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Field Assessment of Environment Policy Operationalisation in Forest Tree Biodiversity Conservation in Uganda

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Abstract

Policies guide management, and practical implementation of national policies is central to their effective operationalisation in the field. On-ground changes in agrarian systems in response to new policies often lead to the transformation of landscapes as a result of management. In Uganda, deforestation proceeds despite the regulations and guidelines in the National Environment Management Policy (NEMP). The purpose of our study was to determine the effectiveness of the operationalisation of the NEMP in Uganda, a case study of Kalangala District.

We used historical data, field observations and interviews to identify indicators to measure the operationalisation of the NEMP. In Kalangala District, key forest categories were identified as cultural-private, commercial-private, and public-gazetted management. We carried out tree species forest inventories, interviewed community members living around these forests and forest managers. We conducted a document analysis of the NEMP policies and standards plus other forest management plans and compared them with grassroots realities in forest restoration and conservation.

Historical data from 1990 to 2015 show reduction in forest vegetation cover from near 60 per cent to under 20 per cent in 25 years. Measurements and counts of current tree populations reveal minimal differences in tree species biodiversity and similar conservation practices among the three categories of forest management systems. Local residents and forest managers reported reductions in the diversity of forest tree species and essential forest ecosystem goods and services. Forest management plans are in line with the NEMP and other international standards, but observations and interviews reveal that current field activities do not indicate success in the effective operationalisation of the NEMP to mitigate the loss of forest tree biodiversity. To overcome current challenges, we identify and describe key indicators for developing a comprehensive tool for the consistent monitoring of the operationalisation of the NEMP.

Keywords: Biodiversity; Policy operationalisation; Ecosystem services; Restoration; Conservation

Introduction

International treaties such as the United Nations Convention on Biological Diversity [1,2], and Ugandan national environmental policies such as the NEMP[3] and the National Forest Policy [4] have been established, and some of them have been implemented successfully. However, key ecosystems including tropical forests continue to face degradation through the loss of diversity of tree species and as a result the reduced potential for people to gain productive livelihoods [5,6]. Changes in the rainforest landscape have been occurring for centuries. Reports by Sheil [7], Gann and Lamb[5] and McDonald[8] describe a global scene where many forests and other ecosystems are highly endangered due to increased human impact, something that dates back over 40,000 years. Recently, this has accelerated, with over six million hectares of rainforest lost in Indonesia between 2000 and 2012, and the annual primary forest loss today amounts to almost twice that in Brazil [9]. A report on the state of rainforests in 2014 showed that in Tropical Africa, between 2000 and 2012, forests were reduced by an area as large as Spain [10].

Uganda's current situation is similar to that of other tropical countries, such as Brazil and Indonesia. The biggest problems resulting from deforestation include the loss of tree biodiversity and stock of harvestable trees due to ineffective forest management, resulting in the loss of human livelihoods. In the Kalangala District, Buggala Island forests are among many tropical landscapes undergoing deforestation [11], giving way to plantation agriculture, logging for timber export, urban settlements, and civil works such as roads. Globally, islands are storehouses of much of our biological wealth and contribute tremendously to successful restoration according to Towns, Daugherty [12], while deforestation makes these forest ecosystems shrink, thus resulting in reduced biodiversity of tree species. Biodiversity, as defined by Boyle and Boontawee [13], refers to 'the variety and variability among living organisms and the ecological complexes in which they occur,' and includes 'diversity in forests within species, between species and of ecosystems'[2]. Typical of many tropical areas, Uganda's reduced species diversity undermines the principles of current environmental management policy, and this leads to a loss in forest structure and function, thus raising questions about the operationalisation of policy.

The effective evaluation of policy operationalisation requires defining measurable terms, indicators, and variables that can be used to quantify policy outcomes, or 'specify the operations required to observe and measure it' [14]. When an environmental policy is ineffective, then there are repercussions such as loss in forest structure and function, which leads to a loss of ecosystem services [15,16]. The result is a degraded forest [2,17-19] from which local residents can no longer access adequate goods and services [20]. Due to the potential losses in forest structure, the effective operation of NEMPs needs to be established through effective forest management plans and systems. These will provide a strong rationale for promoting local programmes towards maintaining and sustaining forest ecosystems. One example of achieving an effective operationalisation of NEMPs is an investment in

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local programmes involving environmental repair activities such as ecological restoration [8].

Ecological restoration is the process of promoting the recovery of an ecosystem that has already been degraded or damaged [5,21]. Restoration aims at rejuvenating the ecosystem through management to some near-original form or at least that which resembles the prior state or 'to another state that can be expected to develop naturally within the bounds of the historic trajectory' [21]. For success, it is important to rejuvenate the entire system rather than to consider only the key species [22]. It is difficult to re-establish a fully functioning ecosystem or replace the original forest with its composition along an altered trajectory [5,21], as we rarely know the structure of the original forest. Even if it is difficult to re-establish a fully functioning ecosystem, there are standards and guidelines provided by the Society for Ecological Restoration (SER) [8]. Environmental policy operationalisation will only be effective if programmes implemented under the respective policy follow principles and guidelines of ecological restoration, such as those given by SER.

SER guidelines assume that 'ecological restoration is accomplished once the assistance of a restoration practitioner is no longer needed to ensure long-term ecosystem sustainability' [5]. Once this assistance is accomplished, there is a lesser need for human involvement. Further improvement is referred to as natural regeneration [22]. When the restoration practitioner is still involved, a management intervention takes place with varying objectives. If an ecological restoration involves the assistance of a restoration practitioner, then we can define their roles in relation to other restorative actions such as rehabilitation, re-vegetation, and recovery. However, ecological restoration varies from other restorative actions in that it not only aims to replace lost vegetation, re-establish some kind of a plant cover, or recover species like other restorative actions, but also to 'reinstate a system from a former time period' [22]. Since this may take decades, government support, personal local commitment, and adequate financing are essential [23]. In order to prevent further degradation, restoration practitioners go beyond measures of mere ecosystem protection (e.g. maintaining the status quo) to 'active intervention to reinstate the lost species or physical conditions' according to Artikinson [22]. Active intervention to prevent further degradation indicates an effective operationalisation of the NEMP. This can be observed as a result of successful forest management, which comes with restoration and conservation of forest tree biodiversity. Success in restoration and conservation of forest tree biodiversity requires government support and harmonising its development plans with internationally agreed policies, the NEMP, and the forest owners' plans. This can be done through public involvement and support for programmes such as efficient plant nurseries[12,22], and considering community needs such that projects result in both conservation and economic gains [24]. This may be a difficult task to accomplish (*Ibid*.), but these approaches can be among the most valuable ones towards ensuring the effective operationalisation of the NEMP.

People are presently surviving on ecosystems that have already been degraded, according to Zheng and Wang [24], and improving the forest ecosystem within this context requires rejuvenation through appropriate forest management that is sensitive to current human needs. Successful management needs to involve ecological restoration programmes that 'improve biodiversity conservation, improve human livelihoods, empower local people, and improve ecosystem productivity' [5]. Both the conservation and restoration of the forest can contribute to sustainable livelihoods and development.

At the global level, land conservation programmes include approaches to integrate ecological restoration into sustainable land management [25]. At the local level, Uganda's NEMP principles embrace sustainability and call for the creation of a healthy environment through the restoration of forest ecosystems or the reclamation of lost ecosystems, conservation, reversing degradation, equitable use, and monitoring changes in environmental quality [3]. Adhering to these principles sets the ground for operationalising NEMPs. The question remains whether the activities implemented in our study areas adhere to the NEMP principles or not. Other legislation such as the National Forestry Plan [4] provides various programmes and strategies for sustainable forest ecosystems. At the field level, forest owners and managers are required to embrace local programmes, working hand in hand with the community to operationalise principles and guidelines for ecological restoration, and the Government of Uganda is required to support these initiatives for facilitating the effective operationalisation of environmental policy [26].

In the context of this study, the effective operationalisation of the NEMP is measured by the extent to which its principles, as well as other guidelines such as those of SER, are followed in our study sites. This can come from review of the status of historical data, and observations of current forest cover, tree species' diversity, and conservation and restoration activities, as demonstrated with implementation of forest management plans and systems that embrace a fully functioning ecosystem or ecological restoration.

We consider this research essential because of the large impacts expected on the landscape due to the ongoing agrarian changes in the Kalangala District [27]. Since there is legislation, such as the NEMP, that addresses these changes, we ask whether the current operationalisation of the NEMP is effective. As there has been a lack of field-based measurement of forests and socio-economic data on the effects of deforestation on people and communities, such as lost sources of livelihood and local programmes to promote ecological restoration in our study sites, there has not been any effort to establish the effectiveness of the NEMP in this particular study area. Therefore, this research was based on the need for information from on-the-ground measurements and surveys of forest owners and other residents to effectively describe the current situation in this region and to provide indicators that can be used in other parts of Uganda as well as in other degraded forest ecosystems. Such data were collected to determine whether the NEMP has been effectively operationalised. Without actually measuring biodiversity in the forests, interviewing people who live nearby and depend on intact ecosystems, and merging this information with the data on recent changes from forest to monoculture oil palm, it has been difficult for policymakers to acknowledge what is happening in the field and to inform appropriate national decisions.

