ferguson, W. (2017). A review of community-based natural resource management. *Applied Ecology and Environmental Research*, *15*(4), 1121–1143. https://doi.org/10.15666/aeer/1504_11211143

Ministry of Environment and Natural Resources (MENR). (2007). *Participatory forest management (PFM) guidelines*. Nairobi, Kenya: MENR.

Mir, Z. R., Noor, A., Habib, B., & Veeraswami, G. G. (2015). Attitudes of local people toward wildlife conservation: A case study from the Kashmir valley. *Mountain Research and Development*, *35*(4), 392–400. https://doi.org/10.1659/mrd-journal-d-15-00030.1

Mogaka, H., Simons, G., Turpie, J., Emerton, L., & Karanja, F. (2001). *Economic aspects of community involvement in sustainable forest management in Eastern and Southern Africa.* Nairobi, Kenya: IUCN — The World Conservation Union, Eastern Africa Regional Office.

Mogoi, J., Obonyo, E., Ongugo, P., Oeba, V., & Mwangi, E. (2012). Communities, property rights and forest decentralisation in Kenya: Early lessons from participatory forestry management. *Conservation and Society*, *10*(2), 182–194. https://doi.org/10.4103/0972-4923.97490

Moktan, M. R., Norbu, L., & Choden, K. (2015). Can community forestry contribute to household income and sustainable forestry practices in rural area? A case study from Tshapey and Zariphensum in Bhutan. *Forest Policy and Economics*, *62*, 149–157. https://doi.org/10.1016/j.forpol.2015.08.011

Mollick, S. A., Rahman, K., Khan, N. I., & Sadath, N. (2018). Evaluation of good governance in a participatory forestry program: A case study in Madhupur Sal forests of Bangladesh. *Forest Policy and Economics*, *95*, 123–137. https://doi.org/10.1016/j.forpol.2018.07.014

Morjaria, A. (2012). *Electoral competition and deforestation: Evidence from Kenya* (ABCDE 2012). *Working paper prepared for World Bank*. Washington, D.C.

Mutune, J. M., & Lund, J. F. (2016). Unpacking the impacts of "participatory" forestry policies: Evidence from Kenya. *Forest Policy and Economics*, *69*, 45–52. https://doi.org/10.1016/j.forpol.2016.03.004

Noordwijk, van M., & Leimona, B. (2010). Principles for fairness and efficiency in enhancing environmental services in Asia: Payments, compensation, or co-investment? *Ecology and Society*, *15(4):17*.

Nsonsi, F., Heymans, J.-C., Diamouangana, J., & Breuer, T. (2017). Attitudes towards forest elephant conservation around a protected area in northern Congo. *Conservation and Society*, *15*(1), 59–73. https://doi.org/10.4103/0972-4923.201394

Ojha, H., Persha, L., & Chhatre, A. (2009). *Community forestry in Nepal: A policy innovation for local livelihoods* (No. 00193). International Food Policy Research Institute.

Oldekop, A. J., Bebbington, J. A., Brockington, D., & Preziosi, F. R. (2010). Understanding the lessons and limitations of conservation and development. *Conservation Biology*, *24*(2), 461–469. https://doi.org/10.1111/j.1523-1739.2010.01456.x

Oldekop, J. A., Holmes, G., Harris, W. E., & Evans, K. L. (2016). A global assessment of the social and conservation outcomes of protected areas. *Conservation Biology*, *30*(1), 133–141. https://doi.org/10.1111/cobi.12568

Ostrom, E. (1999). *Self-governance and forest resources* (No. 20). *CIFOR occasional paper* (Vol. 20). Bogor, Indonesia. https://doi.org/10.17528/cifor/000536

Oyono, P. R., Ribot, J. C., & Larson, A. M. (2006). *Green and black gold in rural Cameroon: Natural resources for local governance, justice and sustainability*. *Working paper 22*. Washington, D.C.: World Resource Institute.

Paavola, J. (2007). Institutions and environmental governance: A reconceptualization. *Ecological Economics*, *63*(1), 93–103. https://doi.org/10.1016/j.ecolecon.2006.09.026

Pagdee, A., Kim, Y., & Daugherty, P. J. (2006). What makes community forest management successful: A meta-study from community forests throughout the world. *Society & Natural Resources*, *19*(1), 33–52. https://doi.org/10.1080/08941920500323260

Parajuli, R., Lamichhane, D., & Joshi, O. (2015). Does Nepal's community forestry program improve the rural household economy? A cost–benefit analysis of community forestry user groups in Kaski and Syangja districts of Nepal. *Journal of Forest Research*, *20*(6), 475–483. https://doi.org/10.1007/s10310-015-0501-6

Patton, M. Q. (2002). *Qualitative evaluation and research methods* (3rd ed.). California, USA: SAGE Publications.

Persha, L., & Meshack, C. (2015). *Is Tanzania's joint forest management program a triple win? Understanding causal pathways for livelihoods, governance and forest condition impacts. 3ie Grantee Final Report. New Delhi: International Initiative for Impact Evaluation (3ie)*.

Poffenberger, M. (2006). People in the forest: Community forestry experiences from Southeast Asia. *International Journal of Environment and Sustainable Development*, *5*(1), 57–69. https://doi.org/10.1504/IJESD.2006.008683

Powers, A. D., & Xie, Y. (1999). *Statistical methods for categorical data analysis*. San Diego, USA: Academic Press, Inc.

Pretty, J. (2003). Social capital and the collective management. *Nature*, *302*, 1912–1914.

PROFOR, & FAO. (2011). *Framework for assessing and monitoring forest governance*. Rome, Italy: The Program On Forests (PROFOR) and Food and Agriculture Organisation.

Prokopy, L. S. (2005). The relationship between participation and project outcomes: Evidence from rural water supply projects in India. *World Development*, *33*(11), 1801–1819. https://doi.org/10.1016/j.worlddev.2005.07.002

R Core Team. (2018). *R: A language and environment for statistical computing.* Vienna, Austria: R Foundation for Statistical Computing. Retrieved from https://www.r-project.org/

Ray, B., Mukherjee, P., & Bhattacharya, R. N. (2016). Attitudes and cooperation: Does gender matter in community-based forest management? *Environment and Development Economics*, *22*(5), 594–623. https://doi.org/10.1017/S1355770X16000358

Ribot, J. C. (2004). *Waiting for democracy: The politics of choice in natural resource decentralization*. Washington, D.C.: World Resources Institute.

Ribot, J. C., Lund, J. F., & Treue, T. (2010). Democratic decentralization in sub-Saharan Africa: Its contribution to forest management, livelihoods, and enfranchisement. *Environmental Conservation*, *37*(1), 35–44. https://doi.org/10.1017/S0376892910000329

Robinson, D. T., Brown, D. G., Parker, D. C., Schreinemachers, P., Janssen, M. A., Huigen, M., … Barnaud, C. (2007). Comparison of empirical methods for building agent-based models in land use science. *Journal of Land Use Science*, *2*(1), 31–55. https://doi.org/10.1080/17474230701201349

Salafsky, N., Cauley, H., Balachander, G., Cordes, B., Parks, J., Margoluis, C., … Margoluis, R. (2001). A systematic test of an enterprise strategy for community-based biodiversity conservation. *Conservation Biology*, *15*(6), 1585–1595. https://doi.org/10.1046/j.1523-1739.2001.00220.x

Samndong, R. A., & Vatn, A. (2012). Forest related conflicts in South-East Cameroon: Causes and policy options. *International Forestry Review*, *14*(2), 213–226.

https://doi.org/10.1505/146554812800923336

Schoonenboom, J., & Johnson, R. B. (2017). How to construct a mixed methods research design. *Kolner Zeitschrift Fur Soziologie Und Sozialpsychologie*, *69*(2), 107–131. https://doi.org/10.1007/s11577-017-0454-1

Seymour, F., Vina, L. T., & Hite, K. (2014). *Evidence linking community-level tenure and forest condition: An annotated bibliography*. San Francisco, USA: Climate and Land Use Alliance.

Shibia, M. G. (2010). Determinants of attitudes and perceptions on resource use and management of Marsabit National Reserve, Kenya. *JournaL of Human Ecology*, *30*(1), 55–62.

Silori, C. S. (2007). Perception of local people towards conservation of forest resources in Nanda Devi Biosphere Reserve, North-Western Himalaya, India. *Biodiversity and Conservation*, *16*(1), 211–222. https://doi.org/10.1007/s10531-006-9116-8

Sinclair, A. J., Collins, A. S., & Spaling, H. (2011). The role of participant learning in community conservation in the Arabuko-Sokoke forest, Kenya. *Conservation and Society*, *9*(1), 42–53. https://doi.org/10.4103/0972-4923.79187

Skutsch, M. (2000). Conflict management and participation in community forestry. *Agroforestry Systems*, *48*, 189–206. https://doi.org/http://dx.doi.org/10.1023/A:1006328403023

Sterling, E. J., Betley, E., Sigouin, A., Gomez, A., Toomey, A., Cullman, G., … Porzecanski, A. L. (2017). Assessing the evidence for stakeholder engagement in biodiversity conservation. *Biological Conservation*, *209*, 159–171. https://doi.org/10.1016/j.biocon.2017.02.008

Stronza, A., & Gordillo, J. (2008). Community views of ecotourism. *Annals of Tourism Research*, *35*(2), 448–468. https://doi.org/10.1016/j.annals.2008.01.002

Suich, H. (2013). The effectiveness of economic incentives for sustaining community based natural resource management. *Land Use Policy*, *31*, 441–449. https://doi.org/10.1016/j.landusepol.2012.08.008

Thondhlana, G., & Cundill, G. (2017). Local people and conservation officials' perceptions on relationships and conflicts in South African protected areas. *International Journal of Biodiversity Science, Ecosystem Services & Management*, *13*(1), 204–215. https://doi.org/10.1080/21513732.2017.1315742

Tole, L. (2010). Reforms from the ground up: A review of community-based forest management in tropical developing countries. *Environmental Management*, *45*(6), 1312–1331. https://doi.org/10.1007/s00267-010-9489-z

United Nations Development Programme (UNDP). (2011). *A users' guide to measuring local governance*. Oslo, Norway: UNDP.

Van Laerhoven, F., & Andersson, K. P. (2013). The virtue of conflict: An institutional approach to the study of conflict in community forest governance. *International Forestry Review*, *15*(1), 122–135. https://doi.org/10.1505/146554813805927219

Western, D., Wright, M., Otto, J., Charles, Z., Robinson, J., Donovan, R., … Sayre, K. (2013). *Natural connections: Perspectives in community-based conservation*. Washington, D.C.: Island Press.

World Bank. (2008). *Forests sourcebook: Practical guidance for sustaining forests in development cooperation*. Washington, D.C.: World Bank.

Yang, H., Harrison, R., Yi, Z. F., Goodale, E., Zhao, M. X., & Xu, J. C. (2015). Changing perceptions of forest value and attitudes toward management of a recently established nature reserve: A case study in southwest China. *Forests*, *6*(9), 3136–3164. https://doi.org/10.3390/f6093136

Zuur, A. F., & Ieno, E. N. (2016). A protocol for conducting and presenting results of regression-type analyses. *Methods in Ecology and Evolution*, *7*(6), 636–645. https://doi.org/10.1111/2041-210X.12577

Chapter 3

Effect of variation in local forest governance on Mt. Kenya forest structure and carbon storage

Vegetation in a section of Mt. Kenya forest.

3.1. Abstract

Community-based forest management is receiving considerable attention due to success in restoring degraded forestlands in the tropics. Effective governance is a prerequisite for successful conservation outcomes but little attention has been paid on local governance and effects of its variability between communities on forest outcomes. We address these gaps through an empirical evaluation of governance quality and how its variability affects forest conditions in Mt. Kenya forest. Qualitative assessment of local governance showed variation among nine selected community forest associations (CFAs), categorised as weakly- or strongly-governed. In each CFA forest site, five quarter-hectare plots were established at 600m intervals and species, condition and diameter at breast height of each tree stem ≥ 10 cm; and for cut stumps, diameter and approximate years since cutting recorded in each plot. Species richness, diversity, composition and carbon storage of live trees, and stumps and basal area density (c. up to10 yrs.) were calculated. Data analysis was carried out using generalised linear mixed models, nonmetric multidimensional scaling and *manyglm.* Species richness were similar between weakly- and strongly-governed CFAs; however, diversity was greater in strongly-governed CFAs. Forest disturbance was lower in strongly-governed CFAs and species composition differed and was influenced by altitude, CFAs governance and CFA site. Mean carbon storage was 116.35 ± 11.45; se Mg C ha^{-1} and 98.36 ± 9.92; se Mg C ha^{-}1 in strongly- and weakly-governed CFAs respectively and was influenced by anthropogenic disturbance and altitude. Our results show that local governance quality varies between community groups and strong governance is essential for successful conservation outcomes.

3.2. Introduction

Extensive areas of tropical forests have been cleared and converted to other competing land uses such as agriculture (Pendrill et al., 2019; (Laurance et al., 2014). But mismanagement of forest resources and increased anthropogenic activities in the tropics, including illegal logging, encroachment and grazing (FAO, 2014; Klopp, 2012 ; Poffenberger, 2006; Duguma et al., 2019) threaten ecosystem functioning and livelihoods of local communities and contribute significantly to biodiversity loss and generate 12 percent of global annual anthropogenic carbon emissions (Barlow et al., 2016). Although globally, the annual rate of forest loss halved from 7.3 M ha yr^{-1} in the 1990s to 3.3 M ha yr^{-1} between 2010 and 2015 (Keenan et al., 2015), it is still high in many parts of the tropics (FAO, 2014). Hansen et al., (2013), for instance, noted a significant trend in annual forest loss in the tropics estimated at an increase of 2101 km^{2} yr^{-1}.

Tropical forests are the most rich species ecosystems on Earth, housing over half of Earth's biodiversity (Lewis et al., 2015), and are important in supporting livelihoods of local communities especially rural poor dependent on them (e.g. Vedeld et al., 2007; Uberhuaga et al., 2012; Angelsen et al., 2014). Further, they provide ecological services important for human well-being and biodiversity (e.g. nutrient cycling, hydrological cycle), and play a fundamental role in global carbon cycle and climate change mitigation by storing carbon in biomass and soils (Pan et al., 2011; Gibbs et al., 2007; Saatchi et al., 2011). For instance, globally, forests stored on average 2.1 Gt CO_2 yr^{-1} during the period 2011–2015 (Kohl et al., 2015; FAO, 2015), with over half of the world's carbon stored in tropical forests; 55% (471 ± 93Pg C) (Pan et al., 2011) indicating their significance in carbon storage. Reducing high deforestation and degradation rates is, therefore, paramount for achieving both conservation objectives and the welfare of local communities dependent on forest resources.

Co-management approaches incorporating local communities as key stakeholders in forest conservation, such as community-based forest management (CBFM), are increasingly acknowledged as important in reducing deforestation. Evidence shows that, under certain conditions, co-management approaches have proved successful in improving forest conditions and outcomes, compared to state management (Oldekop et al., 2016; Wright et al., 2016; Bowler et al., 2012). Strengthened local governance and autonomy in rulemaking for communities managing these resources (Andersson et al. 2014; Agrawal and Ostrom 2001; Pagdee et al. 2006) are key pillars for successful conservation outcomes. Previous CBFM studies show positive ecological outcomes in many areas where CBFM is implemented (e.g. Bowler et al., 2012; Nielsen & Treue, 2012; Lambrick et al., 2014). However, success and effectiveness of CBFM is deduced from assessments of forest outcomes relative to other governance regimes, such as state, indigenous and or private management. Studies do not take in to account local governance and in particular variability of local governance between communities and the effect of this on forest outcomes. Further, studies using variation in governance focus on governance at the national level (e.g. Amano et al., 2018; Umemiya, 2010) but little attention has been paid to how variation in the quality and effectiveness of local governance affects conservation outcomes.

Despite increasing recognition of tropical forests in the global carbon cycle, uncertainty remains regarding their contribution as majority of global carbon stock mapping relies on remote-sensing methodologies (Chen et al., 2015). These inhibit reliable forest carbon stock estimates due to the structurally complex ecosystems in the tropics, where remote-sensing signals tend to saturate quickly (Gibbs et al., 2007). Further, remote-sensing measures may under-estimate carbon emissions from degradation, and selective loss of high carbon density tree species from what resembles intact forests due to rapid canopy recovery and regeneration (Matricardi et al., 2010; Asner et al., 2004), thus masking loss of carbon-intense tree species. Research shows that carbon storage varies greatly in both its magnitude and within ecosystems and is influenced by among other factors disturbances and management practices (Chen et al., 2014). Consequently, high deforestation and degradation rates in the tropics can undermine capacity for carbon storage as tropical forests become sources of greenhouse gas (GHG) emissions (Pearson et al., 2017). Therefore, increasing inventories for carbon biomass assessment in the tropics by using ground-based forest inventories to assess effect of different management practices on carbon storage can provide accurate estimates for carbon biomass. Thus, help devise pragmatic solutions for efficient management of tropical forests in order to enhance carbon storage potential.

Many states have decentralised forest management in the tropics with an aim of reducing high rates of deforestation and degradation, and consequently support climate change mitigation. The last decade has witnessed forest decentralisation through legal reforms and regulatory frameworks (FAO, 2015; RRI, 2012) in many countries to incorporate local communities as key stakeholders in sustainable forest management – commonly referred to as community-based forest management (CBFM). Additionally, commitments by many states on global goals on forest conservation and sustainability of forest resources enshrined in legally binding frameworks and agreements (e.g. UNCED, MDGs, UNDRIP, REDD +[26], Aarhus Convention) that recognise community rights and participation of local and indigenous communities propelled changes in forest governance. Consequently, a continuing shift to co-management approaches between state(s) and local communities in forest governance has substantially increased the forest area under legal community ownership and control, estimated at just over 30 percent of global forest area (RRI, 2014) from 22 percent in 2002 (White & Martin, 2002). Forest decentralisation and CBFM adoption, however, may not necessarily promote efficient forest management and reduced deforestation rates especially in the tropics. Several scholars have identified crucial elements important for successful implementation of CBFM, outcomes and engagement with local communities. Among other factors, strenghtened governance, with clear local autonomy in designing rules, secure rights, well established local

[26] UNCED 2007: United Nations Conference on Environment and Development
MDGs 2000; 2015: Millennium Development Goals
UNDRIP 2007: United Nations Declaration on the Rights of Indigenous Peoples
REDD+: Reducing Emissions from Deforestation and forest Degradation.

institutions that fit local context and defined benefits for communities managing these resources are key pillars for CBFM success (Pagdee et al., 2006; Agrawal & Angelsen, 2009; Baynes al., 2015). Furthermore, these factors have been recognized as paramount in the long-term sustainability across a wide range of common property arrangements (Tucker, 2010).

Strengthened governance characterised by efficient transfer of power and rights from central government to local institutions is central to effective forest conservation (Ribot, 2002; Agrawal, 2001). Further, strengthened governance ensures inclusivity in decision making and local engagement, creating an enabling environment for efficient management of forest resources (Wright et al., 2016; Ribot, 2002), legitimacy of rule making process and higher likelihood of rule compliance (Hayes & Persha, 2010; Seymour et al., 2014). Local communities engaged in rule making are more likely to have their forests in better conditions (e.g. Gross-camp, 2017; Agrawal et al., 2008; Chhatre & Agrawal, 2009). For instance, Persha et al., (2011) showed that where local communities held sole decision-making authority and participated in rule making, forest conditions improved in Tanzania whereas unsustainable forest outcomes occurred when users did not participate in rule making. Consistent with these findings, Andersson et al., (2014) demonstrated that increased participation in rule-making by local communities corresponded to a 3.4 percent increase in forest cover in community forests in Bolivia. On the contrast, lack of meaningful decision making rights for local communities can undermine conservation efforts and weaken local democracy (*see* Essougong et al., 2019; Melis et al., 2017).

Under common-pool resources such as forests, rights conferred to local communities can be disaggregated into use and collective-choice rights or decision-making rights (Schlager & Ostrom, 1992). Among these, decision making rights — including management, exclusion, and alienation rights — yield more power as holders of these rights have authority to set rules to determine how, when and whether harvesting in a resource may occur, and how structure of a resource may be changed (Schlager & Ostrom, 1992). Further, right holders have authority and ability to exclude community members and outsiders who would not comply with set rules and standards (Cronkleton et al., 2012; *see* Gross-camp, 2017) further contributing to efficient management of forests. Thus, rights conferred to local communities are vital in determining resource management outcomes (Agrawal & Ostrom, 2001) where communities can exercise voice in managing resources depended on them.

Local community participation in decision making has been shown to also enhance social benefits of forest management, as sharing of power and responsibilities can build and strengthen institutions, by increasing transparency, trust among actors, co-operation, networking and social learning (Berkes, 2009; Schusler et al., 2003). Mutual trust and networks strengthen social bonds, relationship and collective action thereby increasing groups productivity and sustaining conservation efforts (e.g. monitoring and enforcement), important in reducing exploitation and threats to forest resources. Additionally, where trust is high in community groups, people are more likely to be willing to invest in collective responsibilities with confidence that others will equally do the same (Pretty, 2003), thus enhancing conservation efforts significant for promoting sustainable forest management. Knowledge acquired through social learning and networking, coupled with broad knowledge base communities possess in traditional ecological knowledge about their resources (Andersson et al., 2014; Boafo et al., 2016) can be effective in building interest of local communities in participating to protect the integrity of their resource(s) (World Bank, 2014), which is critical in tackling important global challenges such as poverty, tropical deforestation and global warming (Agrawal and Angelsen 2009; Angelsen et al. 2014; Karky and Skutsch 2010).

Forest outcomes in CBFM are commonly inferred from comparisons with other governance regimes, especially state management. Majority of studies shows CBFM — which allows collaborative management and sustainable use of forest resources by local communities — as a better management approach in forest conservation compared to state management as evidenced through better forest outcomes; higher forest cover, tree basal area and tree stem density (e.g. Bowler et al., 2012; Blomley et al., 2008; Poudel, 2014; Matiku at al., 2011). For instance, Lambrick et al., (2014) documented low levels and fewer signs of anthropogenic damage (cut stems, stumps, and burned trees), more regenerating stems, and reduced canopy openness in community managed areas than in state managed areas in Cambodia. However, studies do not take in to account local governance and in particular variability of local governance between communities and its effect on forest outcomes. Research provides compelling evidence that some local communities develop innovative and effective governance structures (e.g. rules) to govern forests sustainably while others struggle or do not (Tucker, 2010; Nagendra et al., 2005; Ostrom, 1990). A study involving 163 forests including protected and non-protected areas from 13 countries[27] found that where local communities collaborated and

[27] Uganda, Nepal, India, Kenya, Tanzania, Madagascar, Bolivia, Brazil, Ecuador, Guatemala, Honduras, Mexico and the United States.

designed rules to guide forest management, vegetation density was higher, but was sparse where communities were not involved in rulemaking (Hayes, 2006). This alludes to the existence of local governance variation between communities which subsequently may affect forest outcomes. Therefore, it is important to understand how variation in local governance (quality) influences forest conditions and outcomes and in particular where several community groups have management jurisdiction for different sections of a large shared forest ecosystem.

Studies using governance variation focus on governance at the national level and its effect on forest and biodiversity conservation (e.g. Amano et al. 2018; Umemiya et al. 2010), yet conservation occurs mostly at the local grassroots level and may involve differing stakeholders from those at the national level. Although these studies are robust, and national governance index has been used especially by donors to allocate funds and or aid for development and biodiversity conservation (In'airat, 2014; Miller et al., 2013), using national governance might give contradictory or even erroneous findings, as some indicators (e.g. terrorism) used to measure overall national governance index may not be specifically or directly linked to biodiversity and or forest conservation. Umemiya et al., (2010) showed that, globally, improved national governance was associated with a decrease in deforestation rates. However, Brooks et al., (2013) in a systematic global review of 136 community based natural resource management (CBNRM) projects showed lack of evidence that national governance affected four outcomes; attitudinal, behavioural, ecological and economical**,** with authors concluding that national governance may influence project success or outcomes through various mechanisms.

This chapter provides a deeper understanding of how variation of local governance performance at the local level affects forest conditions. A reconnaissance study visit to Mt. Kenya forest in 2016 revealed varying institutional governance structures and levels of participation in CBFM amongst community groups. Some community groups were found to be active, based on activity implementation at site level, while others were not, hence presenting an ideal opportunity for assessment of the effects of local governance variation and on forest conditions. The study aims to assess the following objectives; a) compare species diversity and composition of selected forest blocks managed under varying institutional structures; b) identify factors influencing species diversity and composition in forest blocks under varying institutional governance quality; c) quantify total carbon biomass and examine factors influencing carbon storage in forest blocks under varying institutional governance. By doing so, it is expected that findings will address gaps in understanding effects of variation on local governance within communities on forest conditions with the aim of strengthening local capacity and institutional frameworks for efficient forest management. Further, findings will add to the existing literature on carbon biomass in tropical forests and provide deeper understanding of the influence of local governance on carbon storage.

3.3 Methodology

3.3.1 Study site and design

The study examined multiple community forest associations (CFAs) collecting data at continuous sections of montane indigenous[28] natural forest on Mt. Kenya. The forest was formed as a result of volcanic activity and has a base diameter of approximately 120 km. The forest is both a forest reserve and a national park covering 2,130.82 km^2 and 715 km^2 respectively (*Fig. 3.1*), jointly managed by Kenya Forest Service (KFS) and Kenya Wildlife Service (KWS) (KFS, 2010; KWS, 2010). Community forest associations within Mt. Kenya forest have management jurisdiction over their forest sites or blocks with clearly defined boundaries based on national survey boundaries and or natural features such as valleys, rivers and streams.

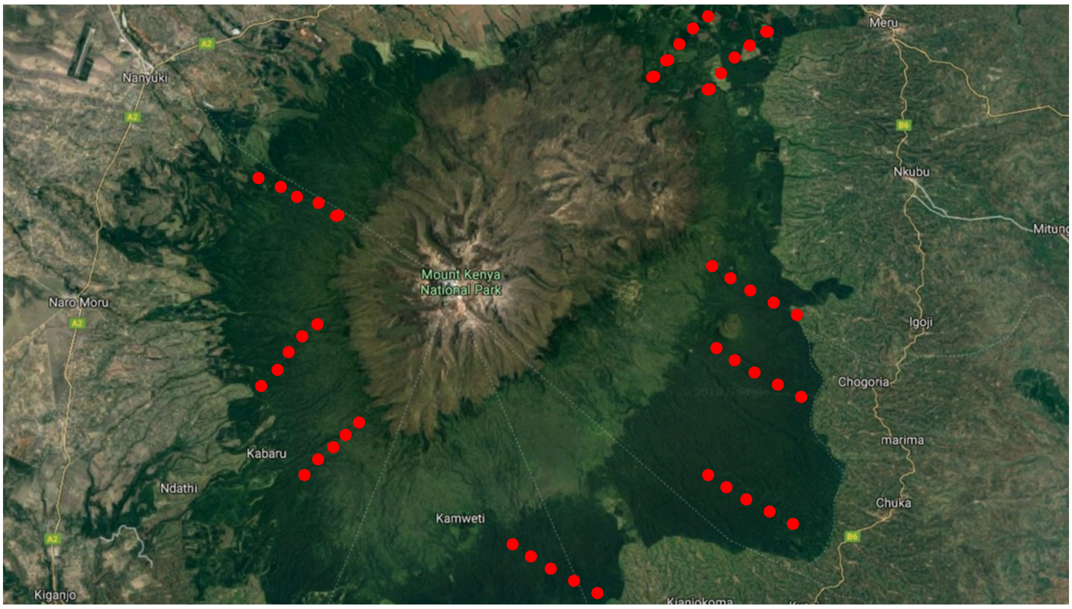

Fig. 3.1. Mt. Kenya forest and graphical presentation of sampled CFAs plots
Source — Mt Kenya forest: Google Earth.

Fourteen CFAs visited during a reconnaissance visit in March−April 2016 revealed striking differences in levels of operation with some being active in forest activities while others were not. Nine out of the fourteen CFAs were selected and this allowed contemporaneous sampling of forest condition (structure, tree species composition) and governance quality across the nine

[28] Kenya's natural forests composed of indigenous species only (Wass, 1995).

replicate CFAs – all with similar ecosystem, and socio-economic and political factors. The assumption was that CFAs had adopted governance structures and systems to guide forest management including decision making, monitoring and enforcement, and controlled human activities in the forest to facilitate regeneration and improvement of forest conditions (Wilkinson et al., 2014).

Forest composition varies with altitude and is divided into five zones with: a) plantation forest zone between 2000m and 2200m in some forest blocks; b) indigenous natural forest starting at 2000m to 2400m; and above this zones of bamboo, grassland and moorland (KFS, 2010). Although protection has been improved through management by two state agencies — KFS and KWS — hence providing additional resources and capacity, competitive pressure and threats from both within and outside still remain (KFS, 2010; Gathaara, 1999).
Human induced activities; agriculture, encroachment, charcoal burning, livestock grazing, cultivation of marijuana (*Cannabis sativa*) and increasing population continue, together escalating pressure in the forest. Additionally, illegal logging targets important and valuable indigenous species such as Meru Oak (*Vitex keniensis*), Croton (*Croton macrostachyus*), Camphor (*Ocotea usambarensis*) and Podo (*Podocarpus latifoli*us) (KFS, 2010). Current threats include encroachment and intensive agricultural activities through a Plantation Establishment and Livelihood Improvement Scheme (PELIS) programme, legalised through the Forest Act 2005, allowing community members to plant tree seedlings and nurture them while farming for a period of three years in clear-felled plantations as an incentive for forest conservation (GoK, 2005).

Local communities living within 5 kms of forest boundary mainly from three Bantu ethnic communities (*Kikuyu*, *Meru* and *Embu)* may voluntarily join and register CFAs, in collaborative efforts with KFS to conserve the forest. The ethnic composition of CFAs is composed of the main inhabitants of the area but also mixed through intermarriages and past settlement schemes initiated by Kenya's government to settle the landless and squatters. These communities share similar culture, religion, closely related languages and practice agricultural farming and livestock keeping.

3.3.2. CFAs governance quality assessment

Note: CFAs governance quality assessment is the same as presented in Chapter two on section 2.3.2, pages 52-54; Table 2.1 and Appendix 2; Table A7 and A8, pages 84-89.

In this Chapter, exploratory data analysis using two governance categories ('strong' — including 'fair', N = 5 CFAs; and 'weak', N = 4 CFAs) gave a substantially better model fit than considering three ('strong', 'fair' and 'weak') categories; therefore, subsequent analyses consider two categories of governance quality; 'strong' and 'weak'.

3.3.3. Forest structure, species diversity and composition

Forest impacts were expected to vary with distance into the forest, as communities may preferentially harvest forest products (e.g. firewood, logs, poles, fodder) close to the village boundary to reduce distance travelled while carrying a heavy load, or due to fear of wild animals such as elephants. Therefore, forest condition in each CFA territory was sampled at indigenous forest zone (natural forest) at increasing distances into the forest in five quarter-hectare belt plots (each 10m x 250m; total area 11.25 $m^2 ha^{-1}$), with the first plot established 600m from the forest entry/gate and 150m from forest path or feeder road inside the forest; subsequent plots were established at regular intervals of 600m. (*Fig. 3.2 & 3.1*). Where plot(s) establishment was hindered by thickets, deep valleys and other natural features, plots were established at the nearest accessible site. Distance from forest entry (m) and altitude (m) at start and end of each plot was measured with a hand-held GPS, (average altitude values for each plot were calculated) on the assumption that these may affect species diversity, composition and carbon biomass. Presence of any human disturbance (e.g. logging, hidden logs/posts, charcoal kilns, debarking and snares) within 100m of plots boundary were recorded whenever encountered. In each plot, the diameter at breast height (dbh, at 1.3m

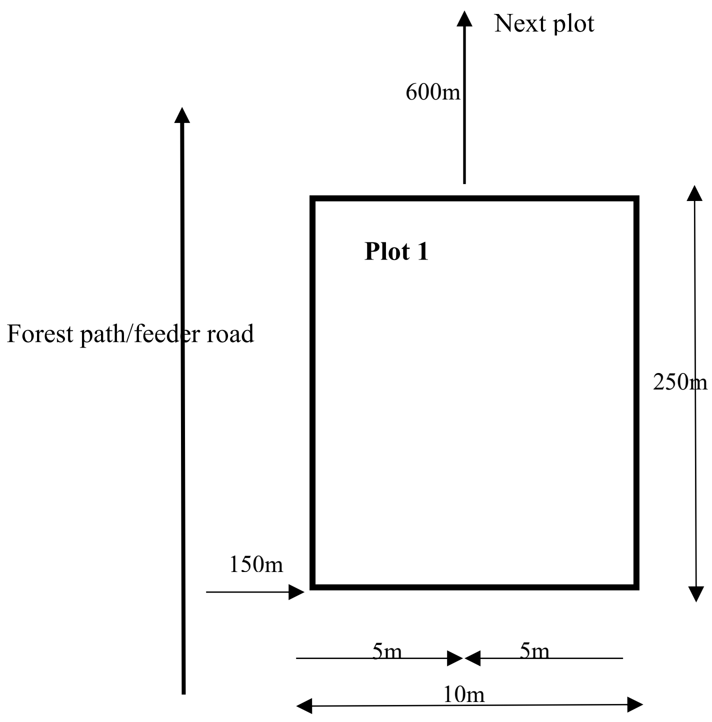

Fig. 3.2. Plot layout within a CFA forest block.

above ground), species and condition (live and dead — standing, fallen, and debarked) of each tree stem ≥ 10 cm; and for all cut stumps, the diameter (at 20cm above ground) and approximate age (years since cutting) were recorded. Mean diameter – dbh (cm) and basal area density (m^2 ha^{-1}) of living trees; stump density (stumps ha^{-1}) and stump basal area density (m^2 ha^{-1}) of stumps cut within c.10 years (i.e. cut from two years after PFM adoption to present) were subsequently calculated for each sampled plot. We considered stumps cut within 10 years, both to allow for error in estimation of stump age, and also allowing a two-year grace period considered sufficient enough for communities to organise themselves, set up and implement necessary governance structures to effectively participate in forest conservation. Alemagi, (2010) found a similar timeframe for governance structure establishment noting that establishment of community-based procedures took an average of approximately 18 months in Cameroon and 18–24 months in Canada.

Each tree stem ≥ 10 cm was identified to species, based on tree leaves, fruits, flowers and the bark (small cuts were made in the trees bark in some instances), by a traditional herbalist cum guide with extensive indigenous and ecological knowledge of the area including skills in tree species identification (e.g. Zhao et al., 2016; Tadesse et al., 2019). The expert guide identified species in all of the nine CFA forest blocks, thus any identification errors were consistent with respect to governance quality. Species were initially recorded in a local language (*Kikuyu or Kimeru*); scientific names were subsequently identified referring to published plant taxonomy and identification guides showing both local and scientific names (Beentje, 1994; Maundu & Tengnas, 2005; Mabberley, 2008). Age of stumps were also assessed by the same guide based on colour intensity, visual appearance and degree of decay of the cut surface (Lund et al., 2014; Tobin et al., 2007).

3.3.4. Carbon storage

Aboveground biomass (AGB) stored in live tree stems of each sampled plot was estimated from stem data and wood density values (g/cm^3) extracted from Global Wood Density (GWD) (Chave et al., 2009; Zanne et al., 2009) and African Wood Density (AWD) (Carsan et al., 2012) databases. Where a range of wood density values were given for a species, the average density was used. Further, where species-specific wood density values were not available, the average wood densities of other species within the same family was taken from the GWD database following (Flores & Coomes, 2011). If wood density values were not available for the family within the GWD database, the mean wood density value for all local species dataset was used, following (Warren-Thomas et al., 2018).

Stem biomass was calculated using Chave et al., (2005) pantropical allometric model for moist tropical forest stands, that was constructed using a large dataset of 2,410 trees ≥ 5 cm diameter, destructively measured from 27 study sites across the tropics. This model was preferred due to lack of a site-specific model for Kenya and the unrivalled large dataset in comparison to site-specific allometric models often with fewer datasets (e.g. Ngomanda et al., 2014; 101 trees used in Gabon) which could be imprecise in estimating carbon biomass. Further, the pantropical model has been found to be accurate in predicting carbon biomass in moist tropical forests with similar mean error to other models developed for tropical African forests (e.g. Fayolle et al., 2013; Djomo et al., 2010; Fayolle et al., 2018) and thus, is robust when tested with moist tropical montane forests (Chave et al., 2005) and may be more accurate than the most recent pantropical equation by Chave et al., 2014 (Fayolle et al., 2018). The pantropical allometric model used for estimating aboveground biomass is given by;

$$AGB_{est}\ (kg) = \rho \times \exp(-1.499 + 2.148\ln(D) + 0.207(\ln(D))^2 - 0.0281(\ln(D))^3)$$

Where:

AGB_{est} = Aboveground biomass estimate

P = Species-specific wood density (g cm^{-3})

D = Diameter at breast height – DBH (cm)

Although including tree height in biomass calculations has been shown to improve estimates of carbon biomass (Chave et al., 2014; Rutishauser et al., 2013), it is difficult to accurately measure individual tree height in natural forests with closed canopy. Allometric equations using tree height generate slightly higher biomass estimates than equations without height (e.g. Borah et al., 2018) and thus, carbon biomass estimates presented in this study are on the lower limit. However, despite the possibility of systematic error, such under-estimation would not introduce directional bias when comparing biomass between forest CFAs of different degrees of intactness. Belowground biomass (BGB) was estimated as 23.5% of AGB per plot (Mokany et al., 2006). Biomass was assumed to be composed of 50% carbon (IPCC, 2006); thus total carbon stored (Mg ha^{-1}) was quantified by summing AGB and BGB per plot and multiplied by 0.5.

3.4. Data analysis

Forest structure within sampled plots in blocks managed under varying CFAs governance (strongly- and weakly-governed CFAs) was examined in terms of: live tree species richness (S), stem and live basal area density, Shannon (*H'*) and Simpson's (D) diversity indices per plot and also cut stump basal area density (m^2 ha^{-1}) and stump density (stumps ha^{-1}) per plot (*Table 3.1*). Simpson Index is weighted on the abundance of common species unlike Shannon Index, and is little affected by addition or loss of rare species (Mccune & Grace, 2002). Using Generalised

Linear Mixed Models (GLMMs), species richness, stem and basal area density, Shannon and Simpson's diversity indices for live tree stems were each related to three fixed predictor variables: CFAs governance quality (strongly- and weakly-governed CFAs); distance into forest (m) and altitude (m) of sampled plots, using R package, lme4 (Bates et al., 2015). CFA site identity was included as a random effect in all models, to account for non-independence (Field, 2009; Grueber et al., 2011) of replicate plots within governance categories (*Appendix 3; Equation 1—models fitted in GLMM*). Additionally, live stems were classified into four dbh class categories; small sized stems; < 20 cm, mid-sized; 21-30 and 31-40 cm; and large sized stems; 51-60 and 61->70 cm and t-tests (Satterthwaite's method in Linear mixed model) done to compare differences in each dbh class category between strongly- and weakly-governed CFAs.

Table 3.1. Summary of variables used in the analysis

Variable name	Description	Type of data
Response variables		
Basal area density of live trees & cut stumps (BL & BC) (m^2ha^{-1})	Calculated from diameter of live trees and stumps cut within 10 years measured in sampled plots measuring 10m x 250m. Five plots established in each of the 9 CFA forest blocks totalling to 45 plots	Continuous
Stump density (SD) Stumps ha^{-1}	Calculated from number of cut individual stumps in each plot and converted to per hectare	Continuous
Species richness (S)	Derived from species abundance data in sampled plots based on Chao 1 estimator using R package, 'iNext'	Continuous
Shannon diversity (H')	Derived from species abundance data in sampled plots based on Chao 1 estimator using R package, 'iNext'	Continuous
Simpson diversity (D)	Derived from species abundance data in sampled plots based on Chao 1 estimator using R package, 'iNext'	Continuous
Predictors		
CFA governance quality (GL)	CFA governance quality assessed using CFAs documentation (minutes, constitution, CFA reports, management plan), categorised into 3 groups (strong, fair, weak) subsequently merged to two categories – strongly- and weakly governed CFAs	Categorical
Plot distance (PD) m	Distance of sampled plot(s) from the first established plot. First plot established at 600 meters from forest gate/entry	Continuous
Altitude (AL) m	Elevation of sampled plot(s) measured in metres at the start of each plot	Continuous
CFA site	Nine CFA sites used as random effect in the analysis to account for grouping of CFA replicate plots within individual CFAs	Categorical

Altitude (m) of sampled plots, was standardised around the mean using the scale function in R to facilitate interpretation of the relative strength of parameter estimates (Grueber et al., 2011; Field, 2009). Multicollinearity of explanatory variables was assessed through Variance Inflation

Factor (VIF) with smallest values — minimum being one — indicating non-multicollinearity and confirmed non-collinearity with VIF < 5 (Field, 2009).

