

## Review

## Management of invasive plant species in Nigeria through economic exploitation: lessons from other countries

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### Abstract

Invasive alien species, once they made entry into a region or country, often become difficult to eradicate and it appears that they have come to stay. Worse still, their adverse effects on the native biodiversity are enormous and they are considered ecologically harmful. Agricultural and economic losses to invasive species are comparatively high. Mechanical control is expensive and difficult in some terrains; chemical control is also expensive, requires constant application and has its environmental implications, while biological control is mirrored with mixed failures and successes. This paper reviewed that economic exploitation of some notorious invasive species in other countries – such as Sudan, Ethiopia, India, Senegal, Mali and the Gambia – and how this had helped reduce the spread of these invasives and at the same time, became source of income to the poor people. It is believed that adopting this concept in Nigeria will create incentives for harvesting invasive species with more commitment, while it is an indirect way of controlling them. Furthermore, harvesting could be labour intensive, thus creating jobs for people, while it provides additional means of income for rural people, which is a key adaptation strategy for climate change.

**Key words:** biological invasions; weed control; economic exploitation; utilization, bioresources; economic potential

### Introduction

Invasive alien species (IAS) are characterised by rapid growth rates, extensive dispersal capabilities, large and rapid reproductive output and broad environmental tolerance (Geesing et al. 2000). It is estimated that as many as 50% of invasive species in general can be classified as ecologically harmful, based on their actual impacts (Richardson et al. 2000).

Invasive species are found in all taxonomic groups and they include introduced viruses, fungi, algae, mosses, ferns, higher plants, invertebrates, fish, amphibians, reptiles, birds and mammals. They have invaded and affected native biota in virtually every ecosystem type, in all regions (Lowe et al. 2000). The number of documented invasive species per country ranged from 9 (Equatorial Guinea) to 222 (New Zealand). There was a total of 542 species that were documented as invasive aliens across the 57

countries examined, including 316 vascular plant, 101 marine, 44 freshwater fish, 43 mammal, 23 bird and 15 amphibian species (McGeoch et al. 2010). The prevalence of invasive species has gone beyond free areas and is now being reported in protected areas across the world. De Poorter et al. (2007) in his report was able to identify 487 protected area sites with IAS recorded as an impact or threat; 106 countries where protected area(s) have been recorded as having invasive species as an impact or threat; in all regions, but especially in Asia, Africa, South and Central America (including Mexico and the Caribbean and Europe) and 326 IAS recorded as an issue for protected areas. Furthermore, the report noted 277 Ramsar sites where invasive species are reported as a threat either from within the site or from within the catchment, as well as 27 World Heritage (WH) sites where invasion by IAS is already taking place (De Poorter et al. 2007).

## Impacts of IAS on biodiversity conservation, agriculture and the environment

### *Biodiversity and environment*

Biological invasions are considered as a key threat to biodiversity (Mooney and Hobbs 2000). Invasion by alien species cause extensive damage on the habitats they invade, which include impact on indigenous species diversity, soil nutrient composition, altering forest fire cycles and loss of productivity of invading ecosystems. It also becomes a threat to endangered or threatened plant species around the world (Pimentel et al. 2005). Invasive species are responsible for the homogenization of floras which causes a substantial threat to biodiversity and ecological integrity of native habitats and ecosystems (Hulme et al. 2003). Invasive species may cause changes in environmental services, such as flood control and water supply, water assimilation, nutrient recycling, conservation and regeneration of soils (GISP 2004; Levine and D'Antonio 2003). Invasive species may also affect native species by introducing pathogens or parasites that cause disease or kill native species (UNEP 2004).

