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Impacts of Plant Invasive Species on Local Farming Communities around Mulanje Mountain Forest Reserve, Malawi

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ABSTRACT

This paper sought to examine the impacts of plant invasive species on communities living around the Mulanje Mountain Forest Reserve (MMFR). 30 respondents were selected using systematic sampling from five villages around the forest. The chi-square was used to test the hypothesis that the plant invasive species had no positive impacts on the local farming communities neighbouring the forest reserve. The findings indicated that plant invasive species had more of negative impacts on communities neighbouring the forest than positive impacts. The results showed that the communities identified reducing agricultural yields as the main threat followed by competition with medicinal plants and firewood. In terms of recommendations, education and awareness was found to be the key for addressing this issue.

1. Introduction

Globally invasive species are considered as the second greatest threat to biodiversity (Bellard et. al., 2016). Invasive species can survive, reproduce and spread unaided across an ecosystem causing detrimental effects on the healthy ecosystems (Van Wilgen & Van Wyk, 1999). Thus these species are termed as predators, competitors and habitat modifiers within an ecosystem (Strayer et. al., 2006; Vie et. al., 2009; McGeoch et. al., 2010; Sanu & Newport, 2010) as they colonize ecosystems within a short time. They are also known to deplete species diversity (Lenda et. al., 2013). For example, these species are responsible for the vulnerability and extinction status of vertebrates globally. The invasive species affect the achievement of the Sustainable Development Goals (SDGs) namely No. 1 on poverty reduction; No. 2 on zero hunger; No. 3 on ensuring healthy lives; No. 6 on availability and sustainable management of water; No. 9 on industry, innovation and infrastructure; No. 14 on aquatic ecosystems; No. 15 on terrestrial ecosystems; No. 16 on peace, justice and strong institutions and No. 17 on partnerships for the SDGs.

Invasive species are non-native (or alien) to the ecosystem and their introduction is so unique that it causes or is likely to cause economic or environmental harm (Nienhuis et. al., 2014).). Examples of IS include Tick bury Lantana camara L., Zebra mussel Dreissena polymorpha, Mexican Pine Pinus patula and the Himalayan yellow Raspberry Rubus ellipticus. Today all continents namely Europe, Africa, Asia, Australia North and South America are affected by these species. In the European Continent alone, invasive species both on land and in water increased by 76% from the period 1970 to 2010 (Butchart et. al., 2010). These species cause damage worth billions of dollars. For example in New Zealand the introduction of a pollinating wasp was accidentally done from Australia and it caused seed setting by the alien Morton Bay Fig tree (Shine et. al., 2000). In the Americas as the harsh winters of British Columbia begin, pine beetles become the conquerors of the British Columbian forests (Maness et. al., 2012). In Africa and Asia L. Camara and P. hysterophorus are amongst the fastest spreading IS from the Americas (Kohli et. al., 2004). They have had a devastating impact on some of the natural ecosystems of high value. In Kenya the L. camara has been devouring Karura Forest in the city of Nairobi (Shah & Irandu, 2015) and Lake Nakuru National Park in Nakuru town. L. camara is amongst the world's top ten plant species known for its fast spreading (Sharma et. al., 2005; Dobhal et. al., 2010; Bhagwat et. al., 2012). In India L. camara was introduced as a garden ornamental by the British colonists in 1807. Since then it has spread and covered much of Southern India (Kannan *et. al.*, 2013).

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According to a study conducted by Aravind et. al. in 2010 amongst the Soliga Community who are hunters and gatherers in the Malai Mahadeshwara Hills Wildlife Sanctuary of Southern Karnataka, the community has reported that they can no longer graze their cattle in the forest nor collect bamboo due to the density and spread of L. Camara. Japan being an island nation is severely affected by IS especially the cherry trees which have now begun to bloom early due to shorter winters and is an inconvenience to annual festivities and results in incurring economic expenditures (Maness et. al., 2012).

The forest ecosystem is one of the most affected in terms of lost revenues, in expenses for their control and in lost conservation values and ecosystem services. Richardson et. al. (2007) asserts that the most direct economic impact of alien IS on the forest sector is related to the loss or reduced efficiency of production. This in turn affects the surrounding communities as their livelihood depends on the forest ecosystems. For example the introduction of the salt cedar Tamarix spp. has led to loss in ecosystem services in the western USA which has been estimated at US$ 7-16 billion over a total of fifty-five years (GISP, 2001). According to a research carried out by Obiri in 2010 on invasive plant species and their disaster-effects in dry tropical forests and rangelands of Kenya and Tanzania, he found that invasive plants are a hazard in the tropical dry forests and rangelands of East Africa and result in increasing poverty amongst communities living around these ecosystems. Another study conducted by Pratt et. al. (2017) in Eastern Africa indicates that these species are a real threat to food security.