The purpose of our study was to determine the effectiveness of the operationalisation of the NEMP in Uganda. We identified key indicators that can be used for developing a tool to practically monitor results of activities recommended in relevant national policies. Suggested methods include using both primary and secondary data sources to establish a forest tree species inventory, conducting interviews with residents and managers in communities living around typical forest sites, and conducting document analysis along with on-ground research to determine whether the operationalisation of the NEMP has been effective in the case of Kalangala District. Our research was guided by four questions: (1) What is the status of natural forest tree species in the studied forests? (2) What ecosystem services do the studied forests provide for local residents living around them? (3) Which restoration practices do communities near the studied forests carry out to operationalise the NEMP? (4) In what ways should the forest management plans and systems in the study areas effectively contribute to operationalising policy?

Based on our results, we provide conclusions and recommendations for viable local programmes that are consistent with the NEMP principles towards the conservation of forest tree biodiversity, and then describe a comprehensive set of indicators for potential future monitoring of activities to help achieve the effective application of policy.

Materials and Methods

This study employed a multi-method approach with forest inventories, face-to-face structured questionnaire- guided interviews, non-participant observations, and document analysis. The documents included journal articles, reports, forest management plans, government publications, books, international regulations, and local ordinances.

Area description

We conducted this study in Kalangala District, in the Ssese Islands near the western shore of Lake Victoria in South-western Uganda (Figure 1). The district comprises 84 widely-scattered islands, with Buggala Island being the biggest. People live in villages, on landing sites, and in semi-urban areas interspersed with forests, smallholder farming systems, and oil palm plantations. According to the Uganda National Bureau of Statistics [28], the 2016 population of Kalangala District was 58,000 people. Main economic activities were oil palm growing and fishing, followed by subsistence agriculture, livestock farming, logging, charcoal-making, and tourism. Oil palm growing began in 1998 [29] and was the main commercial agricultural activity with the nuclear plantation covering about 10,000 ha, followed by fishing. Before the change from forest ecosystems and smallholder agrarian production to oil palm plantations, the Kalangala District had 222 km^2 of a tropical high forest ecosystem, which represented at least half of its total land area, and 40 km^2 of wetland ecosystems (Table 1). About 150 km^2 of total forest area was located on Buggala Island in forest reserves or private forests according to the Green Livelihoods Alliance[30]. It was on the main island that we conducted this study. There are two annual rainfall periods which favour the rain-fed production of cassava (*Mannihot esculenta*), sweet potato (*Ipomoea batatas*), maize (*Zea mays*), banana (*Musa spp*.), and beans (*Phaseolus vulgaris*), mainly for domestic subsistence. Within forests, timber-harvesting and charcoal-making have been traditional and important economic activities in the district.

The cultural-private forest Kibongo covers 224 ha and includes a strip of forest on privately owned *mailo land* [tenure system where the holder of a land title has absolute ownership]. The forest is in Mugoye Sub-county, Mabigo Village, Mulabana Parish, under the management of EssigalyaKibongo and is now surrounded by oil palm plantations. The forest is exposed and accessible, providing some ecosystem goods and services to people in the Mabigo/Njoga fishing village. According to the forest manager, the broader vision of the forest management plan (FMP) was to maintain the clan belief in protecting the cultural forest as their ancestral home, for current and future generations. This is a driving factor for this forest to undertake conservation.

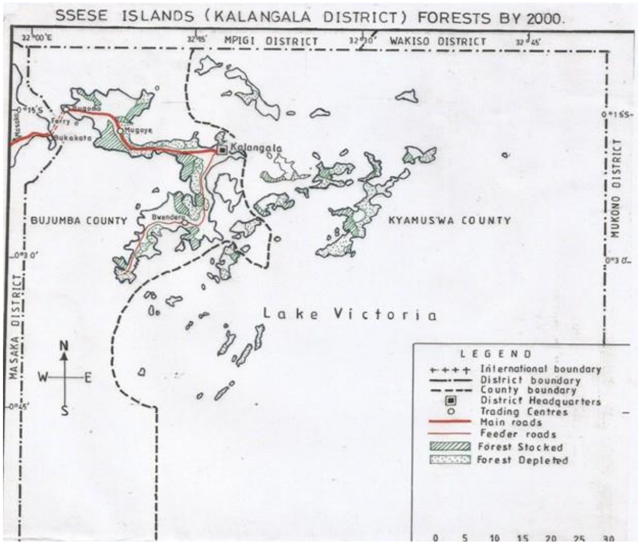

Figure 1: Map showing natural forests stocked and those depleted in Ssese Islands, Kalangala District inthe year 2000. (Drawn with assistance of Cartographer, Department of Geography, Makerere University).

The commercial-privately-owned family forest Munuza is under the system of *mailo* land tenure, with 32.5 ha and managed by Robinson Kiiza. This forest is about 2 km from Kalangala Town Council. Therefore, it is vulnerable because it is one of the easiest to access by people in peri-urban areas for timber-related products like firewood and building poles. The FMP broader vision for this forest was conservation and restoration to earn income from charcoal and carbon trade. Before current ownership, this forest belonged to the government and was accessed by surrounding community members for ecosystem goods and services. Munuza acquired this forest in 2010 after the government's policy to privatise forests.

The public-gazetted forest reserve Towa is one of the largest with 1650 ha in Bujjumba Sub-county, managed by the National Forestry Authority (NFA). The forest reserve is located 4 km to the west of the Kalangala Town Council and is thus very accessible to town residents. In June 2016, the district provided community access to the forest for its ecosystem provisions. Therefore, the recent history of human activities such as those mentioned in Table 1 placed this reserve in the extractive category[31] for the purpose of this study. Towa was a government reserve that had historically provided various ecosystem goods and services, with an FMP having a broader vision of sustainable forest resource management through collaboration with the community.

Sampling design

Kalangala District has two counties: Kyamuswa and Bujjumba (Figure 2). We purposively selected Bujjumba County on Buggala Island because earlier we had carried out research on environmental policy implementation in this county [32]. We purposively selected three sub-counties in this county, namely Kalangala Town Council, Mugoye, and Bujjumba, following our previous research (*Ibid*). From each sub-county, we purposively selected one forest site that represents one of the categories to allow comparisons of private-cultural, commercial-private, and public-gazetted forests. In addition, these forests had been earmarked, internally audited for forest certification, and were found to meet the established forestry standard of the Forest

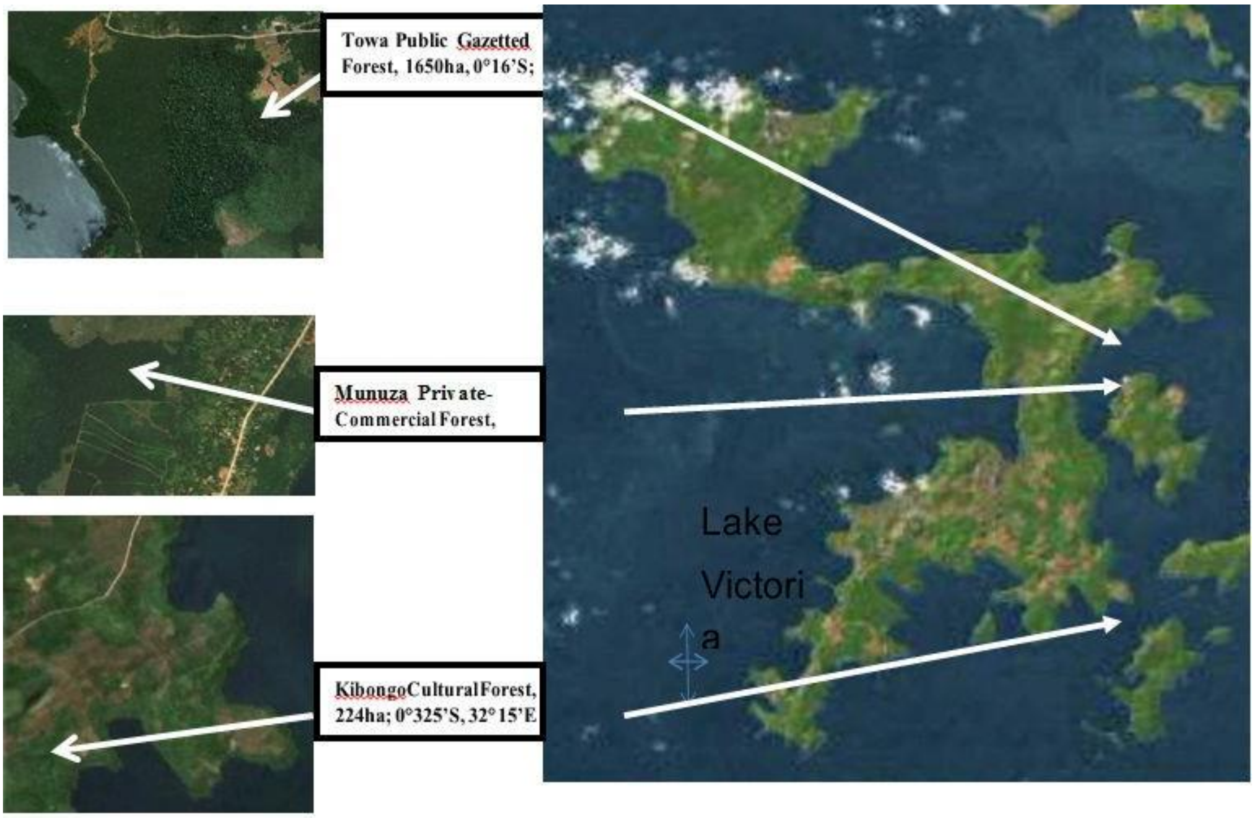

Figure 2: Satellite images of forest sites studied including Towa (Public gazetted), Munuza (commercial and private), Kibongo (Cultural private) natural forests in Bujjumba County, on Buggala Island, Kalangala District, Uganda.