To select the best fitting model, multi-model inference approach based on Akaike's information criterion corrected for small samples sizes (AICc) was used to examine possible combinations of candidate models for each response variable comprising of all predictor variables (Burnham & Anderson, 2002). Model parameters and sum of Akaike Weights (w_i) were calculated and subset models ranked by AICc. The best fitting model for inference was chosen based on Akaike weights (w_i) > 0.9 (Grueber et al., 2011; Burnham & Anderson, 2002). Where uncertainty existed in choosing the best model for inference due to Akaike weights (w_i) of first-ranked model for each response variable being less than 0.9 (*Appendix 3; Table A1 & A2)*, model averaging[29], ranking of variables relative importance (VRI) and effect size were calculated based on the 95% cumulative confidence models set (Grueber et al., 2011; Burnham & Anderson, 2002; 2011) using dredge function in the MuMin package (Barton, 2018) of R software. Akaike weights represent the ratio of ΔAICc values for the whole set of candidate models and provide a measure of strength of evidence for each model (Burnham & Anderson, 2002). Ranking of variables relative importance (RVI) was performed using the summed Akaike weights (w_i) from all candidate model combinations where the variable was present. The higher the RVI value, the more important the variable relative to other variables (Burnham & Anderson, 2002). To assess direction and strength of effect for predictors, 95% confidence intervals (CI) of the full model (where applicable) and model-averaged coefficients were assessed if they overlapped with zero; if CI overlapped with zero, effect of predictor(s) was not supported (Grueber et al., 2011; Boughey et al., 2011).

Whether number of tree species differed under varying CFAs governance was assessed through species accumulation curves, using sample-based rarefaction (Gotelli & Colwell, 2001; Chao et al., 2014), examined through repeated resampling (nbooting) of species density data 999 times, using R package 'iNext' (Hsieh & Chao, 2016) and examining whether 95% confidence intervals of rarefaction accumulation curves overlapped (Grueber et al., 2011). Abundance-based richness estimators – Chao 1 was used to compute species richness and diversity based on hill numbers; species richness, Shannon diversity and Simpson's Index (Chao et al., 2014).

[29] Not done for model having stump density as response variable as only one model was within 95% confidence model set which included all three predictor variables; CFAs governance, distance and altitude. Model has high Akaike weights of 0.909 indicating all three predictors variables were important in explaining stump density (Appendix 3; Table A2).

Chao 1 is a bias corrected non-parametric richness estimator used for estimating the true total number of species in a given area and performs best in empirical comparisons and surveys compared to other estimators especially when there are undetectable species in very diverse assemblage (Colwell & Coddington, 1994).

To examine species composition of live trees in sampled plots within forest blocks managed under different levels of institutional governance, nonmetric multidimensional scaling (NMDS) using the Bray-Curtis dissimilarity matrices (Minchin, 1987) was performed on abundance data from sampled plots. The Bray-Curtis dissimilarity metric measures the distance (dissimilarity) for each pairwise comparison of samples and is robust at handling ecological abundance data with large proportion of zeroes (Minchin, 1987). Stress values, a goodness-of-fit measure that assess how well ordination summarises distances among samples, were examined: low stress values < 0.05 provide excellent representation; 0.1 to < 0.2 is good and > 0.3 is poor and provide arbitrary representation (Quinn and Keough, 2002). Differences in species composition between plots in strongly- and weakly governed CFA forest blocks were examined by performing analysis of variance (ANOVA) through distance matrices — permutational multivariate analysis of variance (PERMANOVA) using R package, 'Vegan' (Dixon, 2003).

To determine factors influencing variation in species composition of live trees in sampled plots, a model-based analysis of multivariate species abundance was done using *manyglm* function in R package 'mvabund' (Wang et al., 2012). The function, '*manyglm'* uses a generalised linear model (GLM) framework to evaluate species composition of communities across sites by fitting a separate GLM to each species using a common set of explanatory variables (Wang et al., 2012). The 'mvabund' package is a flexible and powerful framework for analysing abundance data with different species variances (e.g. rare species) in comparison to other distance-based multivariate analyses and includes an assumption of a mean-variance relationship (Wang et al., 2012). Live trees species abundance data were converted to a 'mvabund' object (using 'mvabund' R package). A GLMM was fitted relating the species abundance object to: CFAs governance quality; distance; altitude of sampled plots (m) and CFA site using a negative binomial distribution appropriate for count/abundance data (Warton, 2005; Wang et al., 2012). To account for non-independence of replicate plots within each CFA site (i.e. CFA forest block), CFA site identity was included as a fixed effect in the GLMM. Statistical significance of predictor variables (*p*-value) were estimated based on 999 bootstrap iterations with PIT trap resampling method (Warton, Thibaut, & Wang, 2017). Before analysis, model fit assumptions were performed using a scatter plot of models' residuals and fitted values.

Total carbon stored in sampled plots was related to: altitude, distance of sampled plots (m) and either quality of CFAs governance or stump basal area density (cut within ten years) in two sets of models by GLMMs (*Appendix 3; Equation 1*) that included CFA site as a random factor to account for non-independence of plots, in a multi-model inference (MMI) framework as outlined previously. Before analysis, multicollinearity of predictors and assumptions of normality was assessed. Further, economically valuable timber species targeted for illegal logging according to Kenya Forest Service (KFS, 2010) and occurring in both strongly- and weakly-governed CFAs plots were identified. Mean aboveground biomass stored by the species in each plot in both CFAs governance categories were calculated. Average stem density (n ha^{-1}) for both economically valuable and less valuable tree species were compared between strongly- and weakly-governed CFAs plots.

3.5. Results

A total of 6091 live tree stems (dbh ≥10 cm) belonging to 68 species (*Appendix 3 Table A5*) were recorded in 45 sampled plots within the nine CFA forest blocks. Of these, only 58 individual stems (0.94%) were not identified to species; these were included in the analysis of stand structure (basal area and stem density) but excluded from analysis of species composition and carbon biomass.

3.5.1. Stand structure parameters of live trees

Mean diameter of live stems — dbh (cm) in strongly- and weakly-governed CFAs plots was similar; 30.7 ± 1.98 cm and 27.6 ± 1.49 respectively (*Table 3.2 &3.3*). Across both governance categories (strongly- and weakly-governed CFAs plots), mean dbh was 29.32 ± 1.29 cm and number of stems were similar in all dbh class categories; small sized stems; < 20 cm, mid-sized; 21-30 and 31-40 cm; and large sized stems; 51-60 and 61- > 70 cm — confidence intervals overlaps with zero (*Appendix 3; Table A3 & Fig. 1A*). Model averaging results indicated that mean basal area density, diameter and stem density was similar in strongly- and weakly-governed CFAs' plots with mean basal area density increasing with increasing altitude (*Fig. 3.3 & Table 3.3*).

Table 3.2. Stand structure parameters of plots within CFA forest blocks managed under varying institutional governance; strongly- and weakly governed CFAs. Mean values with ± S.E. shown. **Bold** indicates significant differences – GLMM analysis table 3.3 and 3.4

Stand parameters	Weakly-governed CFAs (N= 20 plots)	Strongly-governed CFAs (N = 25 plots)
Live trees		
Diameter (dbh ≥ 10 cm)	27.6 ± 1.49	30.7 ± 1.98
Basal area density (m^2 ha^{-1})	50.7 ± 4.76	55.8 ± 4.78
Stem density (n ha^{-1})	562 ± 48.67	525 ± 44.37
Stumps		
Diameter (dbh cm)	16.2 ± 1.53	11.1 ± 1.34
Basal area density (m^2 ha^{-1})	**4.9 ± 1.16**	**0.8 ± 0.19**
Stump density (n ha^{-1})	**130.8 ± 24.33**	**44.6 ± 9.22**

Table 3.3. Models of live tree species richness, Shannon diversity, Simpson index, average dbh, stem density, basal area density and stumps basal area density, showing model-averaged coefficients and conditional standard error (SE), and Relative Variable Importance, for all fixed effects across the 95% cumulative confidence set of candidate models. **Bold** indicates predictors with strong effect on response variable(s) as assessed through RVI and CI — does not overlap zero

Response Variable	Fixed effects	Estimate (β) (± SE)	Confidence Intervals (CI)	z value	RVI[30]
Live tree stems					
Species richness	Intercept	11.468 ± 1.13	(9.260,13.676)	10.180	
	Altitude	**-2.811 ± 0.88**	**(-4.536,-1.085)**	**3.193**	**1.00**
	Distance	-0.411 ± 0.33	(-1.067, 0.245)	1.229	0.38
	CFA governance (strong)	1.688 ± 1.74	(-1.716, 5.093)	0.972	0.31
Shannon diversity	Intercept	6.028 ± 0.85	(4.362, 7.694)	7.091	
	Altitude	**-1.683 ± 0.50**	**(-2.654,-0.713)**	**3.398**	**1.00**
	Distance	-0.173 ± 0.18	(-0.535, 0.190)	0.935	0.30
	CFA governance (strong)	**2.045 ± 0.94**	**(0.207, 3.884)**	**2.181**	**0.67**
Simpson diversity	Intercept	4.401± 0.64	(3.146, 5.656)	6.871	
	Altitude	**-1.189 ± 0.36**	**(-1.895,-0.482)**	**3.299**	**0.98**
	Distance	-0.151 ± 0.17	(-0.485,0.182)	0.892	0.28
	CFA governance (strong)	**1.733 ± 0.68**	**(0.408, 3.058)**	**2.563**	**0.77**
Basal area density m^2 ha^{-1}	Intercept	7.133 ± 0.269	(6.605,7.660)	26.486	
	Altitude	**0.604 ± 0.232**	**(0.145,1.058)**	**2.605**	**0.91**
	Distance	0.310 ± 0.202	(-0.086,0.707)	1.535	0.52
	CFA governance (strong)	0.229 ± 0.456	(-0.665,1.122)	0.501	0.21
Stand density n ha^{-1}	Intercept	22.905 ± 1.423	(20.116,25.694)	16.096	
	Altitude	0.984 ± 1.213	(-1.393, 3.361)	0.811	0.29
	Distance	0.238 ± 0.461	(-0.666, 1.141)	0.516	0.21
	CFA governance (strong)	-0.861 ± 2.545	(-5.849, 4.128)	0.338	0.19
Average dbh	Intercept	5.338 ± 0.191	(4.963, 5.712)	27.952	
	Altitude	0.230 ± 0.153	(-0.069, 0.530)	1.506	0.47
	Distance	0.050 ± 0.088	(-0.122, 0.222)	0.569	0.20
	CFA governance (strong)	0.244 ± 0.318	(-0.380, 0.868)	0.767	0.23
Stumps					
Mean basal area density (m^2 ha^{-1})	Intercept	4.929 ± 0.76	(3.439, 6.419)	6.483	
	Altitude	- 0.164 ± 0.51	(-1.164, 0.835)	0.322	0.17
	Distance	**- 1.088 ± 0.50**	**(-2.082,-0.094)**	**2.145**	**0.79**
	CFA governance (strong)	**- 4.050 ± 1.02**	**(-6.049,-2.049)**	**3.969**	**1.00**

The table shows estimates of effect sizes, standard errors, z value and relative variable importance. CFAs governance is comparison to reference level (weak governance).

[30] RVI — Relative variable importance values are sum of Akaike weights of a variable across all models in the set where the variable occurs. Larger values indicate that the variable is more important relative to the other variables and appears in more and better supported models, while low values indicate that the variable is less important and is in fewer models with less support from the data (Burnham & Anderson, 2002).

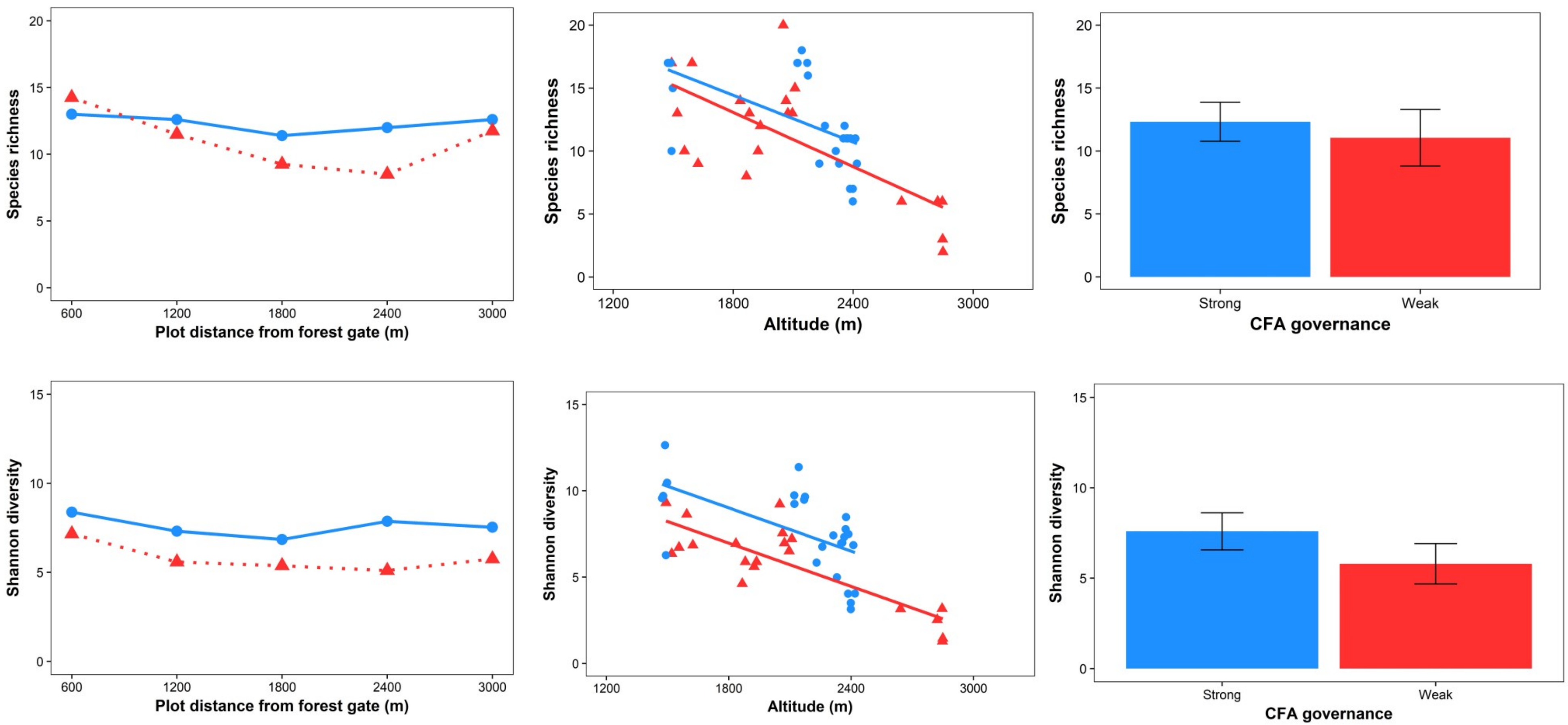

Fig.3.3. Effect of distance from forest entry, altitude of sampled plots and CFA's governance quality on species richness, Shannon diversity, Simpson diversity and mean basal area density (m^2 ha^{-1}) of live trees' in sampled plots within Mt Kenya forest blocks managed with differing governance quality; strongly- (light blue) and weakly- governed CFAs (light red colour).

Cont.

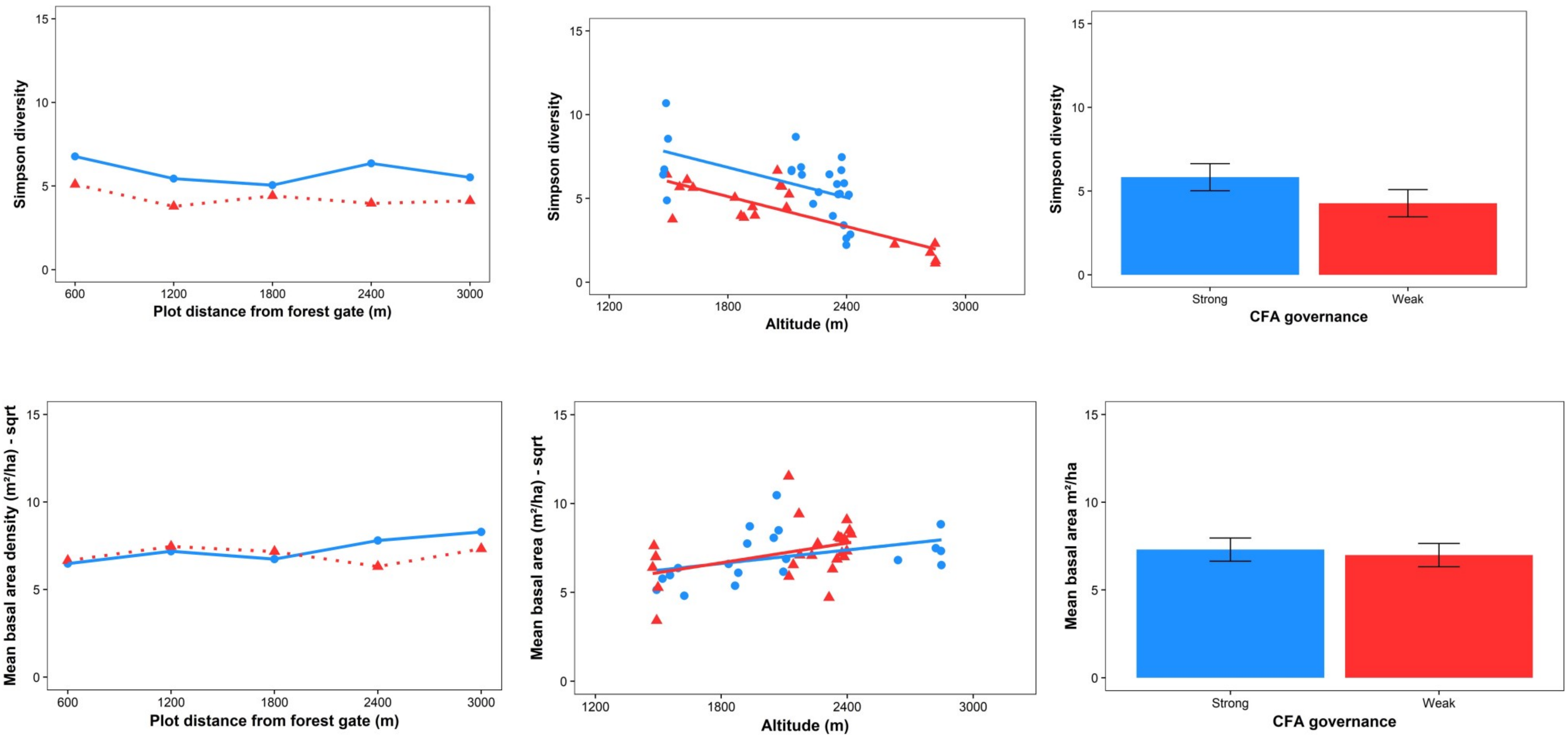

Fig.3.3. Effect of distance from forest entry, altitude of sampled plots and CFA's governance quality on species richness, Shannon diversity, Simpson diversity and mean basal area density ($m^2\ ha^{-1}$) of live trees' in sampled plots within Mt Kenya forest blocks managed with differing governance quality; strongly- (light blue) and weakly- governed CFAs (light red colour).

3.5.2. Anthropogenic disturbance — cut stumps

There were significant differences in stump density and stump basal area density between strongly- and weakly governed CFAs plots (*Table 3.3 & 3.4*). Further, higher number of stumps in the dbh class 21-30cm were found in weakly-governed CFAs plots compared to strongly-governed CFAs. Other stump dbh class categories; < 10, 11-20 and 31-40 cm were similar in both governance categories (*Appendix 3; Table A4 & Fig. 2A*). Model averaging across the 95% cumulative model set (three of eight candidate models, see *Appendix 3; Table A2*) showed that mean stump basal area density was less at greater distance from the forest entry, and in strongly-governed CFAs, but effects of altitude were not supported (*Table 3.3 & Fig. 3.4*).

Table 3.4. Summary results for full model coefficients with fixed effects fitted to predict mean stump density (stumps ha^{-1}). **Bold** indicates variables with strong effect on the response variable as assessed through CI

Response Variable	Fixed effects	Estimate (β) (± SE)	Confidence Intervals (CI)	t value
Mean stump	Intercept	10.329 ± 0.738	(8.851,11.807)	13.995
density	**Altitude**	**-1.513 ± 0.500**	**(-2.514,-0.511)**	**-3.024**
(stumps ha^{-1})	**Distance**	**-1.799 ± 0.498**	**(-2.797,-0.800)**	**-3.609**
(sqrt)	**CFA governance (strong)**	**-4.442 ± 0.991**	**(-6.428,-2.456)**	**-4.480**

The table shows estimates of effect sizes, standard errors, confidence intervals, t-value for fixed effects. CFAs strong governance is comparison to reference level (weak governance).

Multi-model inference (MMI) across eight candidate models for mean stump density resulted in a single supported model within the 95% cumulative confidence set[31] (*Appendix 3; Table A2*), comprising all three candidate predictor variables (altitude, distance, CFAs governance), with stump density decreasing with greater distance from forest entry, greater altitude, and in strongly- governed CFAs (*Table 3.4 & Fig. 3.4*). The model was the best fitting model as assessed through Akaike weights > 0.9 (Burnham & Anderson, 2002) indicating all predictors were important in predicting stump density and significantly influenced mean stump density as assessed through CI.

[31] Model averaging not done as only one model was within 95% cumulative model set and comprised all predictor variables. Model was a good fit with high Akaike weights > 0.9 .

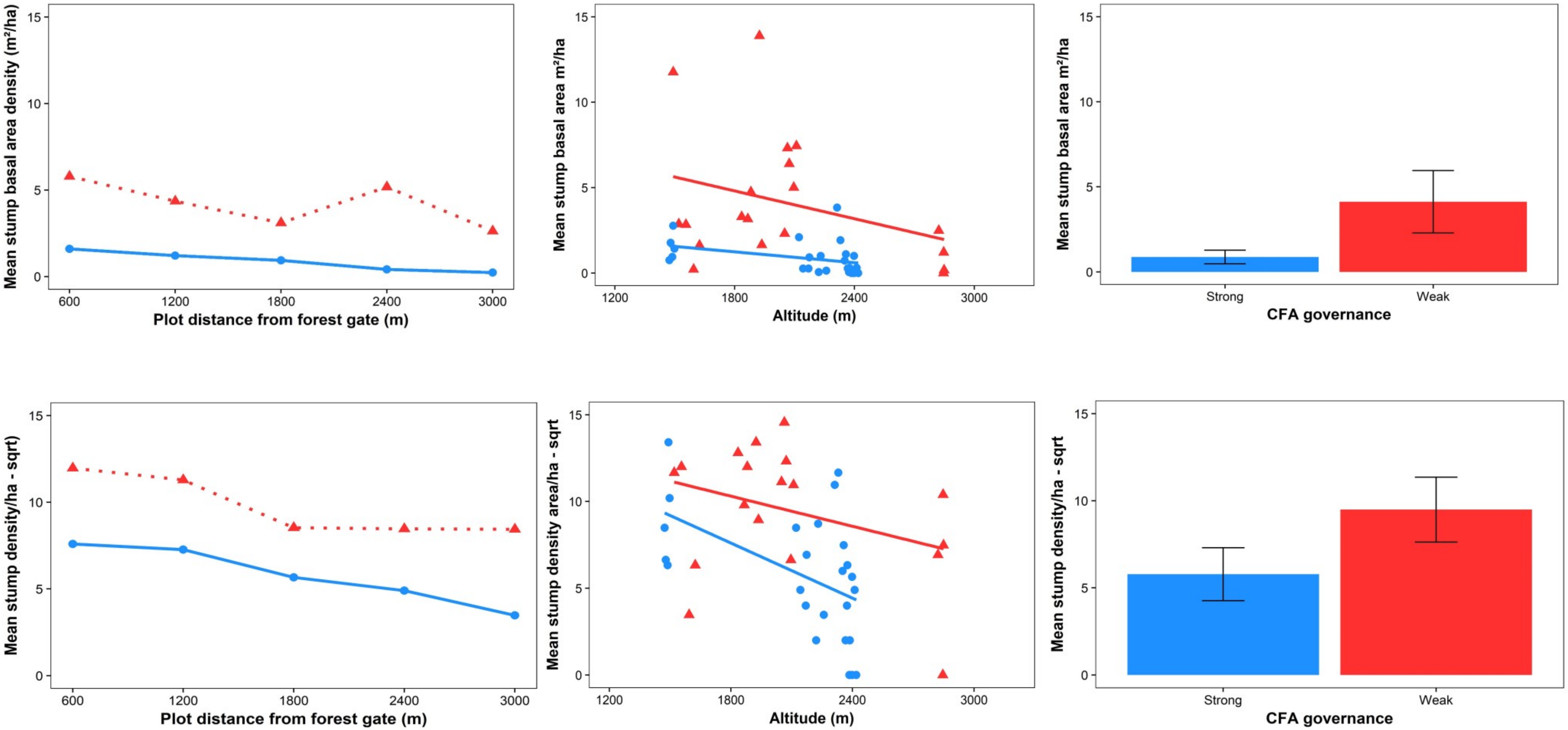

Fig. 3.4. Graphs showing effect of plot(s) distance from forest entry (m), altitude of sampled plots and CFAs local governance on cut stumps' mean basal area density (m^2 ha^{-1}) and mean stump density (stumps ha^{-1}) in plots within forest blocks managed by CFAs with differing institutional governance; strong- (light blue colour) and weak- governed CFAs (light red colour).

3.5.3. Species richness and diversity

Generalised linear mixed model (GLMM) analysis carried out with both observed and estimated asymptotic (Chao1 saturation estimates) species richness and diversity gave similar results, thus observed species richness and diversity was used in further analysis, presentation and results discussion. Sample-based rarefaction (interpolation and extrapolation) increased rapidly and approached a plateau, indicating the number of plots was sufficient to sample composition and that asymptotic richness could be reliably estimated (Gotelli & Colwell, 2001). Rarefaction curves for strongly- and weakly governed CFAs plots had overlapping confidence intervals, indicating a similar asymptotic species richness. However, the curves did not overlap for most of the rarefaction until after all sample plots were pooled together indicating that, for lower sampling intensity (fewer individual stems), plots in strongly-governed CFAs had greater species diversity and density (Gotelli & Colwell, 2011) (*Fig. 3.5*).

Model averaging showed that, plots located at higher altitude supported lower species richness and diversity, however effects of distance from forest entry/gate were not supported.

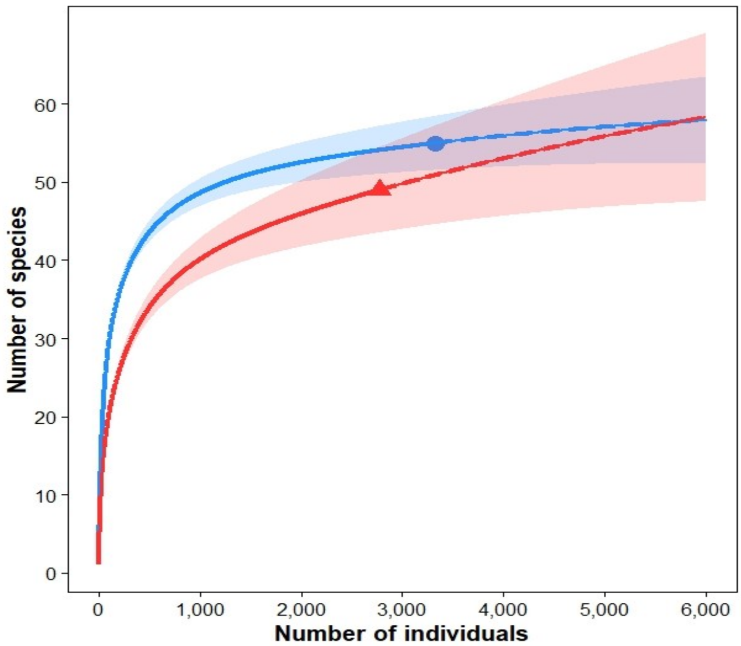

Fig. 3.5. Sample-based rarefaction curves for strongly-(blue) & weakly (red) governed CFA forest plots showing cumulative number of tree species with 95% CI.

Controlling for altitude and distance from the gate, species richness measures per plot were similar between strongly- and weakly governed CFAs plots; however, both Shannon (H’) and

Simpson's diversity (D) Index values were greater in strongly-governed CFAs indicating greater equitability in species distribution (*Table 3.3 & Fig. 3.3*).

3.5.4. Live trees species composition

Non-metric multidimensional (NMDS) ordination of tree species had low stress value (0.144) indicating excellent representation (goodness-of-fit) of distances amongst plot samples (Quinn & Keough, 2002). NMDS showed species composition varied between plots in forest blocks managed under different qualities of institutional governance (*Fig. 3.6*). A permutational multivariate analysis of variance (PERMANOVA) showed species composition differed between the governance categories ($p < 0.001$), that explained 13.6% of variance. Multivariate analysis of tree species abundance data (*manyglm*) was a good fit (as assessed through a scatter plot of models' residuals and fitted values showing random scatter of points, *Appendix 3; Fig. 3A*), and showed that CFAs governance, altitude and CFA site all significantly influenced species composition (*Table 3.5*). CFA site explained the greatest variability in species composition 67.8%; altitude 15.2% while CFAs governance explained 13.6%. Plot distance was not supported in predicting species composition within sampled plots.

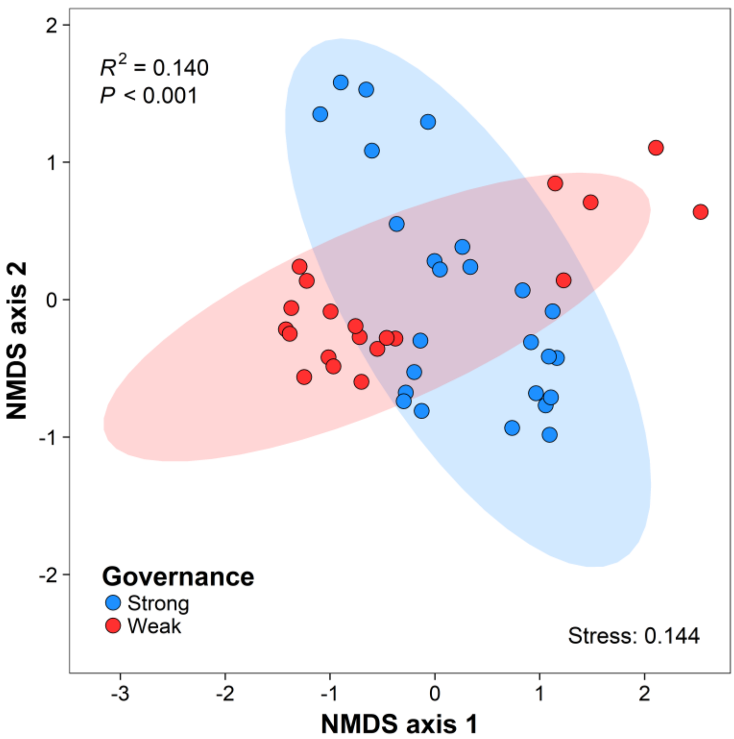

Fig. 3.6. NMDS ordination for live trees species composition in sampled plots managed by strongly- (blue colour) and weakly (red) governed CFAs. Points/plots closer to each other shows similarity in species composition.

3.5.5. Carbon storage

Species-specific wood density values for 63 species were found while five species representing 8.8 percent of total species were not found and mean wood density of the species local dataset was used. Additionally, wood density values from Dryland Database, World Agroforestry Centre database and mean value of species family represented 19.2, 42.65 and 29.41 percent of total species. There was no multicollinearity detected amongst predictors as VIF values were less than 1.5. In strongly-governed CFA plots (*N* = 25), mean above- and below-ground total carbon storage was 116.35 ± 11.45 Mg C ha^{-1} and similar to carbon stored in weakly-governed CFAs plots (*N* = 20; 98.36 ± 9.92 Mg C ha^{-1}). GLMM analysis and model averaging across 95% cumulative model set (5 of 8 candidate models for the two models (*Appendix 3; Table A1)* showed that total carbon stored was influenced by altitude and stumps basal area density (*Table 3.6 &3.7*). In the two models fitted to predict carbon storage, distance and CFAs governance were not supported (*Table 3.6 and 3.7).*

Table 3.5. Results of model-based multivariate analysis of abundance data (*manyglm*) showing fixed variables included in the model to predict tree species composition. **Bold** indicates predictor variables with significant effect(s) on species composition of live trees

Fixed predictor variables	Degrees of freedom	Deviance	*p*-value
Intercept	44	313.1	0.001
CFAs governance	**43**	**519.0**	**0.001**
Altitude	**42**	**519.0**	**0.001**
Distance	41	91.9	0.346
CFA site	**34**	**1195.0**	**0.001**

Table shows deviance table with p - value calculated using 999 resampling iterations via PIT-trap resampling.

Economically valuable timber species targeted for illegal logging according to KFS (KFS, 2010) found in both governance categories and included in analysis were: *Ocotea usambarensis*, *Podocarpus latifolius, Vitex keniensis, Olea capensis and Newtonia buchananii*. They were less frequent in weakly-governed CFAs plots compared to strongly-governed CFAs (*Fig. 3.8*) and stored less aboveground biomass (*Table 3.8*). This shows that these valuable species may have been targeted for illegal logging in weakly-governed CFAs plots hence reduced aboveground biomass per plot. Stem density (n ha^{-1}) for less valuable species were similar for both governance categories (*Fig. 3.8*).

Fig. 3.7 Illegal logging at Chuka forest block or site during data collection, inset — Lead researcher.

Table 3.6. Summary results for model averaged coefficients for models within 95% cumulative model set for all fixed effects; altitude, distance and CFAs governance, to predict total carbon stored (Mg C Ha $^{-1}$). **Bold** indicates variables strongly influencing carbon storage as assessed through RVI and CI

Response Variable	Fixed effects	Estimate (β) (± SE)	Confidence Interval (CI)	z Value	RVI
Carbon stored (Mg C Ha $^{-1}$)	Intercept	10.017 ± 0.43	(9.166,10.868)	23.067	
	Altitude	**0.940 ± 0.35**	**(0.254, 1.627)**	**2.686**	**0.94**
	Distance	0.509 ± 0.35	(-0.171, 1.188)	1.468	0.48
	CFA governance (strong)	0.621 ± 0.69	(-0.735, 1.977)	0.898	0.28

The table shows estimates of effect sizes, standard errors, z value and relative variable importance. CFAs governance is comparison to reference level (weak governance).

Table 3.7. Summary results for model averaged coefficients for models within 95% cumulative model set for all Fixed effects; altitude, distance and stumps basal area density, to predict total carbon stored (Mg C Ha $^{-1}$). **Bold** indicates variables strongly influencing carbon storage as assessed through RVI and CI

Response Variable	Fixed effects	Estimate (β) (± SE)	Confidence Interval (CI)	z Value	RVI
Carbon stored (Mg C Ha $^{-1}$)	Intercept	10.692 ± 0.66	(9.389,11.995)	16.081	
	Altitude	**0.852 ± 0.35**	**(0.150, 1.554)**	**2.378**	**0.87**
	Distance	0.407 ± 0.37	(-0.309, 1.122)	1.115	0.30
	Stumps basal area density (m^2 ha^{-1})	**-0.829 ± 0.30**	**(-1.401, -0.025)**	**2.149**	**0.75**

The table shows estimates of effect sizes, standard errors, z value and relative variable importance.

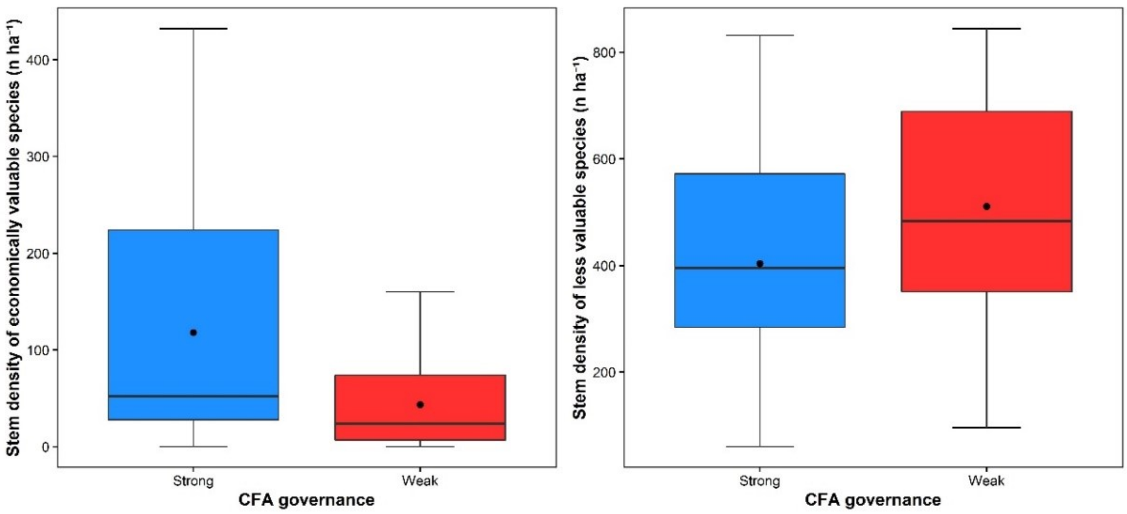

Fig.3.8. Stem density of economically valuable and less valuable timber species in strongly- and weakly-governed CFA plots.

Table 3.8. Economically valuable tree species in Mt. Kenya forest, showing mean AGB per plot ± SE in strongly- and weakly-governed CFAs plots

Economically valuable timber Species		Weakly-governed CFAs			Strongly-governed CFAs		
	IUCN Red List status	No. of stems N= 20	ABG Carbon (Mg C ha^{-1}) N=20	Mean ABG carbon per plot (Mg C ha^{-1})	No. of stems N=25	ABG carbon (Mg C ha^{-1}) (N=25	Mean ABG carbon per plot (Mg C ha^{-1})
Ocotea usambarensis	No status	14	205.27	10.26	18	327.96	13.12
Podocarpus latifolius	Least concern	145	76.37	3.82	389	489.58	19.58
Vitex Keniensis	Endangered	56	15.12	0.76	4	0.84	0.03
Olea capensis	No status	2	4.04	0.20	272	128.79	5.15
Newtonia buchananii	No status	1	10.08	0.50	55	148.28	5.93
Total		**163**	**310.88**	**15.54 ± 5.24**	**738**	**1095.44**	**43.82 ± 9.76**

Status of tree species: IUCN Red list status (IUCN, 2015).

3.5.6. Discussion

We found a positive relationship between strong governance and better forest outcomes. Strong local governance, characterised by CFAs transparency and accountability, decision making, collective action, monitoring and rule enforcement together strongly influenced forest outcomes in terms of; high species diversity, more carbon storage, conservation of valuable timber species and reduced intensity of damaging anthropogenic activities. At Mt. Kenya forest, strong CFAs governance supported better forest outcomes in terms of lower human disturbance rates (mean stump basal area and stump density) and higher species diversity per plot. Further, carbon biomass was significantly influenced by anthropogenic disturbance with more carbon stored in strongly-governed CFAs with less disturbance rates. These findings support other studies indicating that, in general, active involvement of locals in decision making and strengthening of local governance structures improves forest conditions (Takahashi & Todo, 2012; Andersson et al., 2014) by mantaining species diversity (Tadesse et al., 2016; Ameha et al., 2016) and low disturbance rates (Bajracharya et al., 2005).

Although stand structure was similar between weakly- and strongly-governed CFAs (in terms of basal area density, dbh and stand density), weakly-governed CFAs plots were more degraded with a higher stump density, stump basal area density and larger stumps, compared to strongly-governed CFAs plots. Governance structures put in place and enforced in strongly governed CFAs (e.g. rule making, by-laws, monitoring, sanctions) reduced human activities more effectively than weakly governed CFAs. For instance, presence of monitoring committee(s) with sustained regular monitoring and random inspection of forest produce may have increased likelihood of rule compliance in strongly governed CFAs and thus better forest outcomes. Research shows that regular monitoring and enforcement is strongly associated with maintenance of good forest conditions (Tucker, 2010; Andersson et al., 2014; Seymour et al., 2014). In Nepal, active involvement in conservation decisions by community members and strengthening of local institutions increased control of local communities in forest management, resulting to significantly lower mean density of cut stumps (716±170 ha^{-1}) compared to forest sites without community control (1785±275 ha^{-1}) (Bajracharya et al., 2005). Additionally, mean stump basal area and stump density decreased further from forest entry and at higher altitude, most likely due to easier access and short distance covered while carrying heavy load. Similar findings have been reported elsewhere where anthropogenic disturbance decreased with distance from settlements and in lower altitudes (Popradit et al., 2015; Tenzin & Hasenauer 2016).

