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Natural Resource Management in the Northern Albertine Rift Landscape, Western Uganda: Modelling Household Land Utilisation for Conflict Reduction

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Acronyms and Abbreviations

ABM Agent-Based Model

CFM Collaborative Forest Management

FGDs Focus Group Discussions

HES Human-Environmental Systems

NFA National Forest Authority

RPGs Role Play Games

RT Ronald Twongyirwe

SES Socio-ecological systems

Executive Summary

The discovery of oil in the Albertine Rift Landscape has increased pressure on natural resources and heightened the potential for resource use conflicts. Central to these natural resource use pressures are competing interests over land for agriculture, settlement and industrial development. This undermines people's livelihoods and threatens biodiversity conservation. In this project, we had two broad aims: firstly, to increase our understanding of land utilisation patterns and related decision-making through participatory modelling, in order to fill knowledge gaps regarding how the negative effects of the oil industry can be reduced. Secondly, to contribute to thinking about conflict mitigation over land utilisation and access through solutions simultaneously generated through participatory approaches. The study was conducted in four villages around Budongo forest (in mid-western Uganda): Nyabyeya I, Nyabyeya II, Kibwona, and Nyakafunjo whose area is approximately 3.23 km^2, 1.06 km^2, 6.35 km^2, and 1.29 km^2 respectively.

We employed mixed methods including: Focus Group Discussions (FGDs), with a composition of 10 members each (5 male, 5 female), Remote Sensing (RS) data analysis, and participatory modelling through Role Play Games (RPGs) – with a composition of 8-10 members each (4-5 male, 4-5 female). Mapping community resources was also done through village transects. Members drew resource maps during the FGDs (and later compared with RS products): this was followed by discussions on resource use, access and conflict. The groups also generated seasonal calendars to get a sense of time and (gendered) labour resource budgets throughout the year. The emphasis was on understanding utilisation of community resources, especially the interactions between the expanding sugarcane outgrower scheme (see Twongyirwe et al. 2015), strict forest protection and the emerging oil production in the region.

The mapping exercise revealed that community members (FGD participants) were knowledgeable about the relative abundance and spatial extents of each land use/cover in their village, but actual estimates of acreage under each land uses/cover were determined using satellite imagery. Small-scale agriculture is predominant in Nyabyeya I, Nyabyeya II, and Kibwona accounting for 72.9%, 74.4%, and 65.6%, respectively. The acreage under settlement is second to small-scale agriculture, followed by natural forest in Nyabyeya I, Nyabyeya II, Kibwona. Ownership of land with a sugarcane plantation was an indicator of wealth in the villages, and the customary land tenure was the dominant land tenure regime in general. Given wealth distribution it followed that the area under sugarcane is relatively small, but this is projected to increase in the future under status quo and the oil scenario. Nyakafunjo village residents relied on the natural forest (Budongo) for part of their livelihood but were prohibited from establishing sugarcane plantations by the forestry authorities.

The seasonal calendar shows minimal variation in the seasonal cropping activities and gender division of labour across the villages. These are planned around the rainfall months, which generally occur between March and May, and August and November. The gender division of labour was as expected, with women in-charge of food crops and men, the more lucrative cash crops (sugarcane in this case), with inequitable sharing of proceeds within households.

The RPGs show that, on average, sugarcane is projected to increase ($p<0.05$) at the expense of small-scale agriculture in both the baseline (status quo) and oil scenarios. But individual gaming sessions reveal mixed non-linear patterns of ratios of sugarcane to small-scale agriculture, including both increase and decrease in both the status quo and oil scenarios. Furthermore, the RPGs show that there isn't a significant difference ($p>0.05$) between the incomes earned under the status quo and oil scenarios on average. In both scenarios however, incomes progressively increase in general, but income under the oil scenario are on average marginally higher than the status quo scenario except in one group in Kibwona. Also, there is statistically no gender differentiation ($p>0.05$) between patterns in land use and decisions made by both men and women under both scenarios. Although lost in the overall statistics and patterns, during the gaming sessions, some women mentioned that they preferred more food gardens to sugarcane plantations.

Although we lack empirical data on the impact of sugarcane on livelihoods, its aggressive non-linear expansion at the expense of food crops is arguably an emerging form of "land grabbing", similar to what has already been documented in Eastern Uganda (Martiniello, 2020). The notion of "land grabbing" is a topical issue in Uganda today, including in presidential discourse, and its manifestations can take subtle forms, as we describe in the case. The participatory modelling approaches employed (i.e. RPGs) illuminated some dynamics of decision–making at household level but the use of only a few parameters limits capacity to probe this decision-making in depth. More parameters are possible in a quasi-experimental approach, where using computer-based platforms is possible. Future work could therefore combine RPGs and Agent-Based Models (ABMs) in companion modelling approaches.

Land (use) conflicts are extensive in the Albertine Rift landscape, and our data show that these are projected to increase under the oil scenario. Overall, the promise of oil may be leading to land use change and conflict, and the sugarcane dynamics taking place in tandem with this promise provide another layer of complexity in an already intricate local context. In this respect, natural resource management and development policies should be cognizant of the complex broad-based interactions between wildlife, forestry, and livelihoods from small-scale agriculture, sugarcane, pastoralism, tourism, and fishing.

1. Introduction

Land utilisation and ownership can be a key source of conflict in rural areas undergoing rapid development (Rockmore, 2020). This is particularly so when the pressure on limited resources is exacerbated by a growing population wishing to gain access to land, ill–definition of user rights, and competing demands from various actors (Sabir & Torre, 2020). Such pressure is eminent in the Northern Albertine Rift Landscape (NARL) in western Uganda, because the region is a biodiversity hotspot, with endemic plant and animal species (Plumptre et al., 2007), and provides a key source of livelihoods for the local people (Mwavu & Witkowski, 2008; Twongyirwe et al., 2018). The discovery of oil is likely to cause (and in some cases is already causing) a shift in land utilisation patterns. Factors stimulating these changes include, but are not limited to, displacement of people from their original settlements; reduced access to natural resources; an in-flux of migrants working in the oil industry whose households seek to access land; richer landlords "grabbing land" from poorer ones; and changing gender relations at the household level (Byakagaba et al., 2019; Mawejje, 2019; Ogwang & Vanclay, 2019). These could spark undesired conflicts in the local communities.

This study builds on our previous work in the region – where we established deforestation, forest degradation and land use change baselines, as well as detailed livelihood characterisations (Twongyirwe et al., 2017; Twongyirwe, 2015). Deforestation was reportedly driven by agricultural practices, with expanding sugarcane plantations the leading cause of forest erosion on privately owned land south of Budongo forest (Twongyirwe et al., 2015). Furthermore, the spatial and temporal distribution of land utilisation (and demand) and livelihood characteristics in the oil-rich Albertine Rift Landscape are inextricably linked (Twongyirwe et al., 2017; 2018). However, the reasons for, and decision-making mechanisms of land utilisation remain less understood. To bridge this gap – through participatory tools (e.g. community-based mapping and role play games) – we interrogate the nature of the rapidly expanding sugarcane outgrower scheme, and explore local perceptions of the relationship between sugarcane production and small-scale agriculture under the status quo, and under oil production scenarios. The purpose of doing so is to understand how related resource use conflicts arise, taking into account power and gender relations, and how they are or could be mitigated. By engaging with these objectives, we aim to contribute to broader literature and debates on oil imaginaries an emerging petrostate such as Uganda, whilst challenging contemporary debates on "oil curse or blessing" (see e.g. Ogwang, 2020; Ogwang et al., 2019). To understand the methodological approach used in this study and accompanying contemporary debates on the subject of investigation, we provide some theoretical framing in section 2.

The rest of the report is structured as follows. In section 3, we illuminate how natural resource mapping tools and RPGs are employed to understand local farming dynamics, power and gender relations and conflict under the status quo and the oil

scenarios. We present the key findings in section 4 and discuss the results in section 5. We then reflect on the implications of the methodology employed, and the key outputs, and the conclusions in section 6.

2. Theoretical Framing

In this section, we provide some context to our main theme of land use, and reflect on how the promise of oil could fuel land use change, and further complicate sugarcane dynamics in the landscape – with land tenure regimes far from clear. In doing so, we show the multifaceted contexts within which land use decisions have to be made, drawing on literature from other parts of Uganda, and elsewhere in Africa, in the first sub-section. In the second sub-section, we briefly review the evolution of oil discovery in Uganda and the difficult political setting within which extraction is anticipated. We also illuminate the heavily criticised notion of "oil curse or blessing" present in contemporary debates on oil in Uganda, before delving into literature on oil imaginaries, on which our study is premised. In the final part of this section (third sub-section), we demonstrate why mixing social science methods with remote sensing and "participatory modelling" are well suited for soliciting deeper insights into the present and future land use dynamics, especially with the oil promise in the horizon.

2.1 "Land grabbing", land tenure regimes and sugarcane production in Uganda

Land massification for large-scale agricultural and infrastructural projects is (re)emerging and widespread in Sub-Saharan Africa: also referred to as "land grabbing" (White et al., 2012: 619) and a "new scramble for Africa" (Moyo et al., 2012: 182). Land grabbing in a sense that corporate entities (private or public) can gain access and user rights to large chunks of land, often capitalising on complex historical and contemporary contexts and loop holes in national legal and institutional frameworks (White et al., 2012). Such displacements are sometimes violent following compulsory acquisition, and compensation (or a lack of it) is involved (Ogwang & Vanclay, 2019). Similarly, the "new scramble for Africa" reflects a form of "geopolitical struggle" where influential monopolistic firms drive large-scale land acquisition through financialization of national economies (Moyo et al., 2012). Land grabbing is pervasive in present-day Uganda, frequently masked by development narratives whilst dispossessing the poor and vulnerable (e.g. Murphy et al., 2017: 1). Although there are many forms and examples, we limit our discussion to land grabbing/massification for sugarcane production.

Sugar factories demand sustainable supply of cane for profitable businesses. The companies normally own an estate, but if they wish to expand production, they need larger pieces of land which can either be purchased or rented, or franchise-based arrangements can be set up with land owners in the neighbourhood through contracts, also referred to as "outgrower schemes" (pers. communication with

Kinyara factory official during fieldwork). Governments and corporate agri-businesses view the sugarcane commodity as a vehicle through which smallholders could be integrated within commercial agricultural chains so as to hasten rural development and reduce rural poverty (Martiniello, 2020; Martiniello & Azambuja, 2019). Win-win scenarios are envisaged: agribusiness companies obtain regular and standardized quantities of produce while smallholders reciprocally secure access to the market (*ibid*). Yet, social differentiation deeply entrenched in the local political-economy is expected. Middle men, and wealthier landlords (sometimes not necessarily farmers) take the larger share of the sugarcane business proceeds, with the expansion of the sugar frontier at cheap costs (Martiniello, 2020). In here, wealthy entrepreneurs and processing plants maximise value extraction from farmers that undermines labour, whilst dramatically affecting existing livelihoods and landscapes (*ibid*).

The region south of Budongo forest (our study area) is characterised by aggressive expansion of sugarcane that started around 1995, eroding forests on privately owned land and reducing spaces for food production (Twongyirwe et al., 2018). While the locals view sugarcane as a sustainable and reliable source of income (our study), evidence from Eastern Uganda (Busoga region) shows that sugarcane outgrower schemes keep households in the viscous cycle of poverty, with one author calling it "*bitter sugarification*" (Martiniello, 2020: 1). In this scheme, subtle land grabbing is described: land owners are not necessarily displaced, but through signing binding contracts, they are convinced about elusive "inclusive development" through their integration within global agro-industrial production complexes (*ibid*). Ideally, it is the large-scale farmers that should participate in the sugarcane outgrower scheme, as they can afford space for cane and food, or are wealthier and can cope with market fluctuations. Smallholders on the other hand are prone to land dispossession conflict as their land is "locked up" in binding agreements (Martiniello & Azambuja, 2019).

Anecdotal evidence suggests that sugarcane was established in the Albertine Rift landscape in the 1970s (Twongyirwe, 2015), but the current outgrower scheme mirrors the historical colonial imperialism, with widespread transformation of existing forms of land use from subsistence to capitalist commercial farming that skews the benefits of commercial farming towards the capitalist agenda at the expense of the welfare of the local population (Martiniello, 2020; Mwanika et al., 2020). The colonialists approach has had persisting implications for postcolonial development pathways (Mwanika et al., 2020). This could be due to the shifting capitalist governance regimes of Kinyara Sugar Works (sugar company in the region) that has overseen the sugarcane expansion south of Budongo forest.

Land tenure regimes

To better understand the land tenure problems in the study area (as will be shown later), it is important to highlight the different land tenure systems in Uganda. The

1995 Constitution of Uganda and the 1998 Land Act stipulate four distinct land tenure regimes: namely, freehold, leasehold, mailo, and customary – each with different outcomes for agricultural investment and productivity (Okuku, 2006; Place & Otsuka, 2002). First, *freehold* is a legally documented private land ownership system: here, one owns registered land in perpetuity, with full use rights, with possibilities to development the land and use it as collateral. In this system, land can be sold or passed on at free will according to the Uganda Land Act, 1998 [Chapter 227; Part II 3(2)]. The second land tenure regime is the *leasehold tenure system*. This involves a contractual agreement between a landlord granting exclusive use, and a tenant renting for a defined period [Uganda Land Act, 1998; Chapter 227; Part II 3(5)], usually 49 or 99 years (Okuku, 2006). For such a lease period, the tenant can use or develop it and obtain all profits that accrue from its use.

Third: *Mailo land tenure system*. This is a form of land ownership established in Ugandan law as a result of an agreement between the Buganda Kingdom and the British colonial authorities in 1900 (Batungi & Rüther, 2008; Place & Otsuka, 2002), and currently accounts for approximately 20% of Uganda's land "*including the capital city, major influential towns and high value land"* (Musinguzi et al., 2020: 1). This system mainly includes large blocks of land owned by former chiefs and elders who often exercise jurisdiction as 'absentee landlords' (Okuku, 2006). And although established in 1900, it has had a difficult evolution, including abolition and reinstatement (*ibid*), and has created large uncertainties about security of tenancy to–date. *Mailo* tenure differs from the freehold system in that simultaneous ownership by the landowner and a lawful occupant, or 'squatter', who has lived uncontested on the land for 12 or more years, is permitted, but an annual rent is required with the amounts regulated by the government (as stipulated in the 1995 constitution). Because of the complications created by this land tenure system, various political actors use it to patronise the vulnerable for votes in return, or risk eviction by "powerful" landlords (Médard & Golaz, 2013).

The fourth land tenure system in Uganda is the *customary* type. This is the largest land tenure regime in Uganda: it accounted for about 85% by the year 2000 (Batungi & Rüther, 2008). According to the 1998 Uganda Land Act the rights of customary tenants are entitled to official certificates of customary tenure that could indeed permit transfer rights of sale, lease or mortgage, and such certificates of customary ownership could be converted to freehold tenure following a survey of the land (Hunt, 2004). We will return to these land tenure regimes and their implication on land use in the results and discussion sections.

2.2 Uganda's oil context: imaginaries, and the "oil curse" debates

Museveni and the oil discourse

Uganda's oil trajectory has been documented by various authors (e.g. Alstine et al., 2014; Ogwang, 2020; Vokes, 2012). They indicate that early geological work started during the colonial period (in the 1920s), with more promising exploratory work undertaken in the mid-1980s. But the discovery of economically viable oil reserves is more recent, c. 2006-7. Although plans for extraction have been underway for more than a decade, the date for the first oil flow remains unknown. Nonetheless, it is argued that the amount of oil discovered in the Albertine graben could potentially transform Uganda's agriculture-based economy (Vokes, 2012). In this section (2.2), we delve into emerging discussions on oil as a "curse or blessing" to the country, and why such a narrative cannot be sustained in the current context. On the contrary, we argue that notions of "oil imaginaries" are more appropriate. We also briefly review the political context within which these narratives thrive, and finally reflect on oil imaginaries in the light of land use and land cover in our study area (later in the report).

Uganda has a difficult political history marked by economic recession, ethnic rivalry, brutality, and *coup d'état* especially during Idi Amin's and Milton Obote's regimes between 1960 and 1985 (Nyombi & Kaddu, 2015). Museveni's coming to power in 1986 was received with new hope and enthusiasm, but after about 35 years in power, the majority of his contemporaries have either died, or joined the opposition parties, and the nation now dominated by youth is no longer in touch with his 'liberation arguments' that were popular during his earlier years in power (Reuss & Titeca, 2017). To remain relevant, Museveni's discourse has shifted more towards the oil resource, highlighting how he will protect "his oil" to spur economic development, an issue that continues to bother the opposition politicians, civil society organisations and various actors in the private sector (Alstine et al., 2014: 51).

To cement his long stay in power, Museveni relies on patronage and coercion (Reuss & Titeca, 2017). This can be reflected in the way the oil rich region has been heavily militarised: the largest military installation has been established in the oil rich region (Kyangwali, Hoima), and the oil fields are guarded by the Special Forces Group (commanded by his son Gen. Muhoozi Kainerugaba), and a private security company owned by his brother (Salim Saleh) (Vokes, 2012). Museveni's long stay in power following oil discovery was long predicted by some scholars (Barkan, 2011 in Alstine et al., 2014: 51). No wonder the constitution was amended in 2017, to lift the presidential age limit, to pave way for him to contest again in 2021, and if voted (as is likely the case: with already compelling questions about transparency of the elections and curtailing the rights of opposition politicians to reach the populace) – he will have been in power for 40 years by the end of the new term (authors' observations). Based on this context, it is unsurprising to see notions of "oil curse or blessing" present in contemporary debate on oil in Uganda. We briefly turn to these debates.

Oil curse or blessing debates

The "resource curse" also referred to as "paradox of the plenty" is defined as a situation where – contrary to conventional wisdom – mineral and hydrocarbon-related revenues do not necessarily spur economic growth (Polus & Tycholiz, 2017: 3), but instead result into economic decline compared to countries without the non-renewable natural resources (such as oil, gas, minerals) (Veit et al., 2011). The reasons for this are various: 1) resource abundant economies do not reinvest the rents generated from natural resource exploitation into productive assets; 2) the resource booms actually divert economic resources from more productive and innovative sectors; 3) volatility of revenues from the natural resource sector due to exposure to global commodity market swings; 4) government mismanagement of resources; and 5) weak, ineffectual, unstable or corrupt institutions (Harris et al., 2020; Veit et al., 2011).