### *Agriculture and economic losses*

Agricultural losses to invasive species are enormous in all parts of the world. For example, the cassava mealybug (*Phenacoccus manihoti* Matile-Ferrero) was accidentally introduced to the Democratic Republic of Congo in 1973. It rapidly spread causing yield losses of over 80% with an estimated cost to smallholders and subsistence farmers of US\$4.5 billion (Zeddies et al. 2001). Invasive alien species have caused losses worth US\$ 138 billion to the USA (Pimentel et al. 2000). The total economic losses caused by invasive alien species to China were to the tune of US\$ 14.45 billion, with direct and indirect economic losses accounting for 16.59 and 83.41% of total economic losses, respectively (Xu and Ding 2003). Based on eight major crops, Oerke et al. (1994) calculated 13% loss in the world's agricultural output due to weeds. In maize alone, an actual loss due to weeds from 1997-1999 was around US\$1.7 billion. Across Africa, invasive species in the genus *Striga* have a direct impact on local livelihoods, affecting more than 100 million people and as much as 40 per cent of arable land in the savannahs. The cost

of eradicating it is reportedly between US\$7-13 000 million annually (UNEP 2004).

Particular mention must be made of three IAS that have global attention in recent times:

*Chromolaena odorata* (Linn.) King and Robinson – noted as one of the world's 100 worst invasive species (Lowe et al. 2000). In Africa, it is known to be a problem in Benin, CAR, Congo, Côte d'Ivoire, DRC, Liberia, Mauritius, Nigeria, Senegal, South Africa, Swaziland and Togo. Leslie and Spotila (2001) explained how *C. odorata* affected the sex ratio and embryonic development of crocodiles in South Africa's Greater St. Lucia Wetland Park. The arrival and continuous spread of *C. odorata* in Nigeria has posed a serious threat to subsistent and commercial agriculture, where it is a major weed in young tree crop plantations (such as rubber, oil palm, cocoa and fruit trees), cassava, yam, banana, plantain and other important agricultural crops in southern and central parts of the country (Ivens 1974; Ogundola et al. 2007).

*Lantana camara* refers to a multi-taxon hybrid swarm created by horticulturists, beginning in the 18th century, augmented by hybridizations within introduced ranges (Sanders 2006). *L. camara* poisons cattle and destroys understorey species (IUCN/SSC/ISSG 2004). The thickets disrupt access of livestock to grazing and water, interfere with farming and forestry activities, and increase the intensity of fire. By encroaching onto pastures, they reduce the carrying capacity and productivity of agricultural land. *L. camara* is also a weed in a variety of crops, including coffee, coconuts, cotton, bananas, pineapples and sugarcane. Furthermore, the entire plant is toxic and ingestion of the leaves and fruit can poison cattle and sheep, exhibiting as increased sensitivity to sunlight. In some areas, *L. camara* thickets provides resting sites for adult *Glossina* flies and sites for larva position by *Glossina* spp. (Ng'ayo et al. 2005) either on the abaxial surface of leaves or along small twigs in the intertwining mass of branches. *Glossina* spp. (tsetse flies) is responsible for transmitting the parasitic trypanosomes such as *Trypanosoma brucei gambiense* Plimmer and Bradford that cause *nagana*, an animal form of sleeping sickness (trypanosomiasis).

South American water hyacinth, *Eichhornia crassipes* (Mart.) Solms, is termed the world's worst freshwater ecosystem weed. Almost all river bodies in Nigeria have been dominated by

water hyacinth. It now covers parts of Lake Victoria in Africa (Matthews and Brand 2004), many lakes and rivers in the southeastern United States (Schardt 1997), and various water bodies in Asia and Australia (Matthews 2004), often smothering native submersed vegetation. The water hyacinth mats also impeded water circulation, creating an ideal breeding ground in the stagnant water for malaria mosquitoes and the snail hosts of bilharzia. The cumulative effect of these impacts was a downturn in the region's economic productivity. The dense, floating mats of the plant reduces the water current or totally stagnates the river, and helps create habitat for *Anopheles* females to lay eggs and for the larvae of the dipteran vectors of *Plasmodium* spp., the causative agents of malaria (Merritt et al. 1992). The plants also create habitat for snails in the genera *Biomphalaria* and *Bulinus*, hosts for the flukes that cause schistosomiasis (bilharzia), and dipteran vectors (*Mansonia* spp.), of the nematodes that cause filariasis. The snails derive resting sites as well as food (algae and detritus) within mats of water hyacinth (Mitchell 1974 cited in Mark and Smith 2011). Ofulla et al. (2010), cited in Mark and Smith (2011) found that the vectors *Biomphalaria sudanica* Martens and *Bulinus africanus* Krauss were preferably attached to *Eichhornia crassipes* in Lake Victoria, even becoming attached to water hyacinth in greater numbers than to the native hippo grass (probably *Vossia cuspidata* Roxb.). Adults of several *Mansonia* spp. infect humans with the nematode *Brugia malayi* Brug, the causative agent of lymphatic filariasis (Roberts and Janovy 2009). Water hyacinth has also been implicated in harbouring the causative agent for cholera, *Vibrio cholerae* Pacini. Vast quantities of rotting water hyacinth, and consequent drops in dissolved oxygen, can also affect many aquatic animal species.