A total of 68 tree species were recorded across the study site. Although species richness was similar between weakly- and strongly-governed CFAs, consisted with (Matiku et al., 2011; Bajracharya et al., 2005), species diversity was greater in strongly-governed CFAs indicating greater equitability. According to Morris (2010), overall species richness may not change following anthropogenic disturbance as shown in weakly-governed CFAs but species identities may change. Differences in species diversity in strongly- and weakly governed CFAs could be attributed to both anthropogenic disturbances and environmental factors. Mt. Kenya forest has varying physical and environmental attributes influenced by among others climate, soil characteristics, slope and altitude (KWS, 2010). For instance, the climate of the forest is determined by altitude with great differences in altitude among forest blocks and within short distances with average temperatures decreasing by 0.6°C for each 100m increase in altitude (KFS, 2010). Additionally, synonymous with montane forests, the south eastern side (windward) of Mount Kenya forest is more wet compared to the north western side (leeward) (Camberlin et al., 2016) as rainfall increases with altitude, with highest rainfall experienced between 2,700m and 3,100m above sea level (KFS, 2010). As study results shows, CFA site had the greatest variability in explaining species composition and thus, environmental factors in each CFA site such as rainfall, temperature, soil, nutrients etc likely influenced species diversity. Species richness and diversity – both Shannon and Simpson diversity – decreased from approximately 1500-1600m above sea level with increasing altitude. Study results are consistent with previous studies showing that species richness and diversity increased with altitude but up to a certain range approximately 1,500 m above sea level and thereafter a decrease was observed (Grytnes & Vetaas, 2002; Bruun et al., 2006; Gairola et al., 2011).

Anthropogenic disturbance can influence species diversity (Giam, 2017; Martin et al., 2013). Species diversity — Shannon and Simpson's diversity index — was greater in strongly-governed CFAs plots than in weakly-governed CFAs shown to suffer from high anthropogenic disturbances. Governance is associated with forest management and patterns of forest resource use and studies have shown that well-managed forest sites harbour greater species diversity compared to poorly/un-managed or disturbed sites (Bajracharya et al., 2005; Måren et al., 2014). For instance, Tenzin & Hasenauer (2016) reported significant differences in species diversity (Shannon and Simpson's diversity index) in sampled plots with differing land use patterns in Bhutan forest, with semi-disturbed and settlements mixed with agriculture having lower diversity compared to un-disturbed sites attributed to high exploitation and extraction of forest resources. In strongly-governed CFAs, presence of rules and strict enforcement of self-organised governance mechanisms agreed by majority of members (e.g. frequency of harvesting, size of load, mode of transportation and sanctions for infractions) minimised anthropogenic activities as evidenced by low disturbance rate —stump density, basal area density and stump dbh. Further, inclusive participation of members in drafting "rules in use" in forest management increased likelihood of internalising rules content, compliance and enforcement. This is consistent with other studies showing that decision-making participation is significantly associated with rules compliance (Andrade & Rhodes, 2012) and better forest outcomes (Persha et al., 2011; Hayes & Persha, 2010; Chhatre & Agrawal, 2009). Thus, local governance strategies employed played a role in regulating resource use and minimising anthropogenic activities as evidenced by fewer stumps in strongly-governed CFAs.

Strong governance is frequently associated with transparency and accountability, and the transparent manner in which trespassers from within and outside CFAs were treated by enforcing by-laws in strongly-governed CFAs increased members confidence, co-operation and trust (Schusler et al., 2003; Pretty, 2003) in reporting illegal activities/trespassers, thus enhancing members sense of collective responsibility. Some studies have noted the importance of strong mutual trust within local communities in easing pressure and external threats in forest reserves (Zulu, 2013; Murtazashvili et al., 2019), and such strong relations of trust may be key to improved forest conditions and increased participation. Indeed, increased participation in protected areas such as forests is more likely to deliver conservation objectives and is associated with positive conservation and social outcomes (Oldekop et al., 2016; Mogoi et al., 2012; Stapp et al., 2015).

Species composition in Mt. Kenya forest is well documented (e.g. Kindt et al., 2007; Zhou et al., 2018) and can be influenced by environmental attributes and anthropogenic activities. Study findings show that CFA site had the greatest influence in predicting species composition and variability. Thus, species composition was controlled by site-specific abiotic factors (not assessed in this study except altitude) such as temperature, moisture content, altitude, rainfall and soil properties shown to influence plant population dynamics and community composition (Turner et al., 2018; Sellan et al., 2019). For instance, other ecological studies have shown significant influence of environmental characteristics on species composition (e.g. Espinosa et al., 2011; Muenchow et al., 2013). From study findings, altitude of sampled plots strongly influenced species composition, corroborating (KWS, 2010) that vegetation in Mt. Kenya forest varies with altitude. Similarly, other studies report comparable findings on species composition–altitude relationship (Ameha et al., 2016; Ding et al., 2016).

CFAs governance strongly influenced species composition that differed between strongly- and weakly-governed CFAs. Fewer stems of high economic value timber species in weakly-governed CFAs was indicative of selective logging of these species. Thus, increased disturbance rates and selective illegal logging contributed to varying species composition. Increased disturbance and selective logging (legal or illegal) has been shown to significantly alter species composition from the original known levels (Gaui et al., 2019; Ojoyi et al., 2015; Martin et al., 2013).

In Mt. Kenya forest, carbon storage was strongly influenced by anthropogenic disturbances and altitude of sampled plots. More carbon storage was associated with low stump density and decreased with increasing number of stumps in weakly-governed CFAs. Thus, increased stump density has a negative impact on carbon storage. Further, selective logging of high-value timber species, mostly hard wood species such as *Ocotea usambarensis, Podocarpus latifolius and Olea capensis* associated with high carbon content reduced carbon storage in weakly-governed CFAs characterised by high anthropogenic activities. Jew et al., (2016) reported similar findings where moderate utilisation or human disturbance retained carbon stocks but intensive logging and increased human disturbance led to reduced carbon stocks. In total, average carbon storage was 108.35 ± 52.16 Mg C Ha^{-1} consistent with other studies in tropical regions reporting 106 ± 17 Mg C Ha^{-1} and 101.07 ± 27.09 Mg C Ha^{-1} in south Equador and Nepal respectively (Moser et al., 2011; Gurung et al., 2015). However, carbon storage was lower compared to 174.0 ± 42.8 and 172.5 ±10.6 Mg C Ha^{-1} in lower and upper montane forests of Kilimanjaro in Tanzania (Rutten et al., 2015), and 191.6 ± 19.7 Mg C Ha^{-1} in Afromontane forests in Ethiopia (Gebeyehu et al., 2019). The comparatively low carbon biomass in Mt. Kenya forest may be attributed to a long history of intensive illegal logging of economically valuable timber species and increased anthropogenic disturbance (Gathaara, 1999; KFS, 2010). Further, altitude strongly influenced carbon storage as findings showed more carbon storage at higher altitudes. Carbon values reported in this study are on the lower limit as tree height was not factored in and studies have shown that incorporating tree height results into higher carbon biomass values (e.g. Put those studies here). Thus, future studies in the region could incorporate tree height in carbon biomass assessments to ascertain precise amount of carbon stored.

Mean basal area density increased significantly with increasing altitude from approximately 1500 m to 3000 m – maximum altitude recorded. This is consisted with other studies reporting increasing basal area density with increasing altitude from 1500m to 2500m which declined beyond this limit (Acharya et al., 2011; Lieberman et al., 1996). Overall tree density (mean 541 stems ha^{-1}, range 525-562 stems ha^{-1}) was similar to other studies (Naidu & Kumar, 2016; 556 stems ha^{-1}) in other tropical countries but lower (Reddy et al., 2011, 639-836 stems·ha^{-1}) than reported in a montane forest in India. Tree density can be affected by anthropogenic activities, natural events (e.g. wild fires) and environmental factors. Average basal area density recorded for strongly- and weakly-governed CFAs was within the range 50.70 — 55.75 m^2 ha^{-1}, with an average dbh of 28 cm comparable to mature natural forests reported in India and Nepal respectively (Paudel & Sah, 2015; Naidu & Kumar, 2016;). Although no significant differences were found in basal area density between strongly- and weakly-governed

CFAs plots, higher basal area density of live stems in strongly-governed CFAs plots could partly be due to high number of mid-sized stems (31-40; 41-50 cm) and presence of large-sized stems (61-70 cm) absent in weakly-governed CFA plots. This shows that large-sized stems could be targeted for illegal logging in weakly-governed CFAs plots compared to strongly- governed CFAs.

3.5.7 Conclusion

This study has shown that variability of local governance between communities can significantly influence conservation outcomes, thus strong local governance is crucial for successful engagement with local communities and improved forest conditions. Mt. Kenya forest provides vital benefits at multiple scales and especially benefits for sustaining locals' livelihoods and welfare, and communities will continue benefiting from these to fulfil their needs. To balance society's and conservation needs, maintain biodiversity and improve carbon storage, establishment of strong governance structures are vital for sustainability of social-ecological systems such as Mt. Kenya forest. Strong institutional governance mitigates anthropogenic disturbances and or transformations that could affect species diversity, composition and carbon biomass, thus hampering conservation efforts and climate change mitigation strategies. In Mt. Kenya forest, strong local governance characterised by CFAs transparency and accountability, decision making, collective action, monitoring and rule enforcement together strongly influenced forest outcomes in terms of; high species diversity, more carbon storage, conservation of high-value timber species and reduced anthropogenic disturbance in strongly-governed CFAs. Establishing strong governance at local level should aim at empowering and enhancing capacity of local communities by decentralising management and use rights to expand democratic space in exercising voice in sound management of forest resources. It is important to note that failure to institute appropriate governance mechanisms or poor governance can hamper conservation efforts, increase anthropogenic activities which could ultimately threaten species of conservation concern and carbon storage potential. Thus, governance structures and pragmatic management strategies that take into consideration participatory and inclusive decision making strengthens local governance and institutions to maintain and or improve forest conditions and hence register win-win outcomes in socio-economic and conservation goals.

3.5.8. Appendix 3

Table A1. Results of model selection from generalized linear mixed model relating live tree average species richness, Shannon–Wiener Index, Simpson's index, basal area density, carbon biomass, stem density, diameter to; plot distance, altitude and CFA's local governance or stumps basal area density (carbon biomass only). Shown are models' degrees of freedom (df), Log likelihood (logLink), AICc, ΔAICc and Akaike model weights (w_i) for the top models within 95% cumulative set. All models included CFA site as a random effect. All models include the intercept. **Bold** indicates models within 95% cumulative model set

Response variables and model rank	Model	df	LogLink	AICc	ΔAICc	Akaike weight (w_i)
Live trees						
Species richness						
1	**Altitude**	**4**	**-107.407**	**223.8**	**0.00**	**0.401**
2	**Altitude + Distance**	**5**	**-106.616**	**224.8**	**0.96**	**0.249**
3	**Altitude + CFA governance**	**5**	**-106.924**	**225.4**	**1.57**	**0.183**
4	**Altitude + Distance + CFA gov.**	**6**	**-106.147**	**226.5**	**2.69**	**0.105**
5	Distance	4	-109.996	229.0	5.18	0.030
6	Intercept only	3	-111.775	230.1	6.32	0.017
7	Distance + CFA governance	5	-109.863	231.3	7.45	0.010
8	CFA governance	4	-111.641	232.3	8.47	0.006
Shannon–Wiener Index						
1	**Altitude + CFA governance**	**5**	**-79.652**	**170.8**	**0.00**	**0.450**
2	**Altitude**	**4**	**-81.670**	**172.3**	**1.50**	**0.213**
3	**Altitude + Distance + CFA gov.**[32]	**6**	**-79.202**	**172.6**	**1.77**	**0.186**
4	**Altitude + Distance**	**5**	**-81.192**	**173.9**	**3.08**	**0.096**
5	Distance	4	-84.091	177.2	6.34	0.019
6	Intercept only	3	-85.483	177.6	6.71	0.016
7	Distance + CFA governance	5	-83.361	178.3	7.42	0.011
8	CFA governance	4	-84.753	178.5	7.66	0.010
Simpson's index						
1	**Altitude + CFA governance**	**5**	**-73.987**	**159.5**	**0.00**	**0.518**
2	**Altitude + Distance + CFA gov.**	**6**	**-73.575**	**161.4**	**1.85**	**0.206**
3	**Altitude**	**4**	**-76.581**	**162.2**	**2.65**	**0.138**
4	**Altitude + Distance**	**5**	**-76.139**	**163.8**	**4.31**	**0.060**
5	**Intercept only**	**3**	**-79.571**	**165.7**	**6.22**	**0.023**
6	Distance	4	-78.492	166.0	6.47	0.020
7	CFA governance	4	-78.545	166.1	6.58	0.019
8	Distance + CFA governance	5	-77.466	166.5	6.96	0.016
Basal area density						
1	**Altitude**	**4**	**-77.817**	**164.6**	**0.00**	**0.326**
2	**Altitude + Distance**	**5**	**-76.663**	**164.9**	**0.23**	**0.291**
3	**CFA governance + Altitude**	**5**	**-77.688**	**166.9**	**2.28**	**0.104**
4	**CFA governance + Altitude + Distance**	**6**	**-76.528**	**167.3**	**2.63**	**0.087**
5	**Distance**	**4**	**-79.184**	**167.4**	**2.73**	**0.083**
6	Intercept only	3	-80.717	168.0	3.39	0.060
7	CFA governance + Distance	5	-79.041	169.6	4.98	0.027
8	CFA governance	4	-80.574	170.1	5.51	0.021
Carbon biomass (CFAs governance)						
1	**Altitude**	**4**	**-100.827**	**210.7**	**0.00**	**0.334**
2	**Altitude**	**5**	**-99.745**	**211.0**	**0.37**	**0.277**
3	**CFA governance + Altitude**	**5**	**-100.414**	**212.4**	**1.71**	**0.142**
4	**CFA governance + Altitude +**	**6**	**-99.304**	**212.8**	**2.16**	**0.113**

[32] CFA gov. = CFA governance.

Cont;

	Distance					
5	**Distance**	**4**	**-102.704**	**214.4**	**3.75**	**0.051**
6	Intercept only	3	-104.074	214.7	4.08	0.043
7	CFA governance + Distance	5	-102.316	216.2	5.52	0.021
8	CFA governance	4	-103.686	216.4	5.72	0.019
Carbon biomass (stumps BA density)						
1	**Stump basal area + Altitude**	**5**	**-98.863**	**209.3**	**0.00**	**0.343**
2	**Altitude**	**4**	**-100.827**	**210.7**	**1.39**	**0.171**
3	**Altitude + Distance**	**5**	**-99.745**	**211.0**	**1.76**	**0.142**
4	**Stump basal area + Altitude + Distance**	**6**	**-98.474**	**211.2**	**1.89**	**0.133**
5	**Stump basal area**	**4**	**-101.226**	**211.5**	**2.19**	**0.115**
6	Stump basal area + Distance	5	-100.864	213.3	4.00	0.046
7	Distance	4	-102.704	214.4	5.14	0.026
8	Intercept only	3	-104.074	214.7	5.47	0.022
Stem density						
1	**Intercept only**	**3**	**-121.963**	**250.5**	**0.00**	**0.401**
2	**Altitude**	**4**	**-121.608**	**252.2**	**1.71**	**0.171**
3	**Distance**	**4**	**-121.796**	**252.6**	**2.08**	**0.141**
4	**CFA governance**	**4**	**-121.909**	**252.8**	**2.31**	**0.126**
5	**Altitude + Distance**	**5**	**-121.524**	**254.6**	**4.08**	**0.052**
6	**CFA governance + Altitude**	**5**	**-121.529**	**254.6**	**4.09**	**0.052**
7	CFA governance + Distance	5	-121.743	255.0	4.51	0.042
8	CFA governance + Distance + Altitude	6	-121.447	257.1	6.59	0.015
Diameter (dbh)						
1	**Intercept only**	**3**	**-44.203**	**95.0**	**0.00**	**0.278**
2	**Altitude**	**4**	**-43.073**	**95.1**	**0.15**	**0.257**
3	**CFA governance**	**4**	**-43.890**	**96.8**	**1.79**	**0.114**
4	**Distance**	**4**	**-43.973**	**96.9**	**1.95**	**0.105**
5	**CFA governance + Altitude**	**5**	**-42.781**	**97.1**	**2.11**	**0.097**
6	**Altitude + Distance**	**5**	**-42.962**	**97.5**	**2.47**	**0.081**
7	CFA governance + Distance	5	-43.659	98.9	3.87	0.040
8	CFA governance + Distance + Altitude	6	-42.667	99.5	4.55	0.029

Table A2. Results of model selection from generalized linear mixed model relating cut mean stump basal area and stump density to; CFA's local governance, plot distance and altitude. Shown are models' degrees of freedom (df), Log likelihood (logLink), AICc, ΔAICc and Akaike model weights (w_i) for the top models within 95% cumulative set for mean basal area density and first four models for stand density. All models included CFA site as a random effect. All models include the intercept. Bold indicates models within 95% cumulative model set

Response variable & and model rank	Model	df	LogLink	AICc	ΔAICc	Akaike weight (w_i)
Mean basal area density						
1	**CFA governance + Distance**	**5**	**-117.023**	**245.6**	**0.00**	**0.575**
2	**CFA governance**	**4**	**-119.362**	**247.7**	**2.14**	**0.197**
3	**CFA governance + Distance + Altitude**	**6**	**-116.968**	**248.1**	**2.56**	**0.160**
4	CFA governance + Altitude	5	-119.239	250.0	4.43	0.063
5	Distance	4	-123.726	256.5	10.87	0.003
6	Intercept only	3	-125.656	257.9	12.31	0.001
7	Distance + Altitude	5	-123.558	258.7	13.07	0.001
8	Altitude	4	-125.372	259.7	14.16	0.000
Stump density						
1	**CFA governance + Distance + Altitude**	**6**	**-117.511**	**249.2**	**0.00**	**0.909**
2	CFA governance + Distance	5	-121.445	254.4	5.20	0.068
3	CFA governance + Altitude	5	-123.230	258.0	8.77	0.011
4	Distance + Altitude	5	-123.626	258.8	9.56	0.008
5	CFA governance	4	-125.722	260.4	11.21	0.003
6	Distance	4	-127.201	263.4	14.17	0.001
7	Altitude	4	-128.704	266.4	17.18	0.000
8	Intercept only	3	-131.478	269.5	20.31	0.000

Equation 1

Species richness ~ CFA's governance quality[33] + plot(s) distance (m) + Altitude (m) + (1 | CFA site)

Shannon diversity ~ CFA's governance quality + plot(s) distance (m) + Altitude (m) + (1 | CFA site)

Simpson Index ~ CFA's governance quality + plot(s) distance (m) + Altitude (m) + (1 | CFA site)

Live trees basal area density ~ CFA's governance quality + plot(s) distance (m) + Altitude (m) + (1 | CFA site)

Live trees stand density ~ CFA's governance quality + plot(s) distance (m) + Altitude (m) + (1 | CFA site)

Live trees average dbh ~ CFA's governance quality + plot(s) distance (m) + Altitude (m) + (1 | CFA site)

Stump basal area density ~ CFA's governance quality + plot(s) distance (m) + Altitude (m) + (1 | CFA site)

Stump density ~ CFA's governance quality + plot(s) distance (m) + Altitude (m) + (1 | CFA site)

Carbon biomass ~ CFA's governance quality + plot(s) distance (m) + Altitude (m) + (1 | CFA site)

[33] Qualitative assessment using governance indicators adapted from FAO, 2011; UNDP, 2011

Table A3. GLMMs summary results for live trees DBH class categories between weakly and strongly governed CFAs plots.

Response Variable Count DBH class	Fixed effects	Estimate (β) (± SE)	Confidence Intervals (CI)	t value
Less 20 cm dbh	Intercept	0.752 ± 0.789	(-0.828, 2.332)	0.346
	CFA governance	0.296 ± 1.059	(-1.828, 2.416)	0.781
21-30 cm dbh	Intercept	9.554 ± 1.840	(5.526,13.581)	5.193
	CFA governance	-3.608 ± 2.468	(-9.012,1.795)	-1.462
31-40 cm dbh	Intercept	0.929 ± 0.899	(-1.040,2.897)	1.033
	CFA governance	2.257 ± 1.207	(-0.384,4.898)	1.871
41-50 cm dbh	Intercept	0.400 ± 0.625	-0.967,1.767)	0.640
	CFA governance	0.379 ± 0.838	(-1.456, 2.213)	0.452
60 >70 cm dbh	Intercept	0.224 ± 0.263	(-0.303, 0.750)	0.851
	CFA governance	0.045 ± 0.353	(-0.662, 0.751	0.127

The table shows estimates of effect sizes, standard errors, confidence intervals t-value for fixed effects. CFAs governance (strong) is comparison to reference level (weak governance).

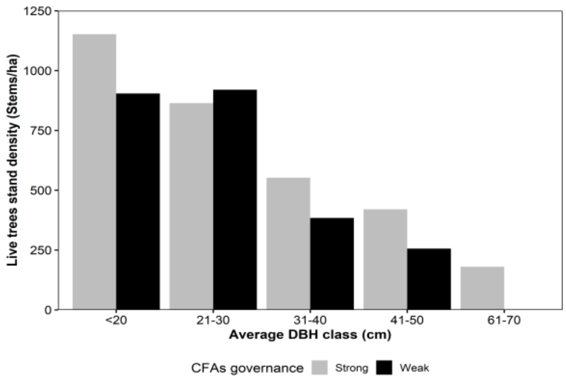

Fig.1A. Stand structure of live stems dbh classes of strongly- and weakly-governed CFAs' forest plots.

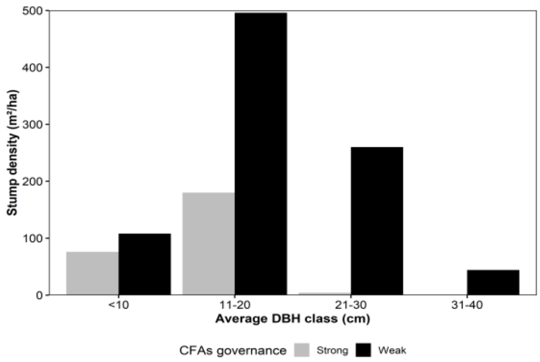

Fig. 2A. Stand structure of cut stumps dbh classes of strongly- and weakly-governed CFAs' forest plots.

Table A4. GLMMs summary results for stumps DBH class categories between weakly and strongly governed CFAs plots. **Bold indicates significant differences in stumps DBH class**

Response Variable Count DBH class	Fixed effects	Estimate (β) (± SE)	Confidence Intervals (CI)	t value
Less 10 cm dbh	Intercept	0.187 ± 0.231	(-0.276, 0.651)	0.808
	CFA governance	0.307 ± 0.311	(-0.315, 0.929)	0.988
11-20 cm dbh	Intercept	4.028 ± 0.842	(2.187, 5.870)	4.786
	CFA governance	-1.671 ± 1.129	(-4.142, 0.800)	1.480
21-30 cm dbh	**Intercept**	**0.899 ± 0.290**	**(0.265, 1.534)**	**3.102**
	CFA governance	**-0.859 ± 0.389**	**(-1.711,-0.008)**	**-2.209**
31-40 cm dbh	Intercept	0.166 ± 0.108	(-0.050, 0.382)	1.539
	CFA governance	-0.165 ± 0.145	(-0.455, 0.124)	1.147

The table shows estimates of effect sizes, standard errors, confidence intervals and t-value for fixed effects. CFAs governance (strong) is comparison to reference level (weak governance)

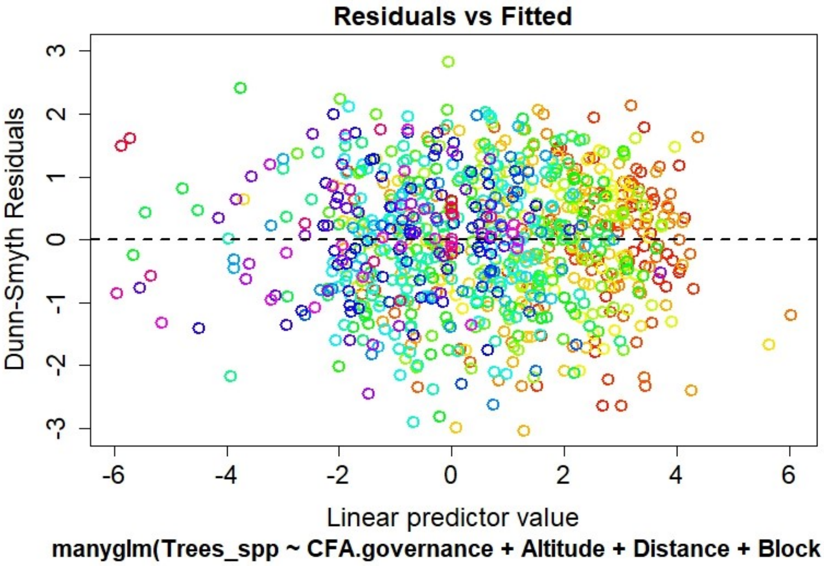

Fig. 3A. Tree species scatter plot

Table A5. Local tree species and scientific names

Local tree name	Scientific name	Family	Wood density source
Mukurue/Mukurwe	*Albizia gummifera*	Mimosaceae	World Agroforestry Centre
Muthandathande	*Bersama abyssinica*	Francoaceae	Local species dataset
Mukwege/mukwethi	*Bridelia micrantha*	Euphorbiaceae	World Agroforestry Centre
Mujuthi/Mucuthi	*Caesalpinia volkensii*	Fabaceae	Family species density
Mukarakara	*Capparis tomentosa*	Capparaceae	Local species dataset
Munogu/Muirongi	*Casaeria battiscombei*	Salicaceae	Dryland Database
Mukungugu	*Cassipourea gummiflua*	Rhisophoraceae	World Agroforestry Centre
Muthaithi/Muthaguta	*Cassipourea malosana*	Rhisophoraceae	World Agroforestry Centre
Murundu	*Celtis africana*	Ulmaceae	World Agroforestry Centre
Mukithia/Mutathi	*Clausena anisata*	Rutaceae	Family species density
Murama/Murema	*Combretum Molle*	Combretaceae	Family species density
Muringa	*Cordia africana*	Boraginaceae	World Agroforestry Centre
Mutundu/Mutuntu	*Croton macrostachyus*	Euphorbiaceae	World Agroforestry Centre
Mukinduri	*Croton megalocarpus*	Euphorbiaceae	World Agroforestry Centre
Muengera/Mwenyiere	*Cussonia spicata*	Araliaceae	Family species density
Mutharagwe/Muti Mwiru	*Diospyros abyssinica*	Ebenaceae	World Agroforestry Centre
Mukambura/Muro	*Dovyalis abyssinica*	Salicaceae	Family species density
Muthare	*Dracaena steudneri*	Agavaceae	Local species dataset
Murembu	*Ehretia cymosa*	Boraginaceae	Dryland Database
Muchogomo/Mununga	*Ekebergia capensis*	Meliaceae	World Agroforestry Centre
Mukunguu/mung'ang'a	*Erythrina melanacantha*	Fabaceae	Family species density
Mukaragati/Mukuria	*Fagaropsis angolensis*	Rutacea	World Agroforestry Centre
Mukuyu/mukuu	*Ficus sycomorus*	Moraceae	Dryland Database
Mugumo	*Ficus thonningii*	Moraceae	Dryland Database
Muthithiku/Mujogajoga	*Hagenia abyssinica*	Rosaceae	World Agroforestry Centre
Munyamwe	*Harungana madagascariensis*	Clusiaceae	Dryland Database
Muraana/Mutarakwa	*Juniperus procera*	Cupresaceae	World Agroforestry Centre
Mukongoro	*Lovoa swynnertonii*	Meliciae	World Agroforestry Centre
Mukarati	*Macaranga kilimandscharica*	Euphorbiaceae	World Agroforestry Centre
Muu/Mung'uani	*Markhamia lutea*	Bignoniaceae	Dryland Database
Mwaugo/Muraga	*Maytenus heterophylla*	Celastraceae	Family species density
Mwanga/Muvangita	*Millettia dura*	Fabaceae	Family species density
Mutuya/Mutuja	*Myrianthus holstii*	Urticaceae	Family species density
Murema	*Myrica salicifolia*	Myricaceae	Family species density
Mutuntuki/Musiri	*Neoboutonia macrocalyx*	Euphorbiaceae	World Agroforestry Centre
Mukui	*Newtonia buchananii*	Mimosaceae	World Agroforestry Centre
Muchorowe/Mwanda	*Nuxia congesta*	Stilbaceae	Dryland Database
Mugimbigimbi/Mungirima	*Ochna sp.*	Ochnaceae	Family species density
Muura/Camphor	*Ocotea usambarensis*	Lauraceae	World Agroforestry Centre
Mucharage	*Olea capensis*	Oleaceae	World Agroforestry Centre
Mutamaiyo/Mutero	*Olea europaea*	Oleaceae	Dryland Database
Muchai	*Osyris abyssinica*	Santalaceae	Local species dataset
Maua	*Pentas lanceolata*	Rubiaceae	Family species density
Mubokado	*Persea americana*	Lauraceae	Family species density
Mwaraka/Maigoya/Kijara	*Plectranthus barbatus*	Lamiaceae	Family species density
Muthengera/mubiribiri	*Podocarpus latifolius*	Podocarpaceae	World Agroforestry Centre

Local tree name	Scientific name	Family	Wood density source
Mutati	*Polyscias kikuyuensis*	Araliaceae	World Agroforestry Centre
Muna/Mutunguru	*Pouteria adolfi-friederici*	Sapotaceae	World Agroforestry Centre
Muiri/Mwiria	*Prunus africana*	Rosaceae	Dryland Database
Mugeta	*Rapanea melanophloeos*	Primulaceae	Local species dataset
Murikitha/Muthigio	*Rhus natalensis*	Anacardiaceae	Family species density
Mukomere	*Rothmannia urceliformis*	Rubiaceae	Family species density
Muhathi/Muthathi	*Sapium ellipticum*	Euphorbiaceae	World Agroforestry Centre
Mutuma/Mutoma	*Schrebera alata*	Oleaceae	World Agroforestry Centre
Nandi flame	*Spathodea campanulata*	Bignoniaceae	Dryland Database
Muthiringo/Murimbi	*Strombosia scheffleri*	Olacaceae	World Agroforestry Centre
Muriru	*Syzygium guineense*	Myrtaceae	World Agroforestry Centre
Mwerere	*Tabernaemontana Pachysiphon*	Apocynaceae	Dryland Database
Munderendu/Muteretu	*Teclea nobilis*	Rutaceae	World Agroforestry Centre
Munderendu/Muteretu	*Teclea simplicifolia*	Rutaceae	World Agroforestry Centre
Muethu/Muhethu	*Trema orientalis*	Cannabaceae	Dryland Database
Mutugati	*Trichilia dregeana*	Meliaceae	Family species density
Mururi/Mutuati	*Trichilia emetica*	Meliaceae	Dryland Database
Mubarakera	*Trichocladus ellipticus*	Hamamelidaceae	Local species dataset
Mubiro	*Vangueria madagascariensis*	Rubiaceae	Family species density
Muthakwa	*Vernonia auriculifera*	Asteraceae	Family species density
Muhuru/Muuru	*Vitex Keniensis*	Lamiaceae	Family species density
Mwako/muringiti	*Xymalos monospora*	Monimiaceae	World Agroforestry Centre

References

Acharya, B. K., Chettri, B., & Vijayan, L. (2011). Distribution pattern of trees along an elevation gradient of Eastern Himalaya, India. *Acta Oecologica*, *37*(4), 329–336. https://doi.org/10.1016/j.actao.2011.03.005

Agrawal, A. (2001). Common property institutions and sustainable governance of resources. *World Development*, *29*(10), 1649–1672. https://doi.org/10.1016/S0305-750X(01)00063-8

Agrawal, A., & Angelsen, A. (2009). Using community forest management to achieve REDD+ goals. In A. Angelsen (Ed.), *Realising REDD+: National strategy and policy options* (pp. 201–212). Bogor, Indonesia: Center for International Forestry Research.

Agrawal, A., Chhatre, A., & Hardin, R. (2008). Changing governance of the world's forests. *Science*, *320*(1460), 1460–1462. https://doi.org/10.1126/science.1155369

Agrawal, A., & Ostrom, E. (2001). Collection action, property rights and decentralization in resource use in India and Nepal. *Politics and Society*, *29*(4), 485–514.

Alemagi, D. (2010). A comparative assessment of community forest models in Cameroon and British Columbia, Canada. *Land Use Policy*, *27*(3), 928–936. https://doi.org/10.1016/j.landusepol.2009.12.006

Amano, T., Székely, T., Sandel, B., Nagy, S., Mundkur, T., Langendoen, T., … Sutherland, J. W. (2018). Successful conservation of global waterbird populations depends on effective governance. *Nature*, *553*(7687), 199–202. https://doi.org/10.1038/nature25139

Ameha, A., Meilby, H., & Feyisa, G. L. (2016). Impacts of participatory forest management on species composition and forest structure in Ethiopia. *International Journal of Biodiversity Science, Ecosystem Services and Management*, *12*(1–2), 139–153. https://doi.org/10.1080/21513732.2015.1112305

Andersson, K., Benavides, J. P., & León, R. (2014). Institutional diversity and local forest governance. *Environmental Science and Policy*, *36*, 61–72. https://doi.org/10.1016/j.envsci.2013.07.009

Andrade, G. S. M., & Rhodes, J. R. (2012). Protected areas and local communities. *Ecology and Society*, *17(4):14*. https://doi.org/http://dx.doi. org/10.5751/ES-05216-170414

Angelsen, A., Jagger, P., Babigumira, R., Belcher, B., Hogarth, N. J., Bauch, S., … Wunder, S. (2014). Environmental income and rural livelihoods: A global-comparative analysis. *World Development*, *64*, S12–S28. https://doi.org/10.1016/j.worlddev.2014.03.006

Asner, G., Keller, M., Pereira, R., Zweede, Jj., & Silva, J. (2004). Canopy damage and recovery following selective logging in an Amazon forest: Integrating field and satellite studies. *Ecological Applications*, *14*(4), 280–298. https://doi.org/http://dx.doi.org/10.1890/01-6019

Bajracharya, S. B., Furley, P. A., & Newton, A. C. (2005). Effectiveness of community involvement in delivering conservation benefits to the Annapurna Conservation Area, Nepal. *Environmental Conservation*, *32*(3), 239–247. https://doi.org/10.1017/S0376892905002298

Barlow, J., Lennox, G. D., Ferreira, J., Berenguer, E., Lees, A. C., Nally, R. Mac, … Gardner, T. A. (2016). Anthropogenic disturbance in tropical forests can double biodiversity loss from deforestation. *Nature*, *535*(7610), 144–147. https://doi.org/10.1038/nature18326

Barton, K. (2018). *MuMIn: Multi-Model Inference*. R package version 1.40.4. Retrieved from http://www.cran.r-project.org/package=MuMIn

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*(1). https://doi.org/10.18637/jss.v067.i01

Baynes, J., Herbohn, J., Smith, C., Fisher, R., & Bray, D. (2015). Key factors which influence the success of community forestry in developing countries. *Global Environmental Change*, *35*, 226–238. https://doi.org/10.1016/j.gloenvcha.2015.09.011

Beentje, H. J. (1994). *Kenya trees, shrubs and lianas*. Nairobi, Kenya: National Museums of Kenya.

Berkes, F. (2009). Evolution of co-management: Role of knowledge generation, bridging organizations and social learning. *Journal of Environmental Management*, *90*(5), 1692–1702. https://doi.org/10.1016/j.jenvman.2008.12.001

Blomley, T., Pfliegner, K., Isango, J., Zahabu, E., Ahrends, A., & Burgess, N. (2008). Seeing the wood for the trees: An assessment of the impact of participatory forest management on forest condition in Tanzania. *Oryx*, *42*(03), 380–391. https://doi.org/10.1017/S0030605308071433

Boafo, Y. A., Saito, O., Kato, S., Kamiyama, C., Takeuchi, K., & Nakahara, M. (2016). The role of traditional ecological knowledge in ecosystem services management: The case of four rural communities in Northern Ghana. *International Journal of Biodiversity Science, Ecosystem Services and Management*, *12*(1–2), 24–38. https://doi.org/10.1080/21513732.2015.1124454

Borah, J. R., Evans, K. L., & Edwards, D. P. (2018). Quantifying carbon stocks in shifting cultivation landscapes under divergent management scenarios relevant to REDD+. *Ecological Applications*, *28*(6), 1581–1593. https://doi.org/10.1002/eap.1764

Boughey, K. L., Lake, I. R., Haysom, K. A., & Dolman, P. M. (2011). Effects of landscape-scale broadleaved woodland configuration and extent on roost location for six bat species across the UK. *Biological Conservation*, *144*(9), 2300–2310. https://doi.org/10.1016/j.biocon.2011.06.008

Bowler, D. E., Buyung-Ali, L. M., Healey, J. R., Jones, J. P. G., Knight, T. M., & Pullin, A. S. (2012). Does community forest management provide global environmental benefits and improve local welfare? *Frontiers in Ecology and the Environment*, *10*(1), 29–36. https://doi.org/10.1890/110040

Brooks, J., Waylen, K. A., & Mulder, M. B. (2013). Assessing community-based conservation projects: A systematic review and multilevel analysis of attitudinal, behavioral, ecological, and economic outcomes. *Environmental Evidence*, *2*(1), 1–34. https://doi.org/10.1186/2047-2382-2-2

Bruun, H. H., Moen, J., Virtanen, R., Grytnes, J.-A., Oksanen, L., & Angerbjörn, A. (2006). Effects of altitude and topography on species richness of vascular plants, bryophytes and lichens in alpine communities. *Journal of Vegetation Science*, *17*(1), 37–46. https://doi.org/10.1111/j.1654-1103.2006.tb02421.x

Burnham, K., & Anderson, D. (2002). *Model selection and multimodel inference: A practical information-theoretic approach* (2nd ed.). New York, USA: Springer-Verlag New York, Inc.

Burnham, K. P., Anderson, D. R., & Huyvaert, K. P. (2011). AIC model selection and multimodel inference in behavioral ecology: Some background, observations and comparisons. *Behavioral Ecology and Sociobiology*, *65*(1), 23–35. https://doi.org/10.1007/s00265-010-1029-6

Camberlin, P., Boyard-Micheau, J., Philippon, N., Baron, C., Leclerc, C., & Mwongera, C. (2016). Climatic gradients along the windward slopes of Mount Kenya and their implication for crop risks. Part 1: Climate variability. *International Journal of Climatology*, *36*(2), 917–932. https://doi.org/10.1002/joc.4394

Carsan, S., Orwa, C., Harwood, C., Kindt, R., Stroebel, A., Neufeldt, H., & Jamnadass, R. (2012). African wood density database. Retrieved April 14, 2019, from http://www.worldagroforestry.org/treesandmarkets/wood/#

Chao, A., Gotelli, N. J., Hsieh, T. C., Sander, E. L., Ma, K. H., Colwell, R. K., & Ellison, A. M. (2014). Rarefaction and extrapolation with Hill numbers: A framework for sampling and estimation in species diversity studies. *Ecological Monographs*, *84*(1), 45–67. https://doi.org/10.1890/13-0133.1

Chave, J., Andalo, C., Brown, S., Cairns, M. A., Chambers, J. Q., Eamus, D., … Yamakura, T. (2005). Tree allometry and improved estimation of carbon stocks and balance in tropical forests. *Oecologia*, *145*(1), 87–99. https://doi.org/10.1007/s00442-005-0100-x

Chave, J., Coomes, D., Jansen, S., Lewis, L. S., Swenson, G. N., & Zanne, E. A. (2009). Towards a worldwide wood economics spectrum. *Ecology Letters*, *12*(4), 351–366. https://doi.org/10.1111/j.1461-0248.2009.01285.x

Chave, J., Réjou-Méchain, M., Búrquez, A., Chidumayo, E., Colgan, M. S., Delitti, W. B. C., … Vieilledent, G. (2014). Improved allometric models to estimate the aboveground biomass of tropical trees. *Global Change Biology*, *20*, 3177–3190. https://doi.org/10.1111/gcb.12629

Chen, J., John, R., Sun, G., McNulty, S., Noormets, A., Xiao, J., … Franklin, F. J. (2014). Carbon fluxes and storage in forests and landscapes. In Azevedo, J. C. et al. (Ed.), *Forest landscapes and global change: Challenges for research and management* (pp. 139–166). New York, U.S.A: Springer Science+Business Media. https://doi.org/10.13140/2.1.3008.0646

Chen, Q., Vaglio Laurin, G., & Valentini, R. (2015). Uncertainty of remotely sensed aboveground biomass over an African tropical forest: Propagating errors from trees to plots to pixels. *Remote Sensing of Environment*, *160*, 134–143. https://doi.org/10.1016/j.rse.2015.01.009

Chhatre, A., & Agrawal, A. (2009). Trade-offs and synergies between carbon storage and livelihood benefits from forest commons. *Proceedings of the National Academy of Sciences*, *106*(42), 17667–17670. https://doi.org/10.1073/pnas.0905308106

Colwell, R. K., & Coddington, J. A. (1994). Estimating terrestrial biodiversity through extrapolation. *Philosophical Transactions: Biological Sciences*, *345*(1311), 101–118. https://doi.org/10.1098/rstb.1994.0091

Cronkleton, P., Saigal, S., & Pulhin, J. (2012). Co-management in community forestry: How the partial devolution of management rights creates challenges for forest communities. *Conservation and Society*, *10*(2), 91. https://doi.org/10.4103/0972-4923.97481

Ding, Y., Liu, G., Zang, R., Zhang, J., Lu, X., & Huang, J. (2016). Distribution of vascular epiphytes along a tropical elevational gradient: Disentangling abiotic and biotic determinants. *Scientific Reports*, *6*(June 2015), 1–11. https://doi.org/10.1038/srep19706

Dixon, P. (2003). VEGAN, a package of R functions for community ecology. *Journal of Vegetation Science*, *14*(6), 927–930. https://doi.org/10.1111/j.1654-1103.2003.tb02228.x

Djomo, N. A., Ibrahima, A., Saborowski, J., & Gravenhorst, G. (2010). Allometric equations for biomass estimations in Cameroon and pan moist tropical equations including biomass data from Africa. *Forest Ecology and Management*, *260*(10), 1873–1885. https://doi.org/10.1016/j.foreco.2010.08.034

Duguma, L., Atela, J., Minang, P., Ayana, A., Gizachew, B., Nzyoka, J., & Bernard, F. (2019). Deforestation and forest degradation as an environmental behavior: Unpacking realities shaping community actions. *Land*, *8*(2), 26. https://doi.org/10.3390/land8020026

Espinosa, C. I., Cabrera, O., Luzuriaga, A., & Escudero, A. (2011). What factors affect diversity and species composition of endangered tumbesian dry forests in southern Ecuador? *Biotropica*, *43*(1), 15–22. https://doi.org/10.1111/j.1744-7429.2010.00665.x

Essougong, U., Foundjem-Tita, D., & Minang, A. P. (2019). Addressing equity in community forestry: Lessons from 20 years of implementation in Cameroon. *Ecology and Society*, *24(1):9*. https://doi.org/10.5751/es-10656-240109

FAO. (2014). *State of the world's forests*. Rome, Italy: Food and Agriculture Organisation.

