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An Overview of the Economic Potential of Water Hyacinth [*Eichhornia crassipes* (Martius) Solms-Laubach] Plant for National Development: The need for adequate Information and Enlightenment in Nigeria

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Abstract
Water hyacinth, **Eichhornia crassipes** (Martius) Solms-Laubach, is a free floating aquatic plant that is regarded as the world's most noxious aquatic weed species. It is found in over 50 countries of the world. It causes practical problems for marine transportation by clogging creeks and lagoons, rivers, lakes, ponds, streams, dams and other freshwater bodies; and by clogging irrigation channels and canals. It also inhibits fishing activities and serves as micro-habitat for a variety of disease vectors such as malaria, schistosomiasis and lymphatic filariasis. Inspite of these disadvantages however, water hyacinth has a lot of practical uses and applications in the industry that could be harnessed for the economic development of the country. It can be used for making paper, fibreboard, furniture, basket and other handicrafts. It can also be used for making fertilizer, for water purification and for biogas production. More importantly, it can be used as a vital feed resource for feeding fish and poultry. Hence, there is the need for adequate information and enlightenment for the Nigerian populace in order to sensitize them on its potential uses so that its benefits can be fully harnessed.

Key words: *Water hyacinth, national development, information, enlightenment.*

Introduction

Water hyacinth, *Eichhornia crassipes* (Martius) Solms-Laubach, is a free floating aquatic weed species with broad leaves; and beautiful, purple or lilac-blue, lily-like lavender flowers. It first made its entry into the Nigerian waters via the Southwest coastal border town of Badagry around September, 1984 (Oso, 1988). It is called "Blue Devil" or "Benghal Terror" in India, "Florida Devil" in South Africa, "German Weed" in Bangladesh and "Water Terror" by fishing communities in creeks and lagoons of South Western Nigeria; and is to be found in over 20 out of the 36 states of the Federation, including the Federal Capital Territory (Bolorunduro, 2002). It is called with different names by different tribes and ethnic groups in Nigeria: Dan gayé (in Hausa), Osibàtà (in Yoruba) and Nakuta (in Nupe).

Internationally, it is regarded as the world's most invasive aquatic weed species because of its devastating effects on aquatic ecology causing great damage to agriculture, fisheries, transportation and navigation; it has also caused damage to the aquatic population, tourism and the environment. It has prolific growth spreading to over 50 countries of the world including USA, China, Argentina, Brazil, India, Sri Lanka, Indonesia, Thailand, Philippines and Egypt; It has also spread to Sudan, Congo, Malawi, Kenya, Uganda, Rwanda, Burundi, South Africa, Tanzania, Zimbabwe and Australia. In short, it has become a world menace. In China alone, water hyacinth grows in 17 provinces and has become a bio-disaster. It is estimated that each year, more than 100 million RMB Yuan (equivalent of 12 million US dollars) is spent on control of water hyacinth throughout China, yet the weed remains vigorous and continues to spread. The weed causes damage in more than 10 provinces while great damage has been reported in five provinces: Yunnan, Guangdong, Zhejiang, Fujian and Taiwan (Jianqing *et al.*, 2000). In Vietnam, it is found in large population in Mekong and Saigon River, spreading to the local communities in the hinterland.

However, the greatest challenge today lies in developing water hyacinth from its menace status into an asset of national value; by seeing the plant as an opportunity instead of a problem. According to Abdel-sabour (2010), the real challenge is not how to get rid of this weed but how to benefit from it and turn it into a crop.

Scientific classification of water hyacinth

Kingdom:	*Plantae*
Phylum:	*Magnoliophyta*
Class:	*Liliopsida*
Order:	*Liliales*
Family:	*Pontederiaceae*
Genus:	*Eichhornia*

Species

E. azurea – Anchored Water Hyacinth
E. crassipes – Common Water Hyacinth
E. diversifolia – Variableleaf Water Hyacinth
E. paniculata – Brazilian Water Hyacinth

Botany of water hyacinth

According to Gopal (1987), *Eichhornia crassipes* is a free-floating aquatic macrophyte growing generally to 0.5 m in height but to nearly 1 m in height in some Southeast Asian locations, forming dense, floating mats. As a free-floating plant, all its nutrients come from the water column (Sculthorpe, 1985). The leaves are thick, waxy, rounded, and glossy and rise well above the water surface on stalks. The leaves are broadly ovate to circular, 10-20 cm in diameter, with gently incurved, often undulate sides. Leaf veins are dense, numerous, fine and longitudinal. Leaf stalks are bulbous and spongy (Gopal, 1987). The inflorescence bears 6 - 10 lily-like flowers, each 4 - 7cm in diameter. The stems and leaves contain air-filled tissue which give the plant its considerable buoyancy (Herfjord, Osthagen and Saelthun, 1994).