## A review of existing control methods

### *Mechanical control*

Mechanical control options include the physical felling or uprooting of plants, their removal from the site, often in combination with burning. The equipment used in mechanical control ranges from hand-held instruments (such as saws, slashers and axes) to power-driven tools such as chainsaws and brushcutters, and even to bulldozers in some cases. In South Africa, the

invasive Australian rooikrans tree (*Acacia cyclops* A.Cunn. ex G.Don) can be effectively controlled by mechanical means alone-cutting and pulling roots-so long as sufficient labour is available (Matthews and Brand 2004). Mechanical control is labour-intensive and thus expensive to use in extensive and dense infestations, or in remote or rugged areas (van Wilgen et al. 2001). In Nigeria, mechanical control of water hyacinth was estimated to cost US\$ 639 per hectare. (Kasulo 2000). It costs the Zambian government approximately US\$ 450 000 to clear 900 hectares of 3,000 hectares *Mimosa pigra* L. infestation on the Kafue Flats. The costs of clearing condensed stands of invasive *Prosopis* species, *Chromolaena* and *Lantana* in riparian vegetation in South Africa between 1997/98 and 2005/6 was about US\$310, US\$ 380 and US\$ 380 per hectare, respectively (Marais and Wannenburg 2008).

### *Chemical control*

Herbicides can be applied to prevent sprouting of cut stumps, or to kill seedlings after felling or burning. Herbicides can target, for example, grasses or broad-leaved species, leaving other plants unharmed. However, there are legitimate concerns over the use of herbicides in terms of potential environmental impacts. Although newer herbicides tend to be less toxic, have shorter residence times, and are more specific, concerns over detrimental environmental impacts still remain. The use of chemical control is often governed by legislation, and the effective and safe use of herbicides requires a relatively high level of training; both of these factors can restrict the use of chemical control on a large scale (van Wilgen et al. 2001). Many invasive plants have been kept at acceptable levels by herbicides. For instance, in Florida, water hyacinth was drastically reduced and subsequently managed by use of the herbicide 2,4-D, combined with some mechanical removal (Schardt 1997). Glyphosate is also another herbicide widely used for controlling invasive species globally. This is because it is a relatively non-toxic chemical that does not persist in the environment. Care must be taken during application to minimize effects to surrounding desirable vegetation. However, herbicide application in a large piece of land taken over by invasive species can be very expensive. Considering that thousands of hectares have been invaded by these and other weeds in Africa it is unlikely that

they will be controlled by mechanical and chemical means alone. Furthermore, the fears of environmental effects of herbicides are still valid.