Stewardship Council. Much as these forests were different according to their broader visions, management locations, sizes, and ecosystem provisions, their similarity was that all were considered for the Forest Stewardship Council certification. Thus, we found the three sites suitable for the present research. Similar to the methods used by Angelsen, Jagger [33], we randomly selected households for interviews. We first visited the Local Council (LC) chairman in each surveyed village, who provided us with the list of residents who lived within 1 to 5 km of the forest in each site. Some villages like Njoga which were on a landing site had been formed after the oil palm plantation acquired and planted locally available former forest land. From lists provided by all LCs, we randomly selected 31, 30, and 30 respondents from Kibongo, Munuza and Towa sites, respectively, making a total sample of 91; the LCs in each site assisted us in locating those homes. Before carrying out questionnaire-guided interviews with residents from each forest site, we conducted a field forest inventory of the selected forest areas.

Forest inventory procedure

The forest inventory was carried out from 6 to 17 July 2016. The objective of the inventory was to record all forest tree species, determine their diameter at breast height (DBH at 1.30 m), and observe and record ongoing management practices as prescribed in the NEMP. In each of the three forest sites, we created three rectangular study plots of 1000 m^2 each. Sampling followed the opening of three randomly selected transect paths at different locations in each site. We used the transect method because it provides more unbiased and precise estimates than non-random methods [34]. The transects included a strip of 5 m to the right and 5 m to the left along the path for 100 m, resulting in each study plot area of 1000 m^2. We took DBH at 1.30 m height to avoid the influence of buttressed root systems. We referred to each of the sites on the map since it was not possible to use aerial observations using our 4 C Quadcopter drone.

We observed and counted all trees and classified them by species. For tree species that we could not identify, we sought the help of local informants with indigenous knowledge (IK) and the forest officer at the district Natural Resource Office. We confirmed the scientific names of all the observed tree species from the website: https://www.tropicos.com. Later, we developed a list of all the observed forest tree species from each forest transect site, and then organised data on various parameters that included the number of total live trees (LS), number of trees with DBH>50 cm (DBH.50), mean DBH (MDBH) [a diameter tape was used to measure circumference; DBH was determined by $C=2\pi r=\pi d$; $d=C/\pi$ [35], C=circumference; r=radius; d=diameter], number of trees species (SN), dominant tree species (DS), rare tree species (RS), number of forest area plots with cut trees (by observing stumps, CS), forest area plots cultivated with food crops

(CP), forest area plots with evidence of trees harvested for charcoal burns (CHAP) and forest area plots with split wood (SW).

To understand the current diversity and health status of the forest, we determined DBH, the minimum diameter was>50 cm for harvesting forest trees for timber and for providing seed for regeneration[36,37], thus individual forest trees<50 cm were classified as 'future harvestable trees'. There is no internationally agreed number of future trees and seed producers to use as a basis for defining a degraded forest. Using the Shannon Diversity Index[38], where a larger number of species indicates greater diversity, we used collected site data and calculated the tree species diversity for each site. We chose the Shannon Diversity Index over others because, historically, it is one of the most frequently used indices of diversity (*Ibid*.), and this is the predominant measure used globally [39].

Shannon Diversity Index Shannon Index $(H)=\sum_{i=1}^{n} P_i \ln P_i$ (Equation 1)

Where *Pi*=proportion of the total count of the th species, and *n*=number of species observed

=natural log of this proportion and s is the number of species found.

Furthermore, the Shannon Diversity Index was preferred because we wanted to quantify the extent of diversity within each forest site ecosystem. The most abundant species could strongly affect other indices such as the Simpson Index, thus weighting rare species relatively lower than common species. While studying forest community attributes, it is not common to use other indices such as Log Series, Margalef Index, McIntosh Index, or Berger-Parker Index (*Ibid*.) [38].

Interviews in communities around selected forest sites

In order to collect robust data that would address the stated objectives, we applied the methods of Castillo-Montoya [40], by utilising a four-phase process to develop the interview framework. The four phases included ensuring that interview questions align with research objectives, constructing an inquiry-based conversation, receiving feedback on interview protocols, and piloting the interview protocol (*Ibid*). To ensure that interview questions align with research objectives, we used additional ideas from Castillo-Montoya [40] by creating a matrix for which we mapped a variety of interview questions to research objectives. Asking a variety of questions helped us construct an inquiry-based conversation.

After developing the protocol and constructing an inquiry-based conversation, we needed feedback on this protocol. The aim was to enhance the reliability and trustworthiness of our interview instrument. Feedback was received after a close reading activity by research team members who checked for structure, comprehension, length, and whether questions were answerable and would meet the research objectives. To test whether the questions would work or not[41], we piloted the interview protocol with a sample of 10 people randomly selected from the same population as those with which the research was to be conducted [40]. Having gone through the four phases, we then tested the reliability and validity of the instrument. We used the method of Taherdoost [42] to calculate the Content Validity Ratio (CVR) for each item. The content validity test was to establish whether the instrument had included all the essential items [43], and with the standard minimum value of CVR being 0.05, we eliminated all items that were not found significant at the critical level. Using Cronbach Alpha coefficient [44], we tested for consistency of the instrument. We based reliability to be equal to or above 0.60 (*Ibid*).

From 18 to 29 July 2016, we conducted face-to-face, structured questionnaire-guided interviews of residents who were selected randomly from lists provided by local leaders in communities around each forest site. Where necessary, we used the questionnaire as a guide to probing deeper. Open-ended questions were asked to avoid confining respondents from sharing additional ideas and to widen the range of responses. Face-to-face interviews gave us the opportunity to observe the intonation and body language [45] of each interviewee, from which we managed to get a deeper meaning of their answers. However, we were aware of the shortcomings that come with the interview method, such as power imbalances [46], and the effect of face-to-face visibility with an interviewer.

As indicated in the sampling procedure, there were 31, 30, and 30 interviews around Munuza, Kibongo, and Towa forests, respectively. Each interview lasted about 30 minutes, and each was conducted in the local Luganda language for all respondents to understand questions without need for interpretation. The senior author is fluent in this local dialect. Responses were reported under four themes, namely the status of the selected forest sites, community experiences with plans and practices, FMPs and systems, and document analysis for FMPs and systems that included challenges and motivations by community and forest managers. We determined the state of each forest based on the interview responses, which described the recent changes in the capacity of the forest to provide them with goods and services, similar to the methods followed in Killmann and Schoene [17,19]. Interview data complemented the transect forest measurements. We determined the 'lost species' as trees not found and their related ecosystem goods as lost from the forest, based on recall reports from community respondents, and as differences between our field inventory and accessible historical data. There were no prior studies showing species diversity in these forests. That is why we benchmarked our field inventory with recall reports from community respondents. Other data collected through interviews with all groups included responses to questions on how easily they could acquire tree seedlings and related challenges. We asked questions about the economic benefits of the identified forest tree species, and about how the community found ways to substitute for the lost and rare species plus the costs of these substitutes. Our research primarily focused on items that were available and those that had been lost from the forest ecosystem as viewed by the respondents, because there were neither any available prior statistical data nor any published information on the historical species, goods, or services from forests available to people nearby.

To supplement the community respondents' data from interviews near the selected forest sites, we interviewed forest managers, treating them as key informants from the three forest sites in order to generate additional and in-depth quality data [47-50]. We designed questions with guidance from the ecological restoration literature [5,8,21]. We asked forest managers about their FMPs and forest management systems (FMS), the extent to which people working or depending on those forest sites understood and followed those management plans and embraced the concept of ecological restoration, and how activities within their FMS contributed to ecological restoration as one way through which the NEMP could become effective. We recognised that data from key informant interviews are limited by a small sample, but they are important because they hold a principal advantage of enabling quality data collection within a relatively short period of time [49], when compared to the time that a researcher would take in carrying out in-depth interviews with scattered members of each community near the forests. Although some researchers, such as Rubin [51], have doubted the capacity of interviews to provide factual data, others such as Thompson [46] have shown the usefulness of interviews as a method of data collection particularly when the goal is to gain in-depth insights and subjective information that may be limited from other sources.

In order to understand community practices towards the effectiveness of the field operationalisation of the NEMP, data on socio-economic and community involvement in restoration and conservation were collected with parameters including the number of respondents practising exotic monoculture(EM)[1]; native monoculture (NM)[2]; farm forestry, mixed native and exotic monoculture (MNE)[3]; mixed native (MN)[4], natural regeneration(NR)[5], and permaculture (PM)[6]. We also gathered information on access to tree seedlings (AS), including sources as well as potentials and challenges in actually getting seedlings (Tables 2-4). We generated correlation matrices that included pairs of the field characteristics that could suggest associations to help us understand the impact of ongoing conservation and restoration practices that could lead to the effective operationalisation of the NEMP in the three selected forest sites.

Correlation analysis of activity data and forest tree biodiversity

We categorised inventory and interview data into activities compliant with the NEMP, activities contradicting the implementation of the NEMP, and indicators of tree biodiversity restoration and conservation. Using R commander, we analysed the categorised data to generate Pearson correlations. Taking the level of significance at $\alpha=0.05$, correlation coefficient matrices were generated showing relationships between indicators of forest tree biodiversity, and community activities data as shown in Tables 4-7. We recognise that limited numbers in some categories of indicators reduce the potential for drawing conclusions from this data.