Malawi is facing a major disaster in terms of livelihoods due to the introduction of IS. According to Malawi's National Biodiversity and Strategic Action Plan (NBSAP), the country is highly prone to 29 IS due to its geographical position, tropical climate and agricultural based economy and also due to the country's heavy reliance on imported products. These species include 17 plants, 3 fish and 9 invertebrates. Some of the key IS in Malawi include Pinus patula, Himalayan Raspberry Rubus ellipticus, Bracken fern Pteridium aquillinum and blue gum Eucalyptus spp. (Government of Malawi [GoM], 2010). The water hyacinth is the most common and wide spread aquatic IS (Phiri et. al., 2001). Lantana camara is the threatening terrestrial alien species and is known to be the largest attacker of native vegetation in areas like the Majete Wildlife Reserve. In some cases the IS are specifically introduced on both land and in water. The best example is the new aquaculture push in Lake Malawi which is also known as the "Galapagos Islands of freshwater" because of its hundreds of cichlid species of endemic fish. These cichlid species have started to disappear fast because of the introduction of the Nile Tilapia which has affected the lake ecologically.

The objectives of this study were to identify the impacts of plant IS on the local farming communities around the Mulanje Mountain Forest Reserve (MMFR) in Malawi and to assess whether plant IS is of any valuable use to the local farming communities. In order to find a scientific answer to the identification of impacts of IS, this research focused on testing the null hypothesis which stated that IS have no positive impacts on local farming communities neighbouring the MMFR.

Mulanje Mountain Forest Reserve (MMFR) is situated in the far southeast corner of Malawi. It is the largest mountainous massif in the afro-montane archipelago ($15^0$75'S $35^0$38E) (figure 1). The massif itself is a huge syenite intrusion of 640km^2, rising steeply and abruptly from the south-central African plains to form a broad plateau of basins and deep river gorges at 1800m, and steep rocky peaks that reach 2800m.

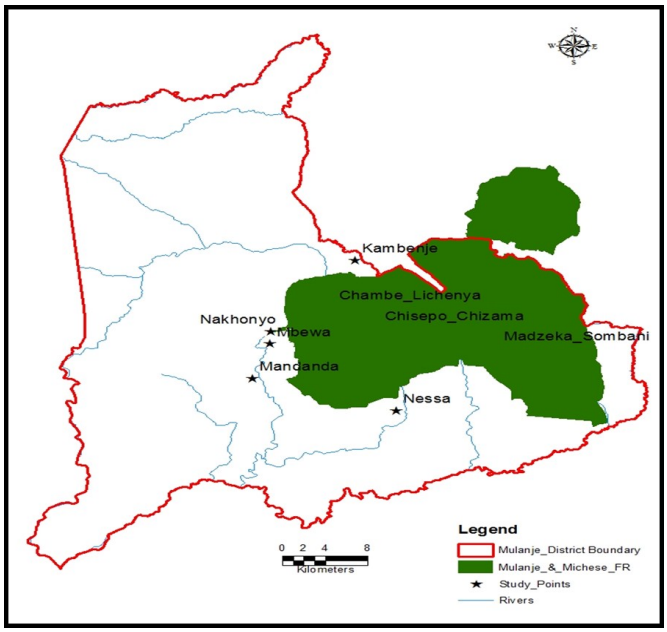

Figure 1: Map of Mulanje Forest Reserve and the sampling villages
Source: Makhambera and Shah, 2018

The forest reserve was gazetted in 1927. It is an ecological island of unique biodiversity as well as a critical water catchment area. It has rich and diverse flora and fauna including at least 30 endemic plants including the Mulanje cedar (a distinctive conifer and national icon tree of Malawi) which only grows to a full height of 40m on the mountain. MMFR experiences mean annual temperature of 20°C with an annual rainfall of 800mm. Mulanje Mountain boasts a variety of ecosystems - the Likhubula dry woodlands areas are unique with cycad species found nowhere else in the world. The Ruo River has tropical rain forest vegetation as it receives up to 100 inches of rain annually.