### *Biological control*

Biological control has been defined as the use of living organisms to control pest species (Waage and Greathead 1988; Watson 1991). Biological control, instead of eliminating the target organism, aims at establishing an equilibrium which maintains its population at a level of negligible harm (Bani 2002). It has been practiced for many decades by a host of countries, especially the USA, Australia, South Africa, Canada, and New Zealand. In the past 150 years, until the end of 1996, more than 350 species of invertebrates and pathogens were deliberately released in 75 countries for the control of at least 133 weed species (Julien and Griffiths 1998). At a national level, success has been achieved in 83, 80 and 61% of biocontrol programmes in New Zealand (Fowler 2000), Mauritius (Fowler et al. 2000) and South Africa (Zimmermann et al. 2004) respectively. The main benefits of biocontrol are that the agents establish self-perpetuating populations throughout the range of the target weed, including areas which are not accessible for chemical or mechanical control; control of the weed is continuous; if successful, there are no negative impacts on the environment; the cost of biocontrol programmes is low relative to other approaches and just requires a once-off investment. It was also estimated that biocontrol agents present in South Africa have reduced the financial costs of mechanical and chemical control by more than 19.8% (US\$ 165 million) (Versfeld et al. 1998). Biological control has been completely successful in about 25% of all cases (McFadyen 1998) and is mired by series of failures. From literature studies, 9 significant successes of biocontrol were noted (Caltagirone and Doult 1989; Matthews and Brand 2004a; Zimmerman et al. 2001; Doult 1964), while 15 failures were also noted in various parts of the world (Cowie 2002; Hays and Conant 2006; Pyke 2008; Cronk 1989; Louda et al. 1997; US Department of Interior 1997; Lockwood et al. 2007; Pringle 2005; Cock and Holloway 1982; Uyi et al. 2009; Hubbs and Jensen 1984). This clearly shows that biological control, though environmentally friendly, has more failures than successes.

It is logical to conclude that the best way to control an invasive species is prevention. From personal experiences, once an alien species is introduced into a new area and it establishes itself and reproduces rapidly, it is almost impossible to eradicate such a species. Unfortunately, all the existing control measures have their limited successes, with their corresponding huge cost of implementation, adverse environmental implications and in most cases, require continuous exercise, hence continuous financial expenses. As a result, many Government institutions in developing countries have abandoned many invasive species control projects, much to favour of continuous spread of invasive species, which is also assisted by climate change processes. In recent times, some ecologists are beginning to include invasive species as part of the biodiversity of an area which needs to be conserved and managed sustainably.

### **“Eradication by Utilization”**

This phrase was first coined by Tessema (2012) to explain the economic exploitation of invasive species as a means of harnessing their economic potentials for meeting basic human needs and at the same time control its spread and possibly eradicate them. As unpopular as this concept seems, it is already being practised in many African countries and other developing countries, where the rural people, in short of basic amenities, were forced to start exploiting these invasive species, only to find out that these invasive species have somewhat better qualities than their indigenous species.

**Exploitation of *Prosopis juliflora*:** The case study of *Prosopis* as an invasive species in many of the developing countries has been widely reported. However, it was discovered that the wood is an excellent fuel, the timber is hard and compares favourably with finest hardwoods such as Teak and Mahogany (Pasicznik et al. 2001). The sweet nutritious pods are relished by all livestock and are made into different foods and drinks. Honey from the flowers is of high quality, the gum is similar to gum Arabic, barks and roots are rich in tannin, leaves can be used as mulch and the tree is a nitrogen fixer to the soil. The pods are used to make flour for cakes, biscuits and bread, pop syrup, coffee substitutes and animal feed in Ethiopia (Admasu 2008).

Collecting and crushing the pods was assumed to contribute to the reduction of seed load to the soil and minimize further spread of the invasion to new areas. From the sales of the prosopis pods, the local people obtained about 15,500 ETB (US\$1,550) while the cooperatives earned a profit of 17,000 ETB (US\$1700) from the sales to livestock feeders. In another report, Serkamo, Sedhafagae and Gelaladura cooperatives in Afar region, Ethiopia were able to clear 396 ha of land in one year between October 2004 and September 2005, sold 188,246 bags of charcoal and earned US\$ 113,176, and also created 233,509 days of labour opportunities for daily labourers in Ethiopia (Admasu 2008).

The reclaimed 396 ha of farmland from prosopis were cultivated and obtained good harvests of sesame, maize, fodder crops and vegetables (onions and tomatoes) both for household and income from cash crops, especially in Gelaladura Kebele. Other benefits of Prosopis for Ethiopian communities include the use of the trees as windbreak and the poles for fencing (Berhaur and Tesfaye 2006).