Since the discovery of commercially viable oil (estimated to be more than 6 million barrels) in the Albertine Graben in western Uganda (Veit et al., 2011), there has been growing scholarship on oil as a resource curse (e.g. Gillies, 2020; Mosbacher, 2013; Ogwang, 2020), and attempts have been made to compare Uganda with "resource cursed" African countries such as Chad, Sudan and the Republic of Congo and in some instances, "resource blessed" Botswana that has used the oil to transform its economy since the 1960s (Mosbacher, 2013: 46). Across the African continent, corruption tendencies in the oil industry involving both public and private actors (local and international) are blamed for the oil curse (Gillies, 2020). Civil society, political actors in the opposition and scholars argue that the lack of transparency is a recipe for the oil curse in Uganda (Nakaiza, 2018; Olanya, 2015). Moreover, citizens' low appetite for accountability from non-tax revenues from oil or foreign aid could hasten the oil resource curse (Cuesta et al., 2019). It is further argued that the lack of rule of law and long history of governance based on patronage further positions Uganda as a "perfect candidate" for the resource curse (Mosbacher, 2013: 44).

Within the Ugandan context however, the on-going debates about "oil boom" or "oil curse" are "misplaced and premature", not least because oil is not yet out of the ground, and the required socio-technical infrastructure are still underdeveloped (Vokes, 2012: 304). Moreover, some scholars assert that the 'resource curse' is more of a reflection of a governance deficit than a resource abundance crisis – with parliaments often in a "weak" position to set up checks and balances for government's accountability (Alstine et al., 2014; Doro & Kufakurinani, 2018). In Uganda, it has been argued that the current oil regulatory framework is fundamentally flawed, with the Minister of Energy and Mineral Development accorded too much powers, to for instance, issue and revoke contracts for oil exploration, production, and export (Mosbacher, 2013: 50). There are some positives however. Although the Ugandan institutions are generally poorly governed with

limited autonomy, they have managed to protect national interest during negotiations with international oil companies albeit not without political settlements and coalitions with "powers from above"/the "invisible hand" (Hickey & Izama, 2016). But the dynamics of Uganda's political settlement raises serious doubts as to whether the levels of elite commitment and bureaucratic capacity displayed will withstand the increasing pressures once oil production commences (*ibid*). In an attempt to avoid the resource curse, the Government of Uganda has sought help from Norway (one of the few countries that have gained from oil) to draft its legislation to manage oil revenue in a transparent manner – but doubts remain over the ability to "transplant" the Norwegian model given Uganda's tricky political, economic and social conditions (Polus & Tycholiz, 2017: 1).

Another criticism of the "resource curse" debate is that it provides no prescription in terms of how pro-poor and sustainable development can be achieved in practice, especially that multiple spatial and temporal scales are involved, with contexts often path dependent (Alstine et al., 2014). The oil imaginaries debates may not prescribe success *per se* but through the present, aspirations and visions of the future at various spatial and temporal scales can be interrogated. We now turn to these debates.

Oil imaginaries

Oil imaginaries are underpinned by diverse epistemologies and ontologies of resource temporality and materiality (Weszkalnys, 2016: 128). Temporality discourses oscillate around "*boom and bust, acceleration and deceleration, and past, present, and future*" (Rogers, 2015: 365). Broader concerns on temporality interrogate how long oil deposits will last as this often shapes national budgeting processes and thinking about alternative energy investments (*ibid*). Imaginaries on materiality are dominated by "visions of modernity" (Tallio, unpublished), culminating in prosperous and sustainable states, where better roads can be constructed, people can earn higher salaries, electricity can be widespread, and sewer systems developed among others (Weszkalnys, 2016: 138). Essentially, materialities can be infrastructural in nature, focusing beyond the oil fields – to include pipelines, tankers, and other transport networks, or can be chemical and microbial in nature, dealing with spillage and impacts on biodiversity and technical capacities to detect and manage the spillage (Rogers, 2015: 372).

Imaginaries can bring the "uncertain future into the present", but the uncertain time-lag between exploration and production can create "cruel optimism", with people's lives indefinitely trapped between exploration and production (Weszkalnys, 2016: 138). Kinyera & Doevenspeck for instance blame overfishing on labour mobilities into Lake Albert region, and because the promised oil work was not forthcoming, the majority turned to fishing, increasing pressure on the fisheries resources (2019: 11). "Excesses" of anticipation can therefore build unrealistic expectations of prosperity,

yielding negative consequences that "*redirect anticipation against itself*" (Weszkalnys, 2014: 211).

Recent empirical work on oil imaginaries in Uganda identifies geographies of conflict framed around local narratives on mobilities of pastoralists, labour, and fishers, and tensions between elephant conservation and local communities in the Albertine rift landscape (Kinyera & Doevenspeck, 2019). They describe how ethnic tensions between the natives *'Banyoro'* and immigrant cattle keepers '*Baraaro*' have been exacerbated by oil prospects in the Albertine region. They argue that the natives are more aware of the past and present, and now hope to secure their futures through clarifying their "share" of the land and oil resources in spite of the fact that the *Baraaro* mobility is neither new nor restricted to Bunyoro area (Kinyera & Doevenspeck, 2019: 9). The authors further highlight the interaction between communities and futures of biodiversity conservation, based on elephant mobility, and although interesting, these are outside the scope of our investigation.

As indicated earlier, visions of a modern Uganda under the oil scenario are pervasive in president Museveni's discourses: Museveni has promised strict control of the resource to benefit Ugandans, but also fears exist over bribery scandals amongst institutions that are mandated to administer the resource (Vokes, 2012: 303). Indeed, if well managed, it is predicted that the oil resource could drive Uganda out of poverty, and propel it into middle income status by 2040 per its Vision 2040 (World Bank, 2016; Ogwang, 2020). In our study, we analyse local imaginaries of land use and land cover under the status quo and oil scenario, and especially the interaction between small-scale agriculture and sugarcane production.

2.3 Mixing social science methods: community-based mapping and Role Play Games (RPGs)

Human–Environmental interactions – also referred to as Human-Environmental Systems (HES) or Socio-Ecological Systems (SES) in the literature (e.g. Biggs et al., 2015) – are inherently complex and "wicked" (Waddock & Waddock, 2020, p.2). On the one hand, their complexity lies in fundamental processes that can often lead to emergent behaviour or phenomena culminating in structural hierarchy and spatial heterogeneity (An et al., 2005). Furthermore, feedback, self-organization, continuous evolution and change in response to external shocks and internal system changes, uncertainty, and time lags are ubiquitous HES/SES characteristics (An et al., 2005; Biggs et al., 2015). On the other hand, their wickedness lies in unsustainable and inequitable utilisation of natural resources on which they depend to 'sustain' today's economic and social systems, leading to for instance, uncontrolled deforestation, and desertification (Waddock & Waddock, 2020).

Because Socio-Ecological Systems (SES) are analytically complex, as a corollary of our partial knowledge of the system whose behaviour is unpredictable and non-linear

(Biggs et al., 2015), we employ proven qualitative social research methods in this study to improve our understanding of land use dynamics and conflict, in the context of oil extraction. In particular, community-based natural resource mapping and Role Play Games (RPGs) were selected. In this section, we elaborate on the theoretical constructs underpinning these approaches, and the benefits of using combined methodologies.

Community–based Mapping

Community–based mapping is defined as a process in which community members "*contribute their own experiences, relationships, information, and ideas about a place to the creation of a map*" (Cochrane & Corbett, 2020, p.2). Such mapping is like "telling a story" that represents the "image" of the community (Murphy et al., 2017). Community–based mapping has various nomenclature in the literature including: sketch mapping, transect walking, participatory 3-D modelling, and social cartography (Cochrane & Corbett, 2020; Milagres et al., 2020).

The community–based mapping methodology is not without limitations however. If not carefully implemented, it can lead to unintended consequences, that could potentially exacerbate conflict, amplify marginalisation and could be extractive in nature (Cochrane & Corbett, 2020, p.4). In section 3.2.1, we explain special considerations made to avoid such negative impacts in this study. The mapping exercise was used as a foundation for the Role Play Games as will be explained later. But before this, the theory underpinning RPG is provided next.

Role Play Games (RPGs) in Land Use Science

Modelling land use and land cover change is one of the leading topics in the burgeoning Land Use Science literature: but model parameterisation is fraught with difficulty, not least because they do not effectively represent human decision–making given its irrational nature (Celio et al., 2019). Role Play Games (RPGs) are an established methodology whose use is re-emerging as being of value in improving our understanding of human decision–making in complex Socio-Ecological Systems (Mariano & Alves, 2020; Merlet et al., 2018). A RPG is a game in which players/participants take on roles of characters in a fictional setting – but are required to make decisions following a structured set of the rules – often overseen by game master who assures adherence (Biggs et al., 2015). Each player takes turns, and has to respond to particular constraints, but unlike in conventional games, RPGs do not have a winner, although the game can provide some entertainment to the participants (Merlet et al., 2018).

In the context of Socio-Ecological Systems, the characters chosen and rules set for the RPG should realistically match the context and system under investigation, to create an interface between science and society (Asplund, 2020). To this end, RPGs have potential to illuminate personal experiences, reflected in decision–making

(Merlet et al., 2018). Moreover, a good RPG design can improve environmental awareness and education, stimulate open communication, provide space for dialogue and expose skewed power relations (Madani et al., 2017; Merlet et al., 2018). After the game, the debriefing session could also generate new perspectives (Merlet et al., 2018). But care should be taken not to influence decision–making through the way the game is introduced – and random allocation of parcels at the beginning of the game is encouraged (*ibid*).

Role Play Games can be used in parameterisation or in combination with Agent-Based Models (ABMs) to further understanding of Human-Environmental interactions (Buchheit et al., 2015; Mariano & Alves, 2020). RPGs could also be used in "companion" modelling ("*a participatory approach based on the co-construction and use of models*": Moreau et al., 2019: 5) – where the outcomes can be used in setting up a computer-based Agent-Based Model (Boissau & Castella, 2006; Buchheit et al., 2015). RPGs are not necessarily replicable outside the region they are intended to work however: there is need for a careful balance between models of conceptual and scientific thinking in game design and everyday experiences among players (Merlet et al., 2018). Credibility of RPGs therefore lies in perceived fit between players and lived experiences, and information sources underpinning the game (Asplund, 2020).

Role Play Games have been used in various disciplines including psychology, social sciences and ecology. We select some examples that have some similarity with our study, to demonstrate how RPGs have been employed in land use science. First: the "SAMBA" RPG was to understand natural resource management in Northern Vietnam (Boissau et al., 2004). The game setup was comprised of: a board that consists of 1600 wooden cubes, each representing a plot of 1000 m^2, 6 sided cubes each painted with different colours representing different land uses and land cover (forest, paddy fields, upland rice, etc). To initialise the game, the game board was set to represent a forest and a village along the banks of a river and players drew a "household" card consisting of 2 factors: mouths to feed and labour force and an assignment of need (e.g. 300 kg paddy/year/person). Players also selected a "paddy field" card approximating their area of paddy field. The combinations of family structures and paddy field areas represented different individual player situations, which mimic real life settings. At the end of successive rounds of play, each representing one year, the players had to decide how to allocate their land, labour, and capital. Other examples include, use of RPGs to: understand watershed management (Promburom, 2004); explore how farmers make decisions on whether to retain or change shrimp production systems (Joffre et al., 2015); and to explore the impacts of three farming practices (rock removal, ploughing of meadow, and pasturing) on trade-offs among ecosystem services in the Mont Lozère, France (Moreau et al., 2019).

3. Study Area, Materials and Methodology

3.1 Study Area

The study was conducted in four villages south of Budongo forest, namely: Nyabyeya I, Nyabyeya II, Kibwona and Nyakafunjo, whose size is approximately 323.4 km^2, 106.18 km^2, 635.2 km^2, and 128.9 km^2 respectively. The villages are located approximately between 1°38′–1°42′N and 31°27′–31°40′E (Figure 1). The study area lies in the Northern Albertine region renowned for abundant natural resources ranging from forests, wild animals, fertile soils to oil rich wells (Mclennan & Plumptre, 2012; Ogwang et al., 2019; Owiunji & Plumptre, 1998). The rainfall received is bimodal in nature, with peaks from March to May and September to November, and a mean annual range between 1150-1500 mm. The minimum annual temperature is 17-20 °C, while the maximum is 28-29 °C. It occupies slopes gently rolling towards the escarpment of the rift valley with an altitude range of 914 m and 1097 m asl. (Turyahabwe et al., 2013). Over the past few decades, small scale–farming has been the predominant land use by people with long-established ties to the area, but in-migration driven by business prospects from the expanding sugarcane outgrower scheme and oil-driven prosperity projections are changing land use patterns (Twongyirwe et al., 2018).

In particular, although oil was first discovered in the region in the 1870s, commercially viable oil reserves were only confirmed in 2006 in the biodiversity hotspot: legislation and production plans have been underway ever since (Mackenzie et al., 2017), however this has not been without violent land dispossession and conflict (Byakagaba et al., 2019; Ogwang & Vanclay, 2019; Ogwang et al., 2019). Furthermore, the demand for timber and timber products, crop raiding by wildlife, insecure land tenure regimes, have also heightened pressure on land and the natural forest, and increased community-level conflicts, and conflicts between the local communities and the protected forest estate authorities (this study).

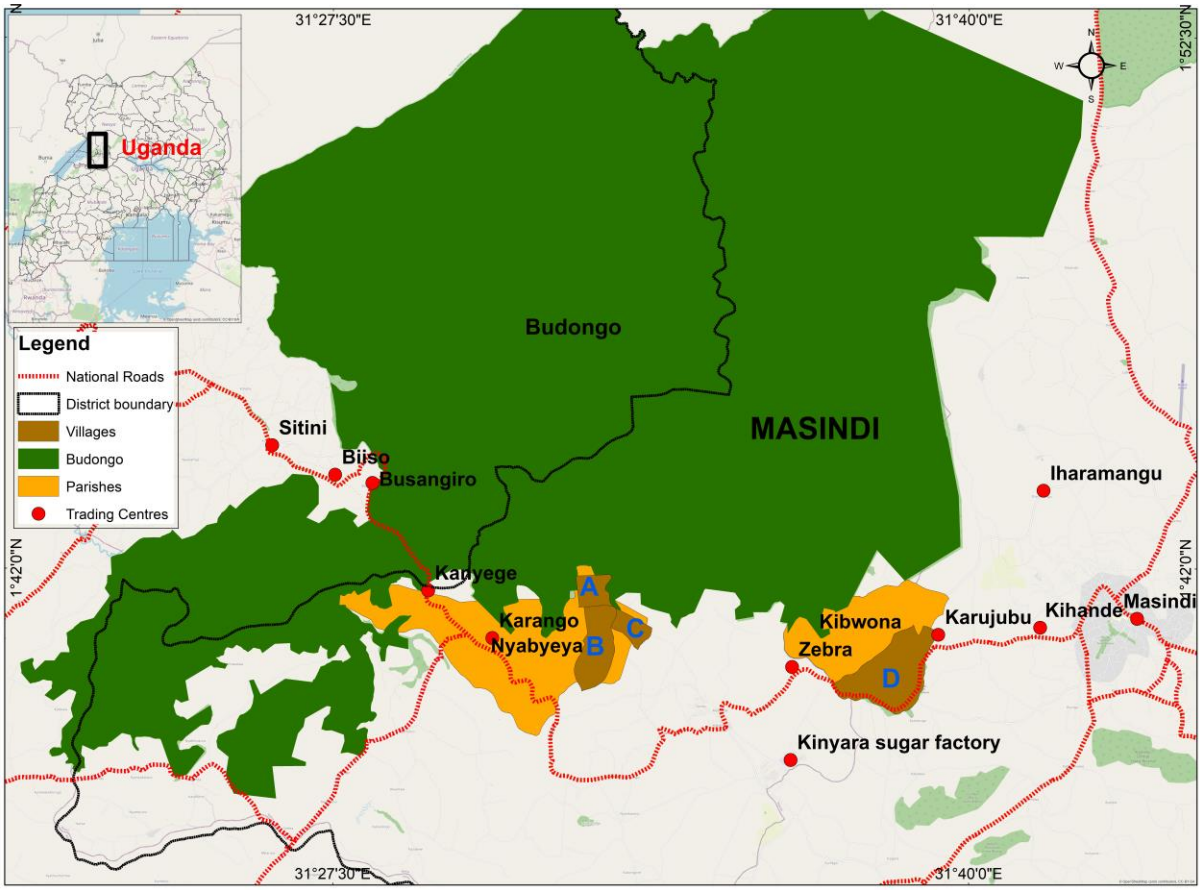


Figure 1. A map indicating villages south of Budongo forest where the study was conducted: A–Nyakafunjo, B–Nyabyeya I, C–Nyabyeya II, D–Kibwona (source: authors)

3.2 Focus Group Discussions (FGDs)

Our study is predominantly qualitative. We conducted eight (8) Focus Group Discussions (FGDs) between May and August 2018, and an additional four (4) FGDs between January and March 2020 in the four study villages. The FGDs were carefully arranged in such a way that the data collected (in 2018) could be used to set up the Role Play Games conducted between January and March 2020. The emphasis was on understanding utilisation of community resources, especially the interactions between the expanding outgrower sugarcane scheme, strict forest protection and the emerging oil production in the region. A number of FGD tools were employed, as elaborated in this section: Mapping community resources was done through village transects. Members drew natural resource maps during the FGDs, followed by discussions on resource use, access and conflict. We also generated seasonal calendars for the communities to get a sense of time, labour and resource allocation throughout the year. Selection of participants (and group composition) was carefully considered. We expound more on these as follows.

3.2.1 FGD Set up: Selecting participants

We have a gendered lens in our approach: we aimed for an equal number of male and female participants in each group in each village. All groups were comprised of 10 people (5 men; 5 women), except for Nyabyeya I that had 12 participants in both groups. In order to minimise bias, our aim was to have a representative sample from the entire village, not consciously picked because the members are influential, or because they are easily accessible, or because they are known to the local resource guides that we worked with. The selection was spearheaded by the local council chairperson and the research team (including Research Assistants, henceforth RAs). The participants were then guided to converge at a central place where the FGD was scheduled to be conducted. Each FGD was comprised of a different set of members.