FAO. (2015). *Assessment of forests and carbon stocks, 1990–2015*. Rome, Italy: Food and Agriculture Organisation.

Fayolle, A., Doucet, J. L., Gillet, J. F., Bourland, N., & Lejeune, P. (2013). Tree allometry in Central Africa: Testing the validity of pantropical multi-species allometric equations for estimating biomass and carbon stocks. *Forest Ecology and Management*, *305*, 29–37. https://doi.org/10.1016/j.foreco.2013.05.036

Fayolle, A., Ngomanda, A., Mbasi, M., Barbier, N., Bocko, Y., Boyemba, F., … Medjibe, V. (2018). A regional allometry for the Congo basin forests based on the largest ever destructive sampling. *Forest Ecology and Management*, *430*(May), 228–240. https://doi.org/10.1016/j.foreco.2018.07.030

Field, A. (2009). *Discovering statistics using IBM SPSS statistics* (3rd ed.). London, UK: SAGE Publications.

Flores, O., & Coomes, D. A. (2011). Estimating the wood density of species for carbon stock assessments. *Methods in Ecology and Evolution*, *2*(2), 214–220. https://doi.org/10.1111/j.2041-210X.2010.00068.x

Gairola, S., Sharma, C. M., Ghildiyal, S. K., & Suyal, S. (2011). Tree species composition and diversity along an altitudinal gradient in moist tropical montane valley slopes of the Garhwal Himalaya, India. *Forest Science and Technology*, *7*(3), 91–102. https://doi.org/10.1080/21580103.2011.597109

Gathaara, G. (1999). *Aerial survey of the destruction of Mt. Kenya, Imenti and Ngare Ndare Forest Reserves.* Nairobi: Kenya Wildlife Service. Retrieved from http://www.unep.org/dewa/Portals/67/pdf/Mt_Kenya.pdf

Gaui, T. D., Costa, F. R. C., Coelho de Souza, F., Amaral, M. R. M., de Carvalho, D. C., Reis, F. Q., & Higuchi, N. (2019). Long-term effect of selective logging on floristic composition: A 25 year experiment in the Brazilian Amazon. *Forest Ecology and Management*, *440*(February), 258–266. https://doi.org/10.1016/j.foreco.2019.02.033

Gebeyehu, G., Soromessa, T., Bekele, T., & Teketay, D. (2019). Carbon stocks and factors affecting their storage in dry Afromontane forests of Awi Zone, northwestern Ethiopia. *Journal of Ecology and Environment*, *43*(1), 1–18. https://doi.org/10.1186/s41610-019-0105-8

Giam, X. (2017). Global biodiversity loss from tropical deforestation. *Proceedings of the National Academy of Sciences*, *114*(23), 5775–5777. https://doi.org/10.1073/pnas.1706264114

Gibbs, K. H., Brown, S., Niles, O. J., & Foley, A. J. (2007). Monitoring and estimating tropical forest carbon stocks: Making REDD a reality. *Environmental Research Letters*, *2*(045023), 13pp. https://doi.org/10.1088/1748-9326/2/4/045023

GoK. (2005). *Forests Act, 2005*. Nairobi, Kenya: Government Printer.

Gotelli, N. J., & Colwell, R. K. (2001). Quantifying biodiversity: Procedures and pitfalls in the measurement and comparison of species richness. *Ecology Letters*, *4*(4), 379–391. https://doi.org/10.1046/j.1461-0248.2001.00230.x

Gotelli, N. J., & Colwell, R. K. (2011). Estimating species richness. In *Biological diversity: Frontiers in measurement and assessment* (pp. 39–54). Oxford, UK: Oxford University Press.

Gross-camp, N. (2017). Tanzania ' s community forests: Their impact on human well-being and persistence in spite of the lack of benefits. *Ecology and Society*, *22(1):37*. https://doi.org/https://doi.org/https://doi.org/10.5751/ES-09124-220137

Grueber, C. E., Nakagawa, S., Laws, R. J., & Jamieson, I. G. (2011). Multimodel inference in ecology and evolution: Challenges and solutions. *Journal of Evolutionary Biology*, *24*(4), 699–711. https://doi.org/10.1111/j.1420-9101.2010.02210.x

Grytnes, J. A., & Vetaas, O. R. (2002). Species richness and altitude: A comparison between null models and interpolated plant species richness along the Himalayan altitudinal gradient, Nepal. *The American Naturalist*, *159*(3), 294–304. https://doi.org/10.1086/338542

Gurung, M. B., Bigsby, H., Cullen, R., & Manandhar, U. (2015). Estimation of carbon stock under different management regimes of tropical forest in the Terai Arc Landscape, Nepal. *Forest Ecology and Management*, *356*, 144–152. https://doi.org/10.1016/j.foreco.2015.07.024

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., … Townshend, J. R. G. (2013). High-resolution global maps of 21st-century forest cover change. *Science*, *342*(6160), 850–853. https://doi.org/10.1126/science.1244693

Hayes, M. T. (2006). Parks, people, and forest protection: An institutional assessment of the effectiveness of Protected Areas. *World Development*, *34*(12), 2064–2075. https://doi.org/10.1016/j.worlddev.2006.03.002

Hayes, T., & Persha, L. (2010). Nesting local forestry initiatives: Revisiting community forest management in a REDD+ world. *Forest Policy and Economics*, *12*(8), 545–553. https://doi.org/10.1016/j.forpol.2010.07.003

Hsieh, T. C., & Chao, A. (2016). iNEXT: An R package for rarefaction and extrapolation of species diversity (Hill numbers). *Methods in Ecology and Evolution*, *7*(12), 1451–1456. https://doi.org/10.1111/2041-210X.12613

In'airat, M. (2014). Aid allocation, selectivity, and the quality of governance. *Journal of Economics, Finance and Administrative Science*, *19*(36), 63–68. https://doi.org/10.1016/j.jefas.2014.03.002

International Union for Conservation of Nature (IUCN). (2015). The IUCN red list of threatened species. Version 2015. Retrieved February 16, 2016, from www.iucnredlist.org

IPCC. (2006). *IPCC Guidelines for national greenhouse gas inventories*. Hayama, Japan.

Jew, E. K. K., Dougill, A. J., Sallu, S. M., O'Connell, J., & Benton, T. G. (2016). Miombo woodland under threat: Consequences for tree diversity and carbon storage. *Forest Ecology and Management*, *361*, 144–153. https://doi.org/10.1016/j.foreco.2015.11.011

Karky, B. S., & Skutsch, M. (2010). The cost of carbon abatement through community forest management in Nepal Himalaya. *Ecological Economics*, *69*(3), 666–672. https://doi.org/10.1016/j.ecolecon.2009.10.004

Keenan, R. J., Reams, G. A., Achard, F., de Freitas, J. V., Grainger, A., & Lindquist, E. (2015). Dynamics of global forest area: Results from the FAO global forest resources assessment 2015. *Forest Ecology and Management*, *352*, 9–20. https://doi.org/10.1016/j.foreco.2015.06.014

KFS. (2010). *Mt. Kenya forest reserve management plan 2010-2019*. Nairobi, Kenya: Kenya Forest Service (KFS).

Kindt, R., Lillesø, J. P. B., & Van Breugel, P. (2007). Comparisons between original and current composition of indigenous tree species around Mount Kenya. *African Journal of Ecology*, *45*(4), 633–644. https://doi.org/10.1111/j.1365-2028.2007.00787.x

Klopp, J. M. (2012). Deforestation and democratization: Patronage, politics and forests in Kenya. *Journal of Eastern African Studies*, *6*(2), 351–370. https://doi.org/10.1080/17531055.2012.669577

Kohl, M., Lasco, R., Cifuentes, M., Jonsson, O., Korhonen, K. T., Mundhenk, P., … Stinson, G. (2015). Changes in forest production, biomass and carbon: Result from the 2015 UN FAO global forest resource assessment. *Forest Ecology and Management*, *352*, 21–34. https://doi.org/10.1016/j.foreco.2015.05.036

KWS. (2010). *Mt. Kenya ecosystem management plan 2010-2020*. Nairobi, Kenya: Kenya Wildlife Service (KWS).

Lambrick, F. H., Brown, N. D., Lawrence, A., & Bebber, D. P. (2014). Effectiveness of community forestry in prey long forest, Cambodia. *Conservation Biology*, *28*(2), 372–381. https://doi.org/10.1111/cobi.12217

Laurance, F. W., Sayer, J., & Cassman, G. K. (2014). Agricultural expansion and its impacts on tropical nature. *Trends in Ecology & Evolution*, *29*(2), 107–116. https://doi.org/10.1016/j.tree.2013.12.001

Lewis, S. L., Edwards, D. P., & Galbraith, D. (2015). Increasing human dominance of tropical forests. *Science*, *349*(6259), 827–832. https://doi.org/doi: 10.1126/science.aaa9932.

Lieberman, D., Lieberman, M., Peralta, R., & Hartshorn, G. S. (1996). Tropical forest structure and composition on a large-scale altitudinal gradient in Costa Rica. *Journal of Ecology*, *84*(2), 137–152.

Lund, J. F., Burgess, N. D., Chamshama, S. a. O., Dons, K., Isango, J. a., Kajembe, G. C., … Treue, T. (2014). Mixed method approaches to evaluate conservation impact: Evidence from decentralized forest management in Tanzania. *Environmental Conservation*, *42*(02), 162–170. https://doi.org/10.1017/S0376892914000241

Mabberley, D. (2008). *Mabberley's plant book*. Cambridge, UK: Cambridge University Press.

Måren, I. E., Bhattarai, K. R., & Chaudhary, R. P. (2014). Forest ecosystem services and biodiversity in contrasting Himalayan forest management systems. *Environmental Conservation*, *41*(1), 73–83. https://doi.org/10.1017/S0376892913000258

Martin, P., Bullock, J., & Newton, A. (2013). Carbon pools recover more rapidly than plant biodiversity in secondary tropical forests. *Proceedings of the Royal Society B*, *280: 20132*. https://doi.org/10.1098/rspb.2013.2236

Matiku, P. ., Caleb, M. ., & Callistus, O. . (2011). The impact of participatory forest management (PFM) on forest integrity and biodiversity in Arabuko-Sokoke forest, Kenya. *Africa Journal of Ecology*, *50*, 184–192. https://doi.org/10.4103/0972-4923.115724

Matricardi, A. T. E., Skole, L. D., Pedlowski, A. M., Chomentowski, W., & Fernandes, L. C. (2010). Assessment of tropical forest degradation by selective logging and fire using Landsat imagery. *Remote Sensing of Environment*, *114*(5), 1117–1129. https://doi.org/10.1016/j.rse.2010.01.001

Maundu, P., & Tengnas, B. (2005). *Useful trees and shrubs for Kenya*. Nairobi, Kenya: World Agroforestry Centre.

Mccune, B., & Grace, B. J. (2002). *Analysis of ecological communities*. Gleneden Beach, Oregon, U.S.A.: MjM Software Design.

Melis, E., Murombedzi, J., & Ribot, J. (2017). Disempowering democracy: Local representation in community and carbon forestry in Africa. *Conservation and Society*, *15*(4), 357–370. https://doi.org/10.4103/cs.cs

Miller, D. C., Agrawal, A., & Roberts, J. T. (2013). Biodiversity, governance, and the allocation of international aid for conservation. *Conservation Letters*, *6*(1), 12–20. https://doi.org/10.1111/j.1755-263X.2012.00270.x

Minchin, P. R. (1987). An evaluation of the relative robustness of rechniques for ecological ordination. *Vegetatio*, *69*(1), 89–107. https://doi.org/10.1007/bf00038690

Mogoi, J., Obonyo, E., Ongugo, P., Oeba, V., & Mwangi, E. (2012). Communities, property rights and forest decentralisation in Kenya: Early lessons from participatory forestry management. *Conservation and Society*, *10*(2), 182–194. https://doi.org/10.4103/0972-4923.97490

Mokany, K., Raison, R. J., & Prokushkin, A. S. (2006). Critical analysis of root: Shoot ratios in terrestrial biomes. *Global Change Biology*, *12*(1), 84–96. https://doi.org/10.1111/j.1365-2486.2005.001043.x

Morris, R. J. (2010). Anthropogenic impacts on tropical forest biodiversity: A network structure and ecosystem functioning perspective. *The Royal Society*, *365*, 3709–3718. https://doi.org/10.1098/rstb.2010.0273

Moser, G., Leuschner, C., Hertel, D., Graefe, S., Soethe, N., & Iost, S. (2011). Elevation effects on the carbon budget of tropical mountain forests (S Ecuador): The role of the belowground compartment. *Global Change Biology*, *17*(6), 2211–2226. https://doi.org/10.1111/j.1365-2486.2010.02367.x

Muenchow, J., Hauenstein, S., Bräuning, A., Bäumler, R., Rodríguez, E. F., & Von Wehrden, H. (2013). Soil texture and altitude, respectively, largely determine the floristic gradient of the most diverse fog oasis in the Peruvian desert. *Journal of Tropical Ecology*, *29*(5), 427–438. https://doi.org/10.1017/S0266467413000436

Muenchow, J., Henrik, von W., Rodríguez, E. F., Rodríguez, R. A., Bayer, F., & Richter, M. (2013). Woody vegetation of a peruvian tropical dry forest along a climatic gradient depends more on soil than annual precipitation. *Erdkunde*, *67*(3), 241–248. https://doi.org/10.3112/erdkunde.2013.03.03

Murtazashvili, I., Murtazashvili, J., & Salahodjaev, R. (2019). Trust and deforestation: A cross-country comparison. *Forest Policy and Economics*, *101*, 111–119. https://doi.org/10.1016/j.forpol.2019.02.001

Nagendra, H., Karna, B., & Karmacharya, M. (2005). Examining institutional change: Social conflict in Nepal's leasehold forestry programme. *Conservation and Society*, *3*(1), 72–91.

Naidu, M., & Kumar, O. (2016). Tree diversity, stand structure, and community composition of tropical forests in Eastern Ghats of Andhra Pradesh, India. *Journal of Asia-Pacific Biodiversity*, *9*(3), 328–334. https://doi.org/10.1016/j.japb.2016.03.019

Ngomanda, A., Engone Obiang, N. L., Lebamba, J., Moundounga Mavouroulou, Q., Gomat, H., Mankou, G. S., … Picard, N. (2014). Site-specific versus pantropical allometric equations: Which option to estimate the biomass of a moist central African forest? *Forest Ecology and Management*, *312*, 1–9. https://doi.org/10.1016/j.foreco.2013.10.029

Nielsen, M. R., & Treue, T. (2012). Hunting for the benefits of joint forest management in the Eastern Afromontane biodiversity hotspot: Effects on bushmeat hunters and wildlife in the Udzungwa Mountains. *World Development*, *40*(6), 1224–1239. https://doi.org/10.1016/j.worlddev.2011.11.009

Ojoyi, M., Mutanga, O., Odindi, J., Aynekulu, E., & Abdel-rahman, E. (2015). The effect of forest fragmentation on tree species abundance and diversity in the eastern arc mountains of Tanzania. *Applied Ecology and Environmental Research*, *13*(2), 307–324. https://doi.org/10.15666/aeer/1302

Oldekop, J. A., Holmes, G., Harris, W. E., & Evans, K. L. (2016). A global assessment of the social and conservation outcomes of protected areas. *Conservation Biology*, *30*(1), 133–141. https://doi.org/10.1111/cobi.12568

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge, UK: Cambridge University Press.

Pagdee, A., Kim, Y., & Daugherty, P. J. (2006). What makes community forest management successful: A meta-study from community forests throughout the world. *Society & Natural Resources*, *19*(1), 33–52. https://doi.org/10.1080/08941920500323260

Pan, Y., Birdsey, R. A., Fang, J., Houghton, R., Kauppi, P. E., Werner, A. K., … Hayes, D. (2011). A large and persistent carbon sink in the world's forests. *Science*, *333*(6045), 988–993.

Paudel, S., & Sah, J. P. (2015). Effects of different management practices on stand composition and species diversity in subtropical forests in Nepal: Implications of community participation in biodiversity conservation. *Journal of Sustainable Forestry*, *34*(8), 738–760. https://doi.org/10.1080/10549811.2015.1036298

Pearson, T. R. H., Brown, S., Murray, L., & Sidman, G. (2017). Greenhouse gas emissions from tropical forest degradation: An underestimated source. *Carbon Balance and Management*, *12*(1). https://doi.org/10.1186/s13021-017-0072-2

Pendrill, F., Persson, U. M., Godar, J., Kastner, T., Moran, D., Schmidt, S., & Wood, R. (2019). Agricultural and forestry trade drives large share of tropical deforestation emissions. *Global Environmental Change*, *56*, 1–10. https://doi.org/10.1016/j.gloenvcha.2019.03.002

Persha, L., Agrawal, A., & Chhatre, A. (2011). Social and ecological synergy: Local rule making, forest livelihoods and biodiversity conservation. *Science*, *331*(6024), 1606–1608. https://doi.org/10.1126/science.1199343

Poffenberger, M. (2006). People in the forest: Community forestry experiences from Southeast Asia. *International Journal of Environment and Sustainable Development*, *5*(1), 57–69. https://doi.org/10.1504/IJESD.2006.008683

Popradit, A., Srisatit, T., Kiratiprayoon, S., Yoshimura, J., Ishida, A., Shiyomi, M., … Phromma, I. (2015). Anthropogenic effects on a tropical forest according to the distance from human settlements. *Scientific Reports*, *5*, 1–10. https://doi.org/10.1038/srep14689

Poudel, D. P. (2014). REDD+ comes with money, not with development: an analysis of post-pilot project scenarios from the community forestry of Nepal Himalaya. *International Journal of Sustainable Development & World Ecology*, *21*(6), 552–562. https://doi.org/10.1080/13504509.2014.970242

Pretty, J. (2003). Social capital and the collective management. *Nature*, *302*, 1912–1914.

Quinn P. Gerry, & Keough J. Michael. (2002). *Experimental design and data analysis for biologists*. Cambridge, UK: Cambridge University Press.

Reddy, C. S., Babar, S., Amarnath, G., & Pattanaik, C. (2011). Structure and floristic composition of tree stand in tropical forest in the Eastern Ghats of northern Andhra Pradesh, India. *Journal of Forestry Research*, *22*(4), 491–500. https://doi.org/10.1007/s11676-011-0193-5

Ribot, J. (2002). *Democratic decentralization of natural resources: Institutionalizing popular participation*. Washington, D.C.: World Resource Institute.

RRI. (2012). *What rights? A comparative analysis of developing countries' national legislation on community and indigenous peoples' forest tenure rights*. Washington, D.C.: Rights and Resources Initiative (RRI).

RRI. (2014). *What future for reform? Progress and slowdown in forest tenure reform since 2002*. Washington, D.C.: Rights and Resources Initiative (RRI).

Rutishauser, E., Noor'an, F., Laumonier, Y., Halperin, J., Rufi'ie, Hergoualch, K., & Verchot, L. (2013). Generic allometric models including height best estimate forest biomass and carbon stocks in Indonesia. *Forest Ecology and Management*, *307*, 219–225. https://doi.org/10.1016/j.foreco.2013.07.013

Rutten, G., Pommer, U., Fischer, M., Hemp, A., Zimmermann, R., & Ensslin, A. (2015). Effects of elevation and land use on the biomass of trees, shrubs and herbs at Mount Kilimanjaro. *Ecosphere*, *6*(3), art45-art45. https://doi.org/10.1890/es14-00492.1

Saatchi, S. S., Harris, L. N., Brown, S., Lefsky, M., Mitchard, T. E., Salas, W. S., … Morel, A. (2011). Benchmark map of forest carbon stocks in tropical regions across three continents. *Proceedings of the National Academy of Sciences*, *108*(24), 9899–9904. https://doi.org/10.1073/pnas.1019576108

Schlager, E., & Ostrom, E. (1992). Property-rights regimes and natural resources: A conceptual analysis. *Land Economics*, *68*(3), 249–262.

Schusler, T. M., Decker, D. J., & Pfeffer, M. J. (2003). Social learning for collaborative natural resource management. *Society & Natural Resources*, *16*(4), 309–326. https://doi.org/10.1080/08941920390178874

Sellan, G., Thompson, J., Majalap, N., & Brearley, F. Q. (2019). Soil characteristics influence species composition and forest structure differentially among tree size classes in a Bornean heath forest. *Plant and Soil*, 173–185. https://doi.org/10.1007/s11104-019-04000-5

Seymour, F., Vina, L. T., & Hite, K. (2014). *Evidence linking community-level tenure and forest condition: An annotated bibliography*. San Francisco, USA: Climate and Land Use Alliance.

Stapp, J. R., Lilieholm, R. J., Upadhaya, S., & Johnson, T. (2015). Evaluating the impacts of forest management policies and community-level institutions in the buffer zone of Chitwan national park, Nepal. *Journal of Sustainable Forestry*, *34*(5), 445–464. https://doi.org/10.1080/10549811.2015.1025080

Tadesse, E., Abdulkedir, A., Khamzina, A., Son, Y., & Noulèkoun, F. (2019). Contrasting species diversity and values in home gardens and traditional parkland agroforestry systems in Ethiopian sub-humid lowlands. *Forests*, *10*(3), 266. https://doi.org/10.3390/f10030266

Tadesse, S., Woldetsadik, M., & Senbeta, F. (2016). Impacts of participatory forest management on forest conditions: Evidences from Gebradima Forest, southwest Ethiopia. *Journal of Sustainable Forestry*, *35*(8), 604–622.

Takahashi, R., & Todo, Y. (2012). Impact of community-based forest management on forest protection: Evidence from an aid-funded project in Ethiopia. *Environmental Management*, *50*(3), 396–404. https://doi.org/10.1007/s00267-012-9887-5

Tenzin, J., & Hasenauer, H. (2016). Tree species composition and diversity in relation to anthropogenic disturbances in broad-leaved forests of Bhutan. *International Journal of Biodiversity Science, Ecosystem Services and Management*, *12*(4), 274–290. https://doi.org/10.1080/21513732.2016.1206038

Tobin, B., Black, K., Mcgurdy, L., & Nieuwenhuis, M. (2007). Estimates of decay rates of components of coarse woody debris in thinned Sitka spruce forests. *Forestry*, *80*(4), 455–469. https://doi.org/10.1093/forestry/cpm024

Tucker, M. C. (2010). Learning on governance in forest ecosystems: Lessons from recent research. *International Journal of the Commons*, *4*(2), 687–706. https://doi.org/10.18352/bmgn-lchr.224

Turner, B. L., Brenes-Arguedas, T., & Condit, R. (2018). Pervasive phosphorus limitation of tree species but not communities in tropical forests. *Nature*, *555*(7696), 367–370. https://doi.org/10.1038/nature25789

Uberhuaga, P., Smith-Hall, C., & Helles, F. (2012). Forest income and dependency in lowland Bolivia. *Environment, Development and Sustainability*, *14*, 3–23. https://doi.org/10.1007/s10668-011-9306-8

Umemiya, C., Rametsteiner, E., & Kraxner, F. (2010). Quantifying the impacts of the quality of governance on deforestation. *Environmental Science and Policy*, *13*(8), 695–701. https://doi.org/10.1016/j.envsci.2010.07.002

Vedeld, P., Angelsen, A., Bojö, J., Sjaastad, E., & Kobugabe Berg, G. (2007). Forest environmental incomes and the rural poor. *Forest Policy and Economics*, *9*, 869–879. https://doi.org/10.1016/j.forpol.2006.05.008

Wang, Y., Naumann, U., Wright, S. T., & Warton, D. I. (2012). Mvabund- an R package for model-based analysis of multivariate abundance data. *Methods in Ecology and Evolution*, *3*(3), 471–474. https://doi.org/10.1111/j.2041-210X.2012.00190.x

Warren-Thomas, E. M., Edwards, D. P., Bebber, D. P., Chhang, P., Diment, A. N., Evans, T. D., … Dolman, P. M. (2018). Protecting tropical forests from the rapid expansion of rubber using carbon payments. *Nature Communications*, *9*(1). https://doi.org/10.1038/s41467-018-03287-9

Warton, D. I. (2005). Many zeros does not mean zero inflation: Comparing the goodness-of-fit of parametric models to multivariate abundance data. *Environmetrics*, *16*(3), 275–289. https://doi.org/10.1002/env.702

Warton, D. I., Thibaut, L., & Wang, Y. A. (2017). The PIT-trap — A “model-free” bootstrap procedure for inference about regression models with discrete, multivariate responses. *PLoS ONE*, *12*(7), 1–18. https://doi.org/10.1371/journal.pone.0181790

Wass, P. (Ed. . (1995). *Kenya’s indigenous forests: Status, management and conservation*. Gland, Switzerland and Cambridge, UK: IUCN.

White, A., & Martin, A. (2002). *Who owns the world’s forests? Forest tenure and public forests in*

transition. Washington, DC., USA: Forest Trends.
Wilkinson, G. R., Schofield, M., & Kanowski, P. (2014). Regulating forestry - Experience with compliance and enforcement over the 25years of Tasmania's forest practices system. *Forest Policy and Economics*, *40*, 1–11. https://doi.org/10.1016/j.forpol.2013.11.010
World Bank. (2014). *Managing forest resources for sustainable development: An evaluation of the World Bank Group's experience*. Washington, D.C.: World Bank.
Wright, G. D., Andersson, K. P., Gibson, C. C., & Evans, T. P. (2016). Decentralization can help reduce deforestation when user groups engage with local government. *Proceedings of the National Academy of Sciences*, *113*(52), 14958–14963. https://doi.org/10.1073/pnas.1610650114
Zanne, E. A., Lopez-Gonzalez, G., Coomes, D., Ilic, J., Jansen, S., Lewis, S. L., … Chave, J. (2009). *Towards a worldwide wood economics spectrum. Dryad Digital Repository. https://doi.org/10.5061/dryad.234*.
Zhao, M., Brofeldt, S., Li, Q., Xu, J., Danielsen, F., Læssøe, S. B. L., … Theilade, I. (2016). Can community members identify tropical tree species for REDD+ carbon and biodiversity measurements? *PLoS ONE*, *11*(11), 1–16. https://doi.org/10.1371/journal.pone.0152061
Zhou, Y., Chen, S., Hu, G., Mwachala, G., Yan, X., & Wang, Q. (2018). Species richness and phylogenetic diversity of seed plants across vegetation zones of Mount Kenya, East Africa. *Ecology and Evolution*, *8*(17), 8930–8939. https://doi.org/10.1002/ece3.4428
Zulu, L. (2013). Bringing people back into protected forests in developing countries: Insights from co-management in Malawi. *Sustainability (Switzerland)*, *5*(5), 1917–1943. https://doi.org/10.3390/su5051917

Chapter 4

Does community-based forest management deliver ecosystem services and livelihoods in Mt Kenya forest?

Community forest association (CFA) members planting tree seedings in PELIS plots already planted with food crops in Njukiri forest.

4.1. Abstract

Forests provide ecosystem services essential for supporting livelihoods of forest-dependent communities. Assessment of livelihood benefits from community-based forest management initiatives show little benefits trickling to communities. However, assessments are anchored on tangible benefits; provisioning services often assessed on monetary terms. Consequently, studies do not capture broad range of ecosystem services supporting locals' livelihoods. Mixed methods are used to explore ecosystem services communities' value, why and who values what, and explore how perceptions of preferred ecosystem services vary among local groups and socio-demographic factors in Mt. Kenya forest. Nine community forest associations (CFAs) were selected and 30 CFA, and 30 non-CFA household head members randomly sampled in each CFA. A survey was administered (n = 540), in-depth interviews conducted with key informants (n =12) and two focus group discussions organised (n = 12-14 each). Potential influence of socio-demographic factors on perceived ecosystem service preferences were explored using canonical correspondence analysis to identify divergent interests from different social groups. Results show that Mt. Kenya forest provides a variety of ecosystem services, with provisioning and regulating services preferred relative to cultural services. Contrasting perceptions to preferred ecosystem services were influenced by CFA membership, education and age of respondents, with CFA membership contributing the most to divergent interests in ecosystem services. We show the importance of incorporating local communities in ecosystem service assessments to understand preferences of diverse social groups with an aim of devising acceptable and sustainable solutions for enhancing ecosystem service flow to targeted beneficiaries taking into account conservation and preference needs.

4.2. Introduction

Globally, decentralisation of forest management integrating social-economic and ecological needs through co-management approaches such as community based forest management (CBFM) has contributed to successful ecological outcomes (e.g. Lambrick et al., 2014; Nielsen & Treue, 2012). Successful outcomes improve forest conditions, maintain vital ecosystem functioning and thus increase the supply of forest ecosystem services (Miura et al., 2015; Birch et al., 2014). As a result, local communities especially forest dependent rural households benefit from a diverse range of ecosystem services important for their livelihoods and well-being (FAO, 2014b; Le et al., 2012; Rasmussen et al., 2017). However, CBFM studies show mixed socio-economic outcomes on livelihoods of local communities participating in CBFM (e.g. Adams et al., 2016; Corbera et al., 2017). Nevertheless, majority of the studies focus on tangible evidence of high-value material benefits, especially provisioning services (often assessed at market value) while excluding other services (e.g. regulating and cultural services) crucial for communities' well-being (Chan et al., 2012; Queiroz et al., 2017). Yet, human dependence on ecosystem services and demand for reliable provision for almost all ecosystem services is increasing (MEA, 2005; Guo et al., 2010; Raudsepp-Hearne et al., 2010).

Different communities (and other stakeholders) often attach different values to ecosystem services depending on contribution to their well-being (Small et al., Munday, & Durance, 2017). For instance, local farmers can attach great value to a forest because of links to agricultural activities and food production; bee keepers may value the same forest as a source of income through honey production; researchers and scientists may view the same area as 'natural laboratories' while forest dependent communities may regard the same forest as important for material benefits and cash income. Reconciling divergent interests of different social groups in communities by incorporating them in ecosystem service assessments is important to understand what ecosystem services are preferred by whom and why, in order to identifying different and competing preferences individuals and social groups place on ecosystem services. These assessments are important as they provide a rapid assessment and valid measure of ecosystem services that are directly linked to human well-being (Burkhard et al., 2012; Olander et al., 2018). Thus, providing crucial information for better decision making and policy intervention to effectively deliver ecosystem service priorities and sustainable livelihoods for different target groups while conserving the environment.

Forests provide ecosystem goods and services that support key sectors important for functioning and growth of world economies (Ferraro et al., 2012), and the importance of these ecosystem services to human well-being is widely known (Costanza et al., 2017; de Groot et al., 2002; MEA, 2005). The Millennium Ecosystem Assessment (MEA) defines ecosystem services as benefits people obtain from an ecological system for their well-being (MEA, 2005). Local communities benefit from timber (e.g. timber, poles/rafters) and non-timber forest products (NTFPs) such as wild foods, fuel wood, fodder, honey and herbal medicine for both subsistence use and as a source of cash income. This is important especially to income constrained rural households where employment opportunities are limited. For instance, indigenous communities of Nepal depend mainly on collection of NTFPs contributing cash income share of between 44 – 78% of total household income to poor households (Rijal et al., 2011). Further, forests provide regulating services which reduce risk of natural disasters such as floods and landslides (World Bank, 2008; Bradshaw et al., 2007), support livelihood activities such as agriculture (FAO, 2016) and form a critical component of global climate change mitigation through carbon storage and sequestration (Sunderlin et al., 2008; Karky & Skutsch, 2010). The Millennium Ecosystem Assessment (MEA) categorised these benefits into four distinct categories; provisioning, supporting, regulating and cultural services (MEA, 2005).

Increased recognition of potential contribution of ecosystem services in improving human well-being and quality of life, and possible effects of human activities on functioning of ecosystems in delivering ecosystem services (Raudsepp-Hearne et al., 2010) has witnessed increased calls for integrating ecosystem services into decision making (Díaz et al., 2015). Policy initiatives such as the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (Díaz et al., 2015) has received wide recognition, with many countries keen on incorporating ecosystem services into decision making and policy frameworks at various levels (Díaz et al., 2015). For instance, one hundred and thirty two countries are currently members of the IPBES (IPBES, 2019) which provides scientific information on the state of biodiversity and ecosystem services in response to requests from decision makers. This growing interest on linkages between ecosystem services and decision making is being extended to community-based forest management assessments with an emphasis on community inclusion and participatory approaches in ecosystem service assessments (e.g. Paudyal et al., 2015; 2017; van Oort et al., 2015; Queiroz et al., 2017). This is important in order to capture diversity and preferences of ecosystem services amongst social groups as well as overcome past economic invisibility of biodiversity values, particularly non-monetary benefits (TEEB, 2010) and support inclusive decision making for better management of all forest ecosystem services.

As with many natural resources including wetland and marine ecosystems (e.g. Wangai et al., 2016; Folkersen, 2018), previous studies on assessment of forest ecosystem services and livelihoods provided through CBFM have largely focused on provisioning services e.g. timber, wood fuel, and food crops (Mutune & Lund, 2016; Ameha et al., 2014; Parajuli et al., 2015; Corbera et al., 2017) assessed in monetary terms while important non-market values (e.g. pollination, cultural services) are excluded. For instance, Parajuli et al., (2015) showed that net annual household benefits from mid-hills region in Nepal forests was US$ 66, 40 and 23 for rich, average and poor households participating in CBFM. Indeed, many of CBFM studies have been used to demonstrate benefits accruing to local communities based on economic values of ecosystem services. Economic value domains have superseded (and continue to) over social implications in ecosystem service assessments (Small et al., 2017; Nieto-Romero et al., 2014) but do not capture full scope of benefits people obtain from ecosystems (Chan et al., 2012). This is because direct use of natural resources such as forest ecosystems may support higher levels of community or individual satisfaction and well-being even where monetary incomes are low or do not exist (Folkersen, 2018).

Socio-cultural valuation is a non-monetary valuation method increasingly being applied in ecosystem service assessments to capture broad diversity of values provided by nature (e.g. Queiroz et al., 2017; Martín-López et al., 2012; Kenter et al., 2015). The method is being recommended as an essential requirement for guiding sustainable governance of ecosystem services (Spangenberg et al., 2015). Socio-cultural valuation is based on the importance people — either individuals, groups or both — assign to bundles of ecosystem services, both material and immaterial connected to all types of ecosystem services (Scholte et al., 2015; Alpízar et al., 2001). Additionally, the method is important in capturing people's perceptions of ecosystem services, which may differ based on needs, life experiences and cultural characteristics (Daw et al., 2011; Scholte et al., 2015), and thus, peoples' perceptions are essential in understanding actual contributions of ecosystem services to individuals' or groups' well-being.

Perceptions of ecosystem services are important as they may also affect communities' engagements and intensity of behaviours that either promote or curtail continuous flow of desired ecosystem services (Asah et al., 2014). This is especially so where efficient conservation of natural resources is threatened by economically competing land uses such as palm oil and livestock production in the tropics (e.g. Carlson et al., 2013). Moreover, understanding communities perceptions of forest ecosystem services can more inclusively reflect cultural values and social norms of communities in developing countries who may not value some benefits in economic terms (Folkersen, 2018) and thus support integration of preferred social values into decision making. This assessment comes at a crucial moment when forest ecosystem assessments have been neglected in ecosystem service assessments, with a systematic review for instance, indicating that only 6% of case studies reported on forest ecosystem services, N = 145 (Cruz-Garcia et al., 2017), yet forests are of significant global importance and largest terrestrial ecosystems on earth (World Bank, 2008) providing a wide range of critically important ecosystem services for both human well-being and biodiversity.

Preferences towards ecosystem services may be influenced by socio-demographic factors including personal characteristics such as age, gender, wealth, living environment, education level or membership in environmental organisation(s). These factors ingrain values, judgements, behaviours and general beliefs in individuals or community groups (Stern & Dietz, 1994), hence influencing social preferences for ecosystem services. Ahammad et al., (2019) for instance showed that household wealth influenced variations in perceptions and use of forest ecosystem services in Bangladesh where wealthy households preferred services linked to crop production (e.g. soil protection, soil fertility, pest and disease control) due to large landholding compared to poor households. Furthermore, Quintas-Soriano et al., (2018) showed that gender, education level, land use and climate characteristics played a significant role in influencing people's perceptions of which ecosystem services were important for their well-being. Thus, identifying different and competing preferences which individuals and social groups place on ecosystem services could provide crucial information to effectively deliver ecosystem service priorities for all social groups as well as reduce tensions and conflicts which emanate from divergent social interests and misunderstandings (Jorda-Capdevila & Rodríguez-Labajos, 2015).

This study used social-cultural valuation to examine communities' perceptions of ecosystem services and values, and how these are influenced by socio-economic factors across a sample of multiple community forest associations (CFAs) and non-CFAs respondents in Mt Kenya forest. Questionnaires are the most commonly used method for assessing perceptions of ecosystem services and use (Scholte et al., 2015) and this study employed a combination of mixed methods including surveys, in-depth interviews, focus group discussions and participant observation to identify full range of ecosystem services and contrasting perceptions of local communities on different ecosystem services. In Kenya, community based forest management locally referred to as participatory forest management (PFM) was established through a new forest legislation in 2005 that enables and incentivises voluntary participation in CFAs, but with an emphasis on provisioning services. The study aimed to assess the following objectives; a) examine forest ecosystem services use and preferences for local communities' well-being; b) identify factors influencing perceived preferences for different ecosystem services; c) assess PFM impact and communities' perceptions on access to ecosystem services, and preferred future scenario. As noted by Chan et al., (2012), certain types of values or benefits cannot be adequately appreciated without first being experienced and this study hypothesised to find differences between community members that participate in PFM, that is CFA members — such members receive exclusive rights and access to some ecosystem services and associated benefits — and non-participating members (herein referred to non-CFA respondents).

Findings from this study aims to contribute to a detailed understanding of the role of CBFM in providing ecosystem services for communities' well-being by incorporating both monetary and non-monetary values in co-management approaches. Additionally, findings contribute to emerging concepts on social dimension (social, economic, cultural characteristics) of ecosystem services and linkages with human well-being using social preferences for ecosystem services (e.g. Schröter et al., 2017; Aguado et al., 2018; Nieto-Romero et al., 2014) in a globally relevant example of a CBFM initiative. This will provide valuable insights to bridge knowledge gap on forest ecosystem services from community conservation initiatives and broaden scope for policy formulation to integrate ecosystem services in decision making.

4.3. Methodology

4.3.1. Study Site

Note: Previous chapters— two and three have detailed description of study site on pages 51-52 and 103-104 respectively.

The study was carried out in Mt. Kenya forest. Nine community forest associations (CFAs) out of fourteen CFAs visited were selected for study. CFA and Non-CFAs respondents living within the jurisdiction of each of the selected CFAs were randomly selected as per method described in the following section. Voluntary participation of CFA members in PFM guarantees them of certain exclusive rights to some benefits such as Plantation Establishment and Livelihood Improvement Scheme (PELIS) and timber harvesting rights. Through PELIS, CFA members benefit from half-acre farming plot in clear-felled plantation forests for tree planting as well as crop farming for a period not exceeding three years (GoK, 2005; 2016). Different CFAs have different methods for allocation of PELIS plots to their members (*see Chapter 2 — Appendix 2; Table A7-A8 pages 73-77 on allocation of plots by CFAs*). Limited availability of farming plots against high demand in an area characterised by small land holdings (Emerton, 1997) has led to further subdivision of the plots into smaller parcels (in some sites), with many CFA members missing out on the allocations.