In Sudan, prosopis round wood is used for poles of various sizes for simple construction. The wood burns evenly and hot, as it has a high density and a calorific value estimated at 4,220 kcal/kg in young trees (Khan et al. 1986) which, of course, increases as the trees mature. Prosopis pods are also used in Sudan for livestock fodder (Abedelnoor et al. 2009). The pods were reported to contain between 9 – 17% proteins to 15 – 37% sugar (Oduol et al. 1986), while the flowers were regarded as valuable source of bee forage and honey has become the most widely derived food product from prosopis (Geesing et al. 2004).

Furthermore, Chandrasekaran and Swamy (2009) reported the invasiveness of prosopis in Tamil Nadu region of India. However, in exploiting the tree, charcoal produced from *P. juliflora* has been considered to be one the best in the region, thereby making it a lucrative business and contributing to source of livelihoods, while its harvesting and charcoal production in the area is labour intensive, which provides job for many of the people, most of whom lost their farms earlier to the *Prosopis* invasion.

It should be possible to take pressure off the native vegetation and to contain at least partially the prosopis spread (Geesing et al. 2004). It can be expected that the importance of pods as fodder supply will increase when natural conditions become harsher, seasonally and

locally. The collection and sale of pods has already become a profitable enterprise for local people in Ethiopia (Geesing et al. 2004).

The experience of USA, Paraguay, Argentina, South Africa, Sudan, Oman, Pakistan and Australia have already proved that it is very difficult or even impossible to fully eradicate prosopis using the available methods (Pasicznik et al. 2007; Victor et al. 2007). Particularly, in USA the unsuccessful eradication attempt took extensive efforts for almost a century (Pasicznik et al. 2007). The failure of extensive eradication efforts in many countries using the conventional control methods makes utilizing prosopis an effective strategy to control its spread. The same view is also supported by many researchers who investigated the prosopis problem (Mwangi and Swallow 2005; Pasicznik et al. 2007; Seboka 2009; Ryan 2011).

Typha grass for charcoal: typha grass, *Typha australis*, native to USA and Europe, found its way into African rivers over 20 years ago and within few years, more than 60% of lowland floodable agricultural areas have been invaded by typha grass in Northern Nigeria (Tanko 2007), in addition to major rivers in the region. Similar invasive potentials and environmental impacts of typha grass were also reported in other West African countries. However, mechanisms have been put in place in Mali, Senegal and the Gambia to convert typha grass to “green charcoal”. For example, in Senegal, typha is being harvested, dried and an estimate of 65,000 tonnes of charcoal can be produced from typha in a year, which serve 15% of charcoal demand in Senegal and reduces pressure on the forests (Hellsten et al. 1999), while it was estimated that this operation would save 3000,000 trees given the sales as 42,000 tons of typha charcoal (Caro et al. 2011). Projected jobs created from typha charcoal business ranged from 2,756 for the large scale production to 4,328 using the 3-barrel method, and another 2,607 jobs estimated to be created across all production methods in rural areas from harvesting alone (Practical Action Consulting 2009). Furthermore, the National Agricultural Research Institute in Gambia has produced a machine that can process typha grass stems into charcoal blocks, and this new venture has not become a source of employment to many people in the area (<http://www.agfax.net>). In rural areas of northern Nigeria, the dried stems are used for thatch in roofing or woven into mats.