Generally speaking, before each FGD, we sought permission from the local authorities, and consulted with the local community. Clear parameters for the focus group were set and communicated at the start of each FGD: this included highlighting the purpose of the study (i.e. collecting data that would improve our understanding of decision–making on land use) and what the follow-up would entail (including the need for the data from FDGs to set up the RPGs). Ethical requirements such as confidentiality, informed consent, anonymity (on whatever is said or done in the group session), the right to decline to participate or to withdraw at any time, and asking questions at ease, were communicated before the FGDs. The duration of each FGD was approximately 2 hours (on average). A language barrier raised difficulties in some villages, and although the main medium of communication was through *Runyoro* (dominant local dialect), English and *Kiswahili* were occasionally required. The majority of the respondents were of mixed ethnicity having migrated into the area in the last 50 years. In one village for instance, a respondent mentioned the following: "*Their ancestors settled here (Nyabyeya II) at a time they were working in the forest, so, even when this new generation of Alur came, they had to look for their fellow Alur and join them. So, that is how they colonized the area. Those who came in 1950's settled here first and the second team around 1960's.*" (FGD participant, Nyabyeya II, March 2018).

A total of 84 people participated in FGDs in 2018. Nyabyeya I had two groups of 12 members each, while the other three villages had two groups of 10 members each. The average age of the participants was 39.6±3.1 (mean±95% confidence interval). There is minor but statistically insignificant ($p>0.05$), variation in age of participants across the villages: Nyabyeya I (39.0±5.1), Nyabyeya II (40.3±7.3), Kibwona (39.6±5.5), and Nyakafunjo (39.5±7.7). The majority – some 57.8% – had only acquired primary education, 28.1% had acquired secondary education, 6.2% tertiary education and 7.8% of the participants had not obtained any education at all. While not intentional, there are no significant differences ($p>0.05$) in the education level of the respondents that participated across the villages. Based on the recruitment of the participants that was purely random, we obtained a reasonable sample for unbiased views on the questions that were asked during the FGD. The group discussions were

led by RT with the help of two research assistants. In the following section we highlight the FGD tools employed.

3.2.2 FGD Tool 1: Resource Mapping

This tool was useful for generating village-level maps – drawn by the locals (FGD participants). The rationale was to gain an understanding of perceived land and natural resources exist in each village (with linked issues of ownership and access), how they are linked to local (land) utilisation, and conflicts that (could) arise from competing land use demands: "fault-lines" of community-based conflict (if any) or cooperation related to land and natural resources (linked to social/power divisions: wealth, immigrants, and gender), as well as changing dynamics of resource use and ownership. Before the map was drawn, FGD participants conducted a transect walk through the village for a period of 30-45 minutes on average. Starting with an outline/village boundary, members indicated "important" features on the map. In particular, they delineated important land uses, and land cover (if any) in their village. We emphasised that it was not necessary to develop an absolutely accurate map–the main goal was to obtain useful information about local perceptions of resources. The discussion was guided by the questions below:

1. What is your opinion on land use in your community (proportions/abundance of particular use/land cover)? Are there particular household types or distinct social, ethnic or religious groups with different access to resources, assets, income and power? Which groups are wealthier than others and why?
2. What has been the state of land use/land cover your village in the last 5 years? Is land use changing? Has access to land / what crops are being produced changed in recent years? If so, why? If not, why not?
3. What employment exists locally? What livelihoods do people have (with a gender dimension)? What are some of the activities carried out in this community that put pressure on land?
4. What challenges do you face in land use management?
5. What could be the solution to the challenges mentioned above?
6. How are decisions made on land utilization within the community? Who makes the decisions in a household? (probing for the gender dimension)
7. How have decisions on land use impacted household livelihood?
8. How is oil extraction likely to impact on land use patterns in the village?
9. Are there any land (use) conflicts in your community today? If so, what is the nature of these conflicts, and what are their sources?
10. What are the effects of these conflicts on the livelihood of people in your community?
11. What has been done to resolve current land conflicts and/or those that could emerge in the future?

This session was concluded by asking participants what they have learned from their analysis, and what they themselves can do to change the situation in their community, based on their analysis.

3.2.3 FGD Tool 2: Seasonal calendar, gender division of labour and household activities

We employed this tool for two main reasons: 1) to explore how seasonal variations affect the patterns of life throughout the year in terms of the main agricultural and non-agricultural activities and the division of tasks among family members – with particular attention to gender; and 2) to prompt broader discussion on the main areas of inquiry and the respective issues – in particular, the interaction between small-scale agriculture, sugarcane plantations, and the emerging oil scenario (including issues of rural employment; perceptions, aspirations, household labour allocation), to obtain some insights into (potential of) 'seasonal' conflicts. The materials used include: flip charts, markers, and seeds.

After introducing the purpose of the research and explaining our presence in the community, we asked the participants to identify rainy seasons (i.e. the months when the rains start and end). This was followed by a record of the main livelihood and household activities and related tasks (e.g. child care, food preparation, water and wood collection). The participants then had to agree on, and indicate the timing each activity (in terms of months) on the calendar (designed before the FGD). On the right-hand column, against each activity, FGD participants were tasked to indicate the gender division of labour at household level. Using ten seeds, group members were asked to indicate the relative contribution of women and men to the performance of each task. For instance, ten seeds for women and none for men indicates that women are entirely responsible for doing a particular task, while five seeds for each indicates that women and men share the task equally. During the FGD we looked out for other information with a seasonal dimension (e.g. food shortages, patterns of income and expenditure, diseases or workloads).

3.3 Role Play Games (RPGs)

We drew on the literature, our previous field visits and experience in the landscape to set up the Role Play Game (RPG). We coin "NARL RPG" (Northern Albertine Rift Landscape Role Play Game) to differentiate our Role Play Game from the others in the literature. The RPGs were conducted between January and March 2020 in three villages, namely: Nyabyeya I, Nyabyeya II and Kibwona. In each village, two groups of 8–10 members participated. The idea was not to get a comparison between groups but an overall impression on perceptions and decisions on land use, patterns of sugarcane and small-scale agriculture in the baseline (status quo) and the oil scenarios, as well as (potential) conflicts that arise during the game. As a caveat – we did not necessarily include a conflict scenario or related rules in the RPG – we aimed to observe if, and how conflict would arise organically in the course of the game. The RPG methodology was not used in Nyakafunjo village because, as will be explained later, sugarcane growing was not permitted. The game was comprised of 3 parts, namely: 1) Briefing, 2) Gaming, and 3) De-briefing sessions, led by RT with the help

of two research assistants – with one taking note of the transactions, and pixel changes, while the other was responsible for recording the interactions between members.

3.3.1 Briefing session and game initialisation

To recruit participants, we aimed to include the majority of the local residents that participated in the FGDs in 2018, to build on the previous experience. However, this was not always possible because of the time lag: previous participants who were successfully recruited in 2020 only ranged between 20%–30% in each village. Given that the number of members we worked with are typically small, the gaps were filled following similar procedures employed in the FGDs (see section 2.2.1). Before any game session, the overall objectives and the importance of this project, and why local participation is necessary, were (re)explained. All ethical considerations were reiterated – including consent, confidentiality, anonymity, participation at free will, and possibility to exit at any point if required. Furthermore, we emphasised that the main idea of the game was to reflect real-world scenarios, and that people should make decisions as they would in reality.

Amongst the participants, one was allocated the role of "Kinyara sugar factory" agent – responsible for making pay-outs to the sugarcane outgrowers, monitoring sugarcane plots (newly established, growth stage, and harvest due for payment). Another player was assigned the role of "oil industry" agent – his/her job was to make payments to members of the household providing labour in the oil industry. The other members were assigned the "local resident" role – who made decisions at household level on growing sugarcane (i.e. converting land under small-scale agriculture to sugarcane) or replacing sugarcane plots with "food" gardens (also referred to as "small-scale agriculture") or just maintaining small-scale agriculture, as well as deciding whether to send a member of the family to work off-farm in the oil industry. We aimed for a 50/50 male/female participation, and this was achieved. Overall, the game had 14 rounds split into two independent 7–round sessions. With each round representing 6 months as decisions are made season–by–season; the game was therefore played for 3.5 years per round. In the first part of the game, only the Kinyara sugar factory agent and the local residents were involved (in the baseline/status quo scenario). At the end of the first 7 rounds, the board was reset to the original settings, and members allocated the same number of parcels and cash as at the beginning. In the second part (7 rounds too) both the Kinyara sugar factory and oil industry agents were involved. This was to give a sense of land use dynamics in the oil scenario.

Given that we aimed to capture heterogeneity in the community, half of the members ("local resident" category) were given initial conditions that closely matched their 'assets' (especially land parcels), and based on this allocation, the other half were allocated resources randomly, but in a manner that reflected diversity during the gaming session. Given that the game was played in two rounds, the initial conditions

of each member were recorded, with the aim to reset to the same conditions in the second stage. This is further expounded in section 2.3.2. Two groups participated in the RPG per village, but the initial conditions for each group were not necessarily the same, to reinforce the group heterogeneity reflected at village level (e.g. see Twongyirwe et al., 2017).

To initialise the game, we presented the community map that was drawn during the previous visit: this formed the basis for constructing tiles on the board, to reflect land use and land cover in the village. How the game works, and rules to follow (elaborated below) were explained. Time was allowed for asking questions and seeking clarification before the game to minimise interruptions once the game had started.

3.3.2 Gaming Session: Rules and Procedures

We prepared equal sized cards – each representing a unit of land parcel – but the acreage represented by the card was determined by each group based on average land sizes (and use) at household level in the village. Participants normally agreed on 1 card to represent 1 acre. The idea was not to reconstruct the land sizes in the village to scale especially that land is fragmented, but to give an indication of how many parcels one could reasonably own and utilise for sugarcane growing and small-scale agriculture for subsistence (and cash occasionally). The dominant land uses of interest to this study were placed on the board, using different colours. Green was used to represent forest patches, orange – small-scale agriculture, and sugarcane – purple. The participants used the village map that was drawn during the FGD(s) to populate the board with appropriately coloured cards (see Figure 2).

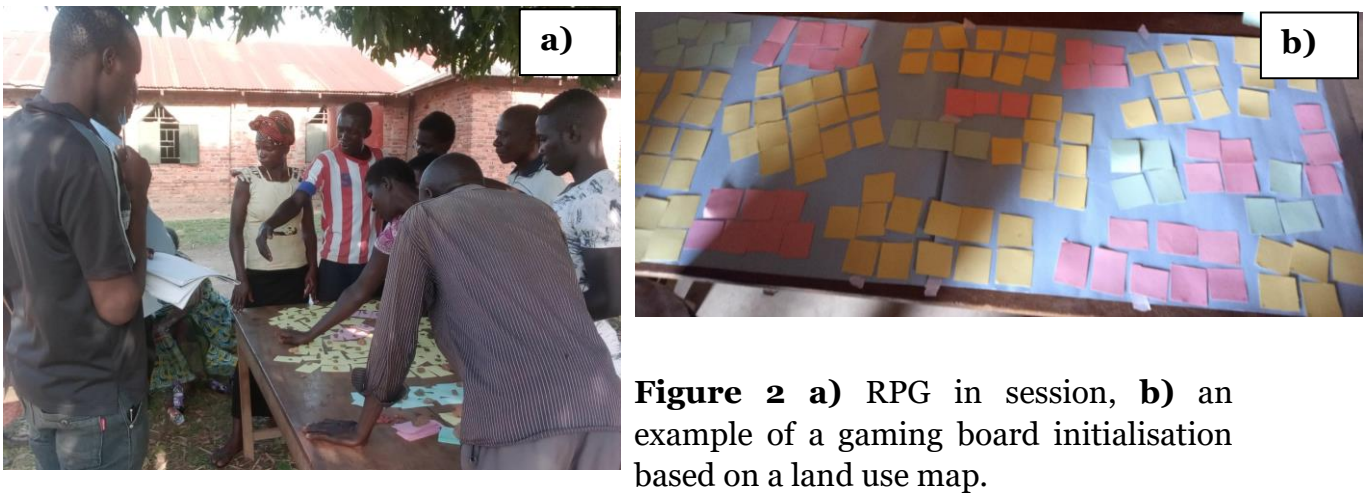


Figure 2 a) RPG in session, **b)** an example of a gaming board initialisation based on a land use map.

The idea was not to reproduce the map, but by allocating cards on the board, we get a sense of which land uses are most widespread – and it was from these parcels that members obtained allocations for the game. Photo credit: authors (Jan 2020).

Once the board had three card categories in appropriate proportions (with consensus from all members), each member was allocated parcels (sugarcane, and small-scale agriculture): half of them based on how many they actually own in real life, and other

half, in a random manner. As the emphasis was not on spatial patterns (no results of the final board spatial outputs were analysed, only total number of pixels were considered) – participants were therefore allowed to pick parcels from the board in close proximity – for ease of demarcation and monitoring. Each participant was allocated an identification number ranging from 1 to 10, and cards on the board owned labelled with this ID (using pencil) for ease of identification.

The sugarcane plots that existed at the start of the game were distributed in accordance to livelihood/gender typologies or randomly as earlier explained. However, if a household decided to convert a new piece of land into sugarcane, upfront costs were met by the sugarcane industry in a franchise-based arrangement (Twongyirwe, 2015). It would take 1 harvest to recover the costs of 1 acre of land. Sugarcane matures in 18 months (i.e. 3 rounds of play), and a harvest is expected from the same piece of land every 12 months (2 rounds of play). It therefore meant that a player that converted a plot of land to sugarcane waited until after 5 rounds of play to claim money for the harvest from the Kinyara sugar factory agent. Sugarcane harvest from one acre of land earned UGX 1,000,000 (~USD 270) for the farmer. Players also had an option to rent land for sugarcane production at a fee of UGX 1,000,000 per annum per plot (1 acre) if needed; participants generally argued that it did not make much sense to rent out a sugarcane garden. If the farmer decided to dispose of 1 acre with sugarcane, such a plot cost UGX 6,000,000 (~USD 1,620). Such a player would not claim costs from sugarcane harvest from that plot in subsequent rounds of play. The costs of selling a plot of land varied per group and village, but members had to agree on before the game. This variation was accommodated in the game set up: The idea was to make the transactions made by the participants as realistic as possible to aid decision–making in a real-life scenario. The cost variations within groups and between villages were minor however.

Small-scale agriculture plots were assumed to be typically for food for household subsistence. From previous household characterisation, this was predominantly the case. Very little food grown was sold by the households (Twongyirwe et al., 2017). Players did not earn any money from the small-scale agriculture plots except if they sold the plot in the course of the game, or converted it to sugarcane plantation. In the latter case, waiting for up to 5 rounds before earning any money from the sugarcane harvest. The cost of selling a plot (1 acre) was UGX 3,000,000 (~USD 810). Small-scale agriculture plots were dominant amongst some villages, and the majority were allocated to the players based on the criteria already described. If a household did not have sufficient plots for small-scale agriculture, they could rent plots from those that had more at a cost of UGX 100,000 (~USD 27) per season.

To aid transactions once the game begun, each player ("local resident") was allocated some cash at hand. Again, this was based on livelihood typologies, at least for half of the players [each household is assumed to have an income between UGX 379,000 to 20,000,000 p.a.: Twongyirwe et al., 2017)]. Members were allocated the equivalent

of last year's cash earned. The other half, we allocated initial amounts of cash randomly, typically between UGX 1,000,000 and UGX 10,000,000 to avoid unrealistic inflation and intentionally providing space for irrational decisions once the game had started. We used a different type of coloured cards with money value indicated to aid cash payments in the course of the game.

Another constraint in the game was family size/number of children. And although this was not considered a major driver for land use decision making, in especially the first 7 rounds of play because members of household do not contribute substantially to income from small-scale agriculture, they were more important in the second 7 rounds of play where household heads had to decide if some members of their household were allowed to find off-farm employment in the oil industry. During the oil scenario, the underlying assumption was that, based on oil and gas legislation that will grant labour opportunities to locals in the region ahead of everyone else, then households could send some of their members to provide casual (and sometimes skilled) labour to the oil industry. Based on the agricultural labour needs at household level, the head of the family could send a member or several members to work in the oil wells. It was assumed that, in return, the household would receive remittances of at least UGX 1,000,000 from each member per season (round of play). Households that also had sugarcane continued to receive income from sugarcane harvests per year (two rounds of play). We observed what decisions they then made about small-scale agriculture and sugarcane plots, in the oil scenario. Family size was assumed to be constant throughout the gaming period however (as new members would not have matured to contribute in a space of 3.5 years played).

Participants were not allowed to encroach on the gazetted forest parcels if they had limited land resources or low income from agricultural activities. There is sufficient evidence of strict forest protection from our previous studies (Twongyirwe et al., 2018, 2017; Ronald Twongyirwe, 2015). There was therefore no need to include forest dynamics in the game, with for instance a "forest ranger" agent.

After the initialisation, each player took a turn, with negotiations across the board. Just like in a chess game, there was no room for being passive. Under normal circumstances, the households should have a minimum amount of income per season for the family to survive, or a minimum amount of crop land for them to grow food to survive. Without these minimums, decisions had to be made to sell land (and migrate from the area if they no longer own any, or use the money from sales to buy cheaper areas or invest in sugarcane growing) or rent plots (at rates determined ahead of the game, for one to judge if they are affordable). Although this threshold was determined by the community, we did not have sufficient rounds of play for members to get to this level.

If a player sold a plot to another member, the labels on the board were changed to reflect the transaction. If a plot was converted to sugarcane from small-scale

agriculture, the orange colour was replaced with purple card, and details written, showing round when the conversion happened. At the end of each turn, the game master (RT) announced the round of play started (e.g. round 3 complete, round 4 now starts…etc). At the end of each round number of parcels on the board and amount of cash were counted and recorded. Overall, the game was simplified: expenditures other than on land purchase, and incomes other than from sugarcane or labour remittances from the oil industry, were not considered.

3.3.3 Debriefing session

After each segment of play (7 rounds), participants were asked why they used their land resources the way they did and the rationale for their decisions. Any conflicts that arose and how they were resolved were discussed. We had an extended discussion on the impact of the oil scenario on land use in their villages, and broader implications on livelihoods, natural resource conflict management. Whilst we were clear on the successes of strict forest protection, the future of forestry, in the context of aggressive commercial sugarcane growing, and property regimes were discussed. Furthermore, although the game was played for a few rounds, reflecting few years, a long view was discussed during debriefing, including perspectives on land use in the village in the context of the current and project oil dynamics in the next 5-10 years.