4.3.2. Data collection

Thirty CFA household-head members or spouses were randomly selected from each of the nine sampled CFAs using membership list registers, minutes and consultation (for CFAs with un-updated membership database) with CFA officials. Additionally, thirty non-CFA household heads/spouses living within each CFA boundary site were identified with support from local administration including chiefs, sub-chiefs and village elders within their jurisdictions. Each village elder working in close collaboration with chiefs and sub-chiefs generated a list of household heads living in their village jurisdiction within an approximate radius of 5 kms from the forest. The lists were used to randomly select non-CFA respondents, with subsequent contact initiated through the local administration. Individual respondents interviewed both CFA and non-CFA represented households and unit of analysis in this study is the household. Further, a total of twenty three key informants were selected from CFA and non-CFAs membership, CFA officials, KFS staff and representatives from the national administration.

Mixed methods integrating a combination of quantitative (surveys) and qualitative (focus groups, interviews, participant observation) research methods were used to collect data from selected key informants, CFA and non-CFA respondents. Mixed methods approach is critical in understanding complex phenomena and provides more breadth, depth, and richness (Schulze, 2003), as well as validity and triangulation by combining strengths of each methodology and neutralising their weaknesses (McKim, 2017). The use of mixed methods enabled collection of both quantitative and qualitative data on: respondent's demographics; ecosystem services perceived important for respondent's well-being; rules and enforcement; forest and ecosystem services access and distribution; opportunities and challenges in ecosystem service delivery as well as a deeper understanding of respondents' perceptions of changes (respondent and societal) facilitated through PFM.

First, a survey questionnaire was used and, semi-structured interviews were conducted with sampled CFA and non-CFA respondents (N = 540). Interviews captured: socio-demographic characteristics of respondents (e.g. gender, education, age, house hold income[34], assets); access to Mt. Kenya forest for material benefits — before and after PFM adoption; forest product utilisation patterns before and after PFM adoption; PFM and CFA harvesting regulations; ecosystem services from Mt. Kenya forest, ecosystem services perceived to contribute most to their/household well-being; opportunities and challenges in forest and ecosystem services access (e.g. harvesting frequency, permits and fees, load size, resource availability etc.) and PFM contribution to households' well-being. Socio-cultural valuation of ecosystem services was undertaken by first asking respondents whether Mt. Kenya forest was important to their household well-being[35]. If respondents answered 'yes', they were requested to list down materials/benefits received from the forest contributing to their well-being. The next step was for respondent to rank only four of the ecosystem services they had identified, in descending order of preferred and most beneficial ecosystem services for their well-being. Participants may be unfamiliar with difficult terminologies commonly used in research such as ecosystem services, biodiversity, well-being (Novacek, 2008; Dawson & Martin, 2015), thus 'ecosystem services' and 'well-being' were simplified by asking respondents to "rank four benefits in order

[34] Assessed from income earned in the past one year 2015-2016 for easy recall and to capture current/latest household income data

[35] Well-being was simplified to respondents as materials needed to lead a good life in their community.

of priority received from Mt. Kenya forest beneficial to you and your household in order to lead a good life in this community". Additionally, more in-depth probing was done to elicit deeper understanding of contribution of ranked ecosystem services to their well-being.

Secondly, in-depth interviews were conducted with a small number of key informants totalling twenty three; 14 CFA and non-CFA member respondents, four CFA officials, three KFS staff and two local administration representatives. In-depth interviews captured: benefits facilitated through PFM; preferred benefits by community members; changes in forest access and product harvest patterns after PFM adoption, rules and enforcement; relationships with CFA, non-CFA members and KFS, opportunities and challenges before and after PFM implementation, and participation (lack of).

Thirdly, two focus group discussions were held, one for CFA members and another for non-CFA members, with twelve and fourteen randomly sampled members respectively. Participants were facilitated in group discussions focussing on; importance of Mt. Kenya forest and benefits received, PFM influence on forest and ecosystem service access, rules and enforcement; forest threats; societal changes after PFM, PFM opportunities and challenges, and preferred future PFM scenario. Lastly, lead researcher participated in events and activities organised by CFAs, using the opportunity to gather more field data through CFAs activities and members participation (e.g. tree planting, elections, meetings) while carrying out interviews in a natural setting to get a deep understanding of PFM process in forest conservation.

4.3.3. Quantitative data analysis

To address the first objective – socio-cultural valuation of ecosystem services perceived as important for respondents or household well-being – the relative importance of each ecosystem service was examined, considering the mean of ranking (preference) scores assigned by respondents in survey responses ($N = 540$). Scores were assigned as first ranked ES (extremely important) = 4; second-ranked (very important) = 3; third (some importance) = 2; fourth (little importance) = 1. Further, if an ecosystem service was not identified and ranked among the top four ecosystem services by a respondent, it was assigned a zero score for that respondent. For each ecosystem service identified and ranked, relative importance was compared between the samples of CFA and non-CFA respondents using a Mann-Whitney test. Additionally, preferred ecosystem services were grouped in to three main categories — provisioning, regulating and cultural services, and differences in mean relative importance given to ecosystem service categories was examined using non-parametric Kruskal–Wallis test followed by post hoc Dunn's pairwise multiple comparison. Dunn's test is a post hoc non parametric test used to examine which means are significant from a small subset combination of group categories (Dunn, 1961).

To assess the second objective — factors influencing respondents' preferences towards ecosystem services, a canonical correspondence analysis (CCA) was performed by relating ecosystem service preference scores to socio demographic factors (age, education level, income, gender and CFA membership) (*Appendix 4; Table A1*). CCA is one of the most popular multivariate ordination techniques in community ecology research used to elucidate relationships between biological assemblages of species and their environment (ter Braak & Verdonschot, 1995; Greenacre, 2007) and has been extended to social science research to examine relations between environmental linkages and society's interactions in sample survey data (Greenacre, 2010; Greenacre, 2007). Consequently, this has led to CCA being widely adopted more recently in social science research to examine relationships in community perceptions towards ecosystem services (e.g. Aguado et al., 2018; Al-Assaf et al., 2014; He et al., 2018). CCA was used to assess the extent to which socio demographic factors influenced respondent's relative preferences across the different ecosystem services perceived as important to their household well-being. A Monte Carlo permutation test (999 permutations) was performed to determine significance of explanatory variables in influencing respondents' preferences to ecosystem services. Interpretation of relationships between ecosystem service preference scores (response variable) and socio demographic factors (explanatory variables) is based on visualisation of objects i.e. variables in relation to ordination space. Distances between objects represent the between-object similarity and closer the explanatory variables are to response variables, an association between them is found (Shankar & Paliy, 2016).
Further, PFM impact on access to ecosystem services was analysed through descriptive statistics by comparing respondents' forest product utilisation patterns before and after PFM. Mann-Whitney paired test was performed on the utilisation patterns to assess change in forest access and products use. All statistical data analysis was performed using R software version 3.5.1 (R Core Team, 2018).

4.3.4. Qualitative data analysis

Objective 3 – Qualitative data from in-depth interviews and focus group discussions on PFM impact on access to ecosystem services, perceptions of local communities on PFM, PFM benefits and preferred future scenario was analysed qualitatively using NVivo software (Patton, 2002). The analysis was also complemented by data from participant observation in the field.

Data were transcribed, coded and analysed thematically by merging closely related patterns or themes emerging from data (Creswell, 2007).

4.4. Results

4.4.1. Forest ecosystem services use and preferences

Mt. Kenya forest provided multiple ecosystem services important for fulfilling key components of communities' well-being. Respondents identified a total of twenty-two ecosystem services with both provisioning and regulating services being most preferred in comparison to cultural services *(Fig. 4.1)*. Results show significant differences in relative importance given to ecosystem service categories; between provisioning and cultural services, and regulating and cultural services (post hoc Dunn's test, $p < 0.05$). However, no significant differences were found between provisioning and regulating services (post hoc Dunn's test, $p > 0.05$). Additionally, although CFA and non-CFA respondents differed in valuation of some provisioning and regulating services (Man-Whitney test, $p < 0.05$), preferences towards cultural services were similar amongst the two groups (Man-Whitney test, $p > 0.05$ (*Fig. 4.1*).

Among provisioning services, wood fuel, fodder/grazing and water provision were the most important and highly ranked ecosystem services preferred by both CFA and non-CFA respondents (*Fig. 4.1*). Similar preferences for wood fuel between the two groups (Mann-Whitney test, $p = 0.224$) showed high dependence of local communities on Mt. Kenya forest as a source of wood fuel for energy needs. However, CFA respondents gave greater preference to fodder harvesting or grazing, bee keeping and PELIS (Mann-Whitney test, $p < 0.05$) while non-CFA respondents preferred water provision and timber or posts (Mann-Whitney test, $p < 0.05$) (*Fig. 4.1*). PELIS was perceived by both CFA respondents and key informants as the most important and preferred PFM benefit owing to high yields of important staple crops especially potato farming including high revenue generated from sale of surplus production. Other food crops grown included maize, cabbage, beans, carrot, peas and kale.

Participant observation in sites where PELIS was being implemented and in-depth interviews with respondents and key informants revealed increased opportunities for locals and booming business in former sleepy villages including small-scale retail enterprises, employment, expanding markets and towns, improved infrastructure and flourishing transport industry. For instance, respondents reported harvesting between 20-25 bags of potatoes (90kg each bag) each season (two seasons in a year) from half-acre plot with sales price ranging between Ksh. 1,800 and 2,500 (1 US$ = ~ Ksh. 100) per bag depending on season and market demand. All PELIS beneficiaries interviewed reported changes in improved living standards with revenue generated utilised in; purchasing assets (motorcycles, bicycles, land, durable household goods), education, house construction/renovation and meeting other family obligations such as dowry payment. However, despite PELIS being an exclusive benefit to CFA members to increase motivation for participation in PFM , this study found that non-CFA members can also access these benefits, albeit illegally upon payment of "rental fees" to CFA members or officials in some CFA sites. Other provisioning services identified by respondents included: fishing, herbal, manure, seed bank and wild terrestrial foods with similar preferences for all services between CFA and non-CFA respondents (Mann-Whitney test, $p > 0.05$).

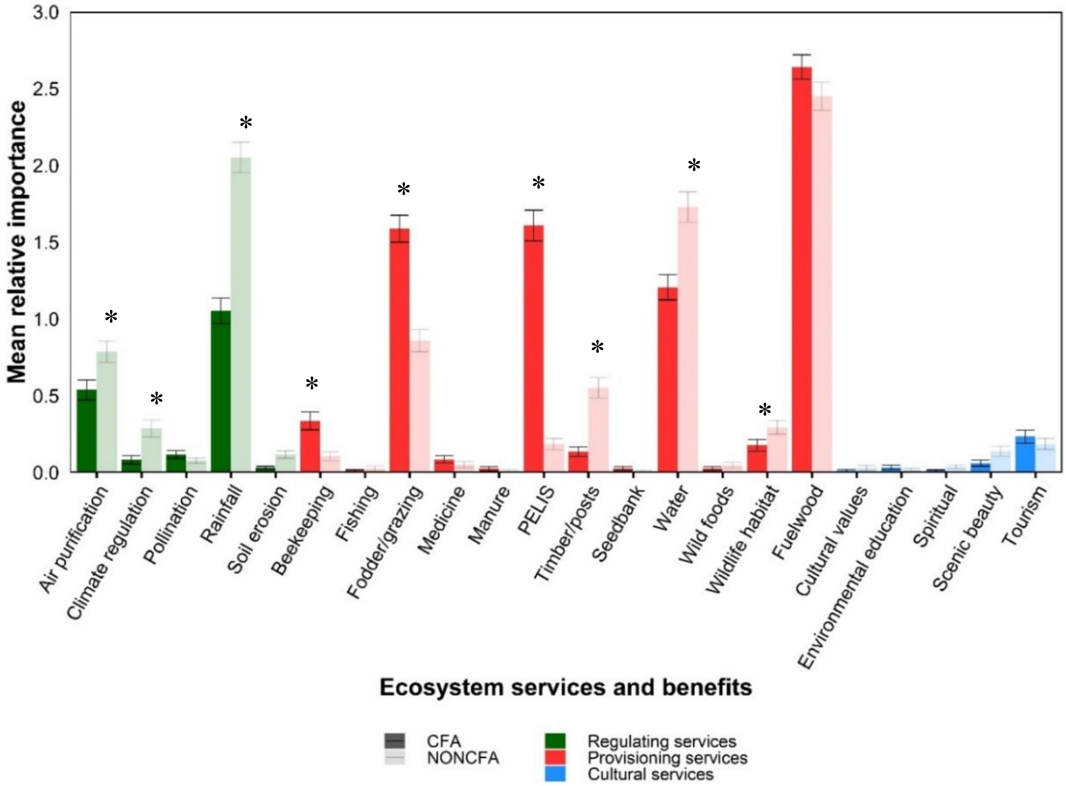

Fig. 4.1. Perceived mean relative importance (with SE) of ecosystem services (ES) between CFA and non-CFA respondents. Asterisk* represents significant differences in mean relative importance of ES between CFA and non-CFA respondents. Dark and light colours represent CFA and non-CFAs respondents' responses respectively.

Regulating services were the second most preferred ecosystem services by both CFA and non-CFA respondents, with rainfall attraction and air purification ranked higher than other services in this category (*Fig. 4.1*). Preferences for regulating services differed significantly between CFA and non-CFA respondents whereby, CFA respondents preferred pollination services only while non-CFA respondents valued rainfall attraction, climate regulation and soil erosion control as important services for their wellbeing (Mann-Whitney test, $p < 0.05$). Other regulating services identified included air purification with similar ranking preferences between CFA and non-CFA respondents (Mann-Whitney test, $p > 0.05$) (*Fig.4.1*).

Cultural services were ranked lower than provisioning and regulating services by both CFA and non-CFA respondents (*Fig. 1*). Identified cultural services included: environmental education; spiritual values; scenic beauty; tourism attraction and cultural identity, but all were ranked as having little importance to respondent's well-being, with similar ranking preferences between CFA and non-CFA respondents (Mann-Whitney test $p > 0.05$).

4.4.2. Factors influencing ecosystem service preferences

Canonical correspondence analysis (CCA) model indicated a significant association between socio- demographic factors and perceived preferences for ecosystem service (p = 0.001, 999 permutations). A CCA permutation test indicated that CFA membership, age, gender and education level had significant influence on respondents' perceived preferences for ecosystem services, $p < 0.05$ (*Table 4.1*). However, household income level did not have an effect on ecosystem service preferences, $p > 0.05$ indicating both low and high income households depend on Mt. Kenya forest for crucial services important for their well-being.

Table 4.1. CCA permutation test analysis on socio demographic factors influencing ecosystem services preferences. **Bold** indicates predictors with significant effect on perceived ecosystem service preferences

Response Variable	Fixed effects	df	Chi-square	F	*p*-value
ES preference rank	Household income	1	0.0058	0.821	0.689
	Age	**1**	0.0159	**2.234**	**0.003**
	Post primary	**1**	**0.0130**	**1.828**	**0.014**
	Gender	**1**	**0.0181**	**2.542**	**0.001**
	CFA membership	**1**	**0.1232**	**17.322**	**0.001**

The first CCA Axis explained 73.8 percent of the total variation in respondents' preferences to ecosystem services (*Appendix 4; Table 2A*) and showed a contrast in ecosystem service preferences related mainly with CFA membership. Respondents with larger positive scores on this axis (positive loadings) were non-CFA respondents who mainly preferred regulating and provisioning services (a few) including; climate regulation, rainfall attraction, soil erosion control, wildlife habitat, water provision and timber/posts (*Fig. 4.2 & Appendix 4; Table 2A*). Although preferences for cultural services did not differ between CFA and non-CFA respondents (Mann-Whitney test, $p > 0.05$, *Fig. 4.1*), CCA visualisation showed an association between non-CFA respondents, cultural value and scenic beauty (*Fig. 4.2*), with both ES ranked higher by non-CFA respondents (*Fig. 4.1*). Respondents with larger negative scores in the first CCA axis (negative loadings) were CFA members who primarily preferred provisioning services including fodder harvesting/grazing, manure, PELIS, herbal medicine and seed collection (bank).

Pollination services was the only regulating service most preferred by CFA respondents (*Fig. 4.1 & 4.2*).

The second CCA axis, explained much less (only 12.7%) of the total variance (*Appendix 4; Table 2A*), but showed a contrast in ecosystem service preferences related with gender, age and education level. Respondents with larger positive scores in this axis (positive loadings) tended to be mid aged (< 55 years) females, with lower level of education (mainly primary education) who preferred provisioning (e.g. wild terrestrial foods, wood fuel, medicinal herbs) and cultural services specifically environmental education.

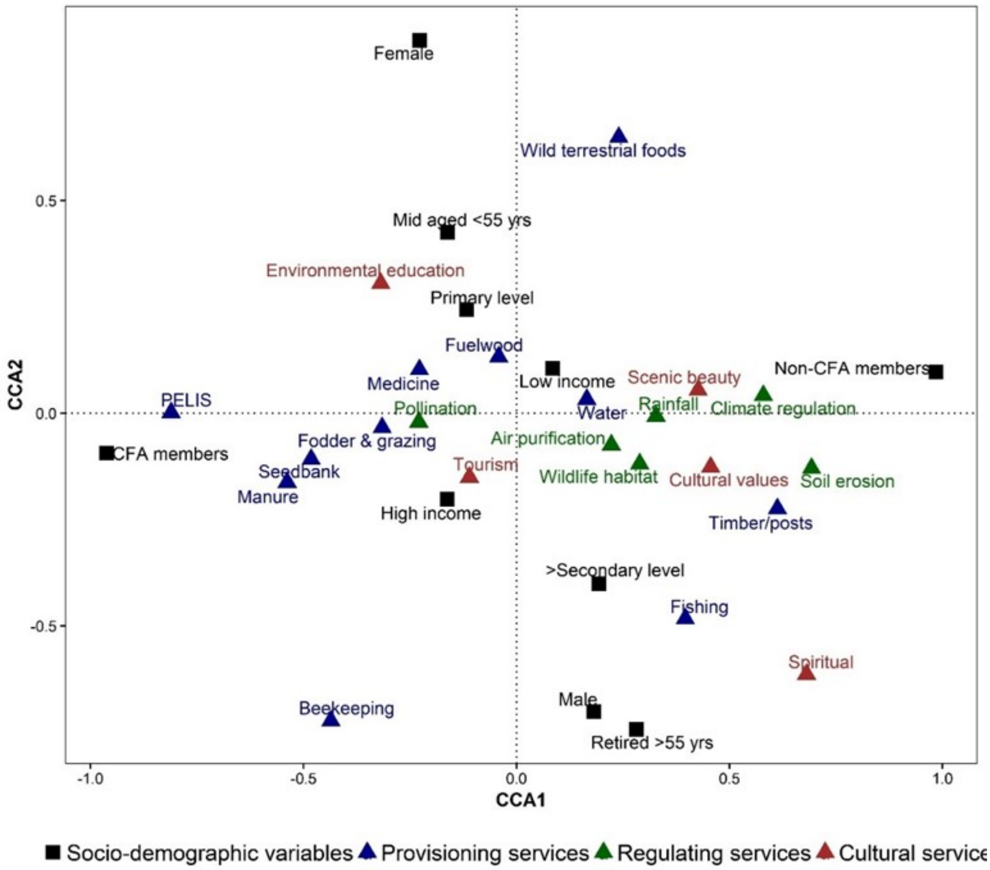

Fig. 4.2. Biplot of the first two CCA axes, showing relationship between ecosystem service preference (dependent variables) as perceived by CFA and non-CFA respondents and socio-demographic factors (explanatory variables).

This indicates a desire for less educated mid aged females to acquire new skills and knowledge to enhance their understanding in forest and environment related issues (*Fig. 4.2*). In contrast, respondents with larger negative scores (negative loadings) on the second CCA axis tended to be retired or older, males, and had a higher level of education (above secondary level) with a preference for: regulating services (e.g. wildlife habitat, soil erosion control); provisioning (bee keeping and fishing), and spiritual and religious cultural values (*Fig. 4.2 & Appendix 4; Table 2A).*

4.4.3. Participatory forest management (PFM) impact on access to ecosystem services

Forest products utilisation patterns differed before and after PFM adoption (Wilcoxon signed-rank test, $p = 0.001$, with a decline in the proportion of respondents accessing the forest for material benefits after PFM adoption (*Fig. 4.3*). A decline is noted for proportion of respondents accessing the forest for timber harvesting (illegal), as well as a decline in harvesting of subsistence products such as fuel wood, medicinal herbs, fodder, livestock grazing and terrestrial foods after enactment of new forest Act legalising PFM (*Fig. 4.4*). However, slight increase in proportion of respondents accessing the forest for farming (PELIS) and water harvesting or use is noted in comparison to previous state management of Mt. Kenya forest (i.e. before PFM — *Fig. 4.4*).

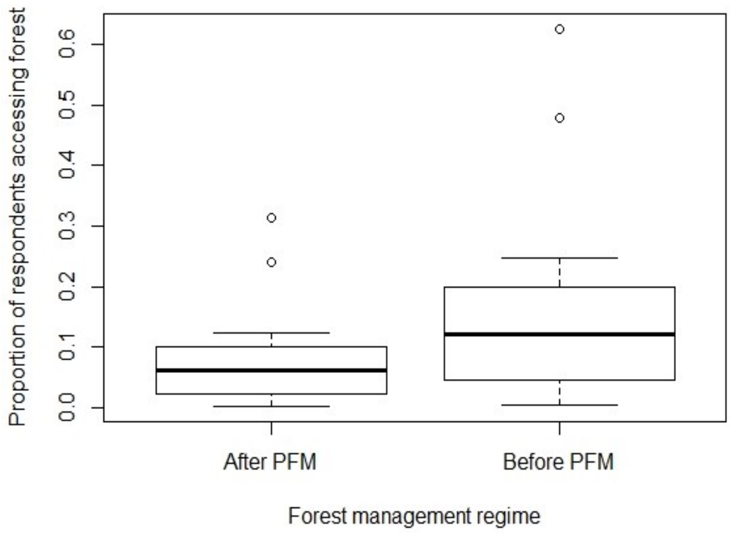

Fig. 4.3. Respondents' access to Mt. Kenya forest before and after PFM adoption.

In-depth interviews with key informants revealed that new regulations influenced forest access hence changes in forest products utilisation after PFM adoption. Additionally, coordinated collaboration efforts between KFS staff and CFA members increased capacity and monitoring activities with monitoring team(s) covering larger sections of the forest thus, making it possible to detect trespassers/illegal activities. For instance, perceived decline in forest products harvesting and illegal activities (e.g. charcoal production, timber harvesting) was attributed by respondents to coordinated monitoring and enforcement of rules between CFAs and KFS in some sites (e.g. Gathiuru, Kamulu, Embu, Kabaru); "*I only collect firewood on Tuesdays every week to last me a whole week… the youths patrol all forest beats and If they find you in the forest apart from Tuesdays, they will call the rangers and take you to court" (CFA female member).*

However, in-depth interviews with respondents revealed that perceived exorbitant charges levied on forest products by both KFS and CFAs after PFM adoption may have led to changes in forest utilisation patterns; "*I stopped going to the forest… I now get fodder from my own land or rent grazing land from neighbours… KFS charges Ksh. 50 and 20 per cow and sheep per month respectively, I have 6 cows and 9 sheep besides goats, where do I get all the money to pay*?" (Non-CFA male member).

This study established that a permit issued by KFS and CFAs upon payment of required charges was needed to access the forest to harvest permitted products or grazing of livestock (in some sites). Non-compliance leads to consequences as reported by respondents such as warnings, confiscation of livestock or harvested products and equipment (e.g. machete), sanctions and or harsh punishment such as being taken to court and auction of confiscated livestock. Fees for forest products are uniform across most CFA sites with KFS charging Ksh. 50, 20, 100 and 100 per month per cow, per sheep, bale of fodder and fuel wood per back/head load respectively (1 US$ = ~ Ksh. 100), while CFA levies for the same products differed among CFA sites. Additionally, PELIS plots where farming is currently permitted were charged at Ksh. 500 for half-acre farming plot with additional charges levied by CFAs. Water access for channelling water for irrigation and domestic use is charged by KFS if it occurs inside the forest, with many rivers and streams originating from and traversing the area (e.g. River Rupingazi, Thegu and Sagana) and providing water to local residents.

Fig.4.4. Cattle grazing in Mt. Kenya forest.

Qualitative data from in-depth interviews and focus group discussions (separate CFA and non-CFAs discussions) revealed hidden conflicts and resentment between CFA and non-CFA members over forest access for material benefits. Whereas permission was granted to both CFA and non-CFA members for forest product harvest upon payment of the required fees to KFS and CFAs (in some sites), informal rules could be applied to non-CFA members. Majority of non-CFA respondents reported that despite payment of permit for product harvest, they also paid extra amount of money inform of bribes to patrolling KFS rangers in order to be allowed to carry or transport harvested products from the forest; "*I don't know anybody in this village who has never paid a bribe to …but it is even worse if you are not a CFA member because non-CFA members are blamed for illegal logging in this area* (non-CFA male member).

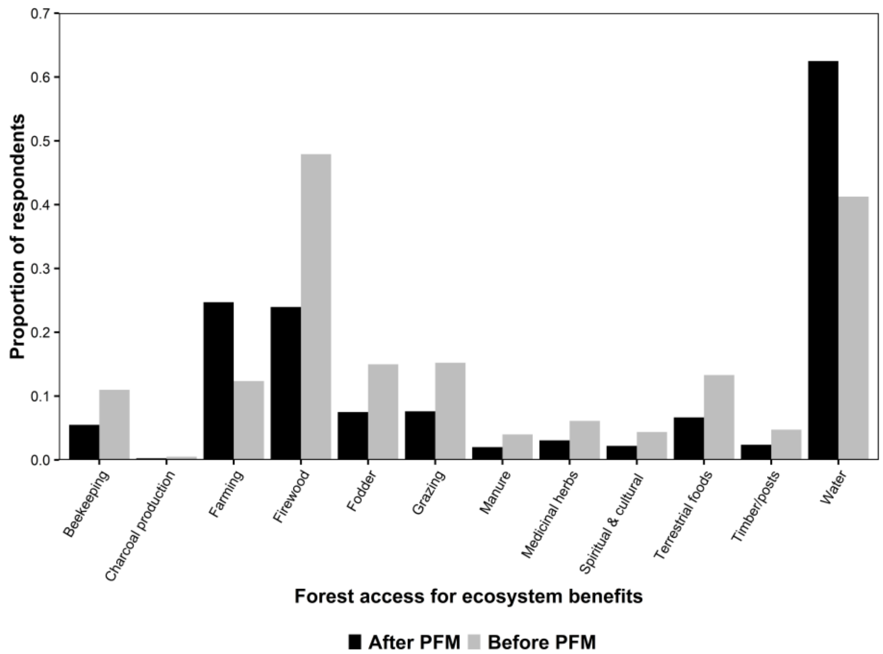

Fig. 4.5. Respondents' forest products utilisation patterns before and after PFM implementation.

Additionally, special treatment accorded to CFA members such as bereaved CFA member households being exempted from fees payment especially on fuelwood collection was perceived to be unfair by majority of interviewed non-CFA respondents. For instance, according to respondents, verbal permission granted to bereaved CFA member families by CFA officials was sufficient to allow collection of fuel wood from the forest. On the contrary, bereaved families of non-CFA members needed permission and introductory letter(s) from the national administration — the village Chief — but this still did not guarantee permission for fuel wood collection by non-CFA member households; "*I went to CFA office and the Secretary told me to get a letter from Chief… I brought the letter back to the office and was told to wait for Chairman's* *approval… I called and even made visits to the office but no positive response*. *I ended up getting firewood from elsewhere" (Non-CFA male member).*

Fig. 4.6. Fuel wood collection in Mt. Kenya forest.

Further, local traditions often requires community members to show support, empathy and compassion to bereaved families, with support expected from members in the same village/community — in this case, CFA and non-CFA members residing in the same village. As a result, non-CFA respondents suspect that they have been discriminated even in circumstances beyond membership affiliation where support and compassion is most needed.

Similar discriminatory sentiments were echoed by majority of non-CFA respondents interviewed, who also claimed to receive greater punishment for illegal activities and minor rule breaking (e.g. exceeding harvesting frequency or load size, use of unauthorised mode of transportation,) compared to CFA members. This was corroborated through in-depth interviews with CFAs respondents and officials affirming that first time offenders belonging to CFAs membership were first given warning(s) before any further measures were taken e.g. sanctions or being taken to court. Furthermore, both CFA and non-CFA respondents blamed each other for illegal activities and forest destruction but this study found that although both groups engaged in illegal activities (particularly in some sites such as Chuka, Chogoria, Irangi), CFA members were more privileged in accessing information and thus had less chance of being caught. (unlike non-CFA members). This is because some CFA members close to officials were privy to CFAs activities and operations (e.g. patrol and monitoring) unlike non-CFA members. This was corroborated by a CFA member who alluded to being acquainted with CFA classified information and hence avoided being in the forest during such operations; "*I am now constructing this house and I got all these logs from the forest (respondent pointing to logs in his* *compound) …I cannot buy these from the market when the forest is just here… I know everything planned by CFA*" (CFA male member).

Moreover, CFA members were more knowledgeable on forest conservation issues and aware of their rights especially on forest access and other bundle of rights — enshrined in the Forest Act (GoK, 2005; 2016). Consequently, they were well informed of rules and regulations governing conservation of the forest compared to non-CFA members. Greater awareness of forest rules and rights was attributed to both formal and informal trainings for CFA members facilitated by KFS and external partners (e.g. NGO's, donors) on forest conservation and related issues as well as members' involvement in crafting their CFA by-laws; "*when we started, we were trained by Green Belt Movement – GBM*[36] *— on the new Forest Act and over the years, I have attended many trainings … I now know the importance of this forest and my rights*" (CFA female member). It is through these trainings that CFA members have been empowered and internalised their bundles of rights as well as being knowledgeable on benefits prohibited and allowed. Lack of knowledge and understanding of benefits and rights permitted through the Forest Act is the driving force behind rights infringement and bribes payment especially by non-CFA members; "*I used to pray in the forest before PFM… but now I no longer go there because I would get stopped and harassed by the rangers… sometimes I would give them something small to let me go"* (non-CFA male member). This is despite the fact that KFS does not charge individuals or groups for using the forest for cultural and religious/spiritual activities. Another respondent added; "*I just see the forest from far… I cannot go for leisure activities in the forest like walks, picnics… because I will be arrested for trespassing, yet the government gave us this forest"* (non-CFA male member).

Qualitative data from semi-structured interviews and focus group discussions revealed that significant decline in the proportion of respondents accessing the forest after PFM adoption. This was also corroborated through quantitative data (*Fig. 4.3*) and could be attributed to a combination of factors. Firstly, regulations, CFA by-laws and strict enforcement to support sustainable harvesting of forest products (e.g. frequency of harvesting, load size, transportation mode and permit payment). This is enforced through increased capacity in monitoring activities regulating forest access and harvests. As a result, only permit holders can

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[36] Green Belt Movement (GBM) is a local NGO founded in 1977 by the late Nobel laureate, Professor Wangari Maathai that empowers communities, particularly women, to conserve the environment and improve livelihoods.

access the forest with non-permit holders treated as trespassers; "*Anyone found in the forest without a permit is a trespasser and liable to punishment/charges*" (KFS ranger).

Secondly, instant punishment meted by KFS staff (e.g. beatings, bribes/fines, confiscation of livestock, forest products and equipment) to rule breakers was reported —by both KFS staff and respondents — as successful in deterring repeat offenders. KFS rangers reported to preferring instant punishment because of convenience relative to taking trespassers to court; preserving exhibits and prolonged court process mostly abused by offenders through low bail terms. Instant punishment meted to trespassers seem to have worked as majority of interviewed respondents especially women reported to paying for the permit rather than risking their machetes being confiscated, yet, were more expensive compared to permit fees.

Fig. 4.7. Livestock confiscated for non-payment of grazing fee.

Thirdly, only women were allowed to carry machetes and axes in majority of CFAs sites, as men were perceived to engage in illegal activities such as timber harvesting. Consequently, only women could carry out activities requiring use of such equipment unlike in the past (before PFM). Additionally, fencing of the forest in many forest blocks regulate access points to the forest with KFS guards stationed at permitted entry gates, with unauthorised entry liable to prosecution.

4.4.4. Respondents' desired future scenario for participatory forest management (PFM)

Focus group discussions and in-depth interviews revealed contrasts between CFA and non-CFA respondents on desired future scenarios for participatory forest management (PFM). Majority of CFA member respondents participating in PFM attributed better forest conditions and increased forest cover to CFA's involvement and active participation in forest conservation. Thus, members desired continuity of PFM over the long-term to ensure better forest management, increased forest cover, improved livelihoods as well as strengthening and maintenance of social benefits arising from participation in PFM; strong bonding and relationships, knowledge sharing, sense of belonging, forest ownership; confidence, security and feelings of satisfaction. However, respondents alluded to fears of losing their new acquired livelihoods attributed to short-term nature of material benefits in particular PELIS perceived by majority of respondents as most beneficial and important to their well-being. PELIS was closely linked by respondents to food security, increased incomes and improved standards of living, and farming land in an area synonymous with small landholdings and land scarcity. These fears were corroborated by a KFS forest station manager who pointed out that, although PELIS benefits were felt within the locality and far way (e.g. new markets, employment, retail and transportation opportunities, improved infrastructure), PFM and in particular PELIS was unsustainable in the long-term and gains made over the years could be reversed once planting of clear-felled plantations was completed and rehabilitation of degraded forest land finalised; "*madam, this programme is not sustainable because once rehabilitation is finalised, community members will lose farming land and they will start engaging in illegal activities as they are now used to getting money from PELIS*".

Fig. 4.8. Bags of potatoes from PELIS programme ready for transportation to markets.

CFA members suggested recommendations which will ensure continuous trickling of benefits to communities; increased farming period from the current three years to five years; provision of more land for farming to meet high demand, and implementation of benefit sharing mechanisms[37] between community and government. Further, respondents recommended scrapping of forest products taxation fees to allow free access to permitted benefits as an incentive for many man-hours spent in conservation activities.

Non-CFA respondents and some key informants on the other hand recommended an immediate end to the PFM programme, both in Mt. Kenya forest and the country at large, blaming the programme especially PELIS — farming in the forest — on prolonged and current drought witnessed in the country including Mt. Kenya forest and its environs (delayed short rains expected in October 2016 during data collection); "*Madam….just look outside and see the clear skies… it is now November and there is not a single drop of rain in this area*" *(Chief - National Administration representative).* Furthermore, PELIS was blamed by non-CFA respondents and some key informants for declining forest cover, loss of indigenous tree species, low levels/volumes of water, dry river beds, soil erosion, declining water quality and frequent water related diseases in the villages. These impacts were attributed to PELIS activities through illegal cutting of indigenous trees, encroachment for land expansion for farming (including in the river banks), over-use of agricultural inputs (e.g. pesticides), water abstraction and over-irrigation in planted farms. One respondent summed up the nature of forest destruction attributed to PELIS activities; "*If we go inside this forest, we can even play football match, the soil is bare, the forest is bald…there are no trees…they cut them down to do farming*" (Non-CFA male respondent).

An illustration of the deep resentment between CFA and non-CFA respondents was the accusation of PELIS for degenerating social values and cohesion that bind family's and society together, with non-CFA respondents attributing prolonged periods spent away in the forest to broken families. Although this was not part of the study objectives, societal values came out strongly during focus group discussions and in-depth interviews. Furthermore, participant observation during data collection showed that temporary shelters were constructed in the forest by CFA members due to long periods spent tending their farms during the day and also protecting their farms from human-wildlife conflict at night.

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[37] Although the Forest Act 2005 recommended formulation of guidelines on incentives and benefit sharing between the government and communities, bill to legalise implementation of the same has been delayed.

Fig. 4.9. Temporary shelter constructed inside Mt. Kenya forest.

4.5. Discussion

Assessing social values of ecosystem services that local communities hold has enabled comprehensive understanding of different types of ecosystem services provided through CBFM. Both monetary and non-monetary benefits are important in fulfilling livelihood needs and well-being of local communities, supporting other previous studies (Summers et al., 2012; Ahammad et al., 2019). This research shows the importance of assessing ecosystem services by incorporating communities' perceptions which captured intangible benefits excluded from conventional markets (Ninan & Inoue, 2013) and in previous studies. Different social groups including; CFA and non-CFA respondents, females and males revealed contrasting preferences for ecosystem services, shedding light on perceptions that different groups place on different ecosystem services. Thus, study findings support planning and decision making process to effectively deliver ecosystem service priorities for conservation and target beneficiaries needs.

Study findings show that Mt. Kenya forest provides a wide range of ecosystem services that are inextricably linked to the well-being of respondents. The forest provides provisioning, regulating and cultural services, with provisioning and regulating services being most preferred by respondents. These findings support previous studies showing society's preference for provisioning services, followed by regulating services (e.g. Rodríguez et al., 2006; Tibor et al., 2013). As demonstrated by Defries et al., (2004), society's preference for ecosystem services follows a hierarchical rung focusing first on provisioning services, followed by regulating, cultural and supporting services which is linked to human short-term needs. Preferences differed amongst social groups and were influenced by socio-demographic factors including CFA membership, age, gender and education level, with CFA membership contributing the most to variation in ecosystem service preferences. CFA respondents preferred mostly provisioning services, i.e. tangible material benefits such as PELIS, fodder as important for their well-being, which could directly or indirectly be converted into cash income in nearby and far markets (e.g. sale of dairy products, food crops). Economic incentives and returns is a strong motivating factor for community participation in conservation initiatives (Kellert et al., 2000; Brooks et al., 2013) and CFA respondents preferred tangible benefits linked to satisfaction of immediate needs and generation of cash income. On the other hand, non-CFA respondents preferred mainly regulating (e.g. rainfall attraction, soil erosion control, climate regulation) and a few provisioning services (water, fuel wood) linked to their immediate needs and main economic activity i.e. agriculture. They rely largely on rain-fed agriculture compared to CFA respondents who can easily access water for irrigation from rivers through water abstraction permits granted for PELIS activities. Maass et al., (2005) in a study of tropical forest values reported similar findings where respondents acknowledged first services supporting their main economic activities; farmers perceived soil fertility maintenance, pollination and flood control; tourism operators perceived scenic beauty as important values; while landless locals perceived employment opportunity in the tropical forest.

Provisioning services are and will remain crucial for local communities in sub-Saharan Africa (*see* Suich et al., 2015) owing to their clear association in supporting livelihoods especially in rural households. Provisioning services mostly used by majority of respondents, both CFA and non-CFAs respondents include; fuel wood, fodder/grazing and water provision. These findings support Vedeld et al., (2007) in a meta-analysis of 51 case studies from 17 developing countries showing that local communities are highly dependent on forest resources mainly fuelwood and fodder for both subsistence use and cash income. Fuel wood provides a significant bulk of energy consumption in rural areas of sub-Saharan Africa (Word Bank, 2011), with approximately 71% of Kenya’s rural population relying on fuel wood and charcoal as a source of energy (Mahiri & Howorth, 2001). High fuel preferences and similarities between CFA and non-CFA respondents shows the importance and high dependence of the forest as a source of fuel wood for energy requirements (e.g. cooking, lighting, boiling and house heating) occasioned by limited alternatives and small land holdings. These findings support similar studies showing that fuel wood is the most harvested forest product by local communities in Tanzania and Ethiopia (Jew et al., 2019; Asfaw et al., 2013). For instance Asfaw et al., showed that fuel wood was the most used product from joint managed forest in Ethiopia and constituted the largest proportion (79%) of total forest income. Preferences for fuel wood by females in the study findings could be attributed to by-laws authorising only women to carry machetes inside the forest (majority of CFA sites) and also African traditional gendered roles where women and girls are responsible for most domestic chores such as fuel wood collection, fetching water and cooking (Blackden & Wodon, 2006).

Forests provide fodder and grazing land for livestock production which is an important socio-economic activity for communities residing near Mt. Kenya forest and other rural areas in Kenya. Langat et al., (2016) for instance, showed that majority of households approximately 66.8% relied on Mau forest in Kenya as a source of fodder for their livestock, with fodder harvested contributing a monetary value of between Ksh.11,983 to 17,974 (US$ 133 — 200) per household per year. Similarly, in Nepal, fodder was the most harvested NTFP, with a monetary value of US$ 2,194 per year and contributing majority share of total forest benefits, approximately 42.91% to local communities (Anup, Koirala, & Adhikari, 2015). In Mt. Kenya forest, livestock production supports livelihoods and well-being of local communities through consumption and sale of dairy products such as milk to local processing dairies. Significant differences between CFA and non-CFA respondents in fodder preferences could be attributed to taxation levies charged on fodder and grazing per head cow and sheep, and perceived exorbitant by majority of non-CFA respondents. While CFA members have other sources of forest income e.g. PELIS, fuel wood, tree seedlings/saplings which could be used to offset taxation fees for fodder, non-CFA respondents relied on their own sources of income. Thus, seeking alternative sources either from own land or leasing cheaper grazing land from neighbours.