Document analysis

We completed a document analysis of international and national policies, FMPs in comparison with FMS, and community conservation and restoration activities, identified through interviews. Documents included the Convention for Biological Diversity (1992), the National Environment Management Plan (1995), the NFP (2013), the International Standards for Ecological Restoration e.g. [8,25] and the existing FMPs in Uganda. We purposively selected those documents because they were considered to have key objectives leading to ecological restoration and forest tree biodiversity conservation as indicators of the effective application of the NEMP. We did a back-and-forth interplay [52,53] with the documents, scrutinised and compared the content in all documents in order to have organised ideas, and then pointed out the content from the policies, plans, and standards that seemed to be lacking in FMS and community conservation and restoration activities needed for operationalising the NEMP. We also searched for the positive attributes and activities that could lead to operationalising the NEMP. Conclusions on the effective application of the NEMP were based on identifying ways in which on-ground activities were consistent with strategies in the documents analysed, and with field measurements, interview results, and observations of restoration/conservation activities (Table 1).

Results

Our study generated results on the status of selected forests, and on the apparent practices applied by people in surrounding communities and forest managers for conserving forest tree biodiversity that contributed to applying the NEMP in the field. These provided ideas for measurable indicators that we could then use to quantify the effectiveness in operationalising the NEMP in our studied areas.

Land use	1990	2000	2005	2010	2015
Tropical high forest, fully stocked	56.9	58	27.5	25.8	19.7
Tropical high forest, degraded	0.3	3.2	19.4	2.9	5.9
Uniform farmland	0	0	11.4	24.3	31
Subsistence farmland	14.6	12.2	5.5	14.6	14.5
Woodland	0.9	1.7	15.7	15.9	11.1
Bush land	0.2	0	1.2	1.5	1.5
Grassland	26.9	14	9.7	5	6.4
Wetland	0.1	10.9	9.2	8.5	9.1
Urban or built-up area	0.03	0	0.1	0.6	0.8
Impediments	0	0	0.3	0.8	0.1

Table 1: Land use change (percentage of total land) on Buggala Island (1990-2015).
Source: [54]. Figures in percentages, and do not total 100 due to rounding errors.

Status of forests in the region and measurements in selected forests

According to secondary data presented in Table 1, the tropical high forest fully stocked in Kalangala District was reduced from 57% of the area in 1990 to 20% in 2015; there was an increase in uniform monoculture farmland from 0 in 1990 to 31% in 2015, essentially all in oil palm plantings. Before the introduction of oil palm plantations, Kalangala had 13 natural forests, naturally fertile soils, and abundant water resources. The district included 221 km² of tropical high forest, including Buggala Island with 13 forest reserves covering 64.6 km². Kalangala forests met the accepted definition of a forest: it requires an area composed of various types of trees and other vegetation

1 Planting only exotic species such as Oil Palm .
2 Planting single native species; farm forestry.
3 Planting both native and exotic species.
4 Planting a mixture of local native species (landscape/ecological restoration).
5 Management of a native forest with the objective not to keep the forest as it was, but to exploit it sustainably and to foresee its permanency for future generations.
6 Management systems involving integrating crops in a forest environment.

interacting within the ecosystem, with an area more than 0.5 ha in size, trees reaching at least 5 m in height, a canopy cover of more than 10%, and not being used for other activities.

The literature and field results show that the current status of forest tree biodiversity related to potential ecosystem goods, services, and food security in Kalangala District is threatened. This threat is assumed to have multiple causes, but the major change is likely due to over 100 km² (10,000 ha) of forest and smallholder land in this district alone being converted to oil palm plantations over the past two decades[27]. This has occurred despite Uganda's 1995 NEMP [3], the Forestry Plan 2011/12-2022, and the Environmental Impact Assessment Regulations since 1998. Uganda is a signatory to international conventions such as the United Nations Convention on Biological Diversity. These should all guide natural resource management. Yet high rates of deforestation and tree biodiversity loss continue, as evidenced by changes from tropical high forest 'fully stocked' to 'degraded' and to 'uniform farmland' between 1990 and 2015 (Table 1).

The current forest tree species inventory results combined from all three forest sites revealed 50 live trees having DBH≥50 cm in total from nine sampled transect plots, three plots each measuring 1000 m^2 in each forest site (Table 2).

	Kibongo		**Munuza**		**Towa**	
Species scientific name, author in brackets	N	(Pil_nPi)	N	($Pil_n Pi$)	N	($Pil_n Pi$)
Anthocleista schweinfurthii (Gilg.)	0	0	0	0	1	0.027
Antiaris toxicaria(Lesch)	0	0	2	0.035	2	0.042
Bosquia sp. (Thouars ex Baill.)	0	0	0	0	1	0.027
Canarium schweinfurthii(Engler)	1	0.035	1	0.022	0	0
Celtis mildbraedii (Engler)	0	0	0	0	3	0.060
Ficus natalensis(Hochst)	1	0.035	0	0	0	0
Ficus ovate (Vahl)	0	0	0	0	2	0.042
Futumia africana(Stapf)	0	0	2	0.035	23	0.242
Harungana madagascariensis (Lam. ex Poir.)	0	0	18	0.177	1	0.027
Khaya anthotheca(Candolle)	0	0	0	0	1	0.027
Macaranga kilimandscharica(Pax)	5	0.115	0	0	1	0.027
Maesopsis eminii(Engler)	14	0.223	87	0.362	18	0.210
Manilkara butungi (Chiovenda.)	3	0.081	4	0.059	6	0.100
Markhamia lutea (K.Schum)	4	0.097	0	0	0	0
Myrianthus holstii(Engler)	2	0.060	0	0	0	0
Piptadeniastrum africanum(Brenan)	0	0	1	0.022	19	0.217
Pycnanthus angolensis (Welw.)	11	0.192	1	0.022	29	0.273
Raphia farinifera (Hyl.)	2	0.060	0	0	0	0
Tabernaemontana pachysiphon (Stapf)	2	0.060	0	0	0	0
Tetrochidium didymostemon (Baill.)	1	0.035	0	0	5	0.090
Trema orientalis(Blume)	0	0	2	0.035	0	0
Trichilia dregeana(Sonder)	1	0.035	0	0	0	0
Uapaca guineensis (Hutch.)	98	0.271	157	0.321	97	0.359
Uvariopsis tripetala (G.E. Schatz)	1	0.035	0	0	0	0
Xylopia eminii(Engler)	2	0.060	4	0.059	2	0.042
N	148		279		211	

Σ (sum) of (Pi l_n Pi)-=H [Shannon Index]		1.39		1.15		1.81

Table 2. Here Observed tree species diversity and Shannon Index computed in each forest site (3000 m^2 each).

There were fewer trees with DBH≥50 cm in studied plots in Kibongo (5) and Munuza (2) when compared to Towa (43). In addition, each site had a unique total number of trees per 3000 m^2 (Kibongo, 143; Munuza, 277; Towa, 168), with similar numbers of trees in Kibongo and Towa.

The most dominant tree species in the three investigated forest area plots, each totalling 3000 m² per site, was Uapaca guineensis (Hutch.), especially in Munuza forest. In all forest sites, the least dominant species were *Anthocleista schweinfurthii* (Gilg.), *Bosquia sp.* (Thouars ex Baill.), *Ficus natalensis* (Hochst), *Khaya anthotheca* (Candolle), *Trichilia dregeana* (Sonder), and *Uvariopsis tripetala* (G.E. Schatz) (Tables 2 and 3).

Site	Current no. of species	Dominant species	Rare species (found elsewhere but not here)	Site mean DBH (cm)
Kibongo	15	*Uapaca guineensis*	*Trema orientalis, Futumia africana, Newtonia buchananii*	28.4
Munuza	11	*Uapaca guineensis*	*Tetrochidium didymostemon*	24.8
Towa	16	*Uapaca guineensis*	*Canarium schweinfurthii*	37.6

Table 3: Species occurrences, dominant species, rare species and mean DBH of studied forest sites.

Community respondents to the interviews reported the rarest tree species to include *Tectona grandis* (Linnaeus), *Lovoa brownie* (Harms), *Canarium schweinfurthii* (Angler), *Anona squamosa* (Linnaeus), *Garcinia buchananii* (Baker), and *Manilkara butugi* (Chiovenda). We did not find any of the tree species mentioned by the respondents as rare, other than Canarium *schweinfurthii* and *Manilkara butugi*, in any of our inventoried forest sites. The Kibongo cultural forest lacked some common forest tree species found elsewhere (Table 3). The inventory showed that Kibongo and Towa forests had similar tree species in abundance, while Munuza forest had an apparently smaller Shannon Diversity Index (H=1.15) than Kibongo forest (H=1.39) and Towa forest (H=1.81), as shown in Table 2.

We calculated the mean DBH in cm of all live trees, and the results are summarized in Table 3. Although the DBH mean for Towa (37.6 cm) was 42% greater than the average of the other two forest sites, all sites had low mean DBH. The slightly higher mean DBH for Towa was consistent with the high number of trees (43) with DBH>50 cm in this forest site. All three studied forests displayed tree diversity ranging from 11 to 16 tree species found in the three plots in each forest. The investigated plots included trees with DBH<50 cm, and the number of live stems and species number are shown in Table 4.