Generally, water hyacinth has dramatic lavender flowers and shiny green leaves which makes it highly prized as an ornamental plant. The flowers are borne terminally on a lavender spike on an elongated peduncle and are subtended by two bracts. The lower bract has a distinct blade. Each spike has 4-25 flowers (maximum 35) with 8-15 being the most common. The fruit is a thin-walled capsule enclosed in a relatively thick-walled hypanthium developed from the perianth tube. Mature seeds can number 450 per capsule, are 4 x 1 mm, with an oval base and tapering apex. The coat has 12-15 longitudinal ridges.

Eichhornia crassipes can tolerate extremes of water level fluctuation and seasonal variations in flow velocity, extremes of nutrient availability, pH, temperature and toxic substances (Gopal, 1987).

Proximate and mineral composition of water hyacinth

Proximate analysis of water hyacinth leaf by various authors show large variations in its composition. It has crude protein content of 14.2 %, 22.8 % or 13.57 % ; crude fibre content of 20.4 %, 15.0 % or 21.6 %; ether extract, 3.30 %, 4.82 % or 4.49 %; ash, 27.2 %, 12.4 % or 2.71 %; and nitrogen-free extract (NFE), 24.6 %, 30.30 % or 47.33 % (Igbinosun and Talabi, 1982; Fasakin, 2002 and Konyeme *et al.*, 2006 respectively). Foliar analysis for mineral nutrients revealed that calcium, magnesium and potassium ranged from 1.7 to 2.7 %, 0.4 to 1.4 %, and 2.6 to 4.5 % respectively. Phosphorus and sodium were less than 1 %. Crude protein and energy contents varied from 14.6 to 17 % and 3.6 to 3.9 kcal/g dry weights respectively (Sharma and Edem, 1988).

Problems of water hyacinth

Water hyacinth grows in mats up to two metres thick which can reduce light and oxygen, change water chemistry, affect flora and fauna and cause significant increase in water loss due to evapotranspiration. It has been found to tolerate salinity levels up to 0.24 % in Indonesia (Kikuchi *et al.*, 1997) and so causes practical problems for marine transportation, fishing and at intakes for hydropower and irrigation schemes. According to Practical Action (2008), some of the problems of water hyacinth include:

(i) Hindrance to water transport

Access to harbours and docking areas can be seriously hindered by mats of water hyacinth. Canals and freshwater rivers can become impassable as they clog up with densely intertwined carpets of the weed. In Nigeria, ferry service operators, boat operators and other river raft users are counting their losses as they are finding it difficult to navigate safely in the water bodies of Lagos. According to a report by THIS DAY newspaper of 21 October, 2010, some boat operators expressed dismay that the Federal Government has not done anything tangible to address the problem of water hyacinth in the country, especially in Lagos. "The losses we have incurred are enormous. My brother, I cannot count in naira and kobo what I have lost since the water hyacinth invaded our waterways. You can see it yourself. We can't operate the way we ought to operate. You have to stop intermittently to remove them from the propellers of the engines. Otherwise, you will be stuck in the middle of the sea if the engine fails as a result of the weeds and other debris in the waters."

(ii) Clogging of intakes of irrigation, hydropower and water supply systems

Many large hydropower schemes are suffering from the effects of water hyacinth. The Owen Falls hydropower scheme at Jinja on Lake Victoria is a victim of the weeds rapid reproduction rates and an increasing amount of time and money has to be invested in clearing the weed to prevent it entering the turbine and causing damage and power interruptions. Similarly, water hyacinth is now a major problem in some of the world's major dams – the Kariba Dam which straddles the Zambia-Zimbabwe border on the Zambezi River and feeds Harare has pronounced infestations of the weed. Blockage of canals and rivers causes flooding.