Water is an integral part of human life and Mt. Kenya forest is an important source of water for local communities living in close proximity. The forest provides abundant supply and access to clean water, thus partially fulfilling sustainable development goal six and fundamental human right: "access to clean, safe, reliable and secure water" (UN General Assembly, 2015). Majority of respondents both CFA and non-CFAs ranked water highly and important for their well-being with water being used for domestic and agricultural activities. Significant differences in water preference rankings between CFA and non-CFA respondents could be attributed to PELIS activities carried out in the forest, thereby reducing water access and undermining capacity of other users in carrying out their day-to-day activities. In-depth interviews revealed high water preference by non-CFA respondents is attributed to limited access to the commodity vital for their daily activities and well-being. Water abstraction permits granted to CFA members allows unlimited water access and withdrawal from river sources through water abstraction and diversion using pipes and channels directed to farms. Water abstraction permits are issued on the basis that water is used to water tree seedlings and young saplings planted through PELIS although much more water is used for planted crops. Consequently, large uptake of irrigation water from river sources has interrupted natural flow and normal water supply leading to reduced water levels and scarcity.

Reduced water levels has caused simmering rows and tension among stakeholders with non-CFA respondents attributing dry taps, decreased water volumes and declining water quality to farming activities in the forest, as well as other users taking advantage of PELIS programme to divert water for commercial purposes e.g. water bottling. Conflicts and tensions arising from resource scarcity which affect people's ability to sustain their normal ways of life, livelihoods and hence well-being especially in developing countries are well documented (e.g. Camisani, 2018; Ide, 2015). In Mt. Kenya forest, increased tension due to water scarcity and rationing led to cancellation of water abstraction permits (*see* Mungai, 2018) in order to develop an integrated water master plan incorporating all stakeholders and prevent escalation of water conflicts in future.

Significant differences between CFA and non-CFA respondents in PELIS preferences is attributed to the exclusive nature of the benefit conferred to CFA members only. However, this study established that non-CFA members can also benefit albeit illegally by leasing PELIS plots from CFA members or CFA officials (some sites) upon payment of 'rental' fees ranging from Ksh. 20,000 to 40,000 (1US$ = ~ Ksh. 100). There is notable evidence that PELIS programme plays a major role in forest conservation and supporting household's well-being through increased food production, security and household incomes amongst beneficiaries of PELIS plots. This scheme is similar to previous banned '*shamba*' system practised in early 80's and 90's in forests in Kenya where locals were allowed to practise agroforestry in degraded forest lands and grow own crops for a limited period (Oduol, 1986; GoK, 1994). PELIS provides improved crop yields compared to locals' own land and higher returns from sale of surplus crops attributed to high soil fertility, biomass content, ample rainfall and water availability inside the forest. Reed et al., (2017) in a review found that incorporating forests and trees within an appropriate natural resource management strategy such as PFM, has potential in maintaining and enhancing crop yields in comparison to monoculture systems.

PELIS contribution to increased income levels and purchasing power to both beneficiaries and other local communities has supported improved living standards evidenced through employment opportunities (e.g. weeding, harvesting, transportation), small-retail business, new and expanding markets, improved infrastructure, acquisition of durable assets, savings (e.g. *Chama*[38]) and food production and security, a fundamental measure of improved well-being (FAO, 2016). These findings support Ros-Tonen et al., (2013) showing that household income and food security for local communities in Ghana increased substantially attributed to agricultural produce from crop diversification and revenues of crops produced from modified *taungya* system — a collaborative forest management approach, similar to PELIS in Kenya. Food production is most significant for human well-being with increases in food production per capita corresponding to an increase in human well-being (Raudsepp-Hearne et al., 2010). However, sustainability of PELIS programme is uncertain due to short-term nature of benefits to respondents. For instance, short farming periods (three years maximum) and prolonged period plantations take to mature (approximately 20-30 years) before clear-felling is done could reverse gains already made in sustainable forest conservation.

Regulating services were also important in supporting livelihoods and well-being of local communities with rainfall attraction being most highly ranked followed by climate regulation. Additionally, preferences for regulating services (e.g. wildlife habitat, soil erosion control) were mostly associated with older males with higher level of formal education; above secondary school level attributed to higher level of understanding of forest ecological processes. Other studies report similar findings (e.g. Al-assaf et al., 2014; Aguado et al., 2018) where more educated respondents had a preference for regulating services. CFA respondents ranked regulating services lower (except pollination services) compared to non-CFA respondents despite reporting to have attended forest related trainings, and hence presumed to be more knowledgeable on linkages between regulating services, livelihoods and well-being. Non-CFA respondents' preference to regulating services particularly rainfall attraction could be attributed to lack of other sources for water to support agricultural activities, hence relying solely on rain–fed agriculture in comparison to CFA respondents.

Although pollination services were ranked as having little importance to respondent's well-being, there were significant differences between CFA and non-CFA respondents. Preference to pollination services among CFA's respondents is attributed to promotion of bee keeping as an incentive for participation and livelihood diversification in PFM, coupled with

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[38] Chama is an informal table banking, saving and revolving fund practised by majority of respondents interviewed and Kenyans' in general.

extensive support accorded to modern bee keeping by external stakeholders e.g. donors, NGOs in the area. Beekeeping was associated with older CFA male respondents who were knowledgeable on beekeeping and its links with crop production through pollination services. Preferences by older males is attributed to past lifestyle patterns and traditional ecological knowledge (TEK) commonly entrenched amongst the elderly compared to younger generation (Boafo et al., 2016; Gómez-Baggethun et al., 2010). Although TEK has been displaced by modernization processes and western education, it should be considered in forest conservation as areas with beehives in the forest were found with no signs of illegal activities. Study revealed that locals held common belief that a curse might befall someone destroying areas dedicated for beekeeping activities. Many studies show the importance of TEK in biodiversity conservation (e.g. Paneque-Ga´lvez et al., 2018) and when incorporated with current conservation practices, can promote efficient biodiversity conservation.

Significant changes in forest product utilisation patterns before and after PFM adoption is an indication that PFM formalised forest access and products harvest. The proportion of respondents accessing the forest for crucial ecosystem services such as fuel wood and grazing land declined after PFM adoption attributed to increased capacity in regular monitoring (some sites), rule enforcement and taxation of livelihood enhancing products perceived exorbitant by mostly non-CFA respondents. Forests provide a bulk of basic commodities vital for the well-being of many rural households in Africa e.g. fuel wood (Word Bank, 2011; Mahiri & Howorth, 2001), and despite limited options (e.g. electricity, gas) and high poverty levels synonymous with Kenya's rural areas (Hope, 2010) such as within Mt. Kenya environs, where land for own production is also extremely scarce (Emerton, 1996), imposition of taxation fees to subsistence forest products critical to the well-being of forest-dependent communities is a major setback on poverty reduction agenda and realisation of global development goals (SDGs) especially SDG number one — No poverty (UN General Assembly, 2015). Similar to the findings of this study, Chomba et al., (2015) in a study in Ngare Ndare forest found that taxation of livelihood-enhancing forest products had increased vulnerability of disadvantaged groups. This is in contrast to countries such as Nepal where local communities participating in CBFM extensively utilise forests for subsistence products with no cost to communities (Mehta & Heinen, 2001). Thus, PFM in Kenya has restricted access to important benefits through product harvest fees and permits, which might affect vulnerable groups especially poor households dependent on the forest for their well-being.

Forest products taxation could also pose potential health risks (e.g. food and nutrition insecurity, improperly cooked foods) especially to poor households through dietary choices and cooking practices. Sola et al., (2016) for instance demonstrated that communities' substitute foods with high nutritious value which have higher fuel demand e.g. beans, to alternative faster-cooking foods which may have poorer nutritional balance. Additionally, other components of community's well-being (e.g. education, food) may be negatively affected as funds meant for food are diverted to fuelwood needs/purchase. This is because poor households tend to spend a larger percentage of their income on energy than well-off households (Rehfuess & WHO., 2006; Sola et al., (2016).

Divergent views on preferred future scenario for PFM programme between CFA and non-CFA respondents is an indication of divergent interests that arise among stakeholders and social groups in common pool resources. Although CFA is a voluntary grassroot conservation initiative, non-CFA respondents held views that PFM does not incorporate their local needs and demands, and these perceptions could trigger conflicts among communities and between communities and staff of state agencies such as KFS. Water shortages and reduced volumes in rivers occasioned by CFAs activities seems be the major bone of contention affecting the capacity of other stakeholders such as non-CFA respondents in undertaking livelihood activities linked to their well-being. Threats to local livelihoods can trigger resentment and conflicts where those who are negatively impacted may mobilise themselves and oppose activities undermining their livelihood strategies and resources (e.g. Navas et al., 2018; Ohlsson, 2000). Prolonged and frequent conflicts could jeopardise conservation initiatives thus affecting achievement of conservation objectives, and institutions should aim at bringing warring factions together to resolve conflicts by striking a balance between conflicting interests (Paavola, 2007). In Mt. Kenya forest, proposed integrated water master plan for the region will incorporate divergent interests of different stakeholders thus minimise threats to conservation efforts.

4.5.1. Conclusion

Community based forest management in Mt. Kenya forest has contributed to important ecosystem services and associated benefits vital for the well-being of local communities. This study has identified provisioning, regulating and cultural services as important for communities' livelihoods and well-being and shed light on contrasting preferences amongst social groups in the communities. For instance, CFAs respondents preferred provisioning services while non-CFA respondents preferred regulating services. These divergent preferences are linked to production and sustenance of livelihoods important for the groups. Study findings support decision making to devise mechanisms to integrate divergent interests of different stakeholders to deliver ecosystem services to targeted beneficiaries and thus mitigate conflicts and tensions, which often emanate from different interests of stakeholders.

In many ecosystem service assessments, economic valuation has dominated ecosystem service assessments but often fail to capture full array of ecosystem services important for communities' well-being. This has witnessed formulation of decisions targeted at conservation of a single ecosystem service; provisioning, which could undermine conservation and flow of other services such as regulating and cultural services, thus affecting conservation and well-being of local communities. Carefully designed socio-cultural assessments of ecosystem services incorporating local communities in identification of key services supporting their well-being can reveal important ecosystem services that are not captured in existing legal frameworks, thus promote deep understanding of the complex socio-ecological systems. This study contributes to the importance of incorporating social dimension of ecosystem services using non-economic valuation approaches such as social-cultural valuation and promotes a deep understanding of ecosystem services and contrasting perceptions of different social groups for better decision making.

1.7. Appendix 4

Table 1A. Summary of variables obtained from survey and used in the different statistical analyses. Tick √ - indicates the variables used in each statistical analysis (note: CCA: Canonical Correspondence Analysis; M-W: Mann-Whitney

Variables	Type	Description	Descriptive stats (Mean score)	CCA	M-W
Socio-economic variables					
Age	Categorical	Respondents age categorised into categories Mid aged = < 55 years[39] Retired = > 55 years		√	
Gender	Binary	Male and female		√	
Education level	Categorical	Formal education level attained; < primary level = 1; > secondary level =2		√	
Household income	Categorical	Household income earned for the past one year Low income = below average income; < 204,286; high income = above average income > 204,286			
CFA membership	Binary	Voluntary CFA membership; No = 0; Yes = 1	√	√	√
Ecosystem services valuation					
Air purification	Ordinal	1-4 with 1st ranked ES assigned more weight = 4	√	√	
Bee keeping	Ordinal	1-4	√	√	
Climate regulation	Ordinal	1-4	√	√	
Cultural value	Ordinal	1-4	√	√	
Env. education[40]	Ordinal	1-4	√	√	
Fishing	Ordinal	1-4	√	√	
Fodder & grazing	Ordinal	1-4	√	√	
Herbal medicine	Ordinal	1-4	√	√	
Manure	Ordinal	1-4	√	√	
PELIS plot/farming	Ordinal	1-4	√	√	
Pollination	Ordinal	1-4	√	√	
Timber	Ordinal	1-4	√	√	
Rainfall attraction	Ordinal	1-4	√	√	
Spiritual values	Ordinal	1-4	√	√	
Scenic beauty	Ordinal	1-4	√	√	
Seed bank	Ordinal	1-4	√	√	√
Soil erosion control	Ordinal	1-4	√	√	√
Tourism attraction	Ordinal	1-4	√	√	
Water provision	Ordinal	1-4	√	√	
Wild foods	Ordinal	1-4	√	√	
Wildlife habitat	Ordinal	1-4	√	√	
Wood fuel	Ordinal	1-4	√	√	√
Ecosystem service categories					
Provisioning Regulating Cultural	Category of ecosystem service perceived as important by respondent		Kruskal-Wallis test followed by post hoc Dunn's test		

[39] Minimum age of respondents was 21 years
[40] Env. education = Environmental education

Table A2. Results of canonical correspondence analysis constraining ecosystem service preferences (Axis 1 and 2 scores - dependent variables) with social-demographic factors (explanatory variables)

Ecosystem services	**Axis 1**	**Axis 2**
Dependent variables (ecosystem services)		
Cultural services		
Cultural value & identity	0.459	- 0.123
Environmental education	- 0.316	0.309
Spiritual values	0.693	- 0.606
Scenic beauty	0.430	0.058
Tourism attraction	- 0.103	- 0.144
Provisioning services		
Bee keeping	- 0.425	- 0.721
Fishing	0.405	- 0.475
Fodder/grazing	- 0.311	- 0.033
Herbal medicine	- 0.223	0.104
Manure	- 0.539	- 0.167
PELIS (farming)	- 0.808	0.000
Posts/timber	0.618	- 0.221
Seed bank	- 0.481	- 0.116
Water provision	0.168	0.033
Wild terrestrial foods	0.239	0.653
Wood fuel	- 0.044	0.131
Regulating services		
Air purification	0.216	- 0.077
Climate regulation	0.583	0.045
Pollination	- 0.263	- 0.034
Rainfall attraction	0.324	- 0.006
Soil erosion control	0.700	- 0.123
Wildlife habitat	0.295	- 0.114
Explanatory variables		
CFA members	- 0.957	- 0.102
Non-CFA members	0.986	0.105
Female	- 0.230	0.875
Male	0.184	- 0.701
Mid aged (< 55yrs)	- 0.161	0.428
Retired (> 55yrs)	0.282	- 0.749
Primary level	- 0.118	0.238
Above secondary level	0.196	- 0.393
High household income (>Ksh. 204,286)	- 0.162	- 0.207
Low household income (< Ksh. 204,286)	0.085	0.108
Eigenvalue	0.129	0.022
% of variance explained	73.77	12.72
Cumulative % of variance explained	73.77	86.49

References

Adams, C., Rodrigues, T. S., Calmon, M., & Kumar, C. (2016). Impacts of large-scale forest restoration on socioeconomic status and local livelihoods: what we know and do not know. *Biotropica*, *48*(6), 731–744.

Aguado, M., González, A. J., Bellott, K., López-Santiago, C., & Montes, C. (2018). Exploring subjective well-being and ecosystem services perception along a rural–urban gradient in the high Andes of Ecuador. *Ecosystem Services*, *34*, 1–10. https://doi.org/10.1016/j.ecoser.2018.09.002

Ahammad, R., Stacey, N., & Sunderland, C. H. T. (2019). Use and perceived importance of forest ecosystem services in rural livelihoods of Chittagong Hill Tracts, Bangladesh. *Ecosystem Services*, *35*, 87–98. https://doi.org/10.1016/j.ecoser.2018.11.009

Al-assaf, A., Nawash, O., & Omari, M. (2014). Identifying forest ecosystem services through socio-ecological bundles: A case study from northern Jordan. *International Journal of Sustainable Development and World Ecology*, *21*(4), 314–321. https://doi.org/10.1080/13504509.2014.919968

Alpízar, F., Carlsson, F., & Martinsson, P. (2001). Using choice experiments for non-market valuation. *Economic Issues*, *8*, 83–110.

Ameha, A., Nielsen, O. J., & Larsen, H. O. (2014). Impacts of access and benefit sharing on livelihoods and forest: Case of participatory forest management in Ethiopia. *Ecological Economics*, *97*, 162–171. https://doi.org/10.1016/j.ecolecon.2013.11.011

Anup, C. K., Koirala, I., & Adhikari, N. (2015). Cost-benefit analysis of a community forest in Nepal. *Journal of Sustainable Forestry*, *34*(3), 199–213. https://doi.org/10.1080/10549811.2014.1003074

Asah, T. S., Guerry, D. A., Blahna, J. D., & Lawler, J. J. (2014). Perception, acquisition and use of ecosystem services: Human behavior, and ecosystem management and policy implications. *Ecosystem Services*, *10*, 180–186. https://doi.org/10.1016/j.ecoser.2014.08.003

Asfaw, A., Lemenih, M., Kassa, H., & Ewnetu, Z. (2013). Importance, determinants and gender dimensions of forest income in eastern highlands of Ethiopia: The case of communities around Jelo Afromontane forest. *Forest Policy and Economics*, *28*, 1–7. https://doi.org/10.1016/j.forpol.2013.01.005

Birch, J. C., Thapa, I., Balmford, A., Bradbury, R. B., Brown, C., Butchart, S. H. M., … Thomas, D. H. L. (2014). What benefits do community forests provide, and to whom? A rapid assessment of ecosystem services from a Himalayan forest, Nepal. *Ecosystem Services*, *8*, 118–127. https://doi.org/10.1016/j.ecoser.2014.03.005

Blackden, C. M., & Wodon, Q. (eds. . (2006). *Gender, time use, and poverty in Sub-Saharan Africa. World Bank working paper* (No. 73). Washington, D.C.

Boafo, Y. A., Saito, O., Kato, S., Kamiyama, C., Takeuchi, K., & Nakahara, M. (2016). The role of traditional ecological knowledge in ecosystem services management: The case of four rural communities in Northern Ghana. *International Journal of Biodiversity Science, Ecosystem Services and Management*, *12*(1–2), 24–38. https://doi.org/10.1080/21513732.2015.1124454

Bradshaw, J. A. C., Sodhi, S. N., Peh, S. H. K., & Brook, W. B. (2007). Global evidence that deforestation amplifies flood risk and severity in the developing world. *Global Change Biology*, *13*, 2379–2395. https://doi.org/10.1111/j.1365-2486.2007.01446.x

Brooks, J., Waylen, K. A., & Mulder, M. B. (2013). Assessing community-based conservation projects: A systematic review and multilevel analysis of attitudinal, behavioral, ecological, and economic outcomes. *Environmental Evidence*, *2*(1), 1–34. https://doi.org/10.1186/2047-2382-2-2

Burkhard, B., De Groot, R., Costanza, R., Seppelt, R., Jørgensen, S. E., & Potschin, M. (2012). Solutions for sustaining natural capital and ecosystem services. *Ecological Indicators*, *21*, 1–6. https://doi.org/10.1016/j.ecolind.2012.03.008

Camisani, P. B. (2018). Sri Lanka: A political ecology of socio-environmental conflicts and development projects. *Sustainability Science*, *13*, 693–707. https://doi.org/10.1007/s11625-018-0544-7

Carlson, M. K., Curran, M. L., Asner, P. G., Pittman, A. M., Trigg, N. S., & Marion, J. A. (2013). Carbon emissions from forest conversion by Kalimantan oil palm plantations. *Nature Climate Change*, *3*, 283–287. https://doi.org/10.1038/nclimate1702

Chan, M. A. K., Guerry, D. A., Balvanera, P., Klain, S., Satterfield, T., Basurto, X., … Woodside, U. (2012). Where are cultural and social in ecosystem services? A framework for constructive engagement. *BioScience*, *62*(8), 744–756. https://doi.org/10.1525/bio.2012.62.8.7

Chomba, S., Treue, T., & Sinclair, F. (2015). The political economy of forest entitlements: Can community based forest management reduce vulnerability at the forest margin? *Forest Policy and Economics*, *58*, 37–46. https://doi.org/10.1016/j.forpol.2014.11.011

Corbera, E., Martin, A., Springate-Baginski, O., & Villaseñor, A. (2017). Sowing the seeds of sustainable rural livelihoods? An assessment of Participatory Forest Management through REDD+ in Tanzania.

Land Use Policy, (March), 1–14. https://doi.org/10.1016/j.landusepol.2017.09.037

Costanza, R., de Groot, R., Braat, L., Kubiszewski, I., Fioramonti, L., Sutton, P., … Grasso, M. (2017). Twenty years of ecosystem services: How far have we come and how far do we still need to go? *Ecosystem Services*, *28*, 1–16. https://doi.org/10.1016/j.ecoser.2017.09.008

Creswell, W. J. (2007). *Qualitative inquiry and research design: Choosing among five approaches* (2nd ed.). California, USA: SAGE Publications, Inc.

Cruz-Garcia, S. G., Sachet, E., Blundo-Canto, G., Vanegas, M., & Quintero, M. (2017). To what extent have the links between ecosystem services and human well-being been researched in Africa, Asia, and Latin America? *Ecosystem Services*, *25*, 201–212. https://doi.org/10.1016/j.ecoser.2017.04.005

Daw, T., Brown, K., Rosendo, S., & Pomeroy, R. (2011). Applying the ecosystem services concept to poverty alleviation: The need to disaggregate human well-being. *Environmental Conservation*, *38*(4), 370–379. https://doi.org/10.1017/S0376892911000506

Dawson, N., & Martin, A. (2015). Assessing the contribution of ecosystem services to human wellbeing: A disaggregated study in western Rwanda. *Ecological Economics*, *117*, 62–72. https://doi.org/10.1016/j.ecolecon.2015.06.018

de Groot, S. R., Wilson, A. M., & Boumans, M. J. R. (2002). A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecological Economics*, *41*, 393–408. https://doi.org/10.1016/S0921-8009(02)00089-7

Defries, R. S., Foley, J. A., & Asner, G. P. (2004). Balancing human needs and ecosystem function. *Frontiers in Ecology and the Environment*, *2*(5), 249–257.

Díaz, S., Demissew, S., Carabias, J., Joly, C., Lonsdale, M., Ash, N., … Zlatanova, D. (2015). The IPBES conceptual framework - connecting nature and people. *Current Opinion in Environmental Sustainability*, *14*, 1–16. https://doi.org/10.1016/j.cosust.2014.11.002

Dunn, O. J. (1961). Multiple comparisons among means. *Journal of the American Statistical Association*, *56*(293), 52–64. https://doi.org/10.1080/01621459.1961.10482090

Emerton, L. (1996). *Socio-economic survey recommendations for Mt. Kenya forest, project technical paper No. 10*. Nairobi, Kenya.

Emerton, L. (1997). *An economic assessment of Mt. Kenya forest: Conservation and management of indigenous forests*. Nairobi, Kenya.

FAO. (2014). *State of the world's forests*. Rome, Italy: Food and Agriculture Organisation.

FAO. (2016). *State of the world's forests*. Rome, Italy: Food and Agriculture Organisation.

Ferraro, P. J., Lawlor, K., Mullan, K. L., & Pattanayak, S. K. (2012). Forest figures: Ecosystem services valuation and policy evaluation in developing countries. *Review of Environmental Economics and Policy*, *6*(1), 20–44. https://doi.org/10.1093/reep/rer019

Folkersen, M. V. (2018). Ecosystem valuation: Changing discourse in a time of climate change. *Ecosystem Services*, *29*, 1–12. https://doi.org/10.1016/j.ecoser.2017.11.008

GoK. (1994). *Kenya forestry masterplan (KFMP)*. Nairobi, Kenya: Government Printer.

GoK. (2005). *Forests Act, 2005*. Nairobi, Kenya: Government Printer.

GoK. (2016). *The forest conservation and management Act*. Nairobi, Kenya: Government Printer.

Gómez-Baggethun, E., Mingorría, S., Reyes-García, V., Calvet, L., & Montes, C. (2010). Traditional ecological knowledge trends in the transition to a market economy: Empirical study in the Do˜nana natural areas. *Conservation Biology*, *24*(3), 721–729. https://doi.org/10.1111/j.1523-1739.2009.01401.x

Greenacre, M. (2007). *Interdisciplinary statistics: Correspondence analysis in practice* (Second edi). New York, USA: Taylor and Francis group.

Greenacre, M. (2010). Canonical correspondence analysis in social science research. In H. Locarek-Junge & C. Weihs (Eds.), *Classification as a tool for research: Studies in classification, data analysis, and knowledge organization* (pp. 279–286). Berlin, Heidelberg: Springer.

Guo, Z., Zhang, L., & Li, Y. (2010). Increased dependence of humans on ecosystem services and biodiversity. *PLoS ONE*, *5*(10). https://doi.org/10.1371/journal.pone.0013113

He, S., Gallagher, L., Su, Y., Wang, L., & Cheng, H. (2018). Identification and assessment of ecosystem services for protected area planning: A case in rural communities of Wuyishan national park pilot. *Ecosystem Services*, *31*, 169–180. https://doi.org/10.1016/j.ecoser.2018.04.001

Hope, K. R. (2010). Infrastructure constraints and development in Kenya. *Journal of Infrastructure Development*, *2*(2), 91–104. https://doi.org/10.1177/097493061100200201

Ide, T. (2015). Why do conflicts over scarce renewable resources turn violent? A qualitative comparative analysis. *Global Environmental Change*, *33*, 61–70. https://doi.org/10.1016/j.gloenvcha.2015.04.008

IPBES. (2019). The intergovernmental science-policy platform on biodiversity and ecosystem services (IPBES). Retrieved March 25, 2019, from https://www.ipbes.net/

Jew, E. K. K., Burdekin, O. J., Dougill, A. J., & Sallu, S. M. (2019). Rapid land use change threatens provisioning ecosystem services in miombo woodlands. *Natural Resources Forum*, *43*(1), 56–70. https://doi.org/10.1111/1477-8947.12167

Jorda-Capdevila, D., & Rodríguez-Labajos, B. (2015). An ecosystem service approach to understand conflicts on river flows: Local views on the Ter River (Catalonia). *Sustainability Science*, *10*, 463–477. https://doi.org/10.1007/s11625-014-0286-0

Karky, B. S., & Skutsch, M. (2010). The cost of carbon abatement through community forest management in Nepal Himalaya. *Ecological Economics*, *69*(3), 666–672. https://doi.org/10.1016/j.ecolecon.2009.10.004

Kellert, S. R. ., Mehta, J. N. ., Ebbin, S. A. ., & Lichtenfeld, L. L. (2000). Community natural resource management: Promise, rhetoric, and reality. *Society & Natural Resources*, *13*, 705–715. https://doi.org/10.1080/089419200750035575

Kenter, J. O., O'Brien, L., Hockley, N., Ravenscroft, N., Fazey, I., Irvine, K. N., … Williams, S. (2015). What are shared and social values of ecosystems? *Ecological Economics*, *111*, 86–99. https://doi.org/10.1016/j.ecolecon.2015.01.006

Lambrick, F. H., Brown, N. D., Lawrence, A., & Bebber, D. P. (2014). Effectiveness of community forestry in prey long forest, Cambodia. *Conservation Biology*, *28*(2), 372–381. https://doi.org/10.1111/cobi.12217

Langat, D. K., Maranga, E. K., Aboud, A. A., & Cheboiwo, J. K. (2016). Role of forest resources to local livelihoods: The case of East Mau forest ecosystem, Kenya. *International Journal of Forestry Research*, *2016*, 1–10. https://doi.org/10.1155/2016/4537354

Le, H. D., Smith, C., Herbohn, J., & Harrison, S. (2012). More than just trees: Assessing reforestation success in tropical developing countries. *Journal of Rural Studies*, *28*, 5–19. https://doi.org/10.1016/j.jrurstud.2011.07.006

Maass, J. M., Balvanera, P., Castillo, A., Daily, C. G., Mooney, A. H., Ehrlich, P., … Miranda, A. (2005). Maass 2005 Ecosystem services of tropical dry forests. Insights from long- term ecological and social research on the Pacific Coast of Mexico. *Ecology and Society*, *10(1):17*.

Mahiri, I., & Howorth, C. (2001). Twenty years of resolving the irresolvable: Approaches to the fuelwood problem in Kenya. *Land Degradation and Development*, *12*(3), 205–215. https://doi.org/10.1002/ldr.433

Martín-López, B., Iniesta-Arandia, I., García-Llorente, M., Palomo, I., Casado-Arzuaga, I., Del Amo, D. G., … Montes, C. (2012). Uncovering ecosystem service bundles through social preferences. *PLoS ONE*, *7*(6). https://doi.org/10.1371/journal.pone.0038970

McKim, A. C. (2017). The value of mixed methods research: A mixed methods study. *Journal of Mixed Methods Research*, *11*(2), 202–222. https://doi.org/10.1177/1558689815607096

Mehta, J. N., & Heinen, J. T. (2001). Does community-based conservation shape favorable attitudes among locals? An empirical study from Nepal. *Environmental Management*, *28*(2), 165–177. https://doi.org/10.1007/s002670010215

Millennium Ecosystem Assessment (MEA). (2005). *Ecosystems and human well-being: Synthesis*. Washington, D.C.: Island Press.

Miura, S., Amacher, M., Hofer, T., San-Miguel-Ayanz, J., Ernawati, & Thackway, R. (2015). Protective functions and ecosystem services of global forests in the past quarter-century. *Forest Ecology and Management*, *352*, 35–46. https://doi.org/10.1016/j.foreco.2015.03.039

Mungai, A. (2018, August 27). Irony of dry Mt. Kenya rivers despite rainfall. Retrieved February 14, 2019, from https://www.standardmedia.co.ke/article/2001293588/mt-kenya-rivers-run-dry-despite-rainfall

Mutune, J. M., & Lund, J. F. (2016). Unpacking the impacts of "participatory" forestry policies: Evidence from Kenya. *Forest Policy and Economics*, *69*, 45–52. https://doi.org/10.1016/j.forpol.2016.03.004

Navas, G., Mingorria, S., & González, B. A. (2018). Violence in environmental conflicts: the need for a multidimensional approach. *Sustainability Science*, *13*, 649–660. https://doi.org/10.1007/s11625-018-0551-8

Nielsen, M. R., & Treue, T. (2012). Hunting for the benefits of joint forest management in the Eastern Afromontane biodiversity hotspot: Effects on bushmeat hunters and wildlife in the Udzungwa Mountains. *World Development*, *40*(6), 1224–1239. https://doi.org/10.1016/j.worlddev.2011.11.009

Nieto-Romero, M., Oteros-Rozas, E., González, J. A., & Martín-López, B. (2014). Exploring the knowledge landscape of ecosystem services assessments in Mediterranean agroecosystems: Insights for future research. *Environmental Science and Policy*, *37*, 121–133. https://doi.org/10.1016/j.envsci.2013.09.003

Ninan, K. N., & Inoue, M. (2013). Valuing forest ecosystem services: What we know and what we don't. *Ecological Economics*, *93*, 137–149. https://doi.org/10.1016/j.ecolecon.2013.05.005

Novacek, M. J. (2008). Engaging the public in biodiversity issues. *Proceedings of the National Academy of Sciences*, *105*(Supplement 1), 11571–11578. https://doi.org/10.1073/pnas.0802599105

Oduol, P. A. (1986). The Shamba system: An indigenous system of food production from forest areas in Kenya. *Agroforestry Systems*, *4*, 365–3 73.

Ohlsson, L. (2000). *Livelihood Conflicts - Linking poverty and environment as causes of conflict*. Stockholm, Sweden: Sida.

Olander, L. P., Johnston, R. J., Tallis, H., Kagan, J., Maguire, L. A., Polasky, S., … Palmer, M. (2018). Benefit relevant indicators: Ecosystem services measures that link ecological and social outcomes. *Ecological Indicators*, *85*(June 2017), 1262–1272. https://doi.org/10.1016/j.ecolind.2017.12.001

Paavola, J. (2007). Institutions and environmental governance: A reconceptualization. *Ecological Economics*, *63*(1), 93–103. https://doi.org/10.1016/j.ecolecon.2006.09.026

Paneque-Ga´lvez, Jaime Pe´rez-Llorente, I., Luz, A. C., Gue`ze, M., Mas, J.-F., Macı´a, J. M., & Orta-Martınez, Martı´ Reyes-Garcı´a, V. (2018). High overlap between traditional ecological knowledge and forest conservation found in the Bolivian Amazon. *Ambio*, *47*, 908–923. https://doi.org/10.1007/s13280-018-1040-0

Parajuli, R., Lamichhane, D., & Joshi, O. (2015). Does Nepal's community forestry program improve the rural household economy? A cost–benefit analysis of community forestry user groups in Kaski and Syangja districts of Nepal. *Journal of Forest Research*, *20*(6), 475–483. https://doi.org/10.1007/s10310-015-0501-6

Patton, M. Q. (2002). *Qualitative evaluation and research methods* (3rd ed.). California, USA: SAGE Publications.

Paudyal, K., Baral, H., Burkhard, B., Bhandari, S. P., & Keenan, R. J. (2015). Participatory assessment and mapping of ecosystem services in a data-poor region: Case study of community-managed forests in central Nepal. *Ecosystem Services*, *13*, 81–92. https://doi.org/10.1016/j.ecoser.2015.01.007

Paudyal, K., Baral, H., Lowell, K., & Keenan, R. J. (2017). Ecosystem services from community-based forestry in Nepal: Realising local and global benefits. *Land Use Policy*, *63*, 342–355. https://doi.org/10.1016/j.landusepol.2017.01.046

Queiroz, L. de S., Rossi, S., Calvet-Mir, L., Ruiz-Mallén, I., García-Betorz, S., Salvà-Prat, J., & Meireles, A. J. de A. (2017). Neglected ecosystem services: Highlighting the socio-cultural perception of mangroves in decision-making processes. *Ecosystem Services*, *26*, 137–145. https://doi.org/10.1016/j.ecoser.2017.06.013

Quintas-Soriano, C., Brandt, S. J., Running, K., Baxter, V. C., Gibson, M. D., Narducci, J., & Castro, J. A. (2018). Social-ecological systems influence ecosystem service perception: A programme on ecosystem change and society (PECS) analysis. *Ecology and Society*, *23(3):3*. https://doi.org/10.5751/ES-10226-230303

R Core Team. (2018). *R: A language and environment for statistical computing.* Vienna, Austria: R Foundation for Statistical Computing. Retrieved from https://www.r-project.org/

Rasmussen, L. V., Watkins, C., & Agrawal, A. (2017). Forest contributions to livelihoods in changing agriculture-forest landscapes. *Forest Policy and Economics*, *84*, 1–8. https://doi.org/10.1016/j.forpol.2017.04.010

Raudsepp-Hearne, C., Peterson, G. D., Tengö, M., Bennett, E. M., Holland, T., Benessaiah, K., … Pfeifer, L. (2010). Untangling the environmentalist's paradox: Why is human well-being increasing as ecosystem services degrade? *BioScience*, *60*(8), 576–589. https://doi.org/10.1525/bio.2010.60.8.4

Reed, J., van Vianen, J., Foli, S., Clendenning, J., Yang, K., MacDonald, M., … Sunderland, T. (2017). Trees for life: The ecosystem service contribution of trees to food production and livelihoods in the tropics. *Forest Policy and Economics*, *84*, 62–71. https://doi.org/10.1016/j.forpol.2017.01.012

Rehfuess, E., & World Health Organization. (2006). *Fuel for life: Household energy and health*. Geneva, Switzerland. Retrieved from http://www.who.int/iris/handle/10665/43421

Rijal, A., Smith-Hall, C., & Helles, F. (2011). Non-timber forest product dependency in the Central Himalayan foot hills. *Environment, Development and Sustainability*, *13*, 121–140. https://doi.org/10.1007/s10668-010-9252-x

Rodríguez, J. P., Beard, T. D., Bennett, E. M., Cumming, G. S., Cork, S. J., Agard, J., … Peterson, G. D. (2006). Trade-offs across space, time, and ecosystem services. *Ecology and Society*, *11(1):28*. https://doi.org/10.5751/ES-01667-110128

Ros-Tonen, M. A. F., Insaidoo, T. F. G., & Acheampong, E. (2013). Promising start, bleak outlook: The role of Ghana's modified taungya system as a social safeguard in timber legality processes. *Forest Policy and Economics*, *32*, 57–67. https://doi.org/10.1016/j.forpol.2012.11.011

Scholte, S. S. K., van Teeffelen, A. J. A., & Verburg, P. H. (2015). Integrating socio-cultural perspectives into ecosystem service valuation: A review of concepts and methods. *Ecological Economics*, *114*, 67–78. https://doi.org/10.1016/j.ecolecon.2015.03.007

Schröter, M., Kraemer, R., Mantel, M., Kabisch, N., Hecker, S., Richter, A., … Bonn, A. (2017). Citizen science for assessing ecosystem services: Status, challenges and opportunities. *Ecosystem Services*, *28*, 80–94. https://doi.org/10.1016/j.ecoser.2017.09.017

Schulze, S. (2003). Views on the combination of quantitative and qualitative research approaches. *Progressio*, *25*(2), 8–20. Retrieved from http://umkn-dsp01.unisa.ac.za/handle/10500/195%5Cnhttp://uir.unisa.ac.za/handle/10500/195

Shankar, V., & Paliy, O. (2016). Application of multivariate statistical techniques in microbial ecology. *Molecular Ecology*, *25*(5), 1032–1057. https://doi.org/10.1111/mec.13536

Small, N., Munday, M., & Durance, I. (2017). The challenge of valuing ecosystem services that have no material benefits. *Global Environmental Change*, *44*, 57–67. https://doi.org/10.1016/j.gloenvcha.2017.03.005

Sola, P., Ochieng, C., Yila, J., & Iiyama, M. (2016). Links between energy access and food security in sub Saharan Africa: An exploratory review. *Food Security*, *8*(3), 635–642. https://doi.org/10.1007/s12571-016-0570-1

Spangenberg, H. J., Görg, C., & Settele, J. (2015). Stakeholder involvement in ESS research and governance: Between conceptual ambition and practical experiences – risks, challenges and tested tools. *Ecosystem Services*, *16*, 201–211. https://doi.org/10.1016/j.ecoser.2015.10.006

Stern, P., & Dietz, T. (1994). The value basis of environmental psychology. *Journal of Social Issues*, *50*(3), 65–84.

Suich, H., Howe, C., & Mace, G. (2015). Ecosystem services and poverty alleviation: A review of the empirical links. *Ecosystem Services*, *12*, 137–147. https://doi.org/10.1016/j.ecoser.2015.02.005

Summers, J. K., Smith, L. M., Case, J. L., & Linthurst, R. A. (2012). A review of the elements of human well-being with an emphasis on the contribution of ecosystem services. *Ambio*, *41*, 327–340. https://doi.org/10.1007/s13280-012-0256-7

Sunderlin, W. D., Hatcher, J., & Liddle, M. (2008). *From exclusion to ownership? Challenges and opportunities in advancing forest tenure reform*. Washington, D.C.: Rights and Resources Initiative.

TEEB. (2010). *The economics of ecosystems and biodiversity: Mainstreaming the economics of nature: A synthesis of the approach, Conclusions and recommendations of TEEB*. Nagoya, Japan.

ter Braak, C. J. F., & Verdonschot, P. F. M. (1995). Canonical correspondence analysis and related multivariate methods in aquatic ecology. *Aquatic Sciences*, *57*(3), 255–289. https://doi.org/10.1007/BF00877430

Tibor, H., Joern, F., Câmpeanu, C., Milcu, A., Hanspach, J., & Fazey, I. (2013). The importance of ecosystem services for rural inhabitants in a changing cultural landscape in Romania, *6333*(12). https://doi.org/10.5751/ES-06333-190242

UN General Assembly. (2015). Transforming our world: The 2030 agenda for sustainable development. Retrieved October 17, 2018, from https://www.refworld.org/docid/57b6e3e44.html

van Oort, B., Bhatta, L. D., Baral, H., Rai, R. K., Dhakal, M., Rucevska, I., & Adhikari, R. (2015). Assessing community values to support mapping of ecosystem services in the Koshi river basin, Nepal. *Ecosystem Services*, *13*, 70–80. https://doi.org/10.1016/j.ecoser.2014.11.004

Vedeld, P., Angelsen, A., Bojö, J., Sjaastad, E., & Kobugabe Berg, G. (2007). Forest environmental incomes and the rural poor. *Forest Policy and Economics*, *9*, 869–879. https://doi.org/10.1016/j.forpol.2006.05.008

Wangai, P. W., Burkhard, B., & Müller, F. (2016). A review of studies on ecosystem services in Africa. *International Journal of Sustainable Built Environment*, *5*(2), 225–245. https://doi.org/10.1016/j.ijsbe.2016.08.005

Word Bank. (2011). *Wood-based biomass energy development for Sub-Saharan Africa: Issues and approaches*. Washington, D.C.: World Bank.

World Bank. (2008). *Forests sourcebook: Practical guidance for sustaining forests in development cooperation*. Washington, D.C.: World Bank.

Chapter 5

Key findings and discussion

5.1. Key findings

This research sought to contribute to CBFM literature to broaden our understanding of local governance quality at local level in order to provide pragmatic solutions for efficient management of forest resources and reducing rural poverty through sustainable livelihoods. The strategy was to examine how heterogeneity of governance quality between local communities (judged based on universal principles of good governance) affected forest conditions and communities' attitude towards sustainable forest management. As the literature reviewed in this thesis shows, this is among few studies where forest conditions and outcomes were assessed against governance quality at the local level, a departure from the more numerous studies that compare forest outcomes between different management regimes (e.g. CBFM and state management). Thus, this approach provides a better understanding of strengths and weaknesses in local governance responsible for CBFM successes or failures in co-management initiatives with an aim of devising mechanisms for best-fit approach for strengthening local governance in line with local context. The following is a summary of key findings from this research.