Mulanje Mountain Forest Reserve spans the two districts of Mulanje and Phalombe. There were an estimated 37,500 people living in 85 villages when this research was undertaken. Mulanje is considered a maize -deficit area that contains approximately 66% of the poorer households of the population. The outskirts of the mountain are mainly surrounded by tea estates and the majority of the local people attain their livelihoods by working in the tea estates.

2. Methodology

In terms of research design, the study used both the quantitative and qualitative approaches. Quantitative approach involved the collection of numeric data to get phenomena results of interest using bar graphs and percentages.

Qualitative approach was used to collect extensive narrative (non-numeric) data in order to get insights into the phenomena of interests like uses of the IS. It also included open-ended questions so that respondents could express their own views.

The study used primary data which was collected through the use of semi-structured questionnaires which were administered to community household heads to get their views on the impacts of IS, their uses and management solutions. It also used observations to know more about the use of the species and threats. Furthermore key informant interviews were conducted so as to get a clear knowledge of the IS with regards to origin and cause of their infestation, their benefits as well as their environmental impacts and the management systems applied so far and to get their perceptions about the IS and solutions. These key informants were purposively sampled and were used to collect data on social and ecological management on the IS. The key informants included the forest department (the district forestry officer for Mulanje District), Community Forest Management Committee (CFMC), the civil society such as the Mulanje Mountain Conservation Trust (MMCT) and other stakeholders with interest on Mulanje Mountain.

Out of 85 villages surrounding the forest, a sample of five villages namely Nakhonyo, Mbewa, Kambenje, Nnesa, and Mandanda were purposively selected for the study from the Eastern, Western and Southern part of the reserve so as to consider various sides of the reserve. They were selected based on their location, distance to the forest, population, farming communities and age of the villages (figure 2). To get the household respondents, systematic random sampling method was used whereby every 11th household was included in the sample. There were a total of 320 households in the five villages. A total of 30 respondents were selected from these five villages. Systematic sampling of respondents was done using a list of households which was obtained from the village headsmen. The distribution of respondents per village is shown in Table 1.

Table 1: Respondent distribution

Village	Total No. of Households	No. of households sampled
Nnesa	72	7
Kambenje	81	7
Mandanda	75	7
Nakhonyo	49	5
Mbewa	43	4
Total	**320**	**30**

Source: Makhambera and Shah, 2018

The data collected was both primary and secondary. Primary data was obtained from the community respondents through the use of standard questionnaires. The secondary data was obtained from the relevant United Nations websites, biodiversity country reports and UNEP publications. Journal articles were also used to check on threats and benefits of invasive species to local communities around protected areas. The main aim of the data collection was to identify the impacts of IS.

Data analysis was done using the Statistical Package for Social Sciences (SPSS). The questionnaire data was coded and entered into SPSS Computer package. It was then summarized using descriptive statistics such as percentages, frequencies, cross tabs and presented using graphs, tables and charts. The inferential statistics of chi -square was used to test the hypothesis that IS have no positive impacts on local farming communities neighbouring the MMFR.

3. Results and Discussion

In terms of the characteristics of the respondents, there were 18 (60%) women and 12 (40%) men. A total of 27 (90%) indicated that they were married while 3 (10%) stated that they were single. In terms of occupation, majority of them were in the farming business indicating that they understood the impact of the IS from the farmers point of view (figure 2).

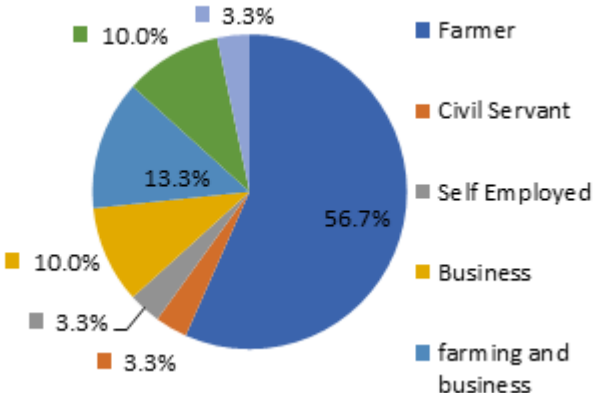

Figure 2: Occupation of respondents
Source: Makhambera and Shah, 2018

The majority of respondents which were 16 (53.4%) were aged between 31 to 60 years while 14 were in the age group of 21-30 years (46.6%). In the age group of 31-60 years, the majority which was 8 (26.6%) were in the cluster of 31-40 years. In terms of the education levels, majority – 22 (73.3%) had basic education, 3 (10%) had secondary while only 5 (16.7%) had no education. Data from the respondents was collected based on their knowledge in terms of their awareness of IS and whether the IS had any positive or negative impacts.