Inventory Observations/Interview data category	Factor abbrev.	Factor Definition	Number in Kibongo	Number in Munuza	Number in Towa
Observed indicators of forest state	DBH.50	DBH>50	5	2	43
	LS	Live trees	148	279	211
	SN	Tree species Number	15	11	16
Observed practices contrary to the NEMP	CHAP	Charcoal burning plots	0	2	2
	CP	Plots cultivated with crops	1	1	2
	CS	Cut trees plots	3	3	3
	SW	Split wood plots	1	2	3

Table 4: Indicators of forest state and practices observed as contrary to the NEMP in the studied sites.

All plots had evidence of cut trees, charcoal plots, cultivated plots, and split wood. Sites Kibongo and Munuza had one plot each under food crop cultivation while site Towa had two of these plots. There were no forest plots with charcoal burning in Kibongo, but there were two such plots in Munuza and two in Towa. All investigated sample forest area plots in the three forest sites had evidence of split firewood activities (Table 4).

Respondent community experiences, plans and practices in the forest

There were 91 respondents, 39 female and 52 male, from 3 villages adjacent to the studied forest sites. Generally, males were more often available than were female interviewees in these villages, except for Towa where the numbers of male (15) and female (15) respondents were the same. In order to understand the social and economic dynamics associated with these results, we used information from all 91 interviews. The results showed that 83% of the respondents were extremely concerned about the current general forest state and reduced forest tree biodiversity. They also mentioned essential goods and services whose supply was inadequate as well as the current substitutes which were expensive (Tables 5 and 6). Based on the interviews, the effectiveness of the operationalization of the NEMP was questionable.

Site	Fire Wood	Char-Coal	Grass	Medicine	Poles	Timber	Fruits	Water	Bush Meat	Delicacy/food	Total
Kibongo	15	13	01	10	05	09	05	04	01	03	66
Munuza	24	08	06	09	03	10	10	04	02	11	87
Towa	23	19	00	04	04	11	02	03	00	04	70

Table 5: Ecosystems goods in each of three forest sites as reported by respondents in surrounding communities (Number of respondents reporting each item).

Respondents described what they gained from the forests, but now in reduced amounts as compared to previous times before the widespread planting of monoculture oil palm. One respondent was concerned about inadequate water:

Our water supply has been blocked by a sewage pipe from the oil palm plantation, so we have to move longer distances to look for water or buy a jerry can at 500 shillings…

On the other hand, there were respondents who mentioned having improved their income status as 'out-growers' in the monoculture oil palm plantation. One farmer said:

I have been able to build a house using my income as an oil palm out-grower…

People in all three communities reported some effects from the loss of forest tree biodiversity and gave details on the lost ecosystem goods and services, although among those people there were some whose incomes had improved and they were not concerned with forest goods and services. Some ecosystem goods had substitutes, while others did not (Table 6). For instance, the substitute for herbal medicine was visiting a health centre, although this was often not affordable for some residents. Respondents mentioned long distances (10-15 km) to clinics that were not well stocked with necessary drugs. Visiting a professional medical doctor cost about 2 Euros each time, which is expensive for a majority of the people who lived on less than 1.90 Euros per day (poverty threshold as determined by the World Bank in 2015). This is compared to the cost of the free indigenous ethnobotany knowledge and herbs shared in the community, as well as other related materials picked from forests and shared freely. One respondent was concerned and said:

I am a traditional healer but I find it very difficult to acquire the herbal medicine I need for my patients…I cannot easily share the prescribed medicine because I know that my clients will not find it so I have to look for it by myself…

Before deforestation		**After deforestation**	
Ecosystem services /goods	Estimated cost	Substitute service/good	Estimated cost
Firewood	Collected free from nearby forest	Poor quality firewood/or charcoal and stove	About 1 Euro per bundle of firewood; charcoal stove at 2 Euro as one time cost; at least one sack of charcoal per month at 15 Euro
Charcoal	Burned from nearby hardwood at one Euro per sack	Poor quality charcoal bought from far away	One sack per month at 15 Euro per sack
Grass	Collected free for thatching and mulching by community members	Iron sheets for roofing	Each iron sheet at 10 Euro, thus 200 Euro for 20 sheets in addition to nails and labor
Herbal medicine	Abundantly free collection	Some medicine was not substituted; for some clinics now provided the solution, but were also (10-15 km) away	A visit to a clinic costs a minimum of 2 Euro, in addition to about 2 Euro for transport

Poles	Abundantly free collection of strong wood with high quality	Poles of poor quality, and have to be bought and from a distance	Each pole costs about 0.3 Euro per pole plus transport costs
Timber	Of quality such as *Tectona grandis* (Mukebu), and harvested from nearby forests at 1 Euro per piece	Of poor quality such as *Uapaca guineensis* (Mukusu) or harvested young like *Maesopsis* sp. (Musizi) or quality wood is imported from DRC	Wood of *Tectona grandis* costs a minimum of 22 Euro per piece of 7 feet (2.1 m)
Wild fruits	Abundantly free collection	Now buying fruits for vitamins from markets or substituting with multivitamin syrups.	One kg of fruit costs about 1 Euro or a syrup bottle (100 ml) at 2Euro
Clean water	Collected freely from nearby shallow wells	Clean water fetched from far or bottled water bought from shops act as substitutes.	It takes 0.18 Euro labor to collect one jerry can of clean water or 0.3 Euro to buy bottled mineral water
Bush meat or lake fish	Hunted abundantly from nearby forests and shared freely or fish from shallow waters nearby	Beef or pork are available meat sources, or fish from deep waters; majority of community members can no longer afford these sources.	One kg of either costs about 2 Euro when found; fish are rarely found in the market, and cost over 2.5 Euro each
Wild collection food	Wild mushrooms, yams and other food sources collected freely from forests	Rarely found and no longer part of the menu for majority	Knowledge and taste of such food lost among the youth

Table 6: Ecosystem goods and services, their substitutes and estimated costs as reported by respondents in studied sites.

Community participation in restoration and conservation

A total of 77 respondents reported that their communities were involved in activities such as introducing EM, NM, MNE, MN, NR and PM, all aimed at ecological restoration and conservation (Table 7a).

Interview results showed that the largest numbers of people (36) were involved in mixed reforestation of both native and exotic species, while others were involved in mixed native tree planting, exotic monoculture, and native monoculture with the smallest number of participants. This data shows that generally there was low participation in restoration and conservation practices.

Inventory Observations Data	Factor abbrev.	Factor Definition In numbers (# of people)	Number in Kibongo	Number in Munuza	Number in Towa
Reported practices compliant with the NEMP	EM	Exotic Monoculture	5	8	2
	MN	Mixed Native	9	3	12
	MNE	Mixed Native and Exotic	9	14	13
	NM	Native Monoculture	3	0	2
	NR	Natural Regeneration	9	3	6
	PM	Permaculture	9	13	9
	AS	Access to seedlings	20	21	24

Table 7a: Factors on community activities promoting restoration and conservation.

Results show that practices had different effects on forest tree biodiversity as evident in correlation analysis (Table 7b). Residents' responses to other interview questions showed that some activities did not encourage ecological restoration and would thus lead to the ineffective operationalisation of the NEMP. These included charcoal burning (CHAP), splitting wood (SW), and cultivating in forests (CP) as indicated in Table 8, for example, showing that charcoal burning had a negative relationship (r=-0.327) with tree species number (SN).

	Indicators of restoration and conservation of forest tree biodiversity correlation coefficients with NEMP operationalising practices		
Practices for operationalising the NEMP	DBH>50	Live Stems-LS	Species number-SN
Mixed Native species planted	0.964	-0.348	0.866

Mixed Native species and Exotic species planted	0.442	0.855	-0.327
Only Native species planted	0.066	-0.999	0.756
Natural Regeneration	0.066	-0.999	0.756
Permaculture practiced	-0.556	0.877	-0.982
Exotic species planted	-0.556	0.877	-0.982
Access to Seedlings	0.953	0.219	0.454

Table 7b: Correlation matrix for practices that operationalise the NEMP.

	Relationship between indicators of forest tree biodiversity restoration and conservation with NEMP Non-conforming practices (Coefficient values=r)		
NEMP Non-conforming practices	DBH>50 cm	Live Stems-LS	Species number-SN
Charcoal burning (Plots)	0.442	0.855	-0.327
Split Wood cases	0.831	0.481	0.189
Cultivated Plots	0.998	-0.022	0.655
Cut stems	0	0	0

Table 8: Correlation matrix for practices not compliant with operationalisation of the NEMP.

Some of the exotic species grown included oil palm, pine, and eucalyptus, and people involved in these practices mainly aimed at commercial production rather than ecological restoration. In addition, 49 respondents reported their involvement in either natural regeneration or permaculture, including goals to rejuvenate some components of the original forests. Towa and Kibongo had the lowest number of participants in permaculture. In general, the people interviewed were making some efforts to restore the forest ecosystem even though they had various challenges in their attempts to accomplish these plans which made it difficult for most of them to participate in appropriate restoration and conservation activities.

FMPs and systems for Towa, Munuza, and Kibongo forests

The public forest (Towa) manager mentioned having an FMP in draft form that was still on the shelf and not followed. He further explained that he was following other guidelines and by-laws. The broader vision of his plan was to conserve, protect, and collaborate with the community through activities including opening boundaries. However, the manager mentioned gaps in boundary opening, consequently bringing about encroachment on *mailo* land. Another activity was gazetting of public and private forests (i.e. designation for specific activities), although there were still challenges in doing this, while encroachment continued. Respondents mentioned that they supported district land boards in providing proper documentation on forest ownership. However, land boards gave out land belonging to forest owners or the government without clear documents to guide the process. In the same way, encroachers used wrong GPS coordinates and ended up taking trees from the public forestland. Towa had an FMP in line with the NEMP guidelines, although it was hardly followed (Figure 3). The Towa manager said:

Restoration is on a minimal scale because people take this forest as a public good and so everyone wants to freely benefit from it….