Strong governance and higher economic benefits to local communities were found to be strong motivating factors for favourable attitudes and pro-conservation behaviours towards forest conservation amongst local communities. Inclusive participatory processes in strongly-governed CFAs promoted decision making on forest management, sharing of benefits and other opportunities (e.g. trainings) with greater likelihood of perceived fairness and transparency, thus facilitating acceptance of decisions and enforcement by local communities. Additionally, capacity building supported skills and knowledge acquisition for the majority of respondents, promoting collective action, livelihood diversification strategies, and improved capacity of local communities to sustain participation in conservation (Chapter 2). On the hand, local community members in weakly-governed CFAs were found to be more likely to exhibit negative attitudes towards forest conservation irrespective of economic benefits (high or low). The main reasons respondents in weakly-governed CFAs gave for their negative attitudes towards forest conservation was exclusion from major decision making including benefits sharing, failure to conduct (credible) elections, frequent and prolonged conflicts, financial mismanagement and entrenched patronage (Chapter 2).

Strongly governed CFAs' forest sites exhibited better forest conditions in terms of higher species diversity, carbon storage and reduced forest disturbances – with fewer and smaller cut stumps thus, low stump basal area and low stump density. Strong governance in strongly-governed CFAs contributed to better forest conditions due to presence of rules and enforcement (e.g. forest access and harvesting rules), regular monitoring and random inspection of harvested forest products by monitoring committee(s). These were largely absent in weakly-governed CFAs, perhaps exposing their forest sites to 'unregulated open access', subject to over-exploitation and degradation (Chapter 3).

The study further showed that community based forest management provided a wide range of ecosystem goods and services important for local communities' livelihoods and well-being. Preferences for ecosystem services was strongly influenced by affiliation to a community conservation group, that is CFAs and socio-demographic factors including education level, age and gender (Chapter 4). The study found that CFA respondents preferred provisioning services perceived important for their well-being while non-CFA respondents were more inclined to choose regulating services. In regard to CFA respondents, economically valuable forest products and activities (PELIS and timber harvesting) were more appreciated owing to high economic returns generated hence more potential for improved living standards (Chapter 2 and 4). Both CFA respondents and non-CFA's had low preferences for cultural services. Further, males with higher level of education (> secondary level) preferred regulating services while females with lower level of education (< primary level) preferred provisioning services.

5.2. Discussion

Study findings add to the growing body of literature on CBFM and contributes to increased calls for examination of governance arrangements in biodiversity conservation (e.g. Brockington et al., 2018). Governance quality at the local level can determine success of conservation objectives. Strong governed institutions are essential in promoting effective biodiversity conservation and can be achieved through communities' recognition, inclusivity in decision making processes, strengthening of institutional capacity and provision of sufficient economic and non-economic benefits. Incorporating these elements in co-management initiatives can promote realisation of goal 15[41] of Agenda 2030 and thus ensuring inclusivity of local communities. Good governance in CBFM is deemed to contribute to fairness in distribution

41 Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

of both economic (sharing of resources) and non-economic benefits (e.g. influencing decision making, inclusive representation) with great prospects for poverty reduction and improved well-being (McDermott & Schreckenberg, 2009; Pokharel & Tiwari, 2013). In strongly-governed CFAs, while inclusive decision making and rules succeeded in regulating use of forest resources, they also facilitated distribution of benefits through established mechanisms. Priority for benefits allocation mostly economically valuable benefits such as farming plots were granted to those who never benefitted in previous allocations. For instance, this was done in such a way that every member had an opportunity to receive at least one half-acre plot before allocation of more plots to previous beneficiaries (Chapter 2). In this way, a majority perceived that decisions made and implemented were for the benefit of every participating member and the community at large (through community investments and welfare initiatives), thus supporting favourable attitudes towards forest conservation. When rules are agreed upon and viewed as legitimate, they can stabilize expectations and influence behaviour (Murtazashvili, et al., 2019). Further, perceptions of justice in resource distribution and governance processes can promote self-determination, internalised motivation and rule compliance through changes in behaviours (DeCaro et al., 2015; Martin et al., 2014). As indicated in the study findings, good governance and perceived equity (of high value benefits) in strongly-governed CFAs led to enhanced motivation and thus active participation in conservation initiatives. Thus, good governance can facilitate fairness and equity in sharing of economically valuable benefits thus promoting poverty reduction especially in rural forest dependent households in the tropics where majority are poor (Ferraro et al., 2011).

Low motivation and negative attitude towards forest conservation was widely expressed by respondents in weakly-governed CFAs. Poor governance — unilateral decision making by CFAs officials, financial mismanagement, election of officials and unequal benefit sharing of highly valuable benefits, mostly skewed towards officials themselves and loyal members were challenges facing forest conservation in weakly-governed CFAs. Community members dissatisfaction with a lack of transparency in governance processes demotivated majority from participation, harbouring of negative attitudes towards conservation, whereby some engaged in illegal activities. Frey & Jegen, (2001) note that interventions such as benefits may crowd out intrinsic motivation if the individuals affected perceive them to be unfair, undermining their self-determination and esteem and consequently reducing motivation and participation. Poor governance constitutes crisis situations, often linked to high deforestation (Murtazashvili et al., 2019) such as retaliation through illegal activities (Oyono et al., 2006; Kideghesho et al., 2007) and increased over-exploitation and forest disturbance as evidenced in one CFA which necessitated withdrawal of access rights to minimise human activities. Similarly, exclusion of community members in major decision making can raise issues of mistrust, corruption, wealth-inequality and financial mismanagement (Andersson et al., 2018; Pham et al., 2014) which are major triggers of conflicts as shown in weakly-governed CFAs, and these can weaken social bonds and co-operation in conservation (Skutsch, 2000; Pretty, 2003). A range of governance weaknesses have been identified in CBFM including lack of accountability of leaders, local elite capture, limited local trainings among others significantly affecting members participation in CBFM (Iversen et al., 2006; Essougong et al., 2019).

Ground level data on forest structure were collected from nine CFA forest sites to determine the effect of local governance variability on forest conditions and outcomes. Presence of good governance indicators including rule enforcement and monitoring regulated forest access and use, limiting threats and illegals activities while participation in rulemaking increased likelihood of rule acceptance and legitimacy thus increased rule compliance (Hayes & Persha, 2010; Andrade & Rhodes, 2012). Evidence shows that rule enforcement is an essential element for managing common property resources (Agrawal et al., 2008; Andersson et al., 2014) with rule enforcement and monitoring strongly associated with better forest outcomes (Epstein, 2017; Gibson et al., 2005; Andersson et al., 2014). Respondents participating in rulemaking as indicated in strongly-governed CFAs were more likely to accept the outcome of rules, with rule acceptance promoting voluntary co-operation and strong social capital (Pretty, 2003). Social capital promotes increased trust and networking where individuals align their self-interests to the interests of groups (DeCaro et al., 2015) and lower transaction costs of cooperation as individuals invest more in collective activities (Pretty, 2003) for the benefit of all. This is demonstrated in strongly-governed CFAs where interests of groups superseded personal interests through collective rulemaking for the common good including election of officials of good integrity and character. Therefore, strong governance should be promoted in CBFM principles through integration of principles of good governance and forest management. This can be done through civic education, and both formal and informal trainings to create awareness and instil confidence on good forest governance amongst local populace .

Absence of rules and more importantly, monitoring and enforcement exposed weakly-governed CFAs sites to unregulated access and thus increased exploitation and illegal activities (e.g. illegal cuttings and selective logging of economically valuable timber species). These CFAs characterised by unilateral decision making mostly by CFAs officials and KFS staff lacked regular engagement with local communities, limiting their participation in forest conservation and ultimately low motivation to control internal and external threats, resulting to increased forest disturbance as shown in Chapter 3. Decision making process and policy reforms dominated by local elites and officials as shown in weakly-governed CFAs including state officials affect meaningful decentralisation leading to undesirable conservation outcomes (Ribot et al., 2010; Lund, 2015).

Different communities have varying capacities (e.g. strengths, skills, abilities, experiences) in designing institutional arrangements that shape management of natural resources as previous studies (e.g. Luintel et al., 2017; De Vente et al., 2016) and the findings of this study demonstrates. The emergence and designing of local governance arrangements to conserve common pool resources is driven by changes in society including market forces, technological development, natural calamities (e.g. drought), economic growth and demographic changes (Agrawal, 2001; Fernández-Llamazares et al., 2016; Berbel & Esteban, 2019). These societal changes can bring about increased resource exploitation to meet growing demand for natural resources leading to resource degradation and scarcity (Oldekop et al., 2012; Campos et al., 2018), and other environmental challenges which may directly or indirectly affect communities well-being. Community perceptions and experiences arising from such challenges (over-exploitation, resource scarcity and degradation) can compel local communities (in some instances with support from other stakeholders) to take action in response to such changes in order to ensure continuous supply of vital resources to safeguard their well-being.

Perceptions of local communities as cause or drivers of resource scarcity and consequences arising from such scarcity e.g. conflicts, threats to livelihoods, well-being and biodiversity may compel local communities to design governance strategies for conservation in order to mitigate such threats. Oldekop et al., (2012) for instance, shows that high demand and scarcity of resources among two indigenous communities in the Ecuadorian Amazon led to formulation of rules to regulate game hunting, fishing and timber harvesting in communal land. According to the authors, timber shortage occasioned by increased harvesting by locals and external timber merchants led to scarcity, with local members forced to buy wood from neighbours or market as building material. The experiences and consequences of sourcing timber from external sources which was previously available on communal land necessitated changes in management of timber resources through regulation of timber sales by locals, logging restrictions and ban imposed on timber merchants.

Importance of natural resources in supporting the well-being of local communities (e.g. wood fuel, fodder, water e.t.c) especially in developing countries is well documented (e.g. Wunder et al., 2014; Vedeld et al., 2007; Angelsen et al., 2014). However, rampant resource exploitation has led to degradation and scarcity of vital resources necessitating the adoption of bottom-up self-governed arrangements to regulate and or adjust harvesting activities to safeguard sustainability (Fernández-Llamazares et al., 2016; Oldekop et al., 2012). In Kenya, prolonged exploitation, misuse, illegal activities and mismanagement of forest resources (KFS, 2010; Gathaara, 1999) threatened resource availability (e.g. water, valuable timber species such as camphor) and interfered with ecological functioning of forest ecosystems (Morgan, 2009), thus, catalysing the design and implementation of local governance structures to control resource use and exploitation through participatory forest management (PFM). In participatory approaches such as PFM, strong local governance is paramount for effective conservation of common pool resources particularly where growing competition from other uses (e.g. farming, settlements) and increased demand for resources catalyse resource degradation and scarcity. For instance, Fernández-Llamazares et al., (2016) in their findings show that over-exploitation and decreasing availability of thatch palm — *Geonoma deversa* in Bolivian Amazonia led local communities into crafting rules restricting frequency and intensity of harvesting to prevent resource exhaustion, thus ensuring sustainability over time. Increased demand and depletion of vital resources coupled with changes in their availability is instrumental in compelling local communities to design and implement governance mechanisms that can withstand existing pressures and trigger behavioural change. This is aimed at promoting wise utilisation of resources and regeneration that enables continuous flow of the resources.

In Mt. Kenya forest, local communities through CFAs are key stakeholders in forest conservation with a responsibility of establishing and implementing governance structures for efficient management of forest resources. Whereas formation of CFAs in Mt. Kenya forest took place in the early phases of PFM adoption —2006— as the forest was used as a pilot site to determine viability of decentralising forest governance to local communities (Mogoi et al., 2012), CFAs under study differed in local governance processes, structures and activity implementation as the findings of this study show. Despite all CFAs receiving guidance and technical assistance from government agencies and the private sector e.g. NGOs, their structural governance differed from the onset. In the early implementation of PFM, strongly-governed CFAs displayed transparency and accountability through inclusive engagement of members in decision making processes and activity implementation as evidenced in CFAs' documentation (e.g. minutes, reports, management plans, constitution). For instance, to regulate access and promote sustainable utilisation of forest resources, against increasing demand and scarcity of vital resources such as fodder, wood fuel — respondents reported to facing ever-increasing distances in the forest in search of wood fuel — a set of rules for forest products — for both sale and household use or consumption — encompassing products harvesting, transportation and sanctions for non-compliance were crafted and agreed on by majority of members to address resource over-exploitation.

Inclusive participatory processes in decision making ensures that rules devised conform with local needs and conditions, increasing likelihood of rule compliance (Seymour et al., 2014) important for regulating consumption and use, thus, avoiding tragedy of the commons (Ostrom, 1990). Early engagement of local communities in rulemaking and CFAs' activities in strongly-governed CFAs created a practise for promoting transparency and inclusivity, hence increasing likelihood of rule internalisation, compliance and self-monitoring, and increased participation, important components for more effective forest governance and conservation efforts (Agrawal et al., 2008; Persha et al., 2011; Seymour et al., 2014). Strongly-governed CFAs' governance processes and structures differs considerably with weakly-governed CFAs owing to exclusion of local communities in decision making processes (e.g. elections, funds management), absence of rules and lack of enforcement of existing forest laws. This could be attributed to differences in groups' organisation at the formative stages such as early engagement and inclusion of local communities in strongly-governed CFAs important in strengthening relationships, trust and increased efforts in conservation. Exclusion of community members in decision making processes as evidenced in weakly-governed CFAs erodes trust, social capital and will to co-operate/act for common good (Pretty, 2003) leading to increased forest destruction and reduced locals' participation as previous studies (e.g. Oyono et al., 2006; Ros-Tonen et al., 2013) and findings of this study show.

Market access and integration of natural resources into market economy may negatively affect local governance and cooperative institutions for sustainable resource management (Agrawal, 2001). This is especially where communities are heavily dependent on natural resources for their livelihoods. This is because they are more likely to increase harvesting levels to diversify their household incomes due to presence and or expansion of markets. For instance, forest environmental income from sale of forest products e.g. fuelwood, wild foods and fodder by local communities represents on average 22-28 percent of total household income in developing countries (e.g. Vedeld et al., 2007; Uberhuaga et al., 2012). This shows that markets are important sources of locals' income and increased demand from the markets may compel local communities to diversify their household incomes through increased and uncontrolled harvesting, ultimately affecting future habitat quality of focal and native species (Tremblay et al., 2018). For instance, in highly competitive markets, local communities are under immense pressure to over-exploit forest resources for short-term economic gains leading to increased harvests and diversity of harvested products that yield greater economic advantage (e.g. Morsello et al., 2014; Silva et al., 2019).

Competitive markets exist in Kenya for forest products and activities (Mogoi et al., 2012; GoK, 2018) in areas adjacent to forest resources such as Mt. Kenya forest and farther away. This demand in wood products is projected to rise sharply in the country by 2030, with demand for poles projected to increase at 58.2 per cent, building timber (43.2 per cent), wood fuel (16.1 per cent) and charcoal (17.8 per cent) (KNBS, 2019). In all CFAs under study, demand for forest products in areas surrounding the CFA sites and other forest resources is exceedingly high as evidenced by increased number of registered sawmill companies, small scale/retail enterprises on wood fuel, posts and fodder (KNBS, 2019). While regulation of timber harvesting and logging is strictly governed by KFS, harvesting of other forest products (e.g. wood fuel, charcoal, fodder, manure, medicinal herbs) and other activities (e.g. farming, ecotourism) are controlled by CFAs. As a result, CFAs internal governance mechanisms (e.g. by-laws and enforcement, monitoring, decision making, regular communication) are crucial in regulating forest products exploitation and supply in markets.

Weak investments in governance structures as demonstrated by weakly-governed CFAs reduces social capital thus, hindering co-operation amongst community members and access to market economies may likely increase un-cooperative behaviours as individuals engage in behaviours that increase harvesting efforts in return for increased profits (Godoy et al., 2007). Increased harvesting efforts exacerbates resource degradation and scarcity as individuals pursue individual interests at the expense of groups' interest. Lack of transparency in decision making processes (e.g. elections, benefits sharing, funds utilisation), absence of by-laws to regulate harvesting, lack of enforcement and non-compliance with existing laws (e.g. Forest Act 2016) in weakly-governed CFAs coupled with access to lucrative markets for forest products (e.g. timber/posts, firewood) drives uncontrolled harvesting and exploitation of forest resources (e.g. debarking, illegal logging) as shown in Chapter 3. This despite ecological consequences of such activities (e.g. degradation, changes in availability of valuable timber species such as camphor, vitex keniensis e.t.c) which may not be internalised as a communal problem as individuals engage in individual short-term interests to maximise profits at the expense of conservation efforts and possible initiatives of collective action. Absence of viable control mechanisms (e.g. internally agreed by-rules) to regulate harvests, coupled with exclusion of locals in decision making processes as evidenced in weakly-governed CFAs, increases likelihood of more harvests for sale, negatively affecting social capital by reducing cooperative behaviour on collective work (Rizek & Morsello, 2012; Agrawal, 2001) as individual's self-interests to generate more income supersedes groups' interests. On the other hand, where rules are formulated and agreed upon as witnessed in strongly-governed CFAs, they can promote internalised motivation and rule compliance through changes in behaviours (DeCaro et al., 2015; Martin et al., 2014) and thus regulate supply of forest products in markets through harvesting regulations (e.g. harvesting frequency, quotas, mode of transportation, eligible products for harvest and sale).

Strong institutional governance is vital for enhancing social capital (e.g. trust, confidence) in resource management (Pretty, 2003) which is crucial in controlling and regulating harvests destined for markets through cooperation and pro-conservation behaviours (Godoy et al., 2007). In strongly-governed CFAs, challenges associated with market forces and integration of natural resources into the market economy have been overcome through presence of internally agreed by-rules and enforcement of such rules regulating products harvesting (e.g. frequency of harvesting, size of load, mode of transportation e.t.c). In Ethiopia, presence of strong governance institutions in Chilimo PFM programme led to controlled harvesting of dead wood for subsistence and commercial purposes with strict control enforced on live trees — limited to support members in house construction (Cronkleton et al., 2017), thus, leading to positive outcomes on forest conditions (Ameha et al., 2016). Consequently, strong governance as shown in strongly-governed CFAs enhances trust, confidence, solidarity and constrain individual behaviour to favour the interests of the group thus overcome challenges posed by access to market economies.

Community based forest management in Mt. Kenya forest provides ecosystem goods and services at multiple scales, and more importantly to local communities living in close proximity. Legal access to livelihood enhancing forest products and activities (enabled through Forest Act) provides basic materials for subsistence use and income generation thus supporting different components of communities' well-being and resilience during times of crisis (e.g. drought). The forest provides provisioning (e.g. fire wood, fodder, wild foods, timber/posts, water), regulating (e.g. air purification, pollination, climate amelioration) and cultural services (e.g. education, spiritual and cultural values) (Chapter 4) supporting other studies showing that forests are main sources of livelihood for vast majority rural households mostly in the tropics

(Rasmussen et al., 2017; Nguyen et al., 2015; Paudyal et al., 2017). Study findings show that fuel wood and water were the most accessed commodities by local communities (both CFA-members and non-members) indicating the importance of the forest for basic needs such as energy supply. Wood-based biomass energy such as fuel wood constitutes the major source of energy needs, approximately 81% in Sub-Saharan African households (Word Bank, 2011).

The forest is also a source of forest income for many local communities generated from sale of forest products (e.g. fuel wood) and income generating activities (e.g. PELIS, bee keeping, tree seedlings) important for supporting household needs. Environmental income can be important for low-income rural households with little household capital (Vedeld et al., 2007) and can sometimes equal or exceed income from crops and livestock produced by small holders (Wunder et al., 2014; Mamo et al., 2007). As shown in study findings, the PELIS programme has provided food security to participating households with substantial economic benefits from sale of surplus commodities, thus contributing to improved standards of living for households. Studies from elsewhere; Tanzania, Ghana and Nepal showed similar findings where CBFM facilitated significant improvements in household food security (Pailler et al., 2015; Kalame et al., 2011; Karki et al., 2018). Food insecurity is one of the greatest challenges of the 2st century threatening the survival of many people globally, and the role of forests in enhancing food security especially to marginalised and vulnerable societies is important (Vira, Wildburger, & Mansourian, 2015). Thus, strengthening local governance and linkages between sustainable forest management and food security in co-management initiatives are needed to improve food security, diversity forest livelihoods and support poverty reduction strategies especially in developing countries.

Preferences for forest ecosystem goods and services significantly differed based on affiliation to environmental organisation i.e. CFAs and demographic factors including age, gender and education level (Chapter 4). The effects were larger in magnitude for CFAs membership than demographic factors indicating strong influence of membership to a conservation institution on preferences concerning forest goods and services. CFAs and non-CFA respondents preferred provisioning services and regulating services respectively with CFAs respondents more inclined towards economically valuable material benefits such as PELIS. According to La Ferrara, (2002), an individual's decision to join a group is strongly determined by expected net benefits from participation, explaining CFAs respondents preferences to tangible benefits specifically higher perceived value products and activities Further, education had a strong effect on ecosystem service preferences whereby highly educated males (>

secondary level) preferred regulating services while females with lower level of education (< primary level) preferred provisioning services such as fuel wood and wild terrestrial foods. Findings compare with other studies showing that demographic factors and affiliation to conservation groups or activities significantly influences preferences for ecosystem goods and services (Martín-López et al., 2012; Rodríguez et al., 2006). Findings are crucial to inform better decision making to devise and implement mechanisms for strengthening local governance to incorporate social groups in capacity building in order to understand ecosystem services and their benefits. Through improved awareness, all social groups and interested stakeholders can collaborate together and sustain efforts for enhancing supply of ecosystem services while at the same time meeting diverse interests and preferences of different groups.

The Forest Act formalised communities' access to forest products through permit payment for products harvested, both subsistence and for sale purposes. Permit fees paid monthly is solely determined by KFS without wider community consultation. The taxing of livelihood enhancing products goes against the objectives of CBFM; provide sustainable livelihoods to local communities for poverty reduction and SDG goal 15 — "increasing the capacity of local communities to pursue sustainable livelihood opportunities" (target 15.c).
Contrary to the norm in other countries such as Nepal where local communities have free access to subsistence products (Malla, 2000; Mehta & Heinen, 2001), taxation of subsistence products in Kenya is curtailing access to livelihood products and could pose a threat to other components of communities' well-being (e.g. health) through for instance use of contaminated water and improperly cooked foods. This is especially so in this period of global climate change which poses significant challenges and increased threats (e.g. scarcity of resources, food insecurity) to poor rural households depending on natural resources whose nation's social capacity to manage them remains low (Fischer, 2017; Kreft et al., 2015). Additionally, taxation of livelihoods products such as fuel wood through CBFM in Mt. Kenya forest and elsewhere in the country may exacerbate income inequality and increase poverty levels as poor households spend their little income on energy needs besides other basic necessities such as food.

Secure property rights (secure tenure) and sustainable benefits to local communities can greatly motivate communities' participation in forest conservation and modify use behaviour in forest utilisation patterns (Cronkleton et al., 2017), thus, improved forest conditions in the long-term. Secure property rights is associated with an assurance of long-term incentives, recognised as legitimate and upheld by government agencies and society (Lawry et al., 2012; Stevens et al., 2014). As a result, forest dependent communities may dedicate their efforts towards long-term conservation of natural resources (e.g. forests) for continuous supply of livelihood-enhancing benefits. However, in Mt. Kenya forest and other forests in the country, KFS retains the right to withdraw access rights and abolish CFA agreements if not satisfied with forest conservation performance, with neither opportunity for negotiation nor restitution for affected communities (GoK, 2016). Negotiation is a precondition for successful co-management initiatives for individuals/organisations to arrive at collective decisions that restores order (Plummer et al., 2004), and is a continuous problem-solving process involving extensive deliberations (Carlsson & Berkes, 2005). Lack of negotiation platforms (and capacity) between local communities and KFS, and insecure rights is undermining co-operation and collaboration in forest conservation including provision of livelihoods to local communities. For instance, unilateral decision making by KFS led to withdrawal of forest access rights in 2018 — suspension of PELIS programme in some sites (e.g. Ngong forest), moratorium on logging and extraction of timber in all community forests including ban on subsistence products in Chuka forest, water usage/abstraction including for PELIS in Mt. Kenya forest (GoK, 2018; KNBS, 2019; Mungai, 2018).

From the extensive literature on commons regimes, individuals or communities who lack secure property rights are unable to take long-term sustainable approaches in conservation, use of resources and enforcement measures as they are strongly inclined in using and maximising returns before they are lost to others or taken away(Banana & Gombya-Ssembajjwe 2000; Larson & Dahal, 2012). This is evidenced in the PELIS programme where farming for a restricted period of time (maximum three years), small land size and limited land availability has reduced motivation to co-operate from some members who pursue free-riding activities to maximise their benefits. Among these include farming beyond the stipulated three years permitted in the Forest Act (witnessed crops planted for the consecutive 5th year during field work), planting of indigenous trees which take time to mature and close canopy instead of exotic species meant for commercial purposes and permitted in plantation zones, failure to tend young seedings/saplings with low survival rates and thus prolonging the period available for crop farming, and illegal cutting of indigenous trees close to riverine banks for land expansion. These illegal activities are attributed to lack of foreseeable long term economic benefits and fear of losing new found economic freedom as plantations take lengthy periods (approximately 30 years) to mature before clear-felling is done. Similar to these findings, lack of secure tenure in Ghana coupled with short term benefits in crop farming and inability of local communities to cultivate desired crops despite payment of high tenancy fees, together led to illegal activities, deforestation and delayed tree planting efforts (Damnyag et al., 2012). Comparable to Mt. Kenya forest and given the high uncertainties in future benefits from CBFM, opportunistic over-exploitation of forests and encroachment ostensibly through legalised activities such as PELIS will continue to undermine efficient management of forest resources unless drastic measures are put in place to ensure long-term incentives for local communities.

Besides economic incentives for community participation, capacity building contributes to broadening skills and knowledge hence enhancing capacity of locals' participation and contribution in meetings, events and in forest activities. Through prudent use of revenue generated and opportunities from external stakeholders, strongly governed CFAs facilitated training opportunities (related to forests and livelihoods) for majority of their members thus enhancing locals' competence in handling responsibilities associated with co-management (e.g. conflict management through conflict resolution committees). This in comparison to very few members trained from weakly-governed CFAs. Capacity building can increase communities capacity to negotiate and participate in activities thus supporting them in carrying out conservation responsibilities (Brooks, Waylen, & Mulder, 2013). Further, training is important for enhancing social capacity for communities capacity to respond to environmental changes (Hahn et al., 2006; World Bank, 2008; Berkes, 2009), such as new rules or mechanisms for responding to increased threats or changing situations. Thus, building capacity of local communities through trainings and environmental education is crucial for enhancing level of knowledge and information for communities in order to ensure co-management success (Pomeroy et al., 2001).

5.3 Contributions from this research

Further, taking study evidence into account**,** findings provide compelling evidence for taking into account local governance quality in assessments of conservation effectiveness to provide crucial insights for decision making to improve conservation outcomes. The generalisation of CBFM success based on comparisons of forest outcomes with other governance approaches such as state management could mask important governance elements derailing or promoting successful conservation outcomes and may hide variations in institutional performance on different dimensions (Agrawal & Benson, 2011). Further, evidence of studies comparing forest outcomes appears inconclusive as to which management regime is effective with for instance, some studies indicating strict protection is associated with better outcomes than sustainable use areas (Nolte et al., 2013), others indicate the opposite (Porter-Bolland et al., 2012; Nelson & Chomitz, 2011), while other studies show no difference between the governance regimes (e.g. Bray et al., 2008). These contradictory findings could imply that governance or management type may not be an ideal proxy for measuring and explaining conservation success. Thus, approaches taken in this study in the assessment of local governance quality as a proxy for measuring conservation success in CBFM appears effective in identifying elements responsible for conservation outcomes. More research should be done incorporating governance quality to measure conservation effectiveness while at the same time identifying strengths and weakness in local institutions with an aim of devising and implementing mechanisms for addressing such weaknesses.

Secondly, this study contributes to the literature on collective action and property rights. Strong local governance and higher economic benefits cannot entirely be attributed to better forest outcomes and positive attitudes in strongly governed CFAs. Nonetheless, positive outcomes in forest conditions and favourable attitudes towards conservation could also have been shaped by collective action of local communities. Property rights based on inclusive engagement of locals in decision making provided a platform for social capital to flourish; strengthening networks, relationships (and new) and building trust amongst locals thus lowering transaction costs through increased co-operation and confidence in investing in collective activities in forest conservation (Pretty, 2003; Murtazashvili et al., 2019). Although strong governance provided a platform for enhancing collective action, these together reinforced each other guiding efficient forest management and social outcomes in strongly governed CFAs. The capacity of strongly governed CFAs to control illegal activities through monitoring and individual responsibility (self-reporting) in forest conservation indicates a key aspect of organised collective action. This collective responsibility not only resulted to better forest conditions but also promoted rural investments for society's welfare (e.g. infrastructure development – dams, bursary school fees, welfare revolving fund) and transparency in selection of officials during elections. Thus, combination of strong governance, higher economic benefits and collective action contributed to favourable attitudes towards conservation and better forest outcomes in strongly governed CFAs sites. On the contrary, frequent conflicts in weakly-governed CFAs generated distrust with cooperative arrangements and strong social bonds unlikely to emerge in such circumstances (Pretty, 2003; Sanginga et al., 2007), thus undermining conservation efforts as study findings shows (Chapter 3). Weakly-governed CFAs' failure to enforce internal decisions for collective use through for instance harvesting by-laws and regular monitoring, exposed forest sites to increased over-exploitation and illegal activities as shown through higher disturbance rates.

This study shows that Mt. Kenya forest supports well-being of local communities through provision of a wide range of ecosystem services which have different values to society. Locals benefit mostly from provisioning (e.g. fuel wood, fodder), regulating services (e.g. air regulation) and cash income important for sustaining livelihoods. Incorporating social dimension of ecosystem services in ecosystem service assessments is essential as it supports identification of a wide range of ecosystem services supporting well-being. Both monetary and non-monetary benefits were identified with contrasting preferences for ecosystem services amongst social groups, providing insights for decision making to develop mechanisms for sustaining flow of ecosystem services to meet divergent interests and for conservation purposes. Thus, this study contributes to the literature on sustainable forests, ecosystem services and human well-being in which ecosystem functioning and future forest benefits requires strong regulatory and multi-level interactions of institutions (e.g. local, national) to conserve forests for continuous flow of ecosystem services to targeted populace and for biodiversity conservation.

5.4. Policy implications

The findings from this research provides important insights into issues of co-management initiatives such as CBFM. Research findings highlights relevance of policies that address local forest governance as well as benefits, both economic and non-economic incentives for leveraging local support and favourable attitudes towards forest conservation. Both strongly- and weakly-governed CFAs' management approach in forest conservation depicts parallel realities of community conservation initiatives that occur across many areas in developing countries. As shown in study findings, strong local governance based on universal principles of good governance and sufficient benefits (economic and non-economic) are strong motivating factors for achieving better conservation and social outcomes. Synergies between these two are important for promoting win-win outcomes in biodiversity conservation and sustainable livelihoods as well as strong social capital, greatly contributing to the objectives of CBFM.

5.4.1. Local forest governance

As more countries work towards the realisation of Agenda 2030, more effort is needed to emphasise greater inclusivity of local communities in decision making processes by reducing barriers to effective community engagement. Presently, some government agencies aided by officials of grassroots institutions continue to pursue top-down approaches in forest conservation creating hurdles to sustainable forest management. This narrative could be changed through policies that promote local autonomy, shared responsibility for joint decision-making and regular consultation between local communities and government agencies. Further, policies that promote good forest governance should be integrated in co-management initiatives through continuous identification of governance strengths and weaknesses in local institutions with an aim of designing and implementing solutions to identified weaknesses to improve quality of governance. The quality of governance is important as it often determines whether forest resources are used efficiently, sustainably and equitably (PROFOR & FAO, 2011) with better governance associated with lower forest pressures (Ceddia et al., 2014). Further, inclusive participation in rulemaking leads to better forest outcomes (Persha et al., 2011; Andersson et al., 2014), transparency and equity in benefit sharing (Hayes & Murtinho, 2018; Mollick et al., 2018). Governments and other stakeholders e.g. NGOs have a key responsibility for promoting good forest governance by supporting development and enforcement of mechanisms for promoting and sustaining transparency, fairness and inclusivity in sustainable forest management.

5.4.2. Sustainable livelihoods

Forest resources provide vital material benefits for meeting livelihood needs of local communities. However, management of forest resources in past decades neglected local needs as livelihood activities of many forest-dependent communities were deemed illegal (Kaimowitz, 2003; DeGeorges & Reilly, 2009) which triggered conflicts undermining conservation efforts through illegal activities. However, the concept of sustainable development and co-management approaches such as CBFM recognised community participation in forest governance to address high deforestation rates and society’s needs to reduce poverty levels, mostly in developing countries (World Bank, 2008; FAO, 2010). To promote sustainable livelihoods and reduce poverty levels, scholars have increasingly advocated for tangible and sufficient economic benefits to enable communities meet increased costs of conservation (Mogaka et al., 2001; Kellert et al., 2000), often borne by the poor in society (Green et al., 2018). This has not been achieved based on many studies globally showing that communities continue to receive low value benefits while states retain significant legislative control on economically valuable activities and forest products (Anderson et al., 2015; Mogoi et al., 2012). To improve communities livelihoods and human well-being, policy reforms would do well by transferring user rights for economically valuable products and prioritising local communities in such activities including timber harvesting and concessions, carbon trading, eco-lodges/camps which benefit mostly external stakeholders yet carry out little conservation activities. Increasing capacity of local communities through trainings from early stage(s) of groups formation and continuous training can provide local communities with relevant skills for engaging in such activities, compete with well-established companies (where applicatble) as well as diffuse tensions and conflicts which may affect conservation activities through series of litigations (e.g. Kenya Law, 2013). Non-governmental organisations may perform better in offering soft skills (e.g. leadership and organisational capacity, fundraising and proposal writing, financial management, conflict resolution, transparency and accountability etc.) while state agencies can provide technical skills such as monitoring, pruning, thinning and timber harvesting to tap community's potential instead of seeking external stakeholders (Koech et al., 2009). Additionally, formulating and fast-tracking implementation of benefit sharing guidelines to inform what percentage share of benefits acrue to different stakeholders, for instance between states and local communities could provide much needed security in CBFM and thus long-term conservation efforts by local communities.

Some forest activities provide increased forest income such as PELIS (farming) contributing additional income and hence great potential for improved standards of living amongst local communities. In Ghana, farming in forests was reported as a major source of cash and non-cash income contributing up to 50% of cash income for both male and female farmers (Ros-Tonen et al., 2013). While higher economic benefits engender favourable attitudes towards forest conservation as shown in study findings and may provide pathway(s) out of poverty (Angelsen et al., 2014) through increased purchasing power, farming and related activities may not be compatible with conservation objectives especially where security of tenure is not guaranteed. For instance, encroachment to forest resources for land expansion, commercial agriculture using mechanised equipment's as reported in Mt. Kenya forest (GoK, 2018) and intensive use of farm inputs — pesticides, fertilisers to increase yields could reduce forest cover and affect other biodiversity resources. The effects of intensive use of farm inputs on plant and animal species including water resources in CBFM programmes are not yet clear, despite many countries including Kenya, Ghana and Nepal having legalised farming in forests through CBFM (Akamani et al., 2015; Kalame et al., 2011; Karki et al., 2018). Policies should aim at enforcing good farming practices while increasing capacity of local communities to engage in livelihood diversification schemes compatible with forest conservation (e.g. bee keeping, mushroom and butterfly farming, tree nurseries, community woodlots, tourism etc). For instance, '*Kipepeo'* project where local farmers grow butterfly pupae for export in Arabuko-sokoke forest continue to generate more income for local communities (Gordon & Ayiemba, 2003) while preserving the forest. Further, support should go towards improving organisational leadership and capacity to encourage local communities to form co-operatives for marketing and sale of their nature-based produce and lock out middlemen who impoverish farmers with low prices as witnessed in Mt.

Kenya forest. This will contribute to win-win outcomes in conservation and sustainable livelihoods for poverty reduction thus working towards realisation of Goal 15c of vision 2030.

5.4.3. Ecosystem services and valuation

To provide sustainable livelihoods and enhance conservation effectiveness, policies should focus on management of all ecosystem services including provisioning, regulating and cultural services. Identifying what ecosystem services are valued, by whom and why is the first step for a comprehensive understanding and improving management effectiveness of all ecosystem services. Non-monetary valuation methods such as social-cultural valuation incorporating community participation is one such method supporting inclusive identification of a wide range of ecosystem services beneficial to local communities. Further, social-cultural valuation is essential in capturing divergent interests of different stakeholders and social groups (Martín-López et al., 2012; Aguado et al., 2018) important for reviewing policies seemingly emphasising and supporting protection of provisioning services. Prominent focus on provisioning services could neglect and jeopardise provision of other services (e.g. regulating) equally important for supporting livelihoods and human well-being which may in the long-term contribute to increased poverty levels amongst local communities. Since millennium ecosystem assessment (MEA, 2005), the concept of ecosystem services, values and importance to human well-being has increasingly gained attention over the years (e.g. TEEB, 2010; Díaz et al., 2015) prompting integration into sustainable development agendas (De Groot et al., 2002; Costanza et al., 2017). However, challenges remain in valuation of non-market services (Small et al., 2017), thus affecting decision making for better management. Policies should aim at incorporating both economic and non-economic valuation methods to capture the importance and values of forest ecosystem goods and services to improve decision making for efficient management for both conservation and livelihood needs targeting different needs and groups in society.

Civic education and trainings on importance of ecosystem services should be promoted in co-management initiatives to enhance knowledge on the importance of different types of ecosystem services. This is because findings show that individuals with different levels of education (e.g. primary, secondary) have preferences for different ecosystem services. For instance, higher educated males preferred regulating services while less educated females preferred provisioning services. Other studies support these findings, showing strong influence of education level on ecosystem service preferences (Oteros-Rozas et al., 2014; Quintas-Soriano et al., 2018). Since level of education is important in influencing preferences and utilisation patterns of different ecosystem services, policies should identify pathways to create and impart knowledge on different types of ecosystem services and they support different components of human well-being. This will improve understanding on ecosystem services, functioning and may foster sustainability mechanisms motivating local's participation in conservation of different ecosystem services.

5.5. Study limitations

Some limitations that could have influenced study findings were encountered as with many studies where factors beyond researcher's are common. This does not imply that findings are not relevant for generalisation but fits the purpose of this research. Consequently, research findings provides positive step towards assessment and understanding of local governance quality and its influence on conservation and social outcomes in community based conservation initiatives. There was lack of control or baseline data for both forest structure parameters and CFAs governance indicators immediately after PFM adoption. These baseline parameters would have provided strong support linking outcomes to identified factors (i.e. local governance, economic and non-economic incentives). Sills & Jones (2018) advices that before and after treatments (i.e. PFM) — where in this case before implies immediately after PFM adoption — are needed to account for potential role of local governance in conservation and social outcomes. Further, it was beyond the scope of this study to establish unobserved characteristics of social capital arising from either earlier collaboration of local communities with external stakeholders before and after PFM or from other community initiatives not related with forestry which could have influenced outcomes. For conclusive findings, there is need to control for these confounding parameters (Baland et al., 2010). Nonetheless, this research provides useful data and findings that can be used in future work to gauge long-term improvement or deterioration of identified factors and effect of any future changes on conservation, livelihood and attitudinal outcomes.

Lack of updated records particularly in weakly-governed CFAs meant relying on some information for local governance assessment mostly from CFAs officials, thus subject to some methodological limitations. Although information provided was validated from interviews from some members, KFS staff and participant observation (in forest sites), research shows that respondents may be inclined to respond in a socially desirable way (Nuno & John, 2015), by projecting a positive image, perhaps hoping for some potential benefit in the future (Stecklov et al., 2018).

5.6. Further research

Carbon biomass assessment presented in this study did not take into account tree height, which is an essential component in carbon biomass quantification. Studies incorporating tree height give higher estimates of carbon biomass storage and may provide precise amount of carbon stored (e.g. Borah et al., 2018; Chave et al., 2014). To ascertain precise amount of carbon biomass stored in Mt. Kenya forest, future studies should aim at incorporating tree height in carbon assessment as findings presented and discussed could be the lower limit.

Variability of local governance (quality) exists between communities participating in co-management initiatives such as CBFM as study findings shows. Therefore, I recommend future studies to focus more on assessment of local governance quality in participating communities for a more comprehensive understanding of CBFM successes or failures in forest conservation. Qualitative assessment of local governance quality can provide deeper understanding of complex governance processes and combination with quantitative assessments can provide reliable and precise measurements important for future governance-conservation studies. Although assessment of governance quality including perceptions of good governance whether local or national may be difficult to measure as assessments may partly rely on individual experiences and expectations, these assessments are important and will in future support measurement of governance strengths and weaknesses in community conservation institutions. This is important to identify critical areas for further improvement in order to develop local institutions suitable for tacking local environmental challenges.

This study showed there was a strong linkage between local governance quality and social capital. Similarly, many studies have demonstrated that social capital is an important element influencing success of common property resources such as forests. However, it is a complex concept as it involves many facets including but not limited to beliefs, values, networks, co-operation, trust, confidence etc. Similar to the universally accepted principles of good governance guiding assessment of governance quality both at the local and national level, there is need for more empirical studies to develop and test ideas to develop common measurement indicators or principles. This would support standard measurement of the concept and support future studies in examining how much influence social capital alongside other parameters contribute to conservation outcomes.

