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Research Application Summary

Socio-economic drivers of ecosystem service provision

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Abstract

Land degradation is one of the major problems affecting not only Uganda but the whole of Sub Saharan Africa (SSA). This challenge is partly due to high population densities and overexploitation of natural resources. Farmers in SSA have now resorted to clearing of the forests in a bid to look for land for settlement, energy requirements and growing of crops to feed the ever increasing population. Options that are left to the farmers are either to use intensive land use systems or depend on the ecosystem services that are provided by the diversified land use systems. As one moves away from diversified to simplified land use systems, ecosystem services may reduce. Since farmers always go for that option that maximize their benefit, decisions can be based on the attributes of the land use systems but more so, on the socio-economic factors that surround them. Such factors for example include land tenure, farmer demographic characteristics, and farmer's income, among others. Literature suggests that there are mixed factors that influence land use intensities in different parts of the world. This study will identify the socio-economic factors that influence land use decisions in ecosystem services provision in Mt Elgon region of Uganda with a view to expanding the knowledge base as well as guiding decision makers in planning activities.

Key words: Diversified land use, ecosystem services, land use intensity, Mt Elgon, natural resources management, soil fertility management

Résumé

La dégradation des terres est l'un des problèmes majeurs qui touchent non seulement l'Ouganda, mais toute l'Afrique subsaharienne. Ce défi est en partie dû à la forte densité de population et à la surexploitation des ressources naturelles. Les agriculteurs de l'Afrique subsaharienne ont maintenant recouru au déboisement des forêts dans le but de chercher des terres pour s'y installer, couvrir les besoins en énergie et la production de cultures pour nourrir la population toujours croissante. Les options laissées aux agriculteurs sont soit d'utiliser des systèmes intensifs d'utilisation des terres, soit de dépendre des services écosystémiques fournis par les divers systèmes d'utilisation des terres. Au fur et à mesure que l'on s'éloigne des systèmes diversifiés aux systèmes simplifiés, les services écosystémiques peuvent se réduire. Étant donné que les agriculteurs optent toujours pour cette option qui maximise leurs avantages, les décisions peuvent être fondées sur les attributs des systèmes d'utilisation des terres, mais plus encore sur les facteurs socio-économiques qui les entourent. Parmi ces facteurs figurent, par exemple, le régime foncier, les caractéristiques démographiques des agriculteurs et le revenu des agriculteurs. La littérature suggère qu'il existe des facteurs mixtes qui influencent l'intensité de l'utilisation des terres dans différentes parties du monde. Cette étude permettra d'identifier les facteurs socio-économiques qui influencent les décisions d'utilisation des terres dans la fourniture des services écosystémiques dans la région de Mt Elgon en Ouganda en vue d'élargir la base de connaissances et de guider les décideurs dans les activités de planification.

Mots clés: Diversification de l'utilisation des terres, services écosystémiques, intensité de l'utilisation des terres, Mt Elgon, gestion des ressources naturelles, gestion de la fertilité des sols

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Background

The East African Community countries rely heavily on agriculture for food security, economic growth, employment, and foreign exchange earnings. In Uganda, Agriculture contributes 22.6% of GDP (UBOS, 2015), and 90% of foreign exchange earnings (Kandji and Verchot, 2014). Coffee and cotton are two crops that are currently dominating the agricultural sector in Uganda as a source of income in terms of exports. These crops are a main source of livelihood to a large portion of the population.

Specifically, coffee is the major export crop in Uganda employing over 3.5 million families through coffee-related activities (UCDA, 2012). Arabica coffee production systems are concentrated and intensive in highland areas. These regions account for 40% of the total coffee volume produced in Uganda (Jassogne *et al*., 2013). Production in Uganda is however under threat from a combination of constraints including: climate change variability, declining soil fertility, ravages of pests and diseases, a dwindling per unit land area, and market uncertainties (Jonsson *et al.*, 2014). These factors trap the smallholder coffee farmers who depend on the crop for their livelihoods in a vicious circle of low incomes and poverty. In addition, many soils in the highlands are degraded due to the intense cultivation and erosion arising from high population densities and the over-exploitation of natural resources (Mugagga *et al*., 2013).