3.4 Complementing Community-based Mapping: Remote Sensing Land Use and Land Cover in the Studied Villages

Our interest was in verifying the extent to which community-based mapping could be useable, or what caveats one should consider when, for instance, operationalising a Role Play Game that is based on indications of quantities of land uses that are of interest. To this end, we analysed Landsat 8 imagery acquired in January 2020. We assumed no major land use changes since our last field visit in May 2018. This was confirmed through informal interviews with local leaders that guided our fieldwork when we last visited.

The classification of the image was undertaken using Erdas Imagine software (version 2016) following standard procedures extensively documented in some of our previous work (e.g. Twongyirwe et al., 2015). In brief, the raw image was downloaded from the USGS website (at earthexplorer.usgs.gov) and bands were stacked to create false colour composites, followed by image subset extract each of the villages we studied. The village layers were obtained from Uganda Bureau of Statistics. Training sites were then selected over various land uses/land cover, based on our previous visits and knowledge of the area. These were used in extracting an average spectral signature for the classification. The Maximum Likelihood Classifier (MLC) was chosen to classify the image: it puts pixels in a corresponding class with the maximum likelihood of belonging to it based on a pool of spectral signatures (Nangendo et al., 2007). We selected five classes: natural forest, woodlots,

settlements, small-scale agriculture and sugarcane plantations. We have good knowledge of the villages following our longstanding experience in the region. Based on this, we can confirm that the classification was reasonably accurate.

3.5 Data Analysis

Our data was mostly qualitative. We extracted themes from the FGDs in line with the study objectives. Remote sensing data were only used for comparison with mapping outputs from the FGDs. RPG data were summarised using plots – to show patterns in decision–making. Three variables were plotted: small-scale agriculture, sugarcane parcels, income (cash at hand). We define the main parameters of our graphical exploratory analysis as follows:
(i) Rounds: We interpret this as a replacement of time (season). Each round represents six months, per the seasonal calendar from previous fieldwork.
(ii) Gender: We have two: Male and Female gender. In our graphics, Male gender is denoted by solid curves, and dashed curve for the Females, for ease of comparison.
(iii) ID: For ethical reasons, we do not display the names of participants, but rather Identity numbers (ID) given to each participant, ranging from 1 to 9. These participants' IDs are indicated on the graphs.
(iv) Net income: We also perform basic econometrics by tracking the running incomes of each participants at every timestep following the basic formula:
Net Income = Total Incomes – Total Expenditures.
The main source of the income in the RPG are; income from selling/renting land (Small-scale agriculture or Sugarcane plantation), income from labour service to oil industry, income from selling sugarcane harvest to the factory. While the main expenditure in the game are related to buying/renting land parcels. The various income/expenditure is updated every timestep, summed and then used to calculate the Net Income at every timestep.
We present graphs from our exploratory analysis, presenting time series of land cover ratio change for all the participants in the villages (Nyabeya I, Nyabeya II and Kibwona) under both status quo and oil scenarios, followed by an exploration of income dynamics under both scenarios for each village.

We also subjected a range of variables indicated above to non-parametric correlation tests (spearman's correlation tests preferred in our case). We test differences in means of total land parcels (small-scale agriculture and sugarcane) under the status quo and oil scenarios. As the data are non-normally distributed, a non-parametric Kruskal-Wallis test is employed.

4. Findings

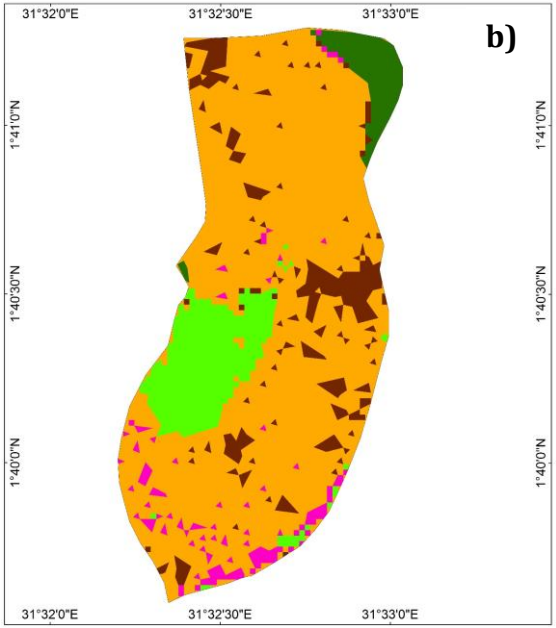
4.1 Village–level resource mapping, land use/land cover, and perceived livelihood differentiation

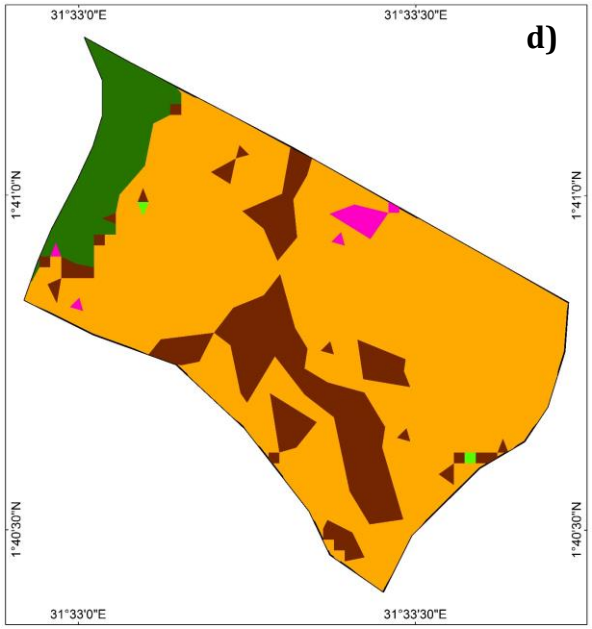
The locals (FGD participants) indicate relative abundance and spatial extents of each land uses/cover (Figures 3 and 4). A visual assessment indicates some agreement with maps generated from classifying Landsat imagery. Generally speaking, FGD participants indicated that small-scale farming covered the largest percentage of land use in all the villages. Indeed, there is also a reasonable agreement with the amount of sugarcane and forest cover indicated on the maps (e.g. remarkable agreement between Figures 4a and 4b, and Figures 4c and 4d, and southwestern parts of Figures 3a and b), although spatial extents varied in places. For instance, there is more sugarcane mapped in Figure 3c than that detected in 3d, especially "strips" indicated in the south and west in the former.

Indeed, from 2020 classification, small-scale agriculture is dominant in three study sites accounting for 72.9%, 74.4%, and 65.6%, in Nyabyeya I, Nyabyeya II, and Kibwona respectively. The acreage under settlement is second to small-scale agriculture, followed by natural forest in Nyabyeya I, Nyabyeya II, Kibwona (Table 1). Nyakafunjo is peculiar: the majority of the village space – some 39.1% – is under forest, and has no sugarcane compared to the other villages. As identified in the FGD mapping too, area under sugarcane in Nyabyeya I and Nyabyeya II from remote sensing imagery is relatively small, accounting for 3% and 1% respectively. Kibwona has a significantly higher acreage under sugarcane accounting for 13.8%. Woodlots were identified in all villages, although their acreage is much smaller than the other land uses/cover (Table 1).

Table 1 Size of land uses/cover (ha) classes in the studies villages from the Jan 2020 Landsat image classification

Land use/cover	Nyabyeya I	Nyabyeya II	Kibwona	Nyakafunjo
Natural forest	13.42	8.88	20.85	50.36
Woodlot	13.90	0.15	20.61	6.57
Settlement	27.86	17.14	88.24	45.42
Small-scale agriculture	235.59	78.98	417.83	26.58
Sugarcane plantations	9.64	1.03	87.89	0.00
Total acreage (in ha)	**323.41**	**106.18**	**635.42**	**128.93**





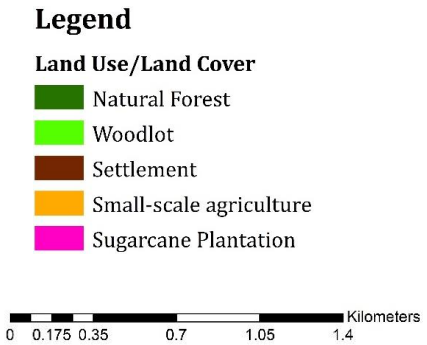
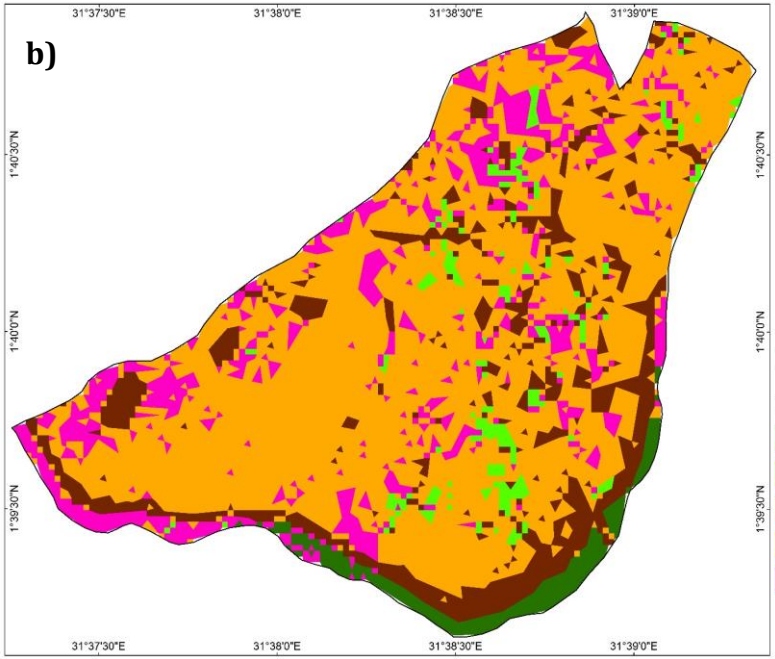


Figure 3 Map of studied villages drawn by local participants versus maps generated from analysing Landsat imagery acquired in 2020: a) community map of Nyabyeya I, b) Classification of Nyabyeya I, c) community map of Nyabyeya II, d) classification of Nyabyeya II



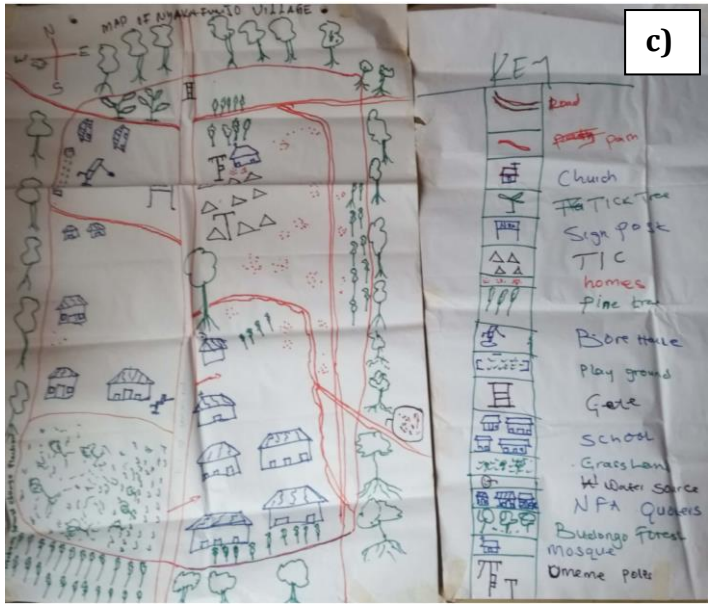


Figure 4 Map of studied villages drawn by local participants versus maps generated from analysing Landsat imagery acquired in 2020: a) community map of Kibwona, b) Classification of Kibwona, c) community map of Nyakafunjo, d) Classification of Nyakafunjo

4.1.1 Livelihood differentiation

In the studied villages, there is minimal variation in livelihood typologies, based on qualitative measures of wealth, employment, livestock kept, access to the natural forest and food crops grown (Table 2). In all villages ownership of sugarcane is considered an important wealth indicator, with the "rich" owning more than 2 or 3 ha. More residents were perceived to belong to "middle" income status (Table 2).

Table 2 Perceived livelihood differentiation at village level

Characteristics/Village	Nyabyeya 1	Nyabyeya II	Kibwona	Nyakafunjo
Wealth indicators for the "Rich"	- Own sugarcane plantations > 3 ha, - Formal employment (colleges, NGOS, LGs)	- "Nice house" – made of bricks, and with iron sheets, - Total land size > 3 ha, - Own sugarcane plantations >2 ha	- Own sugarcane plantations >2 ha - "Enough" food, - Schooling children, - Owns a car or motorcycle, - Permanent house	- Permanent house - Own a motorcycle - Absentee landlords (or own properties outside the village)
Wealth indicators for the "Middle" class	- Own sugarcane plantations 0–3 ha	- Own sugarcane plantations 0–2 ha	- Owns sugarcane 0–2 ha	- Middling
Wealth indicators for the "Poor"	- Have no sugarcane plantations	- Live in grass thatched huts - Owns no sugarcane	- Cannot afford growing sugarcane	(not identified)
Proportion of wealth categories (qualitative estimates)	Poor > Middle class > Rich	Middle class > Poor > Rich	Poor > Middle class > Rich	Poor > Middle class > Rich
Wealth differences based on religion/tribe	No noticeable differences	None reported	None reported	*Banyoro* were perceived to be richer
Ethnicity/dominant tribes reported in the village			*Banyoro, Acholi, Alur, Iteso, Batoro, Banyankole, Lugbar*	*Alur, Lugbar, Banyoro* and *Lendu* (from Congo)
Employment opportunities in the village	In schools – teaching and cooking, night guarding, NGOs	Protecting sugarcane against vermin, weeding	Casual labour in sugarcane plantations & Kinyara sugar factory, bars as waitresses, shop attendants, teaching	Digging in the gardens, brick laying
Livestock kept	Small ruminants kept – rarely too: 1 or 2 goats per HH in spite of wealth status	None reported	None reported	None report
Land tenure	Predominantly customary, with some freehold ("*people come in to buy land*")	Predominantly customary, with some buying and renting	Mainly customary, with freehold system increasing	Predominantly customary with some freehold
Access to the natural forest (Budongo)	No access allowed, expect for firewood gathering and building poles	No access, expect for firewood gathering and "light" building materials	No access, expect for firewood gathering	Access controlled: women allowed to collect firewood
Conflict due to Land boundary demarcations/violations	Conflicts due to this are rare: boundaries are clear	Few. No *land* markers, but *"people know their boundaries*"	Many conflicts – unclear land boundaries	Very few to none
Food crops grown (on small scale)	Maize, beans, cassava, groundnuts, rice, "*matooke*" and coffee (very small scale), jackfruit	Maize, beans, sweet-potato, millet, sorghum, groundnuts, cassava	Maize, beans, *matooke*, cassava, groundnuts, sweet potatoes	Maize, beans
Commercial sugarcane growing	Franchise-based, owned by a few members	Franchise-based, owned by a few members	Owned by outgrowers found in village	Not permitted

NGOs – Non-governmental organisations

Other wealth indicators highlighted during the FGDs include: housing structure (e.g. permanent – made of bricks and iron sheets), ownership of cars and motorcycles, schooling children. Wealth was not determined along religious lines:

> "*we don't have noticeable differences in terms of wealth based on religion and tribe… we are multilingual "when we came here, we had the bantu tribes and others. But the truth is Bantu are still behind*" (male FGD participant in Nyabyeya I, March 2018).

Local employment opportunities exist within the sugarcane outgrower scheme – especially during the peak season of harvesting and at Kinyara sugar factory, but the majority of locals work on own farms. Other opportunities exist within local schools (e.g. teaching, and casual labour), conservation organisations, trading in merchandise, and the construction industry.

Barely any livestock are kept by the households, and the majority of crops grown are for home consumption with some surplus for sale in local markets. The dominant crops mentioned include: Maize, beans, cassava, groundnuts, and bananas. Coffee was mentioned in Nyabyeya I – and the participants categorically added that this is in very small quantities.

4.1.2 Land tenure regimes

The land tenure system is shifting from predominantly customary (where land is owned by families and passed on from one generation to another, also often without titles) to freehold (where land is titled, and owned in perpetuity), although the customary system is still dominant (Table 2). The shift in land ownership and titling is apparently driven by "*outsiders that buy land within the village*", although this is not always without dissatisfaction across all the villages where we undertook the study:

> "*Our land is small like 1 or 2 ha: Most of the forest college land was for our parents but they chased them away so we don't have enough land… There are 2 armed policemen and one forest officer moving around all the time. Getting in the* [plantation] *forest is extremely risky*" (male FGD participant in Nyabyeya I, March 2018).

Yet the dominant customary system was criticised for slowing down development of the land:

> "*It is actually a problem because people don't have full ownership over land. You cannot use land freely according to how you want, for example you may want to sell your portion but then your siblings come and say that it is abominable to sell the family land…. so you must buy your own land, and give up on making decisions on customary land*" (male FGD participant in Kibwona, March 2018).

There was a mixed response on the state of land demarcation in the villages. On the one hand, some respondents reported that clear boundaries between people's land were clear, although future conflicts are anticipated. The main source potentially arising from shifting boundaries.

> "*When you have a neighbour who wants to grab your land, he cultivates as he pushes grass towards another plot. But currently this is not here…. I saw it happening somewhere – not too far away from our village, so, it can happen here*" (female FGD participant in Nyabyeya I, March 2018).

On the other hand, several respondents from various groups in all studied villages, reported the lack of clear land demarcations. We quote two examples as follows:

> "*There are no boundary markers that separate people's land in our village* (male FGD participant in Nyabyeya II).

> *"People just know their boundaries even though there are no boundary markers"* (male FGD participant in Kibwona, March 2018).

Conflicts due to unclear land demarcation were reportedly common in Kibwona. However, the situation seems to be changing with a government initiative to enable residents process titles:

> "*The government tells us to lease and get land titles or certificates of ownership from the town council division. We no longer suffer since they decentralized our districts. They urge us to get land titles and for those that cannot afford the fee, they are given certificates of ownership*" (male FGD participant in Kibwona, March 2018).