It can be argued that using invasive species could contribute to their control while providing ecosystem services to poor rural communities. Commercial use of invasive alien plant species can contribute in uplifting the economic status of poor rural communities. For example, brooms made from *L. camara*, if well promoted, would find a highly susceptible market in the Thulamela Local Municipality in South Africa (Semanya et al 2012). Using invasive tree species such as *Eucalyptus paniculata*, and *Jacaranda mimosifolia* in charcoal production can create employment opportunities in communities. Similar to these findings, the utilisation of seeds of *Caesalpinia decapetala* (lubricant and soap) and *Ricinus communis* (lubricant) may reduce their dispersal capacity (Semanya et al. 2012). The same can be said for *Solanum mauritianum* where fruits (with seed) are pounded and fed to domestic doves. Leaves of exotic plants are usually green and available for most of the year (Albuquerque and Andrade 2002). Therefore, the continued nearly yearlong pressure being applied to evergreens such as *Rubus cuneifolius* (skin rash), *Nerium oleander* (ring worm) and *Senna didymobotrya* (STDs), through the medicinal usage of leaves, can inhibit their growth and eventually the ability of these species to spread (Semanya et al. 2012).

In the Lake Chad region, the prosopis forests extend more than 300,000 ha and have caused serious problems not only for farmers but also for fisherfolk, who can no longer move in the shallow waters of Lake Chad because the trees and roots impede the movement of boats (Geesing et al. 2004). The prosopis wood resource in the Niger side of Lake Chad was estimated to be 2.2 million cubic metres and the average yearly increment to be around 75,000m<sup>3</sup>. Boureima et al. (2001) predicted that that yearly sustainable gross return would be around €2.5 millions per year if this resource were traded on rural wood markets supplying major nearby communities: its exploitation would not only help contain the forests but would also cover the costs of clearing fields and even create additional income. In Niger, the authorities and policy makers have become aware that eradication is not feasible and that the prosopis resource is underexploited. The prosopis forest which was before considered threatening weeds, is today considered a resource whose exploitation can contribute to containing its uncontrolled spread and can also help mitigate rather than aggravate, the precarious food

situation, especially in times of severe drought and food shortage. These vast prosopis resource is still begging for utilization in Nigeria.

Furthermore, the invasive spread of typha grass (known locally as “Kachalla”) over the last 20 years along the water courses and subsequently the floodable lands (fadama) has been the single greatest threat to the local economy. Many of the local communities only began to notice typha in the late 1980s, but by 2000 more than 60% of low lying floodable agricultural lands had been taken over by typha grass (Tanko 2007). According to a DFID-JWL document, in 1985 only 12ha of farmland in Madachi village had been invaded by the grass, but by 2000 this figure had expanded to 216ha; roughly 80% of the fields hitherto under cultivation (Tanko 2007). On the average therefore, production dropped to around 20% of the land’s potential. Downstream of Madachi, along Marma Channel and around Nguru Lake, the general picture is much the same as typha covers an estimated 200km<sup>2</sup> of formerly arable land. Along some stretches of the Marma Channel, e.g. at Kirigidi and Matafari in Kirikasamma LGA, typha grass has taken over local farming and grazing land to such an extent that it now fills the horizon, as far as the eyes can see in every direction. Of course for most of the basin tracts of productive land once given over to wheat and rice cultivation are now totally swamped by typha. Some problems of the typha includes the provision of vast breeding ground for fresh water snails, mosquitoes and other insects, leading to increased incidence of diseases like bilharzias and malaria in humans and liver fluke in livestock. Moreover, typha provides a roosting place for flying crop-pests, like quelea birds, resulting in bird infestation and extensive crop damage, particularly rice, wheat and sorghum. In another development, the presence and invasion of typha is associated to the rise in the level of ground water tables causing potash intrusion of surrounding land, salising the soil and rendering it useless to farmers and grazers (Tanko 2007).

From previous studies on some of the invasive species identified in Nigeria and some other African countries, it was discovered that some of these species have remarkable significance in biofuel production, organic farming, medicinal plant research and herbal therapy, cover cropping, source of food and fodder (Table 1). Therefore, it is believed that if the potentials of these invasives are harnessed, they can change from being an ‘enemy crop’ to an economically