The use of appropriate land use practices is therefore pertinent in mitigating the effects of such shortcomings. These include agroforestry, a traditional resource management practice which improves adaptability through simultaneous production of food, fodder and firewood (Jassogne *et al.,* 2012). Agroforestry has the potential to buffer against current climate variability and food/income risks due to its ability to provide ecosystem services. The services are provisioning say food, fuel wood; regulating for example reducing temperatures in the coffee canopy by 2–3°C (Vaast *et al.,* 2006) and supporting services such as photosynthesis, nutrient cycling. These services in turn result into overall Arabica coffee productivity and therefore increased incomes (Charles *et al.,* 2013). For example, Munyuli (2010) indicated that a total of US$ 149 million is obtained from bee pollination services particularly towards coffee production in the Banana coffee zones of Uganda.

Despite these ecosystem services, it is still a challenge to determine the optimal land use intensity and soil fertility management option in the coffee cropping system and the factors that drive the choices of land use intensities and soil fertility management options. Sine agriculture is fundamentally a social endeavor shaped by market forces, socio and economic policies, and human values (Tilman *et al*., 2002), which are important in managing the environment, knowledge of socio-economic elements of agricultural systems is critical for the assessment of their sustainability and environmental impacts. Hence, this study is set to provide such information.

Literature summary

Ecosystem services can be viewed as the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life (Leon and Rudolfde, 2012) or as functions provided by ecosystems that contribute to human welfare (MA, 2005). These services include pollination, pest control, erosion control, watershed management, and carbon sequestration which are a function of biodiversity levels (Wardle *et al.*, 2011). In fact, an estimation of 40% of the global economy is being derived directly from biological products and processes, and the goods provided by biodiversity (SCBD, 2010). Between 60-75% of crops grown in Uganda to sustain the economy and livelihoods depend on pollinators (Munyuli, 2010). This presents ecosystem services as a central player in nutritional security and socio-economic growth in Uganda where over 80% of the people live in rural areas and depend directly or indirectly on agriculture for their livelihoods. In the end, the development of sustainably productive farming practices is essential if these services are to be harnessed.

Farm-based decisions in Uganda are usually a result of complex social, economic and cultural values at local, regional and national scales and are pertinent in determining the nature and extent of the investment made in agriculture and as such the performance of the sector in terms of delivering ecosystem services and goods. For example, Sserunkuuma (2005) found a high correlation between participation in agricultural training and short-term extension programs and the use of land management practices, household size influencing soil and water conservation practices (Mugisha and Alobo, 2012), tenure insecurity (Deininger *et al*., 2003) and access to inputs, credit and markets play an important role (Pender *et al.*, 2001).

Land use intensity and ecosystem services

It should be noted that there is always a conflict between whether to engage in intensified or extensive land use practices and/or an intermediate between the two systems. This is because intensification is always accompanied with the question of sustainability, likewise, extensive land use systems are confronted with the issue of productivity per unit. There is a need therefore to quantify and measure trade-offs and synergies between agricultural production (associated with intensification) and ecosystem services (associated with extensive systems) by using socio-economic and ecological data from the same sites (Hulme *et al*., 2012). For example, Allan *et al*. (2015) have studied land use intensity and ecosystem multifunctionality. In their study, high land use intensity was associated with high multifunctionality which kept on reducing as more ecosystem services were considered. Farmers might therefore be tempted to opt for provisioning ecosystem services derived from highly intensified land use systems simply because they are rewarded in the market as compared to regulating and supporting services which are derived indirectly (Lerouge *et al.,* 2014). However, with increased land use intensity, the provision of other ecosystem services such as pollination reduces (Morandin and Winston, 2006; Klein *et al*., 2007). Therefore, as a whole, ecosystem services tend to decline as forests are converted to shade coffee and as shade coffee is converted to low-shade coffee systems (De Beenhouwer *et al*., 2013). It should as well be noted that intensifying agriculture involves the use of improved crop varieties and more efficient use of water and plant nutrients. It also goes hand in hand with the more intensive use of pesticides and herbicides, let alone the fact that they themselves do not directly contribute to better crop yields but simply control the potential losses caused by pests, plant pathogens as well as weeds (Oerke, 2006).