Forest protection was reported to be strict in all villages, and access only permitted for fuelwood collection by women, except in Nyabyeya II and Nyakafunjo where residents were allowed to obtain small trees for building (Table 2). Other values of the forest were also reported:

> "*We are given days to collect firewood from the forest. When some women collect it they sell off some to buy salt and other needs and the rest of the firewood is used for cooking at home"* (female FGD participant in Nyakafunjo, March 2018).

> "*Forests are good because we get herbal medicine. Some trees' roots are used as herbal medicine for certain infections and diseases especially among children. To add on what he has said, we get fresh air and rainfall. Actually, areas without trees do not receive rainfall at all. As a result, our local leaders encourage us to plant trees as much as we can*" (female FGD participant in Kibwona, March 2018).

Access to building material has to follow a formal application to the National Forest Authority. These formal processes were not always popular as they disadvantage the illiterate:

"*When we go to collect poles, NFA stops us saying that it should be put in writing. If you don't know how to write, then it is another problem because you will not be able to access the poles*" (male FGD participant in Nyakafunjo, March 2018).

Even with fortress protection, some illegal access to wood for charcoal burning was reported (in Kibwona for example):

"*…. At night, they deal with security guards and gain access into the forest.*" (male FGD participant in Kibwona, March 2018).

Close proximity to the natural forests was not without problem however. Crop raiding from wild animals was highlighted as one of the key problems:

"*…. forests groom animals which destroy our crops. For example, monkeys, chimpanzees among others. We chase them away using dogs but they insist and come back to eat crops.*" (male FGD participant in Kibwona, March 2018).

However, locals demand more access to Budongo forest:

"*For this village to develop, NFA should allow people to kill animals that raid crops. More so, there shouldn't be restrictions on accessing the forest"* (male FGD participant in Nyakafunjo, March 2018).

"*In addition, if NFA would allow people to cultivate the grassland that doesn't have trees, then, it would be okay to grow more food"* (female FGD participant in Nyakafunjo, March 2018).

The National Forest Authority (NFA: a government body mandated to protect forests) is implementing collaborative forest management projects within Nyakafunjo village, to improve livelihoods while keeping forest encroachment at bay. The effort is well recognised by the community:

"*NFA gave us land and seedlings such that we plant trees. These trees are our source of income after sale although land belongs to NFA*" (male FGD participant in Nyakafunjo, March 2018).

"*We even have projects. The hunters are given goats to stop them from poaching*" (female FGD participant in Nyabyeya, March 2018).

4.2 Cropping calendar, and perceived gender division of labour

There is minimal variation in the seasonal cropping activities and gender division of labour across the villages where this tool was employed (Table 3). Cropping activities are planned around the rainfall months, which generally occur between March and May, and August and November. Land preparation and ploughing occur at least a month or two before the rain starts. Across all the villages, this activity is mostly undertaken by women, although ploughing seems to be shared almost equally with men (Table 3). Planting food crops occurs in the first month of the rain (March/August): there seems to be consensus across all the villages that this activity is shared equally by both men and women:

> "*both participate in planting. Actually, as men dig holes, women follow planting seeds and vice versa*" (female FGD participant in Nyabyeya I, March 2018). A similar statement is reiterated by a female participant in Nyabyeya II.

However,

> "*men are more involved in planting 'cash crops'* [e.g. sugarcane] *while women concentrate more on 'food crops'*" (male FGD participant in Nyabyeya I, March 2018). A similar statement is reiterated by a male FGD participant in Nyabyeya II.

Vermin control was mentioned in Nyakafunjo as a time-consuming activity – mostly done by women, and children. Harvesting, transporting the produce and selling (in some instances) is predominantly done by women. Livestock rearing (of chicken, goats and pigs but not cattle) was reportedly shared, although done more by women.

Although woodlots were included on the land use maps, activities related to woodlot establishment and maintenance are not included in the seasonal calendar. One reason for this is that the woodlots are owned by a few people, who are also considered to be among the "wealthy" in the village. Tree planting is a male-dominated activity though.

Table 3 Seasonal calendar and gender division of labour in three villages

Months of the year	J	F	M	A	M	J	J	A	S	O	N	D	Perceived gender division of labour (%)					
													Nyabyeya I		Nyabyeya II		Nyakafunjo	
Activity													**F**	**M**	**F**	**M**	**F**	**M**
Rainfall			x o µ	x o µ	x o µ	o		x o µ	x o µ	x o µ	x o µ							
Land preparation (lashing bushes)	x o µ	o µ	o			o	o µ	o µ	o				30	70	20	80	30	70
Ploughing		x o µ	x o µ			x	x o µ	µ				o	50	50	70	30	50	50
Planting			x o µ	o µ			x	x o µ	x o µ	o			50	50	50	50	50	50
Weeding			x	x µ	x o µ	o		x o µ	x o µ	x o			60	40	80	20	30	70
Vermin control	µ	µ	µ	µ	µ	µ	µ	µ	µ	µ	µ	µ					80	20
Harvesting	o µ	µ				x µ	x o µ	o			x	x o µ	70	30	80	20	70	30
Transporting the harvest	o					x	x o	o			x	x o	20	80	20	80	10	90
Drying & storage	o	o					o	o	o	o		o			50	50		
Selling produce	x	x						x	x			x	80	20				
Livestock rearing (goats)	x µ	x µ	x µ	x µ	x µ	x µ	x µ	x µ	x µ	x µ	x µ	x µ	70	30			70	30
Chicken rearing	x µ	x µ	x µ	x µ	x µ	x µ	x µ	x µ	x µ	x µ	x µ	x µ	70	30			50	50
Pig rearing	x	x	x	x	x	x	x	x	x	x	x	x	50	50				
Providing casual labour to Kinyara	µ	µ	µ	µ	µ	µ	µ	µ	µ	µ	µ	µ					10	90

x – Nyabyeya I, o – Nyabyeya II, µ–Nyakafunjo, F–Female, M–Male members of the household (Blanks –not mentioned in FGD). This tool was not employed in Kibwona as we thought we had reached "saturation" – a good understanding of the cropping calendar and related gender division of labour

4.3 Perspectives on the expanding sugarcane outgrower scheme and oil prospects

On sugarcane

Sugarcane has a history in the villages – which is perceived locally as having often resulted in land dispossession, and in marginalisation of poorer land-owners:

> *"The project for sugarcane growing was started by Kinyara sugar works over 20 years ago. They provide seeds to people – a few people own the land where the sugarcane is grown… Kinyara sugar limited comes in if you have registered enough land, they come and survey, plough (on a loan) until the cane is grown. They come and harvest, and recover their upfront costs. At times, you remain with little money or nothing. But it gives you a starting point to grow sugarcane because the next time you grow it, Kinyara will not come to own it again. What they do is to help people start growing even without money especially during the first harvest.*" (male FGD participants in Nyabyeya I, March 2018).

> "*People who have money come from other places and rent land to grow sugarcane. They count seasons – normally one and half year – and pay land owner according to those seasons*" (male FGD participant in Nyabyeya I, March 2018). This remark is reiterated by respondents in other villages.

> "*Sugarcane is owned by a few members in the village. However, some people from Kinyara (and far away) to hire land from the residents to grow sugarcane…it is not always better to hire land to outsiders… You may not have enough capital to start up the sugarcane business, so you don't have an option apart from hiring your land to someone else"* (male FGD participant in Nyabyeya II, March 2018).

In Nyakafunjo village where sugarcane growing is prohibited due to human-wildlife conflict is viewed as unfair and a way to take away a livelihood from the locals.

> "*We used to grow sugarcane in the past but chimpanzees would come from the forest and destroy them. And as a result, some people would kill them which led NFA* [National Forest Authority] *to intervene and stop sugarcane growing*" (male FGD participant in Nyakafunjo, March 2018).

> "*It is bad that we cannot grow sugarcane and yet others are growing it. So, our development and income levels are down. As you can see, our children do not even go to school"* (male FGD participant in Nyakafunjo, March 2018).

However, growing wood for fuel and building poles practiced on privately owned land (rather than sugarcane growing) is more viable than food crops, grown on small–scale because of the vermin problem.

> "*Pine is grown next to the natural forest due to monetary benefits from owning trees…also wild animals are more likely to raid crops if grown next to the forest, therefore pine growing is a better option*" (FGD participant in Nyakafunjo, March 2018).

The aggressive expansion of sugarcane in for instance Kibwona is creating land shortage as poorer people are renting out their land to wealthier people both from the village and from outside, creating food insecurity for less well-off people who are also turning part of their land over to sugarcane growing. It was mentioned that men have to provide labour in sugarcane plantations at a time that coincides with labour demands for food crop production. However unconventional employment opportunities in the village have also emerged [e.g. "*sex workers within the trading centre have increased these days*" (female FGD participant in Kibwona, March 2018)]. Furthermore, the sugar boom has also had some unintended consequences such as increased (petty) theft and heightened the risk of food insecurity. Food insecurity was viewed as a likely control sugarcane expansion.

> "*Land is scarce but even those with small pieces of land work tirelessly to grow sugarcanes as well. However, the challenge is that it results into hunger since they tend to neglect growing other food crops*" (male FGD participant in Kibwona, March 2018).

> "*All the land cannot be allocated to sugarcane growing. We must spare some land for growing food crops*" (female FGD participant in Nyabyeya II, March 2018).

> "*We plan for the land according to how the family will survive. I cannot plant sugarcane and yet my family is starving because a good sugarcane takes 18 months for you to harvest so by the time you get money out of it your children will have died, instead you opt for maize, beans*" (female FGD participant in Nyabyeya I, March 2018).

Local imaginaries on oil prospects

Uncertainty about land ownership given the oil prospects worried the residents and created mistrust. This did not reduce their scepticism about researchers in the area too (in spite of clearly explaining what our study was about):

> "*You guys are here writing, writing* [all laughing…] *but in future you will be leading the government in evicting us "mbu"* [that] *there is oil discovered here. You start telling us to leave our land and go to settle elsewhere, and yet we are poor… The government just tells you to go away because they want to construct a road, yet the money given to you as a compensation cannot even buy a plot of land somewhere else,*

we are so confused of what to do. So, even seeing you here makes me worried and I am telling you the truth" (male FGD participant in Kibwona, March 2018).

Furthermore, FGD participants anticipate that oil will bring big changes in the studied villages, with mixed consequences on land (dis)possession:

"*Some people will gain from it and others will be affected for example, now that there is oil, roads will be constructed but remember there are people who have plots of land/ plantations along the road. Part of their land will be lost in the process of road construction, so, when you are left with a small piece of land, will you be able to cultivate or construct anything on it? More so, some people constructed their houses (permanent) and settled along the road, so, what will happen during expansion is eviction. Will they be compensated or not? And more to that if they are compensated, where will they go? Land is scarce and very expensive nowadays; do you understand me? However, on the positive side, some people will get employment opportunities as a result of oil discovery. For example, working as guides during the road construction, cooking food for the workers among others. This will be a source of income. Our transport and communication will be improved as well thus creating market for our agricultural products. Basically, the effects of oil discovery will be both positive and negative*" (male FGD participant in Kibwona, March 2018).

"*All things have a good and bad effect. Sugarcane growing will* [likely] *increase, as well as theft due to having nothing to eat. Someone will not sleep hungry when they are seeing a garden of sugarcanes, cassava, sweet potatoes among others. So, development comes with both good and bad things*" (female FGD participant in Kibwona, March 2018).

There is also a view that the oil resource will be useful for future generations:

"*Actually, we are educating children such that they can work in oil industries in future*" (male FGD participant in Nyabyeya I, March 2018).

4.4 Role Play Game Outcomes

At village level, the RPGs indicate that, on average, sugarcane is projected to increase ($p<0.05$) at the expense of small-scale agriculture in both the baseline (status quo) and oil scenarios (Figure 5). Sugarcane expansion is more marked in the status quo and oil scenarios in Nyabyeya I village, consistent in both groups (Figures 5 a and b, and, c and d). In Kibwona, a gentle increase in generally projected, albeit group one had less sugarcane parcels on average (Figures 5 e and f) compared to the other (Figures 5 g and h). In Nyabyeya II sugarcane increase is only marginal overall, and small-scale agriculture declines only slightly in subsequent game rounds in the status quo (Figure 5 i). However, under the oil scenario, sugarcane increase is less marked, but area under small-scale agriculture increases with subsequent game rounds (Figure 5 j).

Individual gaming sessions however reveal mixed non-linear patterns of ratios of sugarcane to small-scale agriculture, including both increase and decrease in both the status quo and oil scenarios (Figure 6). Some players show consistency in decision–making. They for instance consistently increase number of sugarcane plots they own at the expense of small-scale agriculture under both the status quo and oil scenarios: For instance, player 6 in Nyabyeya I (Figures 6 and b); players 2, 4 and 8 in Nyabyeya I (Figures 6 c and d); player 3 in Kibwona (Figures 6 e and f); and player 4 in Nyabyeya II (Figures 6 i and j). Some patterns are more erratic and inconsistent however – sharp changes (spikes) are visible in either scenarios: for instance, player 1 in Nyabyeya 1 (Figures 6 a and b) makes decisions to increase sugarcane under the status quo but then initially increases sugarcane in the first three rounds of the game before a sharp decline under the oil scenario; player 6 in Nyabyeya I (Figures 6 c and d) initially increases number of parcels under sugarcane before reducing in subsequent rounds of play – and this is consistent in both the status quo and oil scenarios while player 1 in the same group decreases sugarcane in status quo but increases it under the oil scenario (Figures 6 c and d). A few players made decisions to reduce on the sugarcane plots they owned under both scenarios: For instance, player 7 in Kibwona (Figures 6 g and h); and player 6 in Nyabyeya II (Figures 6 i and j).

Generally speaking, there isn't a significant difference ($p>0.05$) between the incomes earned under the status quo and oil scenarios on average (Figure 7). In both scenarios however, incomes progressively increase in general, but income under the oil scenario are on average marginally higher than the status quo scenario except in one group in Kibwona (Figure 7 c). In some instances, income variability is large (Figures 7 c, d and e). This variability becomes clearer when individual player patterns are observed under both scenarios (Figure 8). The patterns are erratic and non-linear in all scenarios.

There is statistically no gender differentiation ($p>0.05$) between patterns in land use and decisions made by both men and women under both scenarios: mixed patterns in sugarcane to small-scale agriculture ratios are visible amongst both male and female participants (Figure 6). Although lost in the overall statistics and patterns, during the gaming sessions, some women mentioned that they preferred more food gardens to sugarcane plantations.

From the gaming sessions, correlation analyses show that, generally speaking, number of plots owned under sugarcane is strongly (Spearman's rho > 0.7) and positively correlated ($p<0.05$) with the income from sugarcane harvest in Nyabyeya I (Tables 4 a, c, d), Kibwona (Tables 5 c), Nyabyeya II (Appendix 1) in both the status quo and oil scenarios. Other strong significant correlations (Spearman's rho > 0.7, $p<0.05$) include: strong positive correlation between income earned from sugarcane (harvested and sold) and age in Kibwona oil scenario (Table 5 b), strong negative correlation between income from sugarcane (harvested and sold) and gender in Nyabyeya I oil scenario (Table 4 d). There is a statistically negative correlation ($p<0.01$) between number of plots owned under small-scale agriculture and age of the participant in Nyabyeya I under status quo (Table 4 a). There is a strong positive correlation between number of plots owned under small-scale agriculture and income from selling a sugarcane plantation in Kibwona oil scenario (Table 5 b). A strong positive correlation is also noted between net income and income from sugarcane (harvested and sold) in Kibwona status quo and oil scenario (Tables 5 a, b, c and d) and Nyabyeya II group II oil scenario (Appendix 1). Other significant correlations can be observed from the Tables 5 a-d and Appendix 1 – however these are relatively weak.

From the RPGs – no major conflicts were experienced, except for a few members who attempted to take advantage of others to "grab" their parcels. In the debriefing session, the following are some of the voices about the game outcomes:

> "Land grabbing is very common in day-to-day life. The difference with this game is that the plots are well labelled and it is easy to know when someone wants to take a parcel that doesn't belong to them. In our village, we lack clear boundaries, and the land is not titled" (male RPG participant in Kibwona, Jan 2020).
>
> "This game teaches tolerance. We learn how to live with each other even if we do not agree on decisions your neighbour is making on land use" (female RPG participant in Nyabyeya I, Jan 2020)

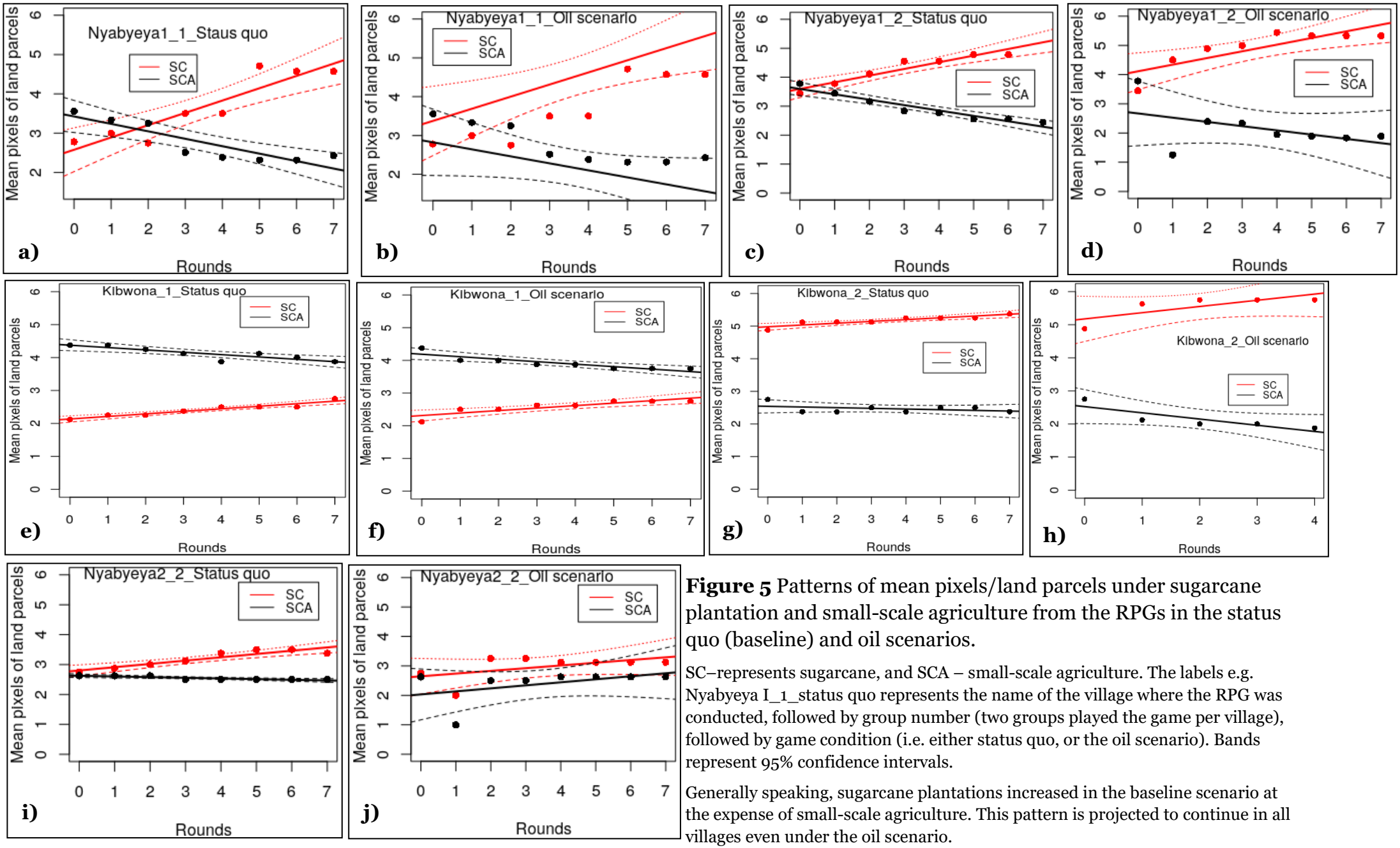


Figure 5 Patterns of mean pixels/land parcels under sugarcane plantation and small-scale agriculture from the RPGs in the status quo (baseline) and oil scenarios.