Both Munuza and Kibongo forest managers mentioned having FMPs on the shelf. One forest manager was reported as saying:

Government development plans are against our conservation plans, for example, GMOs taking a shorter time than the native species….

The broader vision for Munuza was conservation and restoration to earn income from carbon trade. To achieve this vision, the management system for this forest owner involved opening his forest boundaries such that his neighbours could see them and planting fast-growing species such as *Maesopsis eminii* for timber, as well as pruning and thinning. The forest manager of Kibongo had a broader forest vision to protect the forest as a cultural site that benefits current and future generations. To achieve this vision, the owner reported that his management system involved activities including planting native trees such as Tectona grandis; planting other fast-growing species for income; preparing nursery beds; ecotourism; environmental education; advocacy awareness on environmental protection through community radio; and demonstration gardens in schools (Table 9).

		Kibongo	**Munuza**	**Towa**
FMP	Forest management plan	Developed a plan (1)	Developed a plan (1)	No plan developed (0)

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	(with related legal framework)			
FMS	Forest management systems	5 activities nursery beds; ecotourism; advocacy awareness demonstration gardens in schools… member of collaborative forest management committee	4 activities boundary opening, NM, pruning, thinning)	5 activities boundary opening; gazzeting of public and private forests buffer zone community involvement in policing permits

Table 9: Forest management systems and plans to operationalise the NEMP.

Document analysis for FMPs and systems

A major purpose of the document analysis (Figure 3) was to determine how consistent the official documents were with goals of ecological restoration and biodiversity conservation, as indicators of the effective operationalisation of the NEMP. It was apparent that FMPs and community practices were consistent with international regulations and the NEMP guidelines in three ways:

Having FMPs that were consistent with the NEMP guidelines.

Endeavouring to implement activities consistent with the NEMP guidelines.

Having membership in the collaborative forest management committee (in cases of Kibongo and Towa forests)

Thus, we recognise that forest managers and community members took the initiative to restore and conserve forest tree biodiversity as an indicator of effective operationalisation of the NEMP. However, in some ways FMS and community practices were inconsistent with the NEMP guidelines (Table 4), and as shown in Table 7a, few members of the community actually implemented activities promoting restoration compliant with the effective operationalisation of the NEMP.

The following non-compliances, which lead to the ineffectiveness of the operationalisation of the NEMP, were recorded:

Failing to follow existing FMPs (on the shelf).

Carrying out monoculture practices that do not promote forest tree biodiversity and ecosystem productivity.

Overharvesting of trees as evidenced by the low DBH and number of species, minimal number of live stems as an indicator of limited conservation (Table 4).

Charcoal burning as evidenced in all sites and all plots with cut trees as well as split wood.

Cultivating in forests as evidenced by all sites having plots with plantings of food crops.

Having low participation in restoration and conservation practices (Table 7a).

These inconsistencies outweigh the consistencies. The results showed that the inconsistency within community practices and FMS resulted from several challenges such as high cost and limited availability of appropriate planting materials. If the policy does not address these challenges and stimulate activities at the local level to resolve them, environmental policies cannot be deemed effective because of the difficulty in achieving conservation and ecological restoration of forest tree biodiversity.

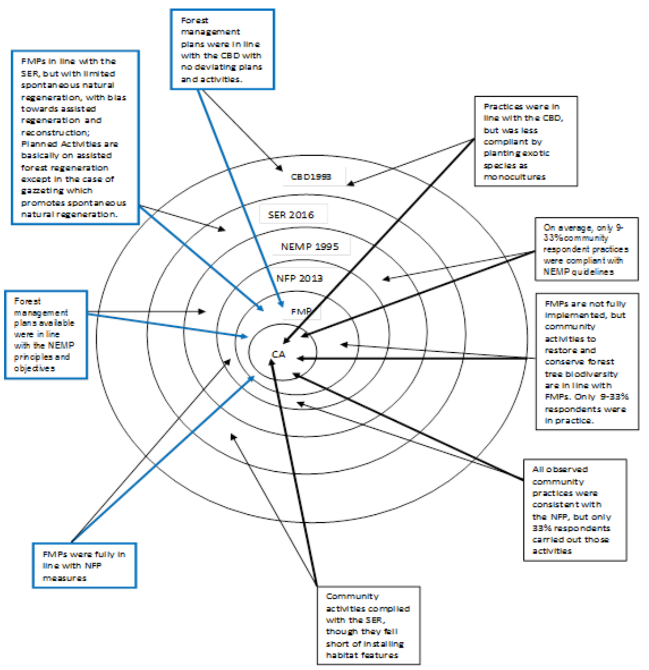

Figure 3: Summary of forest management and community activities consistent with NEMP principles and other guidelines for ecological restoration and biodiversity conservation (Figure 3 is intended for colour reproduction).

Challenges and motivations encountered by community members and forest managers

Despite the awareness of the need and willingness to effectively operationalise the NEMP by restoring a fully functioning forest ecosystem, both community members and forest managers mentioned the limitations to accomplishing this goal as well as their FMPs (Table 10). Among the multiple problems, the most frequently mentioned challenges for the community members were the lack of access to nurseries for planting materials followed by limited finances and lack of information and awareness. As a result, most respondents were not able to plant some of the rare species because they did not have the seedlings they required. Instead, most of those who could access seedlings from the government, an NGO, or any other sources were getting both oil palm and domesticated fruit trees. These were reportedly provided for commercial purposes rather than for re-establishing a fully functioning ecosystem. There was no effort made to involve grassroots communities in identifying the seedlings they needed. On the other hand, forest managers had a range of challenges according to their respective FMPs and broader visions. Reported challenges included not being well-coordinated on the ground, rampant corruption, and hard economic situations, all of which caused disrespect for laws and regulations intended for the effective operationalisation of the NEMP. Another limitation was not being educated on the NEMP principles, thus resulting in a continuing lack of adequate knowledge on the policy in the field, even if people generally perceived policy practices as useful.

Interviewees category	Challenges mentioned
Community	Involvement in monoculture with native species is limited by the difficulty to find native species seedlings
	Monoculture with exotic species has a slow payment process and expensive fertilizers
	Planting mixed native and exotic species has less community involvement; some species do not easily integrate; there is too much pressure on land so we can't grow food/plant trees; no seedlings; no extension services
	Carrying out mixed reforestation with local native species is limited by inadequate land; limited seedlings for rare species; environmental damage thus failure of seedlings to mature; no support from Government; supplied seedlings are of poor quality; uncooperative neighbors who leave their animals to eat young trees planted; no financial capacity to purchase seedlings.
Kibongo forest manager	Government development plans against our conservation plans; poor mind set for what we think is modernisation; high investment in GMOs
Munuza forest owner	Difficulty to access seedlings; threats that I have idle land that can be taxed; neighboring to the oil palm plantation which cover crop (Mukuna) is accessing my forest; High prices of charcoal and demand for timber which have increased theft in my forest
Towa forest manager	No designated FMP to follow; less support and commitment from community; lack of awareness so people enter MoU without clear guidance; people involved are not given enough support e.g. lack seedlings, termites; a need to provide inputs; externalities by other people coming in to use the forest or even burn it; people are also busy with other economic activities and so not able to keep guard of the forest; enforcement response is not immediate so many people take advantage to destroy the forest

Table 10: Challenges faced by the community and forest owners/managers.

Forest owners were concerned about the lack of stakeholder involvement in the development and review process of the NEMP. In addition, there is no clear streamlining of authority/coordination in the implementation of the NEMP, and this limited the district officials' adequate use of policy guidelines. Thus, it was difficult to implement and operationalise the laws and guidelines stipulated within the NEMP towards forest tree biodiversity conservation. Forest managers recommended the full decentralisation of policy implementation. It was reported that to plant a new forest, NEMA approval at the national level was necessary. However, the district could handle the process far more easily, in comparison. In addition, they reported the need for greater involvement and training at the grassroots level and greater awareness of the activities towards complying with policies.

These challenges mainly come from the failure to integrate policy at the local level, such that ecological restoration can be approached at the landscape level, involving all stakeholders in sustainable land management and solving the prevailing state of poor coordination of restoration activities. To meet all the stated principles, ecological restoration should be integrated into sustainable land management at all levels, especially at the landscape level [25]. Despite the identified challenges, interviews and field observations showed that community members and forest managers were determined to work hand in hand with local/district leaders to restore the long-lost forests.

Discussion

Based on document review and the interviews conducted, it is evident that the FMPs in place were in line with the NEMP and other international standards for the restoration and conservation of forest biodiversity. Forest managers and some community members were aware of the pressing need to restore and conserve forests and in fact contributed to the effectiveness of the operationalisation of the NEMP. However, there were several challenges such as lack of appropriate seedlings and awareness on how to exercise restoration plantings, thus limiting the effectiveness to complete this process.

The current NEMP [3] pursues the objectives of conserving, preserving, and restoring ecosystems and maintaining ecological processes and life support systems, especially through the conservation of biodiversity. Our results show that even though FMPs were in line with the NEMP and international guidelines, on-ground actors could not implement some of the planned activities and thus could not operationalise the NEMP effectively. Thus, there was limited conservation of forest tree biodiversity or ecological restoration as defined by Clewell et al. [21] and Gann and Lamb[5], and the lack of awareness of guidelines such as those of the SER (*Ibid*). These findings show a 'policy to practice disconnect' in which policy statements are not aligned with field practices. This disconnect appears to be true for other tropical areas in similar environments, as well, as reported by FAO and JRC [53] and by Seymour et al. [10].