Diversified land use systems are also associated with high species richness (Kleijn *et al*., 2009; Batary *et al.,* 2011; Garratt *et al*., 2011). Among these species are the wild bees, whose pollination services have been studied and authors have suggested that more diverse communities of pollinators may provide more efficient pollination services and finally increased economic benefits (Albrecht *et al.,* 2007). As one is advocating for extensive (diversified) land use systems, ecosystem disservices, those that reduce productivity or increase production costs (herbivory, competition for water, light) should be put into consideration (Gabriel *et al*., 2013). The reduction in yields may in the end necessitate increasing the total area of land under agricultural production which may not be available due to rapid population growth. It is also worth noting that while a farmer who reserves land for pest predators and pollinator habitats will enjoy some benefits, other benefits will be enjoyed by neighbors who avoid the need to rent bee hives or just spray for pests without needing to give up income-generating cropland (Zhanga, *et al*., 2007). Although this is a positive externality, farmers practicing diversified systems may lose interest and end up looking for other rivalrous land use systems. In the end, there must be an incentive if one is to engage in diversified land use practices.

Although the issues of soil degradation and declining soil fertility may necessitate the use of quick solutions such as the use of mineral fertilizers (Gilbert, 2012), these should be in combination with the use of other land conservation practices if sustainability is to be achieved in the long-term (Wall, 2007). It is also argued that in cases where trade-off exists between ecosystem conservation and agricultural production, shifting the view from the plot to landscapes and integrating biodiversity-friendly land-use systems such as agroforestry into development strategies would be appropriate (Schroth and McNeely, 2011). This will not only address the problem of soil fertility depletion, food security, shortage of fuelwood, fodder and land degradation, but it will as well play an important role in climate change mitigation.

Socio-economic factors that influence the choice of land use intensities

A farmer will only choose to use a land use system if it is believed to attain higher returns compared to other available alternatives. Agriculture is a social endeavor shaped by market forces, socio- and economic factors as well as human values (Tilman *et al.*, 2002). It is therefore imperative that the factors influencing farmers' decisions to use a land use practice are explored. For example, with increases in population growth, it is known that the demand for food, fuel and fiber will increase (Godfray *et al.*, 2010; Haberl *et al.,* 2010; Tilman *et al.*, 2011). This implies that farmers will be more concerned with higher productivity per unit piece of land. This in the end will call for more intensive land use systems than extensive systems. Speciality markets especially in coffee is a new concept in the market today. This market supports a distinct value chain in terms of quality (Läderach *et al*., 2006), prohibition of the use of agrochemicals (Méndez *et al*., 2010) and sustainability, among others. With these speciality markets, there is limited use of fertilizers, pesticides, and it encourages the use of organic farming methods. Other factors such as security of land ownership influences land use decisions. In this aspect, better tenure system in terms of security increases the chance that farmers will invest in permanent land use practices such as agroforestry (Kassie and Holden, 2008; Deininger *et al.*, 2009). This is due to the fact that they are aware they will enjoy returns from their investments. On the other hand, in cases where a farmer is liable to cases of eviction, then preference is given to short-term land use practices. Social networks (membership in farmer groups, or associations) and personal relationships are hypothesized to affect technology adoption (Isham, 2007; Nyangena and Kassie, 2011). In cases where limited information and imperfect markets exist, farmers can be in position to get information among themselves on say price of fertilizers, seeds and other inputs. This therefore enables the farmers to use intensive land use methods.

Overall, it should be noted that it is always a complex task to investigate the factors that influence a farmer's decision to a land use practice. This is due to the fact that there is always a tradeoff between one land use practice and another. Therefore models for example nested logit and mixed logit, among others, have been developed to address this dilemma. These models use random utility theory to estimate the probability that an alternative is chosen (Vaiknoras, 2014). So, in the end, the attributes of the alternative, competing options, and characteristics of each individual will determine the likelihood that the alternative (land use system) is chosen. In the end, the best land use practices (in terms of the productivity as well as sustainability) especially in the mountainous areas such as those of Mt Elgon region in Uganda as well as the socio-economic determinants of these systems will be established. This is particularly due to the fact that mountainous areas are very fragile ecosystems presenting a need for evidence-based decision making of their resources.

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