SC–represents sugarcane, and SCA – small-scale agriculture. The labels e.g. Nyabyeya I_1_status quo represents the name of the village where the RPG was conducted, followed by group number (two groups played the game per village), followed by game condition (i.e. either status quo, or the oil scenario). Bands represent 95% confidence intervals.

Generally speaking, sugarcane plantations increased in the baseline scenario at the expense of small-scale agriculture. This pattern is projected to continue in all villages even under the oil scenario.

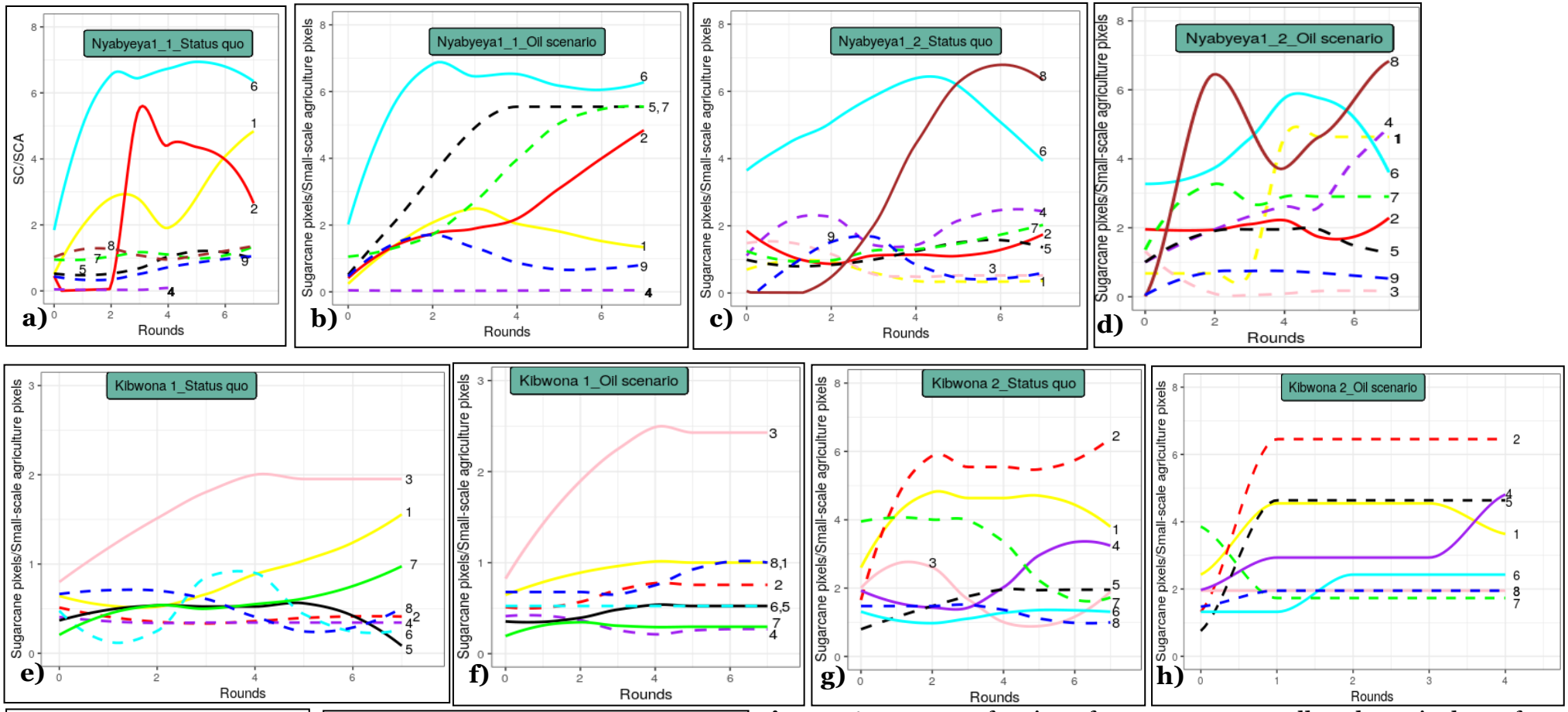


Figure 6 Patterns of ratios of sugarcane to small-scale agriculture from the RPGs in the status quo (baseline) and oil scenarios.

SC–represents sugarcane, and SCA – small-scale agriculture. The labels e.g. Nyabyeya I_1_status quo represents the name of the village where the RPG was conducted, followed by group number (two groups played the game per village), followed by game condition (i.e. either status quo, or the oil scenario). Male gender is denoted by solid curves: Female gender by dashed curves.

Gender: a) & b) 1–M, 2–M, 3–M, 4–F, 5–F, 6–M, 7–F, 8–F, 9–F; c) & d) 1–F, 2–M, 3–F, 4–F, 5–F, 6–M, 7–F, 8–M; e) & f) 1–M, 2–F, 3–M, 4–F, 5–M, 6–F, 7–M, 8–F; g) & h) 1–M, 2–F, 3–M, 4–F, 5–M, 6–F, 7–M, 8–F; i) & j) 1–M, 2–F, 3–M, 4–F, 5–M, 6–F, 7–M, 8–F (M–Male, F–Female).

The amount of sugarcane increases in all the games while that of small-scale agriculture decreases. The decision–making patterns are non-linear though with some spikes, sometimes indicating irrational choices.

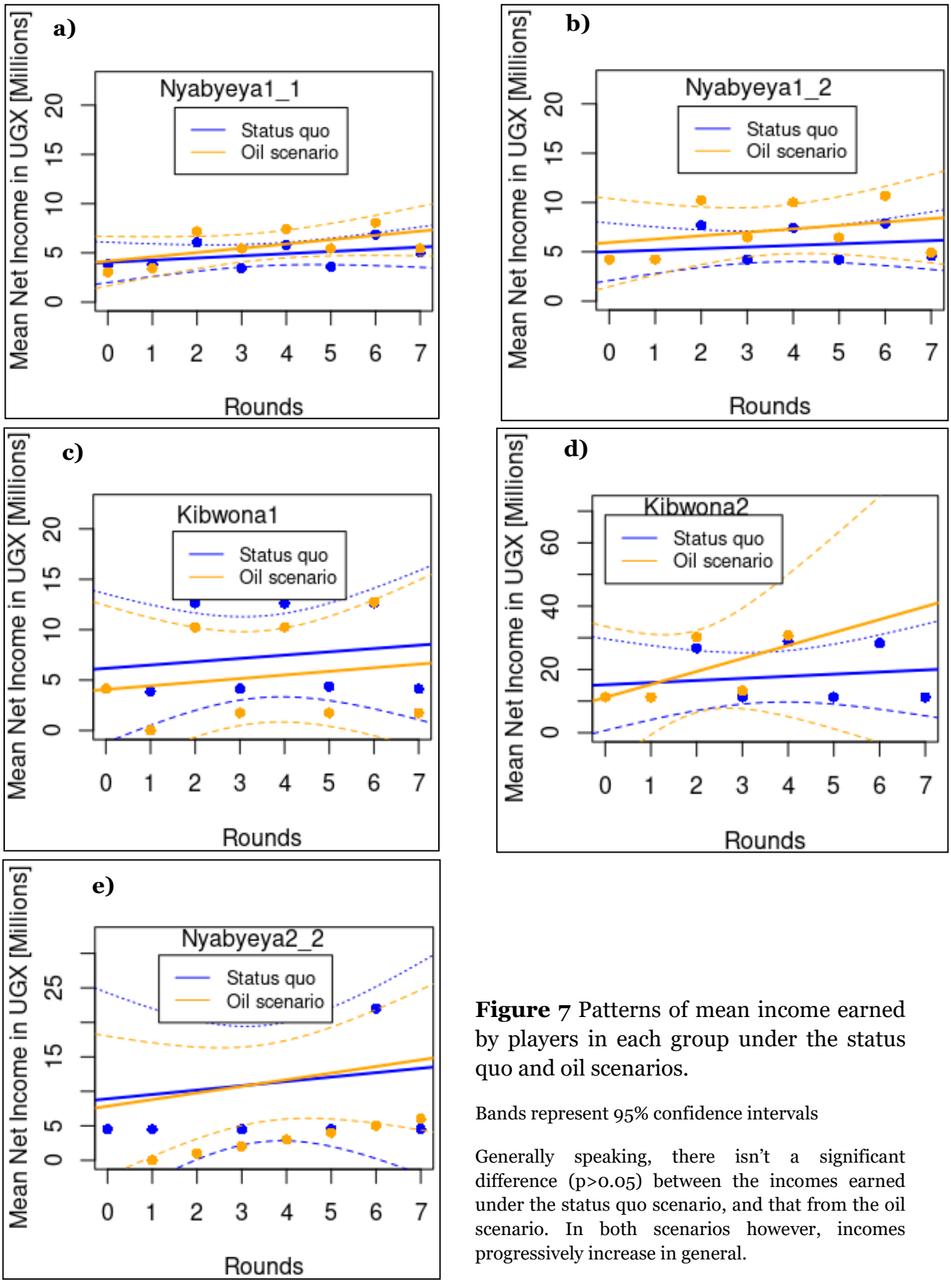


Figure 7 Patterns of mean income earned by players in each group under the status quo and oil scenarios.

Bands represent 95% confidence intervals

Generally speaking, there isn't a significant difference ($p>0.05$) between the incomes earned under the status quo scenario, and that from the oil scenario. In both scenarios however, incomes progressively increase in general.

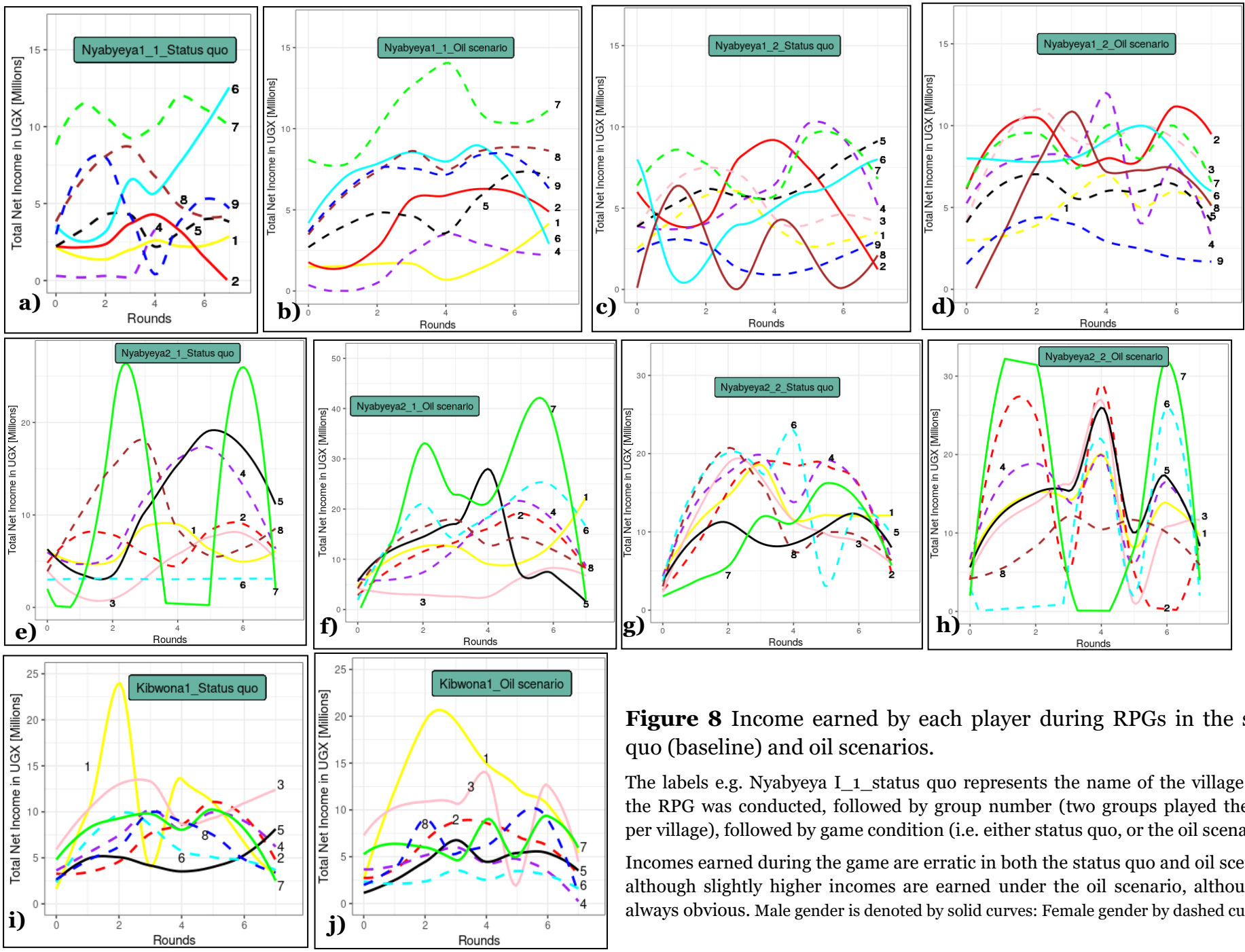


Figure 8 Income earned by each player during RPGs in the status quo (baseline) and oil scenarios.

The labels e.g. Nyabyeya I_1_status quo represents the name of the village where the RPG was conducted, followed by group number (two groups played the game per village), followed by game condition (i.e. either status quo, or the oil scenario).

Incomes earned during the game are erratic in both the status quo and oil scenarios, although slightly higher incomes are earned under the oil scenario, although not always obvious. Male gender is denoted by solid curves: Female gender by dashed curves.