Changes in the landscape and the state of forests

Based on data on tropical high forests that are fully stocked and degraded (Table 1) in Kalangala District, the reduction in the forest area was similar to the data presented by an independent confirmation from a published estimate indicating that more than 10,000 ha of forest had been converted from a forest ecosystem to oil palm plantations since 1990 [29]. Secondary data show that decrease in forest cover was inversely proportional to changes in the agrarian system characterised by oil palm mono-crop plantation agriculture, as recently presented in our consortium report on the impact of oil palm plantations in the Kalangala landscape [54]. The expansion of oil palm plantings continues despite the NEMP principles and guidelines. It is a sign of disjointed implementation and operational ineffectiveness of the environment policy and national policies on the commercialisation of agriculture.

According to forest inventory studies, it was evident that the mean Diameter at Breast Height (DBH) was low for all forests (Table 3), meaning that the case study sample forests were currently young and most mature trees had already been harvested. Forest managers stated that earlier overharvesting of forest resources had occurred before the privatisation of ownership. However, in the case of the commercial-private Munuza forest, the loss of mature trees and smaller diversity index implied the apparent goal of a private commercial forest manager to maximise short-term income from forest investment and to only conserve those species with commercial timber value. In fact, the high number of trees per unit area observed in this forest indicated positive efforts to rejuvenate the forest for future commercial exploitation. Furthermore, our results based on this single example suggested that due to the challenging economic situation, private forest owners prioritised income generation, access to the carbon market, and harvesting timber, rather than ecological restoration, which is contrary to international standards [1,5] and goals under the NEMP (1995) [3]. One implication is that government control must be part of the preservation and restoration equation.

Although Kibongo had no evidence of charcoal burning and only one observed plot under cultivation and one plot with evidence of split firewood extraction, this forest had 15 observed tree species, essentially the same as the government forest Towa, which had 16 species. This could be due to the small number of transects or could represent a loss due to the 'tragedy of the commons' archetype as noted above [55]. We recognise that the low number of live stems, future trees, harvestable trees, and low species number in the Kibongo forest limits the productivity of the ecosystems [5]. This is supported by the interview results which show that Kibongo has the lowest number of ecosystem goods and services. In contrast, the government reserve public forest Towa appeared to be less degraded with the largest number of harvestable trees remaining by far and a greater forest tree biodiversity. When compared to Kibongo and Munuza, Towa had the highest Shannon Diversity Index value (Tables 2 and 3), although there was no applied FMP. This was probably due to the strict policing and capacity to control deforestation in the government forest when compared to those forests that were managed by a community or an individual owner, both of which showed results of overexploitation. This implies that Towa has the capacity to improve even more if its management has a well-documented FMP and follows it, in addition to supporting the laws and ordinances. It is useful to note that all calculated Shannon Index values were far lower than those reported for tropical rainforests in forest sites elsewhere at a similar latitude, for example, H=4.49 in Brazil at a Brazilian Agricultural Research Corporation (EMBRAPA) site [56].

We suggest that it would be appropriate for the government to increase the number of extractive reserves such as the Towa forest, while also working hand in hand with the community to enhance education as well as to help police forests instead of surrendering all management decisions to private owners. In addition, rather than having strictly protected areas or community-managed forests, effective conservation could involve a mix of different strategies including private-public and community-managed forests as suggested by Porter [56], since such community extractive reserves benefit a wider community and have lesser deforestation than do private forests(*Ibid*). Based on interviews, we concur with these authors and agree that local people derive many benefits from forests and that they would do anything to protect their forests for their future. This is similar to Ostrom's [54] conclusions on what happens in 'the commons', and why it is essential to control or sanction the 'free riders' who tend to exploit the uncontrolled community resources.

Inventory results from all three sites showed that mature trees of traditional high-value timber species and other valued species were missing. Community respondents reported the missing species as 'important' or as just 'lost species' which we think contributed to the low level of ecosystem goods and services, and the results imply that the operationalisation of the NEMP is ineffective.

Forest ecosystem goods and services provided to surrounding communities

In the Ssese Islands and other tropical regions, forests provide a variety of services including fresh air, fertile soils, and carbon sequestration which have the potential to contribute to ecosystem health [20,57] and human life[58], plus both timber and non-timber forest products such as medicine and foods, especially in rural communities[59]. FAO [60] described linkages between production and consumption of forest goods and services that will help fulfil human needs. As an example, in Kalangala District, tropical forests provide many ecosystem goods and services. Community respondents reported dependence on these forests for timber, firewood, wild fruits, and medicines. Here, some rare tree species have the potential to provide quality timber for making boats and shelter, yet many of these and other species were reported missing in the forest ecosystem.

When important species become rare or are exhausted, poor households can no longer meet their livelihood needs and are thus disempowered [5]. This often happens due to the degradation of forests [2,17-19] and poor households are left with inadequate goods and services [20]. The decreased supply of common forest goods such as fuelwood constrains food preparation, which lowers nutritional value [6]. Most rural people use wood fuel for food preparation and fish smoking, and the lack of this resource seriously affects them. Similar studies in the Eastern Cape Province of South Africa showed that despite the high levels of electrification, more than 60% of the households still used firewood for cooking [61]. This implies that such losses in the forest structure require effective environmental policies with programmes to both preserve and re-establish forests. However, if such programmes involve tree planting, which is biased towards monocultures and limited by the availability of native tree seedlings, such activities promote neither biodiversity conservation nor ecosystem productivity. We suggest the establishment of efficient plant nurseries as suggested by Artikinson [22] and Towns et al. [12].

Recognition of the importance of ecosystem services to communities can stimulate beneficiaries to devotedly practice tree planting and other practices that ensure the effective operationalisation of the NEMP. Communities in our study area were positive about the need to restore forests, as evidenced by 83% of the respondents reporting a concern about the current forest status, which indicated their desire to get involved in activities towards forest ecosystem restoration. Even with some community involvement, there appeared to be a greater emphasis on practices to plant exotic and native monocultures (Table 7a), which implies that there had been gaps in operationalising the NEMP. According to Seymour [62], forests are important for resilience to climate change and for rural livelihoods. Therefore, it is important to involve and guide the community in ecological restoration and conservation. A complementary approach to promoting the operationalisation of the NEMP could be to increase the number of protected forests through conservation, thus giving a chance to the degraded forests to regenerate naturally and develop enhanced biodiversity [63]. This meets the NEMP principle of using and conserving the environment and natural resources [3]. However, since forests provide sources of livelihoods to people, having strictly protected areas can limit the people's access to required goods. Therefore, it can be vital to have multiple management systems to meet the different management objectives such as the 'provision of rural livelihoods, environmental services or recreational or aesthetic benefits'[6]. The comparisons between our three forest sites under different management illustrate this potential. However, these multiple management systems may not succeed if there are conflicts among the concerned stakeholders such as the government, logging companies, large-scale industrial farms producing oil palm, and subsistence farmers, similar to the controversy and conflict in managing the U.S. forestlands in New Mexico (*Ibid*). This controversy is also similar to our studied area, where there were reports of conflicts, especially on oil palm plantations as shown by FOE [29] and the Green Livelihoods Alliance G.L.A. [30] with limited community practices to conserve or restore forests.

Community practices to conserve or restore forests as a means of effective operationalisation of the NEMP

The observed low rate of effective operationalisation of the NEMP could be due to low participation in conservation activities (Table 7a) and not implementing activities to promote ecological restoration and forest tree biodiversity conservation. Practices such as monoculture plantings, clearing forests for cultivation, charcoal burning, and timber as shown in Table 4 are contrary to the NEMP, the forestry policy, and United Nations Convention on Biological Diversity [1,3,4], as well as the FMPs and other international guidelines.

Charcoal burning was related to limited species number (r=-0.327). Species used for charcoal burning were selected based on their provision of quality charcoal. This way, species numbers were reduced. Where forest trees are cut, the open space with full light stimulates the germination of many seeds, thus explaining a large number of live stems (r=0.855) as indicated in the matrix in Table 8. The results showed that where there was splitting of wood for fuel, there were trees with high DBH values (r=0.831). According to the community, while people are splitting wood, those trees that are easy to split are chosen, and thus big trees are avoided. This tree selection for splitting wood also appears to contribute to fewer species in the forest ecosystem (r=0.189; Table 8). It was also noted that cultivation in the forest was associated with having trees with high DBH value (r=0.998). Thus, farmers clear away all undergrowth and small or young trees for wood while conserving big trees. This way, live stems should be reduced to allow enough solar radiation for crops, but the correlation was not significant (r=-0.022). Since the focus is on conserving the big trees in cultivated areas irrespective of the species, cultivation appeared to favour conserving tree species (r=0.655). These practices were inconsistent with the NEMP, thus indirectly resulting in its ineffective operationalisation, because they largely reduced restoration and conservation activities to promote forest tree biodiversity. We are aware that the correlations demonstrate an association of factors, and not necessarily cause and effect.