**Table 1.** Utilization potentials of selected invasive species in Nigeria.

S/N	Plant name	Uses
1	<i>Typha australis</i>	Typha grass in the Komadugu-Yobe Basin, Hadejia-Nguru wetland and on the Lake Chad can be harvested and processed to charcoal which could serve the domestic energy need of the northern Nigerian population and reduce deforestation in the region.
2	<i>Prosopis juliflora</i> Sw. (DC)	The charcoal potentials of the tree can be used in the Lake Chad region where the tree is becoming invasive, affecting fishing on the Lake.
3	<i>Chromolaena odorata</i>	As notorious as this invasive weed is, the potential of <i>C. odorata</i> in producing biogas has also been reported (Akinluyi and Odeyemi 1989). Nigeria can exploit this economic significance for bioenergy.
4	<i>Eichhornia crassipes</i>	Water hyacinth can be used to produce biogas, even than from agricultural wastes (El-Shinnawi et al. 1989). The remaining slurry can be used as liquid fertilizer (Bhattacharya and Kumar 2010). Water hyacinth is also good for bioremediation (Nigam 2002) and finds relevance in ethnomedicine and ethnoveterinary (Bhattacharya and Kumar 2010), paper production (De Groote et al. 2003) and laundry detergent (Hasan et al. 2006).
5	<i>Lantana camara</i>	<i>Lantana camara</i> as alternative to bamboo for making baskets (Singh et al. 2010) and brooms.
6	<i>Leucaena leucocephala</i> Lam.	The plant is used for firewood and making charcoal, as well as quality wood pulp in paper making. The leaves are ploughed into the soil to improve its fertility and also fed to livestock (Shelton and Brewbaker 1994).
7	<i>Nypha fruticans</i>	The plant is considered invasive in the mangrove forests of Nigeria. The plant yields alcohol even more than other crops (Hamilton and Murphy 1988). In Akwa Ibom, Nigeria, it was reported that the dry fruits were used as fuel to smoke-dry fishes, fruit decoction yields a dye for dyeing fishing nets, seeds are used to make earrings, necklaces, rings, keyholders and other products, while the leaves are used to make roofing mats, ceiling mats and hats which are sold to beach lovers (Udofia and Udo 2005). Nipa palm is also reported to yield high sugar juice (even more than sugar cane) which can be converted to ethanol as biofuel. Tapping nipa is labour intensive, so it can create a lot of jobs for the restive Niger Delta youths.
8	<i>Tithonia diversifolia</i> (Hemsl.)	The leaves are boiled and drunk to treat malaria. Evidence from other parts of the world suggests that <i>Tithonia</i> has been used for a wide variety of purposes which include as fodder; poultry feed, fuel and compost (Nill and Nill 1993).

friendly crop. *Chromolaena odorata* have been reported to be very effective in the production of biogas and also for carbon storage (sink), in addition to the fact that it is also processed to treat malaria and wound disinfection in Southwest Nigeria. One extensively studied aquatic exotic weed is water hyacinth; the plant has been utilized for various purposes such in the production of biogas, vermicompost, gibberlic acid, paper and insulation board and in the treatment of sewage and industrial effluents (Singh 1998). Water fern has been studied extensively and was discovered to be used as compost, mulch, paper pulp, livestock fodder supplement and for the treatment of sewage and effluent (Thomas and Room 1996). Table 1 illustrates the economic potentials of some of the identified invasive species in Nigeria.

Therefore, this paper calls for a paradigm shift in the controlling and management of invasive species wherever they exist. In Nigeria, since biological control efforts of 1970s failed, control of invasive species has been abandoned. Majority of invasive species control have been done by individuals whose farmlands were colonised by invasives, using chemical or mechanical control methods, most of which are ineffective. This is because most of them are peasant farmers who have little or no knowledge on the control of invasives. Therefore, this concept provides an opportunity to the country on another way of controlling these invasive species, learning from the experiences of other developing countries. Efforts should be made at discovering their inherent potentials and this should be harnessed into useful bioresources with huge economic gains for several

stakeholders in the value chain system. This concept of economic exploitation hangs on the fact that these invasive species have economic potentials in them which have not been harnessed for development. In other control methods, the farmers and other stakeholders see the invasive species as ‘enemies’ that must be eliminated, and often times, the efforts in doing this is not sustained. However, if the farmers and other stakeholders view the IAS from different perspective – as a species that can bring wealth – energy will be channelled into it. The control aspect of this concept is that as these invasive species are being harvested for use, their colonization, spread and invasiveness is being effectively controlled. As this becomes established in the region or country, demand for the species will likely increase and this also increases the rate of harvesting, further helping in their control.