References

Agrawal, A. (2001). Common property institutions and sustainable governance of resources. *World Development*, *29*(10), 1649–1672. https://doi.org/10.1016/S0305-750X(01)00063-8

Agrawal, A., & Benson, S. C. (2011). Common property theory and resource governance institutions: Strengthening explanations of multiple outcomes. *Environmental Conservation*, *38*(2), 199–210. https://doi.org/10.1017/s0376892910000925

Agrawal, A., Chhatre, A., & Hardin, R. (2008). Changing governance of the world's forests. *Science*, *320*(1460), 1460–1462. https://doi.org/10.1126/science.1155369

Aguado, M., González, A. J., Bellott, K., López-Santiago, C., & Montes, C. (2018). Exploring subjective well-being and ecosystem services perception along a rural–urban gradient in the high Andes of Ecuador. *Ecosystem Services*, *34*, 1–10. https://doi.org/10.1016/j.ecoser.2018.09.002

Akamani, K., Wilson, P. I., & Hall, T. E. (2015). Barriers to collaborative forest management and implications for building the resilience of forest-dependent communities in the Ashanti region of Ghana. *Journal of Environmental Management*, *151*, 11–21. https://doi.org/10.1016/j.jenvman.2014.12.006

Ameha, A., Meilby, H., & Feyisa, G. L. (2016). Impacts of participatory forest management on species composition and forest structure in Ethiopia. *International Journal of Biodiversity Science, Ecosystem Services and Management*, *12*(1–2), 139–153. https://doi.org/10.1080/21513732.2015.1112305

Anderson, J., Mehta, S., Epelu, E., & Cohen, B. (2015). Managing leftovers: Does community forestry increase secure and equitable access to valuable resources for the rural poor? *Forest Policy and Economics*, *58*, 47–55. https://doi.org/10.1016/j.forpol.2014.12.004

Andersson, K., Benavides, J. P., & León, R. (2014). Institutional diversity and local forest governance. *Environmental Science and Policy*, *36*, 61–72. https://doi.org/10.1016/j.envsci.2013.07.009

Andersson, P. K., Smith, M. S., Alston, J. L., Duchelle, E. A., Mwangi, E., Larson, M. A., … Wong, Y. G. (2018). Wealth and the distribution of benefits from tropical forests: Implications for REDD+. *Land Use Policy*, *72*, 510–522. https://doi.org/10.1016/j.landusepol.2018.01.012

Andrade, G. S. M., & Rhodes, J. R. (2012). Protected areas and local communities. *Ecology and Society*, *17(4):14*. https://doi.org/http://dx.doi. org/10.5751/ES-05216-170414

Angelsen, A., Jagger, P., Babigumira, R., Belcher, B., Hogarth, N. J., Bauch, S., … Wunder, S. (2014). Environmental income and rural livelihoods: A global-comparative analysis. *World Development*, *64*, S12–S28. https://doi.org/10.1016/j.worlddev.2014.03.006

Baland, J. M., Bardhan, P., Das, S., & Mookherjee, D. (2010). Forests to the people: Decentralization and forest degradation in the Indian Himalayas. *World Development*, *38*(11), 1642–1656. https://doi.org/10.1016/j.worlddev.2010.03.007

Banana, Y. A., & Gombya-Ssembajjwe, W. (2000). Successful forest management: The importance of security of tenure and rule enforcement in Ugandan forests. In C. C. Gibson, A. M. McKean, & E. Ostrom (Eds.), *People and forests: Communities, institutions and governance* (pp. 87–98). Cambridge & Massachusetts, London, USA: The MIT Press.

Berbel, J., & Esteban, E. (2019). Droughts as a catalyst for water policy change. Analysis of Spain, Australia (MDB), and California. *Global Environmental Change*, *58*, 101969. https://doi.org/10.1016/j.gloenvcha.2019.101969

Berkes, F. (2009). Evolution of co-management: Role of knowledge generation, bridging organizations and social learning. *Journal of Environmental Management*, *90*(5), 1692–1702. https://doi.org/10.1016/j.jenvman.2008.12.001

Borah, J. R., Evans, K. L., & Edwards, D. P. (2018). Quantifying carbon stocks in shifting cultivation landscapes under divergent management scenarios relevant to REDD+. *Ecological Applications*, *28*(6), 1581–1593. https://doi.org/10.1002/eap.1764

Bray, D. B., ElviraDuran, Hugo, R. V., Jean-Francois, M., Alejandro, V., Balas, M. R., … Jeremy, R. (2008). Tropical deforestation, community forests, and protected areas in the Maya forest. *Ecology and Society*, *13(2):56*. https://doi.org/10.5751/ES-02593-130256

Brockington, D., Adams, M. W., Agarwal, B., Agrawal, A., Büscher, B., Chhatre, A., … Oldekop, A. J. (2018). Working governance for working land. *Science*, *362*(6420), 1257. https://doi.org/10.1126/science.aav8452

Brooks, J., Waylen, K. A., & Mulder, M. B. (2013). Assessing community-based conservation projects: A systematic review and multilevel analysis of attitudinal, behavioral, ecological, and economic outcomes. *Environmental Evidence*, *2*(1), 1–34. https://doi.org/10.1186/2047-2382-2-2

Campos, J. L. A., Araújo, de L. E., Gaoue, G. O., & Albuquerque, P. U. (2018). How can local representations of changes of the availability in natural resources assist in targeting conservation? *Science of the Total Environment*, *628–629*, 642–649. https://doi.org/10.1016/j.scitotenv.2018.02.064

Carlsson, L., & Berkes, F. (2005). Co-management: Concepts and methodological implications. *Journal of Environmental Management*, *75*, 65–76. https://doi.org/10.1016/j.jenvman.2004.11.008

Ceddia, M. G., Bardsley, N. O., Gomez-Y-Paloma, S., & Sedlacek, S. (2014). Governance, agricultural intensification, and land sparing in tropical South America. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(20), 7242–7247. https://doi.org/10.1073/pnas.1317967111

Chave, J., Réjou-Méchain, M., Búrquez, A., Chidumayo, E., Colgan, M. S., Delitti, W. B. C., … Vieilledent, G. (2014). Improved allometric models to estimate the aboveground biomass of tropical trees. *Global Change Biology*, *20*, 3177–3190. https://doi.org/10.1111/gcb.12629

Costanza, R., de Groot, R., Braat, L., Kubiszewski, I., Fioramonti, L., Sutton, P., … Grasso, M. (2017). Twenty years of ecosystem services: How far have we come and how far do we still need to go? *Ecosystem Services*, *28*, 1–16. https://doi.org/10.1016/j.ecoser.2017.09.008

Cronkleton, P., Artati, Y., Baral, H., Paudyal, K., Banjane, M. R., Liu, J. L., … Kassa, H. (2017). How do property rights reforms provide incentives for forest landscape restoration? Comparing evidence from Nepal, China and Ethiopia. *International Forestry Review*, *19*(S4), 8–23. https://doi.org/10.1505/146554817822330506

Damnyag, L., Saastamoinen, O., Appiah, M., & Pappinen, A. (2012). Role of tenure insecurity in deforestation in Ghana’s high forest zone. *Forest Policy and Economics*, *14*, 90–98. https://doi.org/10.1016/j.forpol.2011.08.006

de Groot, S. R., Wilson, A. M., & Boumans, M. J. R. (2002). A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecological Economics*, *41*, 393–408. https://doi.org/10.1016/S0921-8009(02)00089-7

De Vente, J., Reed, M. S., Stringer, L., Valente, S., & Newig, J. (2016). How does the context and design of participatory decision-making processes affect their outcomes? Evidence from sustainable land management in global drylands. *Ecology and Society*, *21(2):24*. https://doi.org/10.5751/ES-08053-210224

DeCaro, A. D., Janssen, A. M., & Lee, A. (2015). Synergistic effects of voting and enforcement on internalized motivation to cooperate in a resource dilemma. *Judgment and Decision Making*, *10*(6), 511–537.

DeGeorges, P. A., & Reilly, B. K. (2009). The realities of community based natural resource management and biodiversity conservation in Sub-Saharan Africa. *Sustainability*, *1*(3), 734–788. https://doi.org/10.3390/su1030734

Díaz, S., Demissew, S., Carabias, J., Joly, C., Lonsdale, M., Ash, N., … Zlatanova, D. (2015). The IPBES conceptual framework - connecting nature and people. *Current Opinion in Environmental Sustainability*, *14*, 1–16. https://doi.org/10.1016/j.cosust.2014.11.002

Epstein, G. (2017). Local rulemaking, enforcement and compliance in state-owned forest commons. *Ecological Economics*, *131*, 312–321. https://doi.org/10.1016/j.ecolecon.2016.09.012

Essougong, U., Foundjem-Tita, D., & Minang, A. P. (2019). Addressing equity in community forestry: Lessons from 20 years of implementation in Cameroon. *Ecology and Society*, *24(1):9*. https://doi.org/10.5751/es-10656-240109

FAO. (2010). *Global forest resources assessment 2010*. Rome, Italy: Food and Agriculture Organisation.

Fernández-Llamazares, Á., Díaz-Reviriego, I., Guèze, M., Cabeza, M., Pyhälä, A., & Reyes-García, V. (2016). Local perceptions as a guide for the sustainable management of natural resources: Empirical evidence from a small-scale society in Bolivian Amazonia. *Ecology and Society*, *21*((1):2). https://doi.org/10.5751/ES-08092-210102

Ferraro, J. P., Hanauer, M. M., & Sims, R. E. K. (2011). Conditions associated with protected area success in conservation and poverty reduction. *Proceedings of the National Academy of Sciences of the United States of America*, *108*(34), 13913–13918. https://doi.org/10.1073/pnas.1011529108

Fischer, F. (2017). *Climate crisis and the democratic prospect: Participatory governance and sustainable Communities*. Oxford, UK: Oxford University Press.

Frey, S. B., & Jegen, R. (2001). Motivation crowding theory. *Journal of Economic Surveys*, *15*(5), 589–611. https://doi.org/10.1111/1467-6419.00150

Gathaara, G. (1999). *Aerial survey of the destruction of Mt. Kenya, Imenti and Ngare Ndare Forest Reserves.* Nairobi: Kenya Wildlife Service. Retrieved from http://www.unep.org/dewa/Portals/67/pdf/Mt_Kenya.pdf

Gibson, C. C., Williams, T. J., & Ostrom, E. (2005). Local enforcement and better forests. *World*

Development, *33*(2), 273–284. https://doi.org/10.1016/j.worlddev.2004.07.013

Godoy, R., Reyes-García, V., Huanca, T., Leonard, W. R., Olvera, R. G., Bauchet, J., … Seyfreid, C. (2007). The role of community and individuals in the formation of social capital. *Human Ecology*, *35*(6), 709–721. https://doi.org/10.1007/s10745-006-9106-1

GoK. (2016). *The forest conservation and management Act*. Nairobi, Kenya: Government Printer.

GoK. (2018). *A report on forest resources and logging activities in Kenya*. Nairobi, Kenya: Government Printer.

Gordon, I., & Ayiemba, W. (2003). Harnessing butterfly biodiversity for improving livelihoods and forest conservation: The Kipepeo Project. *Journal of Environment and Development*, *12*(1), 82–98. https://doi.org/10.1177/1070496502250439

Green, M. H. J., Fisher, B., Green, E. R., Makero, J., Platts, J. P., Robert, N., … Balmford, A. (2018). Local costs of conservation exceed those borne by the global majority. *Global Ecology and Conservation*, *14*, e00385. https://doi.org/10.1016/j.gecco.2018.e00385

Hahn, T., Olsson, P., Folke, C., & Johansson, K. (2006). Trust-building, knowledge generation and organizational innovations: The role of a bridging organization for adaptive comanagement of a wetland landscape around Kristianstad, Sweden. *Human Ecology*, *34*(4), 573–592. https://doi.org/10.1007/s10745-006-9035-z

Hayes, T., & Murtinho, F. (2018). Communal governance, equity and payment for ecosystem services. *Land Use Policy*, *79*, 123–136. https://doi.org/10.1016/j.landusepol.2018.08.001

Hayes, T., & Persha, L. (2010). Nesting local forestry initiatives: Revisiting community forest management in a REDD+ world. *Forest Policy and Economics*, *12*(8), 545–553. https://doi.org/10.1016/j.forpol.2010.07.003

Iversen, V., Chhetry, B., Francis, P., Gurung, M., Kafle, G., Pain, A., & Seeley, J. (2006). High value forests, hidden economies and elite capture: Evidence from forest user groups in Nepal’s Terai. *Ecological Economics*, *58*, 93–107. https://doi.org/10.1016/j.ecolecon.2005.05.021

Kaimowitz, D. (2003). Forest law enforcement and rural livelihoods. *International Forestry Review*, *5*(3), 199–210. https://doi.org/10.4324/9781849771672

Kalame, F. B., Aidoo, R., Nkem, J., Ajayie, O. C., Kanninen, M., Luukkanen, O., & Idinoba, M. (2011). Modified taungya system in Ghana: A win-win practice for forestry and adaptation to climate change? *Environmental Science and Policy*, *14*, 519–530. https://doi.org/10.1016/j.envsci.2011.03.011

Karki, R., Shrestha, K. K., Ojha, H., Paudel, N., Khatri, B. D., Nuberg, I., & Adhikary, A. (2018). From forests to food security: Pathways in Nepal’s community forestry. *Small-Scale Forestry*, *17*, 89–104. https://doi.org/10.1007/s11842-017-9377-y

Kellert, S. R. ., Mehta, J. N. ., Ebbin, S. A. ., & Lichtenfeld, L. L. (2000). Community natural resource management: Promise, rhetoric, and reality. *Society & Natural Resources*, *13*, 705–715. https://doi.org/10.1080/089419200750035575

Kenya Law. Republic v Kenya Forest Service Ex-parte Clement Kariuki & 2 others eKLR (2013). Retrieved from http://kenyalaw.org/caselaw/cases/view/83362

KFS. (2010). *Mt. Kenya forest reserve management plan 2010-2019*. Nairobi, Kenya: Kenya Forest Service (KFS).

Kideghesho, J. R., Røskaft, E., & Kaltenborn, B. P. (2007). Factors influencing conservation attitudes of local people in Western Serengeti, Tanzania. *Biodiversity and Conservation*, *16*(7), 2213–2230. https://doi.org/10.1007/s10531-006-9132-8

KNBS. (2019). *Economic survey 2019*. Nairobi, Kenya: Government Printer.

Koech, C. K., Ongugo, P. O., Mbuvi, M. T. E., & Maua, J. O. (2009). *Community forest associations in Kenya: Challenges and opportunities*. Nairobi, Kenya: Kenya Forest Research Institute.

Kreft, S., Eckstein, D., Dorsch, L., & Fischer, L. (2015). *Global climate risk index 2016: Who suffers most from extreme weather events? Weather-related loss events in 2014 and 1995 to 2014*. Germany: Germanwatch e.V. https://doi.org/978-3-943704-04-4

La Ferrara, E. (2002). Inequality and group participation: Theory and evidence from rural Tanzania. *Journal of Public Economics*, *85*(2), 235–273. https://doi.org/10.1016/S0047-2727(01)00102-5

Larson, M. A., & Dahal, R. G. (2012). Forest tenure reform: New resource rights for forest-based communities? *Conservation and Society*, *10*(2), 77. https://doi.org/10.4103/0972-4923.97478

Lawry, S., McLain, R., Swallow, B., & Biedenweg, K. (2012). *Devolution of forest rights and sustainable forest management: A review of policies and programs in 16 developing countries*. Washington, D.C.: USAID.

Luintel, H., Bluffstone, A. R., Scheller, M. R., & Adhikari, B. (2017). The effect of the Nepal community forestry program on equity in benefit sharing. *Journal of Environment and Development*, *26*(3), 297–321. https://doi.org/10.1177/1070496517707305

Lund, J. F. (2015). Paradoxes of participation: The logic of professionalization in participatory forestry. *Forest Policy and Economics*, *60*, 1–6. https://doi.org/10.1016/j.forpol.2015.07.009

Malla, Y. B. (2000). Impact of community forestry policy on rural livelihoods and food security in Nepal. *Unasylva*, *51*(202), 37–45.

Mamo, G., Sjaastad, E., & Vedeld, P. (2007). Economic dependence on forest resources: A case from Dendi District, Ethiopia. *Forest Policy and Economics*, *9*, 916–927. https://doi.org/10.1016/j.forpol.2006.08.001

Martín-López, B., Iniesta-Arandia, I., García-Llorente, M., Palomo, I., Casado-Arzuaga, I., Del Amo, D. G., … Montes, C. (2012). Uncovering ecosystem service bundles through social preferences. *PLoS ONE*, *7*(6). https://doi.org/10.1371/journal.pone.0038970

Martin, A., Gross-Camp, N., Kebede, B., & McGuire, S. (2014). Measuring effectiveness, efficiency and equity in an experimental Payments for Ecosystem Services trial. *Global Environmental Change*, *28*, 216–226. https://doi.org/10.1016/j.gloenvcha.2014.07.003

McDermott, M. ., & Schreckenberg, K. (2009). Equity in community forestry: Insights from North and South. *International Forestry Review*, *11*(2), 157–170. https://doi.org/10.1505/ifor.11.2.157

Mehta, J. N., & Heinen, J. T. (2001). Does community-based conservation shape favorable attitudes among locals? An empirical study from Nepal. *Environmental Management*, *28*(2), 165–177. https://doi.org/10.1007/s002670010215

Millennium Ecosystem Assessment (MEA). (2005). *Ecosystems and human well-being: Synthesis*. Washington, D.C.: Island Press.

Mogaka, H., Simons, G., Turpie, J., Emerton, L., & Karanja, F. (2001). *Economic aspects of community involvement in sustainable forest management in Eastern and Southern Africa.* Nairobi, Kenya: IUCN — The World Conservation Union, Eastern Africa Regional Office.

Mogoi, J., Obonyo, E., Ongugo, P., Oeba, V., & Mwangi, E. (2012). Communities, property rights and forest decentralisation in Kenya: Early lessons from participatory forestry management. *Conservation and Society*, *10*(2), 182–194. https://doi.org/10.4103/0972-4923.97490

Mollick, S. A., Rahman, K., Khan, N. I., & Sadath, N. (2018). Evaluation of good governance in a participatory forestry program: A case study in Madhupur Sal forests of Bangladesh. *Forest Policy and Economics*, *95*, 123–137. https://doi.org/10.1016/j.forpol.2018.07.014

Morgan, J. (2009). Kenya's heart stops pumping. Retrieved July 12, 2018, from http://news.bbc.co.uk/1/hi/world/africa/8057316.stm

Morsello, C., Delgado, J. A. da S., Fonseca-Morello, T., & Brites, A. D. (2014). Does trading non-timber forest products drive specialisation in products gathered for consumption? Evidence from the Brazilian Amazon. *Ecological Economics*, *100*, 140–149. https://doi.org/10.1016/j.ecolecon.2014.01.021

Mungai, A. (2018, August 23). Water cabinet secretary cancel water diversion. *Standard Newspaper*. Retrieved from https://www.standardmedia.co.ke/article/2001292994/water-cs-cancels-diversion-licences

Murtazashvili, I., Murtazashvili, J., & Salahodjaev, R. (2019). Trust and deforestation: A cross-country comparison. *Forest Policy and Economics*, *101*, 111–119. https://doi.org/10.1016/j.forpol.2019.02.001

Nelson, A., & Chomitz, K. M. (2011). Effectiveness of strict vs. multiple use protected areas in reducing tropical forest fires: A global analysis using matching methods. *PLoS ONE*, *6*(8). https://doi.org/10.1371/journal.pone.0022722

Nguyen, T. T., Do, T. L., Bühler, D., Hartje, R., & Grote, U. (2015). Rural livelihoods and environmental resource dependence in Cambodia. *Ecological Economics*, *120*, 282–295. https://doi.org/10.1016/j.ecolecon.2015.11.001

Nolte, C., Agrawal, A., Silvius, M. K., & Britaldo, S. S. F. (2013). Governance regime and location influence avoided deforestation success of protected areas in the Brazilian Amazon. *Proceedings of the National Academy of Sciences*, *110*(13), 4956–4961. https://doi.org/10.1073/pnas.1214786110

Nuno, A., & John, A. V. S. T. F. (2015). How to ask sensitive questions in conservation: A review of specialized questioning techniques. *Biological Conservation*, *189*, 5–15. https://doi.org/10.1016/j.biocon.2014.09.047

Oldekop, J. A., Bebbington, A. J., Truelove, N. K., Holmes, G., Villamarín, S., & Preziosi, R. F. (2012). Environmental impacts and scarcity perception influence local institutions in indigenous Amazonian Kichwa communities. *Human Ecology*, *40*, 101–115. https://doi.org/10.1007/s10745-011-9455-2

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*.

Cambridge, UK: Cambridge University Press.
Oteros-Rozas, E., Martín-López, B., González, J. A., Plieninger, T., López, C. A., & Montes, C. (2014). Socio-cultural valuation of ecosystem services in a transhumance social-ecological network. *Regional Environmental Change*, *14*(4), 1269–1289. https://doi.org/10.1007/s10113-013-0571-y
Oyono, P. R., Ribot, J. C., & Larson, A. M. (2006). *Green and black gold in rural Cameroon: Natural resources for local governance, justice and sustainability*. *Working paper 22*. Washington, D.C.: World Resource Institute.
Pailler, S., Naidoo, R., Burgess, D. N., Freeman, E. O., & Fisher, B. (2015). Impacts of community-based natural resource management on wealth, food security and child health in Tanzania. *Plos One*, *10*(7), e0133252. https://doi.org/10.1371/journal.pone.0133252
Paudyal, K., Baral, H., Lowell, K., & Keenan, R. J. (2017). Ecosystem services from community-based forestry in Nepal: Realising local and global benefits. *Land Use Policy*, *63*, 342–355. https://doi.org/10.1016/j.landusepol.2017.01.046
Persha, L., Agrawal, A., & Chhatre, A. (2011). Social and ecological synergy: Local rule making, forest livelihoods and biodiversity conservation. *Science*, *331*(6024), 1606–1608. https://doi.org/10.1126/science.1199343
Pham, T. T., Moeliono, M., Brockhaus, M., Le, D. N., Wong, Y. G., & Le, T. M. (2014). Local preferences and strategies for effective, efficient, and equitable distribution of PES revenues in Vietnam: Lessons for REDD+. *Human Ecology*, *42*(6), 885–899. https://doi.org/10.1007/s10745-014-9703-3
Plummer, R., & Fitzgibbon, J. (2004). Co-management of natural resources. A proposed framework. *Environmental Management*, *33*(6), 876–885. https://doi.org/10.1007/s00267-003-3038-y
Pokharel, K. R., & Tiwari, R. K. (2013). Good governance assessment in Nepal's community forestry. *Journal of Sustainable Forestry*, *32*(6), 549–564. https://doi.org/10.1080/10549811.2013.779902
Pomeroy, S. R., Katon, M. B., & Harkes, I. (2001). Conditions affecting the success of fisheries co-management: Lessons from Asia. *Marine Policy*, *25*, 197–208. https://doi.org/10.1016/S0308-597X(01)00010-0
Porter-Bolland, L., Ellis, E. a., Guariguata, M. R., Ruiz-Mallén, I., Negrete-Yankelevich, S., & Reyes-García, V. (2012). Community managed forests and forest protected areas: An assessment of their conservation effectiveness across the tropics. *Forest Ecology and Management*, *268*, 6–17. https://doi.org/10.1016/j.foreco.2011.05.034
Pretty, J. (2003). Social capital and the collective management. *Nature*, *302*, 1912–1914.
PROFOR, & FAO. (2011). *Framework for assessing and monitoring forest governance*. Rome, Italy: The Program On Forests (PROFOR) and Food and Agriculture Organisation.
Quintas-Soriano, C., Brandt, S. J., Running, K., Baxter, V. C., Gibson, M. D., Narducci, J., & Castro, J. A. (2018). Social-ecological systems influence ecosystem service perception: A programme on ecosystem change and society (PECS) analysis. *Ecology and Society*, *23(3):3*. https://doi.org/10.5751/ES-10226-230303
Rasmussen, L. V., Watkins, C., & Agrawal, A. (2017). Forest contributions to livelihoods in changing agriculture-forest landscapes. *Forest Policy and Economics*, *84*, 1–8. https://doi.org/10.1016/j.forpol.2017.04.010
Ribot, J. C., Lund, J. F., & Treue, T. (2010). Democratic decentralization in sub-Saharan Africa: Its contribution to forest management, livelihoods, and enfranchisement. *Environmental Conservation*, *37*(1), 35–44. https://doi.org/10.1017/S0376892910000329
Rizek, M. B., & Morsello, C. (2012). Impacts of trade in non-timber forest products on cooperation among Caboclo households of the Brazilian Amazon. *Human Ecology*, *40*(5), 707–719. https://doi.org/10.1007/s10745-012-9506-3
Rodríguez, J. P., Beard, T. D., Bennett, E. M., Cumming, G. S., Cork, S. J., Agard, J., … Peterson, G. D. (2006). Trade-offs across space, time, and ecosystem services. *Ecology and Society*, *11(1):28*. https://doi.org/10.5751/ES-01667-110128
Ros-Tonen, A. F. M., Insaidoo, F. G. T., & Acheampong, E. (2013). Promising start, bleak outlook: The role of Ghana's modified taungya system as a social safeguard in timber legality processes. *Forest Policy and Economics*, *32*, 57–67. https://doi.org/10.1016/j.forpol.2012.11.011
Ros-Tonen, M. A. F., Insaidoo, T. F. G., & Acheampong, E. (2013). Promising start, bleak outlook: The role of Ghana's modified taungya system as a social safeguard in timber legality processes. *Forest Policy and Economics*, *32*, 57–67. https://doi.org/10.1016/j.forpol.2012.11.011
Sanginga, C. P., Kamugisha, N. R., & Martin, M. A. (2007). The dynamics of social capital and conflict management in multiple resource regimes: A case of the southwestern highlands of Uganda. *Ecology and Society*, *12(1):6*. https://doi.org/10.5751/ES-01847-120106
Seymour, F., Vina, L. T., & Hite, K. (2014). *Evidence linking community-level tenure and forest condition:*

An annotated bibliography. San Francisco, USA: Climate and Land Use Alliance.

Sills, O. E., & Jones, K. (2018). Causal inference in environmental conservation: The role of institutions. In P. Dasgupta, K. S. Pattanayak, & V. K. Smith (Eds.), *Handbook of Environmental Economics* (Vol. 4, pp. 395–437). North Holland, Netherlands: Elsevier B.V. https://doi.org/10.1016/bs.hesenv.2018.09.001

Silva, T. L. L., Campos, J. L. de A., Alves, Â. G. C., & Albuquerque, U. P. (2019). Market integration does not affect traditional ecological knowledge but contributes additional pressure on plant resources. *Acta Botanica Brasilica*, *33*(2), 232–240. https://doi.org/10.1590/0102-33062018abb0310

Skutsch, M. (2000). Conflict management and participation in community forestry. *Agroforestry Systems*, *48*, 189–206. https://doi.org/http://dx.doi.org/10.1023/A:1006328403023

Small, N., Munday, M., & Durance, I. (2017). The challenge of valuing ecosystem services that have no material benefits. *Global Environmental Change*, *44*, 57–67. https://doi.org/10.1016/j.gloenvcha.2017.03.005

Stecklov, G., Weinreb, A., & Carletto, C. (2018). Can incentives improve survey data quality in developing countries?: Results from a field experiment in India. *Journal of the Royal Statistical Society*, *181*(4), 1033–1056. https://doi.org/10.1111/rssa.12333

Stevens, C., Winterbottom, R., Springer, J., & Reytar, K. (2014). *Securing rights, combating climate change: How strengthening community forest rights mitigates climate change*. Washington, D.C.: World Resources Institute.

TEEB. (2010). *The economics of ecosystems and biodiversity: Mainstreaming the economics of nature: A synthesis of the approach, Conclusions and recommendations of TEEB*. Nagoya, Japan.

Tremblay, J. A., Boulanger, Y., Cyr, D., Taylor, A. R., Price, D. T., & St-Laurent, M. H. (2018). Harvesting interacts with climate change to affect future habitat quality of a focal species in eastern Canada's boreal forest. *PLoS ONE*, *13*(2), e0191645. https://doi.org/10.1371/journal.pone.0191645

Uberhuaga, P., Smith-Hall, C., & Helles, F. (2012). Forest income and dependency in lowland Bolivia. *Environment, Development and Sustainability*, *14*, 3–23. https://doi.org/10.1007/s10668-011-9306-8

Vedeld, P., Angelsen, A., Bojö, J., Sjaastad, E., & Kobugabe Berg, G. (2007). Forest environmental incomes and the rural poor. *Forest Policy and Economics*, *9*, 869–879. https://doi.org/10.1016/j.forpol.2006.05.008

Vira, B., Wildburger, C., & Mansourian, S. (2015). *Forests, trees and landscapes for food security and nutrition: A global assessment report*. Vienna, Austria: International Union of Forest Research Organizations (IUFRO). Retrieved from https://www.cifor.org/library/5592/

Word Bank. (2011). *Wood-based biomass energy development for Sub-Saharan Africa: Issues and approaches*. Washington, D.C.: World Bank.

World Bank. (2008). *Forests sourcebook: Practical guidance for sustaining forests in development cooperation*. Washington, D.C.: World Bank.

Wunder, S., Angelsen, A., & Belcher, B. (2014). Forests, livelihoods and conservation: Broadening the empirical base. *World Development*, *64*, S1–S11. https://doi.org/10.1016/j.worlddev.2014.03.007

Appendix

Questionnaire for CFA and non-CFA respondents (Non-CFA respondents asked questions applicable to them

DATA COLLECTION SAMPLE QUESTIONNAIRE

NAME OF ENUMERATOR: ______________________________ **DATE: ______________**
CFA: **CONSTITUENCY:** **SUB LOCATION:**
VILLAGE:

1.0 Demographics (household head/spouse)
Notes

a. Household heads (CFA and non-CFA members) to be interviewed or if absent, relatives (Spouses, sons, daughters etc.) over 18 years of age and familiar with the running of the household affairs to be interviewed to provide the required information.
b. Respondent to make a comment where other members of the household chip in during the interview (Make a mark on the questionnaire)
c. Household in this research comprises of a family/people which cook and eat together

Household head: Yes =1 ☐		No =2 ☐			
If No, Relationship to household head:					
Gender: Male= 1		Female= 2			
Age: years					
Tribe:					
Number of people living in your household:					
Education & number of years spent schooling	None(0)	Primary(1)	Secondary(2)	Tertiary /diploma / Certificate (3)	University degree (4)
Years lived in this area:					
Respondent code number (from list**):**				Mobile No:	

2.0 Socio-economic

2.1	Are your employed? **(tick)** Yes =1 No =0		
2.2	What is your main occupation?		
2.3	Does your household own land? **(tick)** Yes =1 No = 0		
2.4	If yes, what type of ownership (**tick**) and size (in acres) does your household own?		
	Inherited =1	Size:	
	Lease/rent in the forest =2	Size:	
	Lease/rent elsewhere =3	Size:	
	Owned/purchased =4	Size:	
	Others, specify =5	Size:	
2.5	What livestock does your household own. Indicate number of animals/birds		
2.8	What assets do you own if any from the list below? Please **tick** a Yes if you own and No if you don't own		
	a. Bicycle	Yes =1	No =0
	b. Motorcycle	Yes	No
	c. Radio	Yes	No
	d. Television (TV)	Yes	No
	e. Refrigerator	Yes	No
	f. Cart	Yes	No
	g. Motor vehicle	Yes	No
	h. Others: *specify*		

2.9	What business enterprise are you involved in if any e.g. shop, transport etc.

3.0 PFM awareness, activities and benefits

3.1	Do you belong to any networking/association group in this village? (**tick**) Yes =1 No =0					
3.2	Are you a CFA member? Yes =1 No =0					
3.3	Do you know the importance of Mt. Kenya forest? **(tick)** Yes =1 No = 0					
3.4a	If Yes above, list down the benefits you get from the forest important to you and your household					
3.4b	From the materials listed above, rank only four benefits important to your household in order of priority					
3.5	How many years have you been a CFA member?					
3.6	How much do you pay for registration to become a CFA member?					
3.7	How often do you renew the membership after joining the CFA					
3.7	What does your household use as a source of energy for cooking? e.g. firewood					
3.8	What energy efficient technologies does your household use/practice? **(tick)**					
	Fuel-efficient stoves or '*Kuni mbilijiko'*= 1	Cooking basket=2	Biogas= 3	None= 4	Other, *specify*= 5	
3.9	Before Participatory Forest Management (PFM) was adopted in Mt. Kenya forest, were you able to access the forest for material benefits for your household use e.g. posts for home repairs, fire wood, grazing etc.? Yes=1 No=0					
3.10	Please **tick** below the materials you harvested from the forest or activities you did before PFM was introduced					
	a. Wild fruits	g. Fodder for zero grazing	m. Charcoal production			
	b. Medicinal herbs	h. Manure	n. Spiritual & cultural practices			
	c.Firewood	i. Water	o. Others, *Specify*			
	d.Grass for thatching	j. Honey (beekeeping)				
	e.Poles/posts/timber	k. Fish (fishing)				
	f. Grazing in the forest	l. Food or Farming				
3.11	Please **tick** below the materials you now harvest from the forest or activities you do after PFM was introduced					
	a. Wild fruits	g. Fodder for zero grazing	n. Spiritual & cultural practices			
	b. Medicinal herbs	h. Manure	o. Others, *Specify*			
	c.Firewood	i. Water				
	d.Grass for thatching	j. Honey (beekeeping)				
	e.Poles/posts/timber	l. Food or Farming				
	f. Grazing in the forest	m. Charcoal production				

3.12	List down materials you harvest from the forest, frequency of harvesting and amount paid to KFS for product harvests			
	Products/Use	Frequency of harvesting e.g. weekly	Amount paid per month	Other comments

3.13	What benefits are you not allowed to get from the forest which you would like to harvest? List down			
3.14	How have your household assets changed after being a member of a CFA? (**tick**)	Decreased= 1	Remained the same= 2	Increased= 3
3.15	List down what assets you have bought if any or activities done with proceeds received from PFM since joining CFA			

Add any comments on how your life has changed since being a CFA member

3.16	List the main ways in which PFM has been a source of earning a living to you and the income earned annually in the last 12 months (June 2015-June 2016)					
	Product harvest/ Activity	For sale, consumption or Both	Harvesting frequency e.g. weekly	Quantity harvested per harvest	Quantity harvested in a year	Quantity sold in a year	Income earned in a year (Ksh)

3.17	What other livelihood activities does your household do outside the forest to earn an income and sustain your household? List up to five main sources of household income carried out in the last 12 months outside the forest (June 2015-June 2016) and amount earned in the period						
	Product harvest/ Activity	For sale, consumption or Both	Harvesting frequency e.g. weekly	Quantity harvested per harvest	Quantity harvested in a year	Quantity sold in a year	Income earned in a year (Ksh)

3.18	How much time do you devote to forest activities in a month and how are you able to balance the time with other needs for your household?					
3.19	Which seasons do you mostly participate in forest activities (tick and elaborate)					
	None =0	Rain season =1	Dry season =2	Throughout year =3	When needed= 4	Others *explain*=5
3.20	What other benefits has been brought to your village by the CFAs or PFM programme or donors through the PFM programme? e.g. Built infrastructure (schools, toilets, roads, dam etc.), scholarships and bursaries, employment, good relations, security etc.					
3.21	Are you anticipating for any changes in PFM so that you can maximise your opportunities and benefits to improve your standards of living? (**tick)** Yes =1 No = 0					
3.22	If Yes above, please indicate what changes you would like to see effected					
3.23	What are the challenges/difficulties that you have experienced while participating in PFM?					
3.24	How can the challenges you have indicated above be solved?					

4.0 Participation and governance

4.1	Who are the main stakeholders in PFM in this area?
4.2	Did you participate in the preparation of the management plan for your CFA?**(tick)** Yes =1 No =0

<table>
<tr><td>4.3</td><td colspan="6">If Yes above, did you give ideas/contributions/suggestions to be taken into account in the management plan?

Yes= 1 No =0 (If Yes, respondent to elaborate on contributions/ideas given and if were incorporated in plan)</td></tr>
<tr><td>4.4</td><td colspan="6">Are you fully involved in decision making in your CFAs? (e.g. rules and bylaws, fines to be paid, membership fees, activities to carry, who to implement them etc.)

Yes =1 No =0
(If Yes, respondent to elaborate on a variety of contributions made in decision making and give examples where applicable)</td></tr>
<tr><td>4.5</td><td colspan="6">Who do you think most strongly influences the decisions made in your CFA by having a final say on the decisions made</td></tr>
<tr><td>4.6</td><td colspan="6">How do you agree with the statement below on a scale of 1 to 5 where 5 is strongly agree</td></tr>
<tr><td></td><td>CFA members are only notified about decision(s) made without being granted the opportunity to influence the decision-making process (tick)</td><td>Strongly disagree
1</td><td>Disagree

2</td><td>Neutral

3</td><td>Agree

4</td><td>Strongly agree
5</td></tr>
<tr><td>4.7</td><td colspan="2">Do you get sufficient information as you would like regarding the CFA, conservation, participation or, opportunities etc.(tick)</td><td>Never
1</td><td>Sometimes
2</td><td>Very often
3</td><td>Always
4</td></tr>
<tr><td>4.8</td><td colspan="6">Have you participated in meetings where all or some of stakeholders you mentioned in 4.2 were involved in joint review/ analysis of PFM (progress, challenges, review) to chat a way forward

Yes = 1No = 0
(If yes respondent to elaborate on his/her contributions during the meeting(s)</td></tr>
<tr><td>4.9</td><td colspan="6">If Yes above, were any concerns, recommendations that you gave taken on-board for the improvement of PFM delivery/smooth operations of PFM

Yes = 1No = 0</td></tr>
<tr><td>4.10</td><td colspan="6">How many trainings have you attended facilitated through PFM since joining CFA?</td></tr>
<tr><td>4.11</td><td colspan="6">List down the trainings attended</td></tr>
<tr><td>4.12</td><td colspan="6">How would you rate your level of your participation in the CFA, from a scale of 1 to 5, with 5 denoting very high participation</td></tr>
</table>

5.1	Who do you think is in charge of managing Mt. Kenya forest reserve(tick all that apply)	CFA officials 1	CFA (officials & members) 2	CFA officials & KFS 3	CFA &KFS 4	KFS 5	Don't know 6
5.2	Who do you think makes rules, decisions or plans on what needs to be done in the forest						
5.3	Who do you think enforces the rules, decisions or plans on what needs to be done in the forest						
5.4	Who do you think implements the activities conserve the forest						

5.5	Who do you think provides protection and security against illegal activities in the forest						
5.6	Is the allocation of plots in the forest for farming (PELIS) transparent? Yes =1 No = 0 Not applicable= 2 Respondent to elaborate						
5.7	Did you participate in the last elections held to select your officials? Yes =1 No= 0 Respondent to elaborate						
5.8	If Yes above, how do you likely agree that the elections were fair and transparent on a scale of 1 to 5 where 5 is strongly agree **(tick)**		Strongly disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly agree 5
5.9	If you did not vote in the last elections, what prevented you from voting?						
5.10	Does the CFA committee share income and expenditure accounts (income raised and activities carried out) in a year(s) with the CFA members? Yes= 1 No = 0						
5.11	If Yes above, how likely do you agree that the CFA committee is transparent and efficient, on a scale of 1 to 5 where 5 is strongly agree **(tick)**		Strongly disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly agree 5
5.12	The CFA is efficient in conflict resolution & management						
5.13	When the CFA members makes suggestions or opinions or decisions regarding PFM, the matter(s) are taken into consideration by CFA officials						
5.14	When the CFA makes suggestions or opinions or decisions regarding PFM, the matter(s) are taken into consideration by KFS/government						
5.15	Do you have ways/systems of holding CFA officials to be more accountable and transparent in the management of the CFA? Yes= 1 No= 2 (Please elaborate your answer by giving examples)						

Perceptions, feelings and attitude

I would like now to ask you about your feelings and attitude towards PFM programme, assessed on a scale of 1-5, where 5 is strongly agree

		Strongly disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly agree 5
6.1	Since PFM started in this area, I have a positive attitude towards sustainable forest management or PFM					
6.2	Training received in PFM has enabled me to gain more knowledge to participate in conserving the forest					
6.3	The involvement of communities has improved forest conditions in the forest since PFM started					
6.4	The sharing of benefits and opportunities is fair among all CFA members					
6.5	The sharing of benefits is fair between CFA and KFS					
6.6	I am actively involved in decision making on matters of forest conservation in our CFA					

6.7	I am actively involved in carrying out forest activities toconserve the forest					
6.8	I have a good relationship with other CFA members in the community					
6.9	I have a good relationship with non CFA members in the community					
7.0	I/We have a good relationship with KFS					
7.1	I/We have a good relationship with other partners (donors, NGOs etc.)					
7.2	The PFM programme has empowered me and improved all areas of my life (financial, social, relations, human, confidence etc.					