This research indicated that around the MMFR, 96.7% of the respondents were aware that there existed IS in comparison to 3.3% who stated that they were not aware. The invasive plant species found and known to the farming community around the MMNR are Eucalyptus terreticornis, Pinus patula, Mirabilis jalapa L, Lantana Camara L, Canna indica L, Rubus pinnatus wild, Datura innoxia Mill, Pistia stratiotes L and prosopis glanulosa Torr. This is in line with the Convention of Biological Diversity's (CBD) Article 13 on public education and awareness which the GoM has taken into account and in accordance has educated its citizens on the issues of IS.

In other developing countries which have paid attention to food security, people are aware of the IS. For India and Pakistan there is documented data on the awareness of the IS by the citizens.

The same is the case for Kenya, South Africa as well as parts of Ethiopia and Djibouti (Shackleton et. al., 2007). Furthermore, it is through this awareness that communities are using IS for their own benefits unlike in places where the knowledge is not there (Choge et. al., 2012).

3.1 Positive impacts of invasive species

As stated by Choge et. al. (2012), those aware of IS have been using them positively. This knowledge is making people benefit enormously and improve their livelihoods. When the positive impacts of the respondents were analyzed, the results indicated that IS were used as building materials, timber, medicine and firewood. Majority of the respondents used these species for medicine followed by building materials and firewood (figure 3).

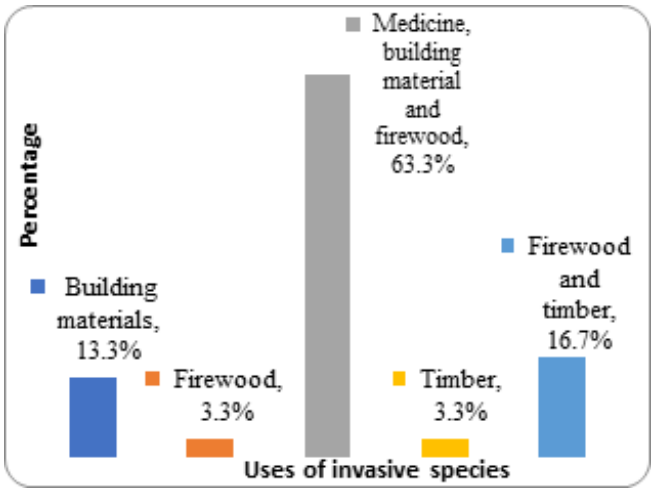

Figure 3: Positive impacts of invasive species on local communities
Source: Makhambera and Shah, 2018

When communities use the IS positively, it is very encouraging as this helps them to understand the species better. The use of IS for firewood is known around the Ranthambore Tiger Reserve in Rajastan, India. The local community has been using the IS prosopis juliflora as a source of firewood whereby they make charcoal and sell, thus generating income from the species (Alers et. al., 2007). Kenya has also undertaken research on the use of IS especially for firewood and charcoal production. The pilot project was conducted in two places - at the Muka Mukuu Cooperative Society in Machakos and the Elangate Wuas Game Ranch in Kajiado. The results indicated very high profits if IS were used (Ministry of Environment, Water and Natural Resources of Kenya (MEWNR) & Ministry for Foreign Affairs (MFA) of Finland, 2013). Furthermore, Food and Agricultural Organization (FAO) together with Kenya Forest Research Institute (KEFRI) have been working with Non-Governmental Organizations (NGOs) to utilize goods and services from IS. The prosopis is one good example where the local communities are encouraged to make prosopis flour and use it for human consumption (Choge et. al., 2006). Statistics by Choge et. al. (2002) show that in 2002 trade in Kenya for prosopis goods was worth US$ 122 per household in some villages in Baringo District while in 2012 in the same areas it was over US$ 1.5 million (Choge et. al., 2012). In spite of this benefit, 50-80% of the people in Baringo want the prosopis to be eradicated totally. At the same time there are plans to build a power station in Baringo to trap power from prosopis biomass (Choge et. al., 2012). This is a technology Kenya wants to borrow from India. Moreover, if IS were used instead of acacia species for firewood, environmental deterioration would be reduced. This has been proved by the use of eucalyptus trees which are grown as plantations and used for fire wood and charcoal. Similarly in Sudan, the National Forest Cooperation has also carried out research on the same and has found that IS are a valuable source of firewood and charcoal (MEWNR & MFA of Finland, 2013).