(iii) Micro-habitat for a variety of disease vectors

The diseases associated with the presence of aquatic weeds in tropical developing countries are among those that cause the major public health problems: malaria, schistosomiasis and lymphatic filariasis. Added to that, water hyacinth may harbour water snakes and other dangerous creatures, like crocodiles, which hide in its clusters, thereby constituting danger to life (Practical Action, 2008).

(iv) Increased evapotranspiration

Various studies have been carried out to ascertain the relationship between aquatic plants and the rate of evapotranspiration compared with evaporation from an open-surfaced water body. Hertford, Osthagen and Saelthun (1994) suggests that the rate of water loss due to evapotranspiration can be as much as 1.8 times that of evaporation from the same surface but free of plants. This has great implications where water is already scarce.

(v) Problems related to fishing

Water hyacinth can present many problems for the fisherman. Access to sites becomes difficult when weed infestation is present, loss of fishing equipment often results when nets or lines become tangled in the root systems of the weed and the result of these problems is more often than not a reduction in catch and subsequent loss of livelihood. In areas where fishermen eke a meagre living from their trade, this can present serious socio-economic problems.

(vi) Reduction of biodiversity

Where water hyacinth is prolific, other aquatic plants have difficulty in surviving. This causes an imbalance in the aquatic micro-ecosystem and often means that a range of

fauna that relies on a diversity of plant life for its existence will become extinct. Diversity of fish stocks is often affected with some benefiting and others suffering from the proliferation of water hyacinth.

Control of water hyacinth

Water hyacinth is a prolific plant with phenomenal breeding rate such that 10 plants can multiply vegetatively to 600,000 plants and virtually carpets an acre (0.40 hectare or 4046m^2) of water in only 8 months (Khan and Thyagarajan, 1988). In one observation, two parent plants produced 300 offsprings in 23 days and 1,200 within 4 months! If it chooses to propagate sexually with seeds, it can produce seeds varying from a few to as many as 5,000 per plant-with the seeds remaining viable for at least 15 years! (Khan and Thyagarajan, 1988). Hence, it is a very prolific weed species that has spread to the tropical and subtropical regions of the world colonizing natural lakes, rivers, water courses, man-made impoundments, irrigation channels and dams.

Three major methods are normally employed in the control of water hyacinth: these are mechanical clearance, chemical control and biological control.

(i) Physical control

Mechanical removal of water hyacinth is carried out using land-based 'clamshell' bucket cranes, draglines or booms or, alternatively, using water-based machinery such as mowers, dredges, and barges or specially designed aquatic weed harvesters. Such methods are suitable for only relatively small areas. Also, many of these techniques require the support of a fleet of water and land-based vehicles for transporting the large quantities of water hyacinth which is removed.

(ii) Chemical control

The common herbicides used are 2, 4-D (2, 4-dichlorophenoxyacetic acid), Diquat and Glyphosate (N-[phosphonomethyl] glycine). The application of glyphosate in Abiala Creek in Delta State, Nigeria, for example, killed mats of water hyacinth in the treated plots within seven days of treatment (Olaleye and Akinyemiju, 1996). 2, 4-D applied at ranges of 1-12 kg/ha, generally by aerial spray especially if applied during hot weather, has proved the most effective chemical control (Gopal, 1987). The main concern when using herbicides is the environmental and health related effects, especially where people collect water for drinking and washing.

(iii) Biological control

Biological control is the use of host-specific natural enemies to reduce the population density of a pest. Of particular interest in the control of water hyacinth plants is the *Cercospora piaropi (*or *Cercospora rodmanii)* discovered in the Rodman Reservoir in Florida, USA. It is an effective fungal pathogen which had been used as a mycoherbicide in the biological control of the weed in USA (Tessmann *et al.*, 2001). Also, six arthropod species had been released around the world: five are insects (two weevils, two moths and a sucking bug), and one is a mite. The two weevils are *Neochetina eichhorniae* and *Neochetina bruchi*; the two moths are *Niphograpta albiguttalis (*synonym *Sameodes albiguttalis)* and *Xubida infusellus*; the mite is *Orthogalumna terebrantis*; and the bug is *Eccritotarsus catarinensis*. One major drawback of this control measure is that it can take several years for the predator population to reach a population density sufficient to tackle the pest problem.