Table 4a Correlation of variables Nyabyeya I Group I Status quo scenario

Spearman's correlation coefficients	Gender	Age	No. plots owned under Sugarcane	No. plots owned under Small-scale agriculture	Income selling Sugarcane plantation	Income Sugarcane harvested & sold	Net income
Gender	1.00	-0.87**	-0.47**	0.55**	-0.09	0.04	0.23
Age	-0.87**	1.00	-0.16	-0.72**	0.00	-0.55	-0.72**
No. plots owned under Sugarcane	-0.47**	-0.16	1.00	-0.40**	-0.05	0.60**	0.29**
No. plots owned under Small-scale agriculture	0.55**	-0.72**	-0.40**	1.00	0.13	-0.19	0.28*
Income selling Sugarcane plantation	-0.01	0.00	-0.05	0.13	1.00	-0.57	0.46
Income Sugarcane harvested & sold	0.04	-0.55	0.60**	-0.19	-0.57	1.00	0.58**
Net income	0.23	-0.72**	0.29*	0.28*	0.46	0.58**	1.00

* significant at p<0.05 (two tailed), ** significant at p<0.01 (two tailed)

Table 4b Correlation of variables Nyabyeya I Group I Oil scenario

Spearman's correlation coefficients	Gender	Age	No. plots owned under Sugarcane	No. plots owned under Small-scale agriculture	Income selling Sugarcane plantation	Income Sugarcane harvested & sold	Income oil industry	Net income
Gender	1.00	-0.87**	0.18	0.11	-0.25	0.18	-0.04	0.23
Age	-0.87**	1.00	-0.28	0.25	0.36	-0.44	0.00	-0.39
No. plots owned under Sugarcane	0.18	-0.28	1.00	-0.43**	0.45	0.27	-0.46**	0.33**
No. plots owned under Small-scale agriculture	-0.25	0.36	0.45	1.00	-0.33	-0.40	-0.15	-0.57**
Income selling Sugarcane plantation	-0.25	0.36	0.45	-0.33	1.00	-0.46	-0.32	0.45
Income Sugarcane harvested & sold	0.18	-0.44	0.27	-0.40	-0.46	1.00	0.07	0.83**
Income oil industry	-0.04	0.00	-0.46**	-0.15	-0.32	0.07	1.00	0.34**
Net income	0.23	-0.39	0.33**	-0.57**	0.45	0.83**	0.34*	1.00

* significant at p<0.05 (two tailed), ** significant at p<0.01 (two tailed)

Table 4c Correlation of variables Nyabyeya I Group II Status quo scenario

Spearman's correlation coefficients	Gender	Age	No. plots owned under Sugarcane	No. plots Rented Small-scale agriculture	No. plots owned under Small-scale agriculture	Income Sugarcane harvested & sold	Net income
Gender	1.00	0.37**	-0.56**	0.24	-0.14	-0.58**	0.06
Age	0.37**	1.00	-0.17	0.24	-0.24**		0.08
No. plots owned under Sugarcane	-0.56**	-0.17	1.00	-0.52	0.08	0.80**	0.25*
No. plots Rented Small-scale agriculture	0.24	0.24	-0.52	1.00	-0.28		0.40
No. plots owned under Small-scale agriculture	-0.14	-0.24*	0.08	-0.28	1.00	0.11	0.10
Income Sugarcane harvested & sold	-0.58**	-0.23	0.80**		0.11	1.00	0.81**
Net income	0.06	0.08	0.25*	0.40	0.10	0.81**	1.00

* significant at p<0.05 (two tailed), ** significant at p<0.01 (two tailed)

Table 4d Correlation of variables Nyabyeya I Group II Oil scenario

Spearman's correlation coefficients	Gender	Age	No. plots owned under Sugarcane	No. plots owned under Small-scale agriculture	Income Sugarcane harvested & sold	Income oil industry	Net income
Gender	1.00	0.40**	-0.23	0.00	-0.70**	0.15	0.12
Age	0.40**	1.00	0.39**	0.21	0.29	-0.01	0.12
No. plots owned under Sugarcane	-0.23	0.39**	1.00	0.32**	0.88**	-0.21	0.40**
No. plots owned under Small-scale agriculture	0.00	0.21	0.32**	1.00	0.41	-0.43**	0.07
Income Sugarcane harvested & sold	-0.70**	0.29	0.88**	0.41	1.00	-0.18	0.80**
Income oil industry	0.15	-0.01	-0.21	-0.43**	-0.18	1.00	0.28
Net income	0.12	0.12	0.40**	0.07	0.80**	0.28	1.00

* significant at p<0.05 (two tailed), ** significant at p<0.01 (two tailed)

Table 5a Correlation of variables Kibwona Group I Status quo scenario

Spearman's correlation coefficients	Gender	Age	No. plots owned under Sugarcane	No. plots owned under Small-scale agriculture	Income selling Sugarcane plantation	Income Sugarcane harvested & sold	Net income
Gender	1.00	-0.6**	-0.38*	0.16	-0.04	-0.18	-0.11
Age	-0.60**	1.00	0.43**	0.22	-0.11	0.43*	0.09
No. plots owned under Sugarcane	-0.38**	0.43**	1.00	0.46**	-0.13	0.78**	0.05
No. plots owned under Small-scale agriculture	0.16	0.22	0.46**	1.00	-0.30	0.64**	0.02
Income selling Sugarcane plantation	-0.04	-0.11	-0.12	-0.30	1.00	-1.00	-0.39
Income Sugarcane harvested & sold	-0.18	0.43*	0.78**	0.64**	-1.00**	1.00	0.82**
Net income	-0.11	0.89	0.05	0.02	-0.39	0.82**	1.00

* significant at p<0.05 (two tailed), ** significant at p<0.01 (two tailed)

Table 5b Correlation of variables Kibwona Group I Oil scenario

Spearman's correlation coefficients	Gender	Age	No. plots owned under Sugarcane	No. plots owned under Small-scale agriculture	Income selling Sugarcane plantation	Income Sugarcane harvested & sold	Income oil industry	Net income
Gender	1.00	-0.6**	-0.32**	-.021	0.45	-0.29	-0.92**	-0.25*
Age	-0.60**	1.00	0.39**	0.55**	0.00	0.32	0.72**	0.18
No. plots owned under Sugarcane	-0.32**	0.39**	1.00	0.35**	-0.11	0.90**	0.34*	0.17
No. plots owned under Small-scale agriculture	-0.21	0.55**	0.35**	1.00	0.94**	0.18	0.21	0.10
Income selling Sugarcane plantation	0.45	0.00	-0.11	0.94**	1.00		-1.00**	0.32
Income Sugarcane harvested & sold	-0.29	0.32	0.90**	0.18		1.00	0.20	0.92**
Income oil industry	-0.92**	0.72**	0.34*	0.21	-1.00**	0.20	1.00	0.29*
Net income	-0.25*	0.18	0.17	0.10	0.32	0.92**	0.29*	1.00

* significant at p<0.05 (two tailed), ** significant at p<0.01 (two tailed)

Table 5c Correlation of variables Kibwona Group II Status quo scenario

Spearman's correlation coefficients	Gender	Age	No. plots rented under Sugarcane	No. plots owned under Sugarcane	No. plots Rented Small-scale agriculture	No. plots owned under Small-scale agriculture	Income Renting Sugarcane plantation	Income Sugarcane harvested & sold	Net income
Gender	1.00	-2.18		-0.07		-0.14	-0.41	-0.34	-0.01
Age	-0.21	1.00		0.57**	0.00	0.06	0.75	0.57**	0.57**
No. plots rented under Sugarcane			1.00	-1.00**		0.58		1.00	-0.26
No. plots owned under Sugarcane	-0.07	0.57**	-1.00**	1.00	-0.20	0.05	1.00**	0.78**	0.32**
No. plots Rented Small-scale agriculture		0.00		-0.20	1.00	-0.14		-0.24	-0.45
No. plots owned under Small-scale agriculture	-0.14	0.06	0.58	0.05	-0.14	1.00	0.73	0.30	0.32*
Income Renting Sugarcane plantation	-0.41	0.75		1.00**		0.73	1.00		0.35
Income Sugarcane harvested & sold	-0.33	0.57**	1.00**	0.78**	-0.24	0.30		1.00	0.83**
Net income	-0.01	0.58**	-0.26	0.32**	0.45	0.32*	0.35	0.83**	1.00

* significant at p<0.05 (two tailed), ** significant at p<0.01 (two tailed)

Table 5d Correlation of variables Kibwona Group II Oil scenario

Spearman's correlation coefficients	Gender	Age	No. plots rented under Sugarcane	No. plots owned under Sugarcane	No. plots owned under Small-scale agriculture	Income Sugarcane harvested & sold	Income oil industry	Net income
Gender	1.00	-0.22		0.07	-0.07	-0.19	-0.50	0.02
Age	-0.21	1.00		0.30	0.18	0.73**	0.55**	0.58**
No. plots rented under Sugarcane			1.00			1.00		-0.26
No. plots owned under Sugarcane	0.68	0.30		1.00	0.15	0.68**	0.51*	0.32*
No. plots owned under Small-scale agriculture	-0.07	0.18		0.15	1.00	0.50	0.33	0.29
Income Sugarcane harvested & sold	-0.19	0.73**	1.00**	0.69**	0.50	1.00	0.66*	0.86**
Income oil industry	0.50*	0.55**		0.51*	0.33	0.66*	1.00	0.52**
Net income	0.02	0.85	-0.26	0.33*	0.29	0.86**	0.52**	1.00

* significant at p<0.05 (two tailed), ** significant at p<0.01 (two tailed)

5. Discussion

The discussion section focuses on four major aspects. Firstly, we unpack local land use, land tenure regimes and livelihoods (including gendered and seasonal division of labour) in the light of the broader Albertine Rift landscape dynamics. Secondly, we then reflect on the aggressive sugarcane expansion under both the status quo (baseline) and oil scenarios. Thirdly, we discuss how the participatory modelling – in particular RPGs employed – could illuminate intrinsic community values and decision–making in peculiar landscapes. We conclude our discussion with a fourth aspect that examines local conflicts over land access and utilisation, and broader implications for natural resource governance and management in a biodiversity hotspot and oil–rich region – in particular, we view this through the lenses of the oil imaginaries literature in the light of our data.

5.1 On land use, land tenure regimes and livelihoods

Land use and land tenure

Our work over the last few years (including this study) has revealed how the complex spatial patterns of land cover change in the Albertine Rift region are reflected in people's decision making over land and crops, linked to change in the dynamics of population mobility, capital investment and market opportunities in the region (Twongyirwe, 2015; Twongyirwe et al., 2018, 2017, 2015). As depicted by the community-based mapping and corroborated by the outcomes of the analysis of remote sensing imagery acquired in January 2020, the two dominant land use typologies in the studied villages are small-scale agriculture and sugarcane plantations. Natural (and plantation) forest cover is mostly outside the villages that we studied, although some small patches can be detected within. This could be because over the last few decades, natural forest patches in the villages outside the protected forest estate were eroded, either for small-scale agriculture, but more for sugarcane growing (*ibid*).

Wealth differentiation was predominantly based on land ownership, with sugarcane viewed as a more lucrative source of income, and perhaps more important than other locally available employment. And because of land fragmentation, barely any cattle (and goats in some instances) could be kept. We speculate that this could be due to limited resources to invest in intensive methods of livestock husbandry.

The *customary* land tenure regime was predominant in all the villages studied; however, certificates of customary ownership were lacking. Because land is passed on from one generation to another, the owners did not feel empowered enough to make decisions regarding its use or disposal as it belonged to a larger family. Moreover, concerns of fragmentation and meagre sizes available precluded some households' participation in the sugarcane outgrower scheme. Women typically have less land security under this tenure regime because of the patrilineal system, where land is

predominantly owned and passed on to boys and men. In situations where large land acquisition is required (e.g. for the oil industry in the Albertine Rift region), women have been found to be more vulnerable, with uncertainty over whether the investors will negotiate with only those with registered deeds, or whether they would acknowledge the legitimacy of a broader range of claims (Doss et al., 2014).

The other land tenure regimes are less common. Very few people in the studied villages had *freehold* land titles due to the high transaction costs involved in both surveying and processing of titles. The residents are also likely less familiar with the process[1], except for those that were reported to be new entrants, who purchased land from the original inhabitants, and required evidence of permanent acquisition (based on the reports that they were wealthier and acquired titles). The lack of a freehold land titles was never reported as a deterrent for participating in the sugarcane outgrower scheme however. In addition, the *leasehold* land tenure system was non-existent in the studied villages. It is also likely less common in the entire Albertine Rift region – except in the urban areas (e.g. Masindi town and Hoima city) where foreigners predominantly acquire land for investment and industrial development, and often the landlord is the Government of Uganda (*pers. communication*).

Similarly, the *Mailo* tenure regime was not mentioned in the villages that we studied. However, further South in the Albertine Rift landscape, a large section of Bugoma forest is under threat of clearance for sugarcane growing – because it apparently belonged to Bunyoro Kingdom under the *Mailo* tenure system (*pers. communication with National Forest Authority [NFA] official in Masindi*, 2020). The NFA official expressed concern about Budongo forest's lack of a land title, and that if some unscrupulous individuals presented one, the forest could also be cleared. Moreover, disposal of land disputes in Ugandan courts of justice takes very many years. Even though the protection of the natural forests in the landscape is currently successful, the lack of land titles over which they lie creates large uncertainties over their safety in the long-term. The complexity of the *Mailo* land tenure system has attracted large development-partner funded projects – in an attempt to find lasting solutions. Some of the recommended research-based solutions include: *"(i) improve the relationship between landlords and tenants, (ii) address all land related disputes on Mailo tenure, (iii) provide adequate information for negotiations between landlords and*

[1] "You apply to District land board, pay application fee, the land committee inspects land and generates the report, the land board sits, it then gives instruction to the surveyor to see the land. You can use a private surveyor but of course under the supervision of the government surveyor. The surveyor makes several reports to the land board and they do what they call a big plan. They but a big plan on a cadastral sheet. The cadastral sheet is a document with all surveyed pieces of land in Uganda. To avoid a title within a title, there is a cadastral sheet where all titles are laid. So, it comes back to the land board which then approves it and the recommends you to get a land title. It is a process; it can take a minimum of 3 months (within 1-3 months) because the board has to sit. By law, the board sits once a quarter, so that is why it takes time. The challenge is that we have some parallel systems running. For instance, why should two bodies issue titles e.g. Uganda land commission and Buganda land board? If we are to reduce "fake titles" this has to be harmonised." (NFA official based in Masindi, 2020)

tenants, and (iv) provide an appropriate Fit-For-Purpose (FFP) technological as well as operational/procedural solution" (Musinguzi et al., 2020: 1).

Livelihoods: Nyakafunjo village forest-based livelihoods

Livelihoods around Budongo forest are mainly based on small-scale agriculture, sugarcane production and access to forest products. Here, we give some attention to forest-based livelihoods, in especially Nyakafunjo village that has received less attention so far. The relationship between small-scale agriculture and sugarcane plantations is explored in more depth in the next section.

Access to non-timber forest products (NTFPs) has long been, and remains an important source of livelihood for local communities around Budongo (*our data*): however, data on potential to alleviate local communities from poverty through NTFPs are lacking, but elsewhere, evidence suggests that whilst important, restrictions limit amount of NTFPs accessed, hence remain of negligible value for improving livelihoods (Bitariho et al., 2016), but they can be of critical value in maintaining them and acting as a safety net, particularly for the very poor and for poor female headed households. Our FGD data informs us that access to fuelwood and building materials from Budongo forest is strictly controlled to limit forest degradation. Moreover, only women and children are permitted to gather firewood from the forest: Men are able to access light building materials for constructing huts (temporary housing structures). Selective timber harvesting was permitted in the past (c. 1920 – 1960): Budongo therefore has regions where the natural forest has recently regenerated (Lukwago et al., 2020). Our previous work shows that this access gives opportunity for illicit activities including illegal logging and poaching (Twongyirwe et al., 2015), although reportedly very risky. For the villages adjacent to Budongo forest (e.g. Nyakafunjo), crop raiding by especially primates and bushpigs sparks off human–wildlife conflict, undermining local support for conservation efforts (Hsaio et al., 2020; Tweheyo et al., 2005). Compensation for loss has not always been forthcoming: it is unsurprising that locals demand for more access to the forest for NTFPs (this study). Moreover, residents of Nyakafunjo felt that they were unjustly prohibited from growing sugarcane (just like the neighbouring villages e.g. Nyabyeya) without equivalent cash crop substitutes. Our data indicate that the locals are fully aware that such a decision was made by the forest authorities to reduce on human-wildlife conflict.

To reduce human-wildlife conflict, Collaborative Forest Management (CFM) was implemented as an innovative structured partnership between key stakeholders (e.g. government departments such as NFA and local communities in this case) through which forest-based communities can gain access to, while taking responsible management of forestry resources (Egunyu & Reed, 2015; Turyahabwe et al., 2013). Such projects typically involve creating income–generating projects for local communities adjacent to the forests (e.g. beekeeping, goat rearing) in "exchange of"

conservation benefits such as increased live stems of timber, pole tree species, trees with harvestable logs, and lowered incidences of human disturbances (Turyahabwe et al., 2013: 36). Again, residents of Nyakafunjo felt that this approach has not done enough to improve their livelihoods as there is often limited community engagement in decision–making, inequality in benefit sharing, also corroborated by an earlier investigation (Turyahabwe et al., 2013).

Livelihoods: Gendered division of labour and seasonal calendar

Our data show that how men and women use their time and labour in the various activities over a cropping calendar is consistent with rural areas in other parts of this region, and indeed further afield. The cropping seasons follow the bimodal rainfall distribution in this region. As is the norm, men tend to engage in the "masculine" work such as land preparation (clearing bushes), while women complement the planting effort for instance. The data do not unearth conflict at gender division of labour except when it comes to sharing of proceeds from the harvest. The women are in-charge of the food crops (viewed as less superior) – and these are predominantly for home consumption. The surplus sold is insignificant. The more "superior crops" such as sugarcane (and woodlots where available) are under the custody of the man who dictates how the proceeds are utilised in the household. Men were also more likely to work off-farm in the sugarcane outgrower scheme, as women tended their gardens and took care of the children. These are broad views from our FGDs. There is surprising a dearth of studies that focus on gender division of labour published in academic literature with which we can compare our findings.

5.2 Expansion of sugarcane under status quo and oil scenarios

Ownership of a sugarcane plantation was viewed as an indicator of a wealthy household in all the FGDs except in Nyakafunjo where sugarcane growing was not permitted. The sugarcane boom is reported to have started after 2002. The rapid expansion of sugarcane threatens food security in the studied villages, and the broader Albertine Rift Landscape. People shift cultivation from food crops to sugarcane and moreover, unlike other crops, sugarcane growing precludes any form of intercropping. It is also the case that land rental decreases acreage devoted to food production, coupled with the use of male agricultural labour also detracting from food crop cultivation and placing a greater burden on women's agricultural labour for own-farming. A trade-off between sugarcane and food production is therefore inevitable. It is unsurprising that during the FGDs, some respondents suggested there could be a threshold beyond which households maybe unwilling to give up more land for sugarcane given the need to fend for their families. FGD data also indicate that incomes from sugarcane were more important for children's education, caring for the sick and purchasing household essentials (e.g. salt, soap, sugar, etc). Some members were unwilling to spend proceeds from sugarcane growing on food purchase. From the RPGs, however, sugarcane production is predicted to increase in the landscape at the expense of small-scale food production.

Such findings are not dissimilar from other sugarcane dominated landscapes in Uganda. For instance, in Eastern Uganda, the majority of households cultivate few crop varieties, lack adequate and nutritious foods, and have inadequate income to purchase food to meet their needs (Mwanika et al., 2020; Mwavu et al., 2018). Furthermore, data from Eastern Uganda show that inadequacy of food within commercial sugarcane-cultivating households shows that generating income does not necessarily increase food security: *to cope with food insecurity, households offer labour in exchange for food, borrow food, ration food, and at times steal* (Mwavu et al., 2018: 1). Interestingly, in spite of food insecurity threat that commercial sugarcane cultivation poses, given its perceived economic benefits, sugarcane plantations are predicted to expand further (*ibid*), a situation envisaged in the broader Albertine Rift landscape too.

The reasons for the expansion of sugarcane into the future in the studied villages in the status quo and oil scenarios are speculative. From the FGDs however, sugarcane is viewed as a secure source of income for the locals. Employment in oil production, they suggest, will provide an additional stream of income which could offset deficits created by reduced food availability following conversion of food plots into sugarcane. On the other hand, the FGDs also indicated that some growers were in the habit of renting out their sugarcane fields to businessmen and opting for other businesses, casting doubt over the sustainability of the enterprise in the future under the oil scenario.

5.3 Participatory Modelling: To what extent could it aid our understanding of intrinsic human decision–making on land use in a peculiar landscape?