Besides having positive socio-economic values, they also have positive ecological values. Examples include pollinators which use IS as additional food as their habitats are greatly affected by disturbances (Williams et. al., 2011). The same is the case for herbivores which also feed on IS due to habitat disturbances (Bartomeus et. al., 2016). Another example includes the Capricorn Beetle which has adapted to feeding on the pedunculate oak Quercus robur (Oleksa & Klejdysz, 2017).

3.2 Negative impacts of invasive species

Most people associate IS with negative impacts. In this research the respondents indicated six impacts of IS which were reducing agricultural yields, damaging infrastructure, competing with medicinal and firewood trees and reducing tourism and water supply. Reducing agricultural yields had the highest negative impact (figure 4). This indicates that the communities living around the MMFR are greatly affected in terms of growing crops as the IS compete for space and do not allow the food crops to grow well. This is in line with what Howard and Matindi (2003) and McGeoch et. al. (2010) found out when conducting a research on the threats of IS in Africa. These species have been found to grow fast in soils rich in nutrients and tend to occupy any gaps in disturbed forests. The species destroy soil and during decay release toxic materials and prevent grazing from taking place. These plants are also found in agricultural fields and reduce yields for farmers. At the same time these species tolerate harsh conditions and grow fast (Wagh & Jain, 2015).

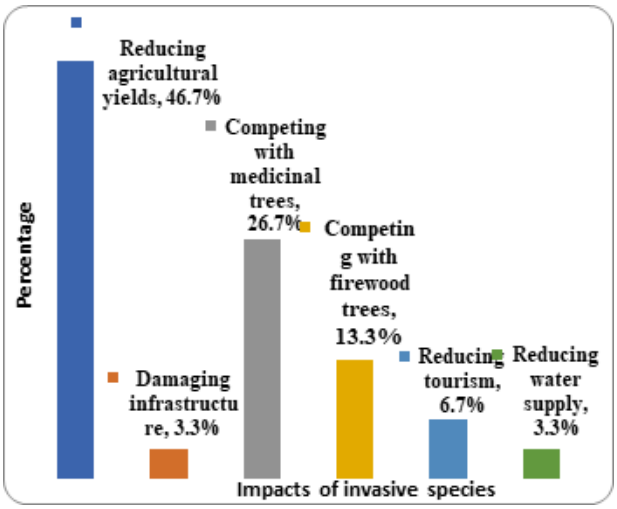

Figure 4: Negative impacts of invasive species on local communities
Source: Makhambera and Shah, 2018

The negative effects have also been highlighted in the research conducted by Moroń et. al. (2009), Vila et. al. (2011) and Lenda et. al. (2013) where they have indicated that these species affect natural ecosystems and take over the indigenous species and in turn affect the food chains. Moreover they also reduce species diversity and density (Ortega & Pearson, 2005). There is dominance of the IS over other species as indicated in the studies by Dogra et. al. (2009) on the Shivalak Hills in India. However in this study the negative impacts have been classified by respondents in terms of the socio-economic impacts.

Studies carried out by Osunkoya and Perret (2011) in Queensland, Australia and Simba et. al. (2013) in Nairobi National Park, Kenya have shown that the soil pH is very high in areas invaded by Lantana Camara. This indicates that the soils are no longer agriculturally productive. At the same time IS are known to increase the nutrient uptake from soil especially nitrogen and phosphorous and in turn reducing their uptake by other plants resulting in lower agricultural yields.

Research by Lui (2011) has shown that IS affect food for livestock as they compete with native plants and grow fast thus limiting food for herbivores. These herbivores avoid invasive plant species like Lantana as it is found toxic to some livestock and also has an unpleasant aroma. Moreover livestock as well as the wild herbivores do not find these species nutritious (Kamau, 1986). Kamau (1986) and Boutton et. al. (1988) found that the IS uptake by animals affects their digestive systems negatively and thus poor forage.

Research carried out by Kent and Dorward (2012) in the forests of Kambudikki, India have indicated that the IS has been a real economic challenge to the Soliga and Lingayat communities. These communities have been using the forests for cattle grazing and the bamboo for weaving baskets. However IS have been a threat to both cattle grazing and bamboo stocks have reduced due to competition. This has resulted in cattle becoming underfed and malnourished making them vulnerable to diseases and wildlife predators. Incomes have reduced as there is less bamboo for making baskets.