The current community involvement in FMS included the planting of monoculture exotic species such as oil palm, pine, and eucalyptus, all with the intention to restore forests. These monocultures may have quick income returns, but do not enhance either ecological restoration or sustainable livelihoods, and may not meet appropriate timber requirements for households [64]. According to forest ecosystem research, 'mixed-species stands are more stable and resilient, and keep soil fertility in better condition than do pure conifer stands' [65,66], even if such plantations can relieve the pressure on natural forests against fragmentation [2]. Evert et al. acknowledge the value of using native tree species to restore forest ecosystems, by paying attention to genetic variations in species among other factors (*Ibid*). This implies that native forest stands, if managed well, can have the potential to improve forest ecosystems better than industrial monocultures.

Our results (Table 7b) indicated that mixed native species planting was associated with species diversity (r=0.866), perhaps because it was practised in degraded forest areas (r=-0.348) where the goal was protecting remaining trees with large DBH (r=0.964). Plantings of mixed native and exotic species were mostly implemented by forest managers with commercial interests, as in the case of Munuza, as high-value species were mostly conserved, and exotic species were planted. This practice apparently led to low species numbers (r=-0.327) and many young live stems (r=0.855). Furthermore, planting of native species went together with natural regeneration, especially in degraded forest areas (r=-0.999), hence leading to a greater forest tree species diversity (r=0.756). These practices had similar effects such as charcoal burning and splitting wood, which both opened up forest thickets and increased the direct solar radiation to stimulate the germination of tree seeds and rapid growth of young trees. Where massive harvesting of trees had taken place, permaculture was also practiced (r=0.556). Permaculture was associated with a low number of species (r=-0.982) since it was deliberate and only conserved valuable tree species. It appeared to lead to the growth of many trees but also to a limited number of species (r=0.877). Similar effects were observed in cases where only exotic tree species were planted. Thus, practised tree planting activities were not fully in line with the NEMP conservation principles and could hardly contribute to an effective operationalisation of the NEMP.

These results imply an urgent need to undertake a massive restoration programme for forests in Buggala Island, Kalangala District, on the lines of the restoration programmes that involved the planting of native trees, monitoring trees for survival and reducing exotic species in New Zealand's Islands [12,22]. Such restoration programmes would operationalise the NEMP better with recognition from public groups and communities. According Chazdon [23], local communities and national programmes could be successful in restoring forests, for example in the Philippines, Brazilian Amazon, Peru, and Indonesia, where such restoration activities promoted community organisations and improved rural livelihoods (*Ibid*). Other than the approach of fully involving communities in restoration and conservation, another route to improving environmental health and reducing management controversies is to operationalise the NEMPs through implementing FMPs and systems.

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Operationalisation of the NEMP through the implementation of FMPs and FMS

Our findings indicated that the studied forests had FMPs, which were based on both international and national policies (Figure 3). In Towa, by-laws and ordinances were followed in addition to national and international policies. The government-conserved forest Towa is an extractive reserve where we found more tree species in the measured plots, reflecting a scenario where conservation was a matter of higher priority than income generation. Nevertheless, Towa's operation with the FMP not being followed called for immediate action as one way to improve management.

The broader vision of the owner of Munuza forest was restoration and conservation. However, this commercial-private forest owner found less value in conservation since he could not get returns to boost his livelihood. On the one hand, this was similar to what Nepstad et al. [31] found regarding Amazon indigenous people, who lost the practice of protecting their forests because they adopted 'the values of a market-based society' (*Ibid*). In the same way, it may explain why the Munuza owner aimed at planting trees (especially fast-growing Maesopsis eminii, and others such as pine and oil palm) to earn carbon credits, not necessarily aiming at ecological restoration. The Kibongo owner's broad vision and management plan fit strategically towards the operationalisation of the NEMP.

Therefore, we acknowledge that management plans and systems in the three forest sites included broader visions that were well aligned to the NEMP principles with the capacity to lead to conservation of forest tree biodiversity and ecological restoration. However, in practice the three forest management scenarios and managers encountered challenges in enforcing the implementation of developed plans. Among such challenges, there is poor coordination of conservation activities and limited stakeholder involvement in the NEMP review process. Some consequences include limited use of policy guidelines, leading to difficulties in meeting the goals of the NFP of ensuring sustainable forests and following the principles of the NEMP, as well as meeting international guidelines such as those stipulated in the UNCBD [1] and other restoration studies [8,25]. Having an FMP on the shelf and not approving it, such as the situation in Towa, may suggest a lack of capacity. Thus, we recommend the need to follow internationally agreed 'standards to help them develop high-quality plans and achieve acceptable ecosystem recovery outcomes'[8]. Other forest owners with FMPs ought to follow/implement those plans to operationalise the policy and achieve their broader visions.

Conclusions and Recommendation

From the interviews of 91 respondents living in communities around selected forest sites, we learned about their limited access to scarce forest ecosystem goods and services and their substitution with other resources which comes at a high cost to families with limited resources. Some ecosystem goods have available substitutes, while others do not. Communities are involved in planting exotic or native species in monoculture or mixtures or promoting passive restoration either by allowing natural regeneration or by planting permaculture systems, often with exotic perennials. Forest managers had broad FMPs which often were not implemented to comply with the NEMP, which was then rendered ineffective. As such, the ad hoc management of those forests is faced with challenges that limit the effectiveness of the operationalisation of the NEMP. Concerned communities would likely perform better restoration practices, but members find it difficult to access forest tree planting materials, information, and financial resources. The Government and NGOs supply either oil palm or fruit tree seedlings, but not the native forest tree species. Forest owners and managers report the challenges they have encountered as a result of these conflicting government development plans that limit the implementation of FMPs. Among other challenges is the taxation of 'idle' forest land. This implies that as the NEMP principles were streamlined into forest plans, the same ought to have happened with grassroots programmes and activities towards the operationalisation of the NEMP.

We conclude from our interviews that Bujjumba county (Buggala Island) forests are reduced in area and have been degraded to the point that they cannot provide adequate goods and services, which appear like a tragedy of the commons. The current FMPs are consistent with the principles of the NEMP and other international guidelines, but management systems and community practices have not been effective enough in reversing either the loss or the degradation of forests which testifies to the ineffectiveness of the operationalisation of the NEMP, thus resulting in a systems failure. Hence, there is a need to sensitise the community and forest management about restoration and conservation practices that meet livelihood needs and ensure the conservation of forest tree biodiversity. Such ecological restoration programmes would not only improve forest tree biodiversity conservation, but would also 'improve human livelihoods, empower local people, and improve ecosystem productivity' [5]. In addition, such programmes can involve efficient plant nurseries [12,22] to support both conservation and economic gains [24]. Such long-term programmes require participation, coordination, teamwork, collaboration, time, and funding. Since community members and forest managers have limited knowledge about details of the NEMP, their activities are not deliberately based on the NEMP although their plans follow the NEMP guidelines. Hence, such activities do not necessarily lead to the effective application of policy. Thus, community and forest managers need to be more aware of the NEMP guidelines and build an easy to use system-based instrument for monitoring activities towards the operationalisation of the NEMP.

From our primary and secondary data, we identified key indicators for developing a tool to monitor the effective operationalisation of the NEMP, and to inform policymakers and implementers. These indicators include:

Consistent government will and financing of conservation and restoration programmes [23]; ii) Coordination, collaboration and networking at local and international levels; iii) Involvement of all relevant sectors of society and disciplines, in planning, implementation and monitoring to ensure restoration and conservation of a diversity of species[67]; vi) Implementation of forest management plans; vii) Government harmonizes its development plans with community conservation plans; viii) Women's involvement in restoration and conservation programmes [68,69] 2007; ix) Conservation programmes empowering local people; x) Information sharing through appropriate channels; xi) Creating community awareness of NEMP principles; xii) Community committed to implementing the NEMP [23]; xiii) Relevant stakeholders fully aware of the full range of possible alternatives, opportunities, costs and benefits offered by restoration[5]; xiv) Presence of practices to enhance ecological integrity, e.g. mixed species stands [65]; xv) Affordable and accessible native and rare tree seedlings [5]; xvi) Government assigning designated extractive reserves; xvii) Community involved in forest policing; xviii) Enforcement of appropriate rules and sanctions; xix) Mixture of conservation strategies[55,57]; xx) Presence of national covenances for threatened tree species, e.g. innovative approaches such as "living collections and threatened trees" [70]; xxi) No cultivation in the forest [71]; xxii) No charcoal burning; (xxiii); Regeneration with previously rare and lost species; xxiv) Trees with height ≥5 m, and canopy cover ≥10% on area ≥0.5 ha ; (xxv) Future trees with DBH>50 cm [5]; xxvi) Development plans include education on both hidden and visible value of forests; xxvii) Readily available forest goods and services[19]; and xxviii) Distance to collect firewood<2 km.

To study this issue further, we propose a process of systems thinking as advanced by Jenny and Russel [72], and that future research should analyse the identified key indicators in order to develop a robust instrument that is easy to use for the continuous monitoring of activities that can be used to measure the effectiveness of the operationalisation of the NEMP. Systems principles offer a framework that allows policy planners and implementers to better understand and work with complex systems that constantly evolve and never attain equilibrium, such as the case of the Kalangala District landscape.

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Author Contributions

Conceptualization and writing, including original draft preparation, data curation -Stella Namanji
Methodology, validation, supervision, review and editing – Charles Francis, Charles Ssekyewa and Geir Lieblein Funding acquisition-Charles Francis, Charles Ssekyewa.

Ethical Approval

Ethical approval of this study was given by the ethics graduate committee IPV and the Norwegian University of Life Sciences graduate school, on April 14th 2015.

Conflict of Interest

We confirm that this study has no conflict of interest financial or otherwise.

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