One of the aims of our investigation was to gain deeper insights into how local communities make decisions on land use: how they choose between small-scale agriculture and commercial sugarcane farming, for instance. To this end, we employed Role Play Games (RPGs) as a method of participatory modelling. Before we can delve into the extent to which such an approach is useful towards understanding complex land use systems, some caveats are required: 1) we acknowledge that given our qualitative approach, our sample size is relatively small. But from a close look at the patterns, arguably saturation had been reached: no strikingly new patterns beyond what we obtained were likely. This is informed by our careful selection of participants, potentially reflecting heterogeneity in the villages (described in section 3.2.1). In any instance, the “replication” of the RPG with separate groups per village provides some backstopping. 2) The RPG was based on a few rules that may not necessarily reflect a full range of variables important for makings decisions on land use at household level. More rules would have made the game extremely cumbersome and difficult for participants to follow. Our interest in

this exploratory work was to use key variables such as income, expenditure, and initial endowments to depict broader sugarcane and small-scale agriculture patterns at village level under both the status quo and oil scenarios. Our previous work indicated that these were major factors. We argue that some understanding of land use patterns and decision making was obtained through the participatory modelling, although large uncertainties remain. We elucidate these views further as follows.

Generally speaking, the RPGs indicated that the area under sugarcane is projected to increase under both the status quo and oil scenarios. This is an indication that locals perceive sugarcane to be more profitable and therefore more likely to be preferred to small-scale agriculture. The decision–making patterns are non-linear, with some spikes in acreages of sugarcane, possibly indicating irrational choices and partial understanding of broader dynamics (bounded rationality). The nuances could lie in participants characteristics. Evidence from econometric models elsewhere suggests that individuals with more education are likely to have a better understanding of their dynamic economic and socio-technical environment, and therefore more likely to make informed decisions, including adopting appropriate technologies to enhance their productivity (Huffman, 2020; Weersink & Fulton, 2020). Our participant education level is generally low, corroborated by our previous study (Twongyirwe et al., 2017), and therefore less likely to be profit maximising. But further studies are required to substantiate this.

Our data show that there is no significant difference between how men and women make decisions on land use both under status quo and oil scenarios. We speculate that this could be because men are the main decision makers / owners and women are reproducing a gendered norm. But we did not run sufficient trials to detect differences. Also, the male and female participants did not have uniform initial conditions (e.g. number of parcels each owns at the start of the RPG) to detect differences in land use patterns in a controlled manner. Decision–making on land use maybe affected by initial endowments (including tenure regimes), path dependence (history of each actor), and multiple feedbacks, with women in a precarious situation more often than their male counterparts (Mastenbroek et al., 2020; Michalscheck et al., 2020). These are complex dynamics that could not be easily included in the RPG however.

Typically, complex systems are adaptive, far from equilibrium and may have multiple tipping points or phase changes, and emergent structures generated from complex interactions, making “cause and effect” difficult to trace (Bishop, 2011; Condorelli, 2016; Preiser, 2019). To go beyond the limitations of RPGs, future work could consider combining qualitative social approaches with Agent-based modelling (ABM). Such a methodology has potential to present a holistic perspective towards understanding the intricacies of land utilisation through a detailed analysis of day–to–day decisions made by the rural communities on utilisation of land resources under different socio–economic, bio–physical and policy constraints. Agent-based

modelling is a simulation method where heterogeneous and autonomous individuals (agents) share a common environment and act upon it, while simultaneously interacting amongst each other in quest for realisation of some self– or common–interests (Ligmann-zielinska & Jankowski, 2007). It provides a unique environment for understanding bio-physical and socio-economic interactions in a real-world context. 'Agents' in ABMs are autonomous software entities constructed by human programmers, in a context that they can pursue their goals in an open–ended manner, in mimicry of a defined social-ecological system (O'Sullivan & Haklay, 2000). Essentially, computer representations of human–like agents, when constrained with a problem, are capable of autonomous reactive or proactive social behaviours which enable us to better understand how an aggregation of individuals leads to complex macro behaviour: the model results can be compared very directly with observations as the agents can map directly onto real-world actors such as households or individual decision-makers (Berger, 2001). Agent autonomy allows for endogenous, not necessarily optimised decision–making, where issues of uncertainty, perception, adaptation, and learning may all be present (Ligmann-Zielinska & Jankowski 2007). The models can then act as exploratory tools that help people to understand the complex interplay between multiple factors at system level that may not be obvious to them from their own individual experience. Therefore, more complex processes in the Albertine Rift landscape can be built into the modelling to gain a better understanding of land use patterns and decision-making in such a heterogenous socio-ecological system. Moreover, initial conditions can be tweaked, and "what-if" questions can be answered through model runs with this approach. If mixed with RPGs and other participatory approaches for validation, the results would be very beneficial.

5.4 Conflicts over land access and utilisation: Implications for Natural Resource Management in the Albertine Rift Landscape

The majority of the conflicts identified in the study have been documented elsewhere in this report, we therefore do not reiterate details in this section. Our aim is to reflect on the broader implications of the current and anticipated future conflicts on land access and utilisation, biodiversity, livelihoods and natural resource governance and management in the Albertine Rift Landscape. We briefly revisit the notion of the oil imaginaries through the lens of local land use and conflict.

Land conflicts

Whilst no major conflicts were experienced during the participatory modelling, except for a few members who attempted to take advantage of others to "grab" their parcels (as conflict was not incorporated into the gaming rules but was hoped to arise organically), FGDs revealed some recent land conflicts, and those that are predicted for the future, under the oil scenario. "Land grabbing" is a topical discourse in Uganda even at the time of writing. It is unsurprising that Museveni (president of

Uganda) instituted a commission of inquiry into land disputes in the country headed by Lady Justice Catherine Bamugemereire, and between 2017 and 2019, a total of 8528 cases (from 123 districts out of 135) had been presented to the commission (New Vision, 2020)[2]. The commission established that "well-to-do persons" had obtained land through illegal means, "bribing their way through all systems of land administration and registration" (*ibid*). Reports of rich businessmen from Kampala conniving with locals (in the case study villages) to buy land very cheaply, taking advantage of the lack of land titles were highlighted during the FGDs, and are predicted to continue. Respondents felt that this would create an in-migration flux that could escalate land conflicts in the region.

Moreover, land conflicts occur at various scales (e.g. household, community and regional levels). Elsewhere in the Albertine Rift region, multinational corporations, have compulsorily acquired land, with government approval, while domestically-owned companies have engaged in various forms of land grabbing, with reportedly compensation either delayed or denied (Kansiime & Harris, 2020). At household level, power and gender dimensions have fuelled land conflicts, with the customary tenure regime creating more confusion. Typically, women have less land rights, although access is often guaranteed through marital relationships, but proceeds are inequitably shared. Land dispossession and displacement even with monetary compensation is not an idea that several FGD participants (especially women) agreed with, and any eviction/relocation suggestions would be vehemently resisted. For example, in Acholiland, some 80-100 women resisted eviction from their land for sugarcane establishment by undressing before the Local District Board and surveyors of the sugar company Madhvani Group that had invited them for consultations (Martiniello, 2015). More broadly, it is argued that current land grabs are a product of ecological scarcity and (in)direct attempts to deepen socio-spatial power inequalities associated with economic and political capital accumulation across different scales and temporalities (Carmody & Taylor, 2016).

Some of the locals converted most of their land into sugarcane, leaving them with limited/no land for food crop farming, and exposing such households to pressures of food insecurity, food (and other forms of petty) theft and conflict with their communities. These issues have been elucidated under section 5.1. Conflicts over forested land are more subtle however – partially due to the strict enforcement. We have also discussed this already. But planting trees on privately owned land is a disincentive, and could be a source of future conflict. One key informant working with the National Forest Authority based in Masindi asked why people would not be stopped from harvesting bananas, millet and other things grown, but are stopped from harvesting trees planted on their own land, or why would have to get a license before harvesting own eucalyptus, or transport the trees.

[2] Bamugemereire hands over land probe report to Museveni, available at https://www.newvision.co.ug/news/1523640/bamugemereire-hands-land-probe-report-museveni (accessed 30.9.2020)

On oil imaginaries and land use

Generally speaking, some people perceived oil as a resource for a few people in comparison to sugarcane that is grown by any household that may wish to participate, provided they have land. One of the oil impact indicators on land use could be a shift from agricultural activities to focus on oil revenues and what is done with them (i.e. whether district government and local communities benefit). From the case study villages however, there is no indication that sugarcane enterprises will be abandoned, instead, there is a projected increase in sugarcane at the expense of small-scale agriculture. The other oil imaginaries issues highlighted earlier in the theoretical framing section (e.g. expectations on productive and innovative sectors, government mismanagement, weak institutions, etc.) are likely to operate at multiple temporal and spatial scales, although their effects maybe felt at the village level. In the current state however, there is no direct linkage, at least from the data that we gathered.

Conflict resolution mechanisms

There is empirical evidence that suggests that since the discovery of oil in the Albertine Rift region, land-related conflicts have grown rapidly, stretching the traditional conflict resolution capacities, that were already in despair because of their "snail pace" and sometimes unjust due to influence from local council committees and clan leaders (Kansiime & Harris, 2020). The cases were too sophisticated for the local systems to resolve, and were since transferred to the court judicial system, which is overly understaffed and overwhelmed with case backlogs (*ibid*). In the case study villages, local ways of resolving land disputes were in place, through the local council system. More broadly though, Uganda has mechanisms in place to manage conflict at various levels with an institutional infrastructure and regulatory frameworks, albeit they are not always effective (Veit et al., 2011).

Visions of the future – and broader natural resources management

While not explicit, our analysis indicates that a mixture of no/(mis)information, mistrust, uncertainty, unpreparedness by institutions, and optimism about success and prosperity, epitomise visions of the future of the case study villages. In the wider landscape, wildlife conservation, sustainable forestry, livelihoods from small-scale agriculture, sugarcane, pastoralism, and fishing are all part of the dynamics. Through the lens of the future, Kinyera & Doevenspeck (2019) examine how oil-related activities in the Albertine region could influence conflicts of different forms and intensity. Based on 'in-the-making' perspective, they analyse geographies of conflict, framed around speculative labour mobility, mobility of a pastoralist ethnic group commonly known as '*Balaalo*', and narratives about oil-induced pressure on fishing, and the link between elephant mobility and community grievances (*ibid*).

Kinyera & Doevenspeck (2019) further argue that conflicts are premised around the visible changes in the Albertine graben resulting from oil activities, and due to what the different actors imagine as their futures. Land sparing and sharing model has been suggested as a simple and powerful way of framing the trade-offs between agricultural production and biodiversity conservation but one that has been subject to much criticism, not least for its failure to consider local level impacts on food security and livelihoods (Jeary, 2019). However, such a model could bring a balance to conservation, forestry and livelihoods in the oil-rich landscape. But by engaging with futuristic narratives in the present, ideal planning for the future of conservation, and livelihoods in the landscape constructed around diverse enterprises, "brings the future to the present" (Kinyera & Doevenspeck, 2019). We agree with this notion indeed: and one way to incorporate participatory approaches into futuristic thinking is to use the outcomes of this study in a participatory Agent-based modelling (ABM) research, elucidated in section 5.4.

6. Conclusion

In this study we analyse the interaction between land use, livelihoods, and natural resource conflict in the Albertine Rift region. In particular, using four case study villages, we examine land utilisation (especially small-scale agriculture and sugarcane plantation) and related decision-making through participatory modelling, under both the current/status quo and the oil scenarios. We also consider land use conflicts and mitigation.

Our data show that land use and relation decision–making are complex, shaped by intricate land tenure regimes, path-dependent livelihood choices – with small-scale agriculture dominant and a main source of food for households, but with sugarcane expansion replacing food plots, for cash. Conflicts over land use have various sources and are perceived at different scales. These range from household level land conflicts, fuelled by unclear boundaries, and land tenure systems – to land grabbing by wealthier actors coming into the landscape due to oil prospects. Crop raiding was a marked problem amongst communities adjacent to Budongo forest. Their exclusion from the sugarcane boom was viewed as a timebomb for future conflict. The gender dimension does not add anything new to what we already know – some crop enterprises (especially food crops) are female dominated, while sugarcane is viewed as a "male" crop. Proceed sharing along gender lines is inequitable, with men more likely to take the larger share, even when they have had less effort.

And while we lack data on the impact of sugarcane on livelihoods, its aggressive non-linear expansion at the expense of food crops is arguably an emerging form of land grabbing, similar to what has already been documented in Eastern Uganda. Moreover, it has heightened the threat of food insecurity and could fuel conflict over food and petty theft amongst communities. The expansion of sugarcane is foreseen in both the status quo and oil scenarios per the Role Play Games across all villages.

Methodologically, we show that qualitative social science approaches can illuminate decision making at household level to a certain extent. But the modelling approaches employed (i.e. RPGs) are based on a few parameters for purposes of easy implementation. More parameter, and tweaking of conditions can only be implemented in an experimental manner using computer-based platforms. Future work could combine RPGs and ABMs in companion modelling approaches.

In conclusion, land (use) conflicts are already numerous in the Albertine Rift landscape, and our data show that these are projected to increase under the oil scenario. From an oil imaginaries perspective, natural resource management and development policies should be cognizant of the intricate interactions between wildlife, forestry, and livelihoods from small-scale agriculture, sugarcane, pastoralism, tourism, and fishing.

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Appendix 1. Correlation tables for Nyabyeya II village

Correlation of variables Nyabyeya II Group I Status quo scenario

Spearman's correlation coefficients	Gender	Age	No. plots owned under Sugarcane	No. plots owned under Small-scale agriculture	Income selling Sugarcane plantation	Income Sugarcane harvested & sold	Net income
Gender	1.00	-0.17	-0.46**	-0.62**	0.17	-0.41	0.10
Age	-0.17	1.00	-0.43**	-0.14	0.00	-0.47	-0.20
No. plots owned under Sugarcane	-0.46**	-0.43**	1.00	0.41**	-0.36	0.73**	0.06
No. plots owned under Small-scale agriculture	-0.62**	-0.14	0.41**	1.00	0.17	0.49**	-0.10
Income selling Sugarcane plantation	0.17	0.00	-0.36	0.17	1.00	0.30	0.29
Income Sugarcane harvested & sold	-0.41	-0.47	0.73**	0.49*	0.30	1.00	0.81**
Net income	0.10	-0.20	0.06	-0.10	0.29	0.81**	1.00

* significant at p<0.05 (two tailed), ** significant at p<0.01 (two tailed)

Correlation of variables Nyabyeya II Group I Oil scenario

Spearman's correlation coefficients	Gender	Age	No. plots owned under Sugarcane	No. plots owned under Small-scale agriculture	Income selling Sugarcane plantation	Income Sugarcane harvested & sold	Income oil industry	Net income
Gender	1.00	-0.17	-0.72**	-0.56**	-0.28	-0.11	0.17	0.22
Age	-0.17	1.00	-0.19	0.13	0.03	-0.65	-0.10	-0.04
No. plots owned under Sugarcane	-0.72	-0.19	1.00	0.39**	-0.17	0.44*	0.04	-0.30*
No. plots owned under Small-scale agriculture	-0.56**	0.13	0.39**	1.00	0.11	0.10	0.07	-0.13
Income selling Sugarcane plantation	-0.28	0.03	-0.17	0.11	1.00	0.82	0.13	0.07
Income Sugarcane harvested & sold	-0.11	-0.65**	0.44*	0.10	0.82	1.00	0.34	0.83
Income oil industry	0.17	-0.10	0.04	0.07	0.13	0.34	1.00	0.27
Net income	0.22	-0.04	-0.30	-0.13	0.07	0.83	0.27	1.00

* significant at p<0.05 (two tailed), ** significant at p<0.01 (two tailed)

Correlation of variables Nyabyeya II Group II Status quo scenario

Spearman's correlation coefficients	Gender	Age	No. plots owned under Sugarcane	No. plots Rented Small-scale agriculture	No. plots owned under Small-scale agriculture	Income selling Sugarcane plantation	Income Sugarcane harvested & sold	Net income
Gender	1.00	-0.17	-0.11	0.94	-0.09	-0.36	0.33	0.10
Age	-0.17	1.00	-0.73**	0.94	-0.26*	-0.16	-0.09	0.05
No. plots owned under Sugarcane	-0.15	-0.73**	1.00	-0.74	-0.60**	-0.13	0.60**	-0.15
No. plots Rented Small-scale agriculture	0.94	0.94	0.74	1.00	-0.94		1.00	0.21
No. plots owned under Small-scale agriculture	-0.09	-0.26*	0.60**	-0.94	1.00	0.05	0.34	-0.16
Income selling Sugarcane plantation	-0.46	-0.16	-0.13		0.05	1.00	-0.34	0.32
Income Sugarcane harvested & sold	0.33	-0.09	0.60**	1.00**	0.34	-0.34	1.00	0.84
Net income	0.10	0.05	-0.15	0.21	-0.16	0.32	0.84	1.00

* significant at p<0.05 (two tailed), ** significant at p<0.01 (two tailed)

Correlation of variables Nyabyeya II Group II Oil scenario

Spearman's correlation coefficients	Gender	Age	No. plots owned under Sugarcane	No. plots owned under Small-scale agriculture	Income selling Sugarcane plantation	Income Sugarcane harvested & sold	Income oil industry	Net income
Gender	1.00	-0.19	0.03	-0.08	0.16	-0.12	-0.11	0.08
Age	-0.19	1.00	-0.25	-0.08	-0.48**	-0.59**	-0.06	-0.04
No. plots owned under Sugarcane	0.03	-0.25	1.00	0.60*	0.38*	0.78**	-0.52**	0.11
No. plots Rented Small-scale agriculture	-0.08	-0.08	0.60*	1.00	-0.12	0.31	-0.47	0.21
No. plots owned under Small-scale agriculture	0.16	-0.48**	0.38**	-0.12	1.00	0.64**	0.24	-0.06
Income Sugarcane harvested & sold	-0.12	-0.59**	0.78**	0.31	0.64**	1.00	-0.23	0.81**
Income oil industry	-0.11	-0.06	-0.52**	-0.47	0.24	-0.23	1.00	-0.06
Net income	0.08	-0.04	0.11	0.21	-0.06	0.81	-0.06	1.00

* significant at p<0.05 (two tailed), ** significant at p<0.01 (two tailed)