Researchers like Oleksa and Klejdysz (2017) in the United States of America have shown that IS have a huge negative impact on infrastructure. For example arundo donax giant reed which has tough fibrous roots penetrates soil. It is known to choke riversides and stream channels, increase forest fires and make frameworks of bridges, dams, roads and culvets very weak. It also competes with all native plants including medicinal (IS Advisory Committee [ISAC], 2016). Another destructive IS is the red oak Q rubra which was introduced in Europe from North America. This species spreads very fast as it begins to occupy rail tracks, road zones and any empty lands (Riepšas & Straigytė 2008; Woziwoda et. al., 2014a). Furthermore it has negative impacts on the forest biodiversity as its leaves turn acidic during decomposition (Woziwoda et. al., 2014b).

As shown in this research, IS have resulted in a fall out in the tourism industry and reduced food security. For example in Kenya the water hyacinth Eichhornia crassipes grows like a carpet and reduces sunlight and in turn affects water quality, recreational fishing and swimming. As both swimming and recreational fishing are reduced, tourism has been a big blow around Lakes Victoria and Naivasha (Waithaka, 2013). Another IS threatening tourism and endangering flora and fauna species is the mikania mikania micrantha. It is found in the humid tropical and sub tropical regions of the Pacific and Asia (Waterhouse, 1994). This species is very common in Nepal and is threatening protected areas like the Chitwan National Park, a UNESCO World Heritage Site. Research carried out by Murphy et. al. (2013) shows a correlation between mikania and the Indian rhinocerous Rhinoceros unicornis (greater one-horned rhinocerous) whereby this mammal has greatly declined in areas of mikania infestation.

The data collected in this research was further analyzed by testing the null hypothesis which stated that the IS have no positive impacts on local farming communities neighbouring the MMFR. Table 2 shows the results of the hypothesis tested using chi square.

Table 2: Results of chi square

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	0.599[a]	4	0.963
Likelihood Ratio	0.933	4	0.92
N of Valid Cases	30		

Source: Makhambera and Shah, 2018

The results indicate that the calculated chi of 0.599 is lesser than the critical thus failing to reject the null hypothesis which states that the IS have no positive impacts on communities neighbouring the MMFR. This finding concurs with the findings of most researches on IS. Research conducted by Sanu and Newport (2010) in the Indian Peninsular, Macharia et. al., (2010) in Central Kenya and Keller et. al. (2011) in Europe indicate that the IS have negative impacts on local communities. They all indicate a heavy loss in terms of food due to competition from these species resulting in food shortage. This is closely followed by impacts on the ecosystem like deficits in the water supply (Sanu & Newport, 2010).

Conclusion

This study concludes that the local farming communities around the MMFR associate IS with negative impacts on food security, infrastructure, damaging firewood and medicinal trees, reducing water supply and tourism. Very few people associate IS with positive impacts which include using them as medicines, building materials and firewood. With climate change, it is very difficult to eradicate IS completely. But mitigation is the key to addressing the issue of IS where people can be encouraged to use the IS for positive effects on the society. Education and awareness on IS is a key in overcoming threats caused by IS. Once people are aware, they would not spread the IS, at least knowingly through attractions like souvenirs. It is also very important to put the message of IS in schools through the official school curriculum so as to create a country wide education and awareness programme.

More stakeholders especially private and NGOs should be involved in spreading this message, help in conducting research, and developing innovative skills on how best the IS can be used like in Kisumu, Kenya where from the water hyacinth the local communities are making furniture, paper and coffins. A unique example is of the late Nobel Prize Laureate, Wangari Mathaai who, when she died was cremated in a coffin made of the water hyacinth! The aim is sound environmental practice and positive use of these species which can contribute to poverty alleviation. Malawi should also introduce strict regulations on IS especially in relation to transport, trade and tourism. The country should also develop national programmes whereby tree planting using indigenous trees is done and also poverty reduction strategies should indicate link between poverty alleviation and biodiversity conservation. Management plans of national forest reserves should also take IS into consideration under the issue of threats as outlined in the CBD Article 8h on prevention of IS.

In order to understand more about the impacts of IS, more data as well as the extent of the spread of invasive species at national level should be made available for research. At the same time there should be more funding dedicated to the eradication of the IS.

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