The term positive utilization refers to the use huge biomass of such weeds for human –welfare purposes instead of destroying them either chemically or biologically (Chandrasekaran and Swamy 2009). There were many series of case studies in which invasive species in an area were harnessed for their economic potentials, some of which were illustrated here:

The economic exploitation of invasive species as one of the ways of managing them has a lot of advantages, which include the following:

1. There are incentives attached to the economic exploitation of invasive species, unlike other control methods that have no economic gain. As soon as all stakeholders involved see these species as bioresources and industrial raw materials, they will be highly dedicated to harvesting and utilization of the invasive species and indirectly reducing the invasive capacity of these invasive species;
2. The rate of control of these IAS will be faster than with other methods, because the more the harvesting, the more the source of income for the gatherers, and this motivate them for intensive harvesting of the species, leading to an increase in the rate of control;
3. Utilization of invasive species is a source of income to rural areas where they are in abundance and leads to diversification of income; this is a key adaptation strategy to climate change. Additional source of income from the utilization of invasive species will reduce further encroachment into protected areas and land use change;

4. National GDP and economic sector of a country will increase from this new economic activity and initiative;
5. Expenses incurred from the harvesting of the invasive species are compensated for in the economic utilization of the products;
6. The conservation and sustainability of native species and protected areas is guaranteed, as the pressure on the harvest of indigenous forest would be greatly reduced;
7. Through continuous harvesting, the spread and invasiveness of these IAS is curtailed.

### Questions on potential drawbacks

How do we commence on economic exploitation of invasive species? This will require exchange of ideas and information on the uses of these invasive species from other West African countries. In addition, an assessment of local knowledge on these plants from the rural dwellers that have been using these plants for local purposes should also be done. Furthermore, a Technical committee should be set up to identify the invasives that require urgent attention, determine the land area covered by these invasives, assess the environmental impacts, and the commercial gains that can arise from the use of these invasive species. Pilot projects should be undertaken in specific areas to ensure its environmental safety. All prospective stakeholders in this project should be identified and intensive trainings should be given to them, especially the communities. Policies need to be formulated to allow and guide the use of these invasive species. Intensive and regular monitoring and evaluation of the projects should be done, while community participation should be strongly incorporated.

What happens when the populations of these invasive species are used up? It should be noted that the major focus for these projects is the control and possibly, the eradication of these invasive species. Success is achieved when these invasives are used up as raw materials. However, considering the wide spread and colonization of invasives such as *Chromolaena odorata*, *Typha australis*, *Eichhornia crassipes* and *Prosopis juliflora* in Nigeria, it will take several years before they can be completely used up. Lands reclaimed from these invasive species can be occupied with farming, while the community participants – collectors and harvesters – can be empowered for farming these reclaimed lands.

## Conclusion

From the foregoing, it could be deduced that the management of invasive species is taking another dimension and is not business as usual. Through the adoption of this method – which is already in use in other countries – in Nigeria, controlling invasive species is moving from total destruction to socio-economic utilisation. This paper has been able to document the management and utilisation of invasive species in other countries, as lessons for Nigerian Government to lean and create an enabling atmosphere for the economic utilization of invasive species in Nigeria. This includes a policy change to allow for the economic exploitation of these invasive species. The economic potentials of some of the invasive species in Nigeria have been acknowledged. Rather than seeing invasive species as a burden, the Government should enable the people to explore the inherent potentials with opportunity for sustainable economic development and livelihoods. This would also include in addition to policy change, identification and training of all stakeholders in the value chain of the projected economic utilization of these invasive species. It is believed that as this concept had worked in other countries, it would also prove useful towards poverty alleviation, income diversification and adaptation to climate change effects in the affected areas.

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