Economic potentials and practical uses of water hyacinth plant

In spite of all the integrated control efforts the world over, water hyacinth is still a world menace, and is spreading into new regions at an alarming rate. Perhaps, the best solution to the water hyacinth problem lies in developing it from its menace status into an asset of national value; by seeing the plant as an opportunity instead of a problem. According

to Abdel-sabour (2010), the real challenge is not how to get rid of this weed but how to benefit from it and turn it into a crop.

Water hyacinth is known to have several practical applications and uses in the industry that when fully developed could contribute tremendously to the economic development of this country. According to Practical Action (2008), some of the economic benefits of water hyacinth include the following.

(i) Paper

The water hyacinth fibre alone does not make a particularly good paper but when the fibre is blended with waste paper or jute, the result is good. The pulp is dosed with bleaching powder, calcium carbonate and sodium carbonate before being heated. Similar small-scale cottage industry papermaking projects have been successful in a number of countries, including the Philippines, Indonesia, and India.

(ii) Fiberboard

Another application of water hyacinth is the production of fiberboards for a variety of end users. The chopped water hyacinth stalks are reduced by boiling and then washed and beaten. The pulp is bleached and mixed with waste paper pulp and a filter agent such as china clay and the pH is balanced. The boards are floated in a vat on water and then finished in a hand press and hung to dry. The physical properties of the board are sufficiently good for use on indoor partition walls and ceilings. Investigations into the use of bitumen coated boards for roofing are underway.

(iii) Yarn and fibre

Fibre from the stems of the water hyacinth plant can be used to make rope. The stalk from the plant is shredded lengthwise to expose the fibres and then left to dry for several days. The rope making process is similar to that of jute rope. The finished rope is treated with sodium metabisulphite to prevent it from rotting. In Bangladesh, the rope is used by a local furniture manufacturer who winds the rope around a cane frame to produce an elegant finished product.

(iv) Furniture and basket making

In the Philippines, water hyacinth is dried and used to make baskets and matting for domestic use. The key to a good product is to ensure that the stalks are properly dried before being used. If the stalks still contain moisture then this can cause the product to rot quite quickly. In India, water hyacinth is also used to produce similar goods for the tourist industry using traditional basket making and weaving skills. In Vietnam, water hyacinth vine is woven around a wood and rattan frame to produce furniture that is very durable and easy to maintain which are then exported to EU countries generating millions of Dollars as revenue every year.

(v) Charcoal briquetting

Eden (1994) considers the requirements for large-scale production of charcoal briquettes from the pyrolysis of water hyacinth. He states that with an energy density of 8.3 GJ/m^3, this would be comparable to the energy density of charcoal at 9.6 GJ/m^3. However, for a plant to produce 40 tonnes per day of briquettes, an area of 12 hectares would be required for drying the water hyacinth; 1,300 tonnes of wet hyacinth would be required daily and the climate would need to be one of low humidity and relatively high temperature.

(vi) Biogas production

This process is one of anaerobic digestion which takes place in a reactor or digester (an air tight container usually sited below ground) and the usable product is methane gas which can be used as a fuel for cooking, lighting or for powering an engine to provide shaft power. The residue from the digestion process provides a fertiliser rich in nutrients. A study was carried out in India with quantities of up to 4000 litres of gas per tonne of semi dried water hyacinth being produced with a methane content of up to 64 % using a mixture of animal waste and water hyacinth (Gopal, 1987).

(vii) Water purification

Water pollution is one of the biggest problems in the world today; and it has been established that water hyacinth can be used to aid the process of water purification either for drinking or for liquid effluent from sewage systems. In sewage systems, the root structures of water hyacinth provide a suitable environment for aerobic bacteria to function. Aerobic bacteria feed on nutrients and produce inorganic compounds which in turn provide food for the plants. The plants grow quickly and can be harvested to provide rich and valuable compost. Water hyacinth has also been used for the removal or reduction of nutrients, heavy metals, organic compounds and pathogens from water in bioremediation (Gopal, 1987).

(viii) Fertilizers

Water hyacinth can be used on the land either as a green manure or as compost. As a green manure, it can be either ploughed into the ground or used as mulch. According to Singh (1997), compost made from water hyacinth contains 2 % N, 0.65 % P_2O_5, 0.6 % K_2O and 2.73 % CaO; and this has been found to be nearly twice as rich as town compost and four times as rich as farmyard manure from cattle. In developing countries where mineral fertilizer is expensive, it is an elegant solution to the problem of water hyacinth proliferation and also poor soil quality. In Sri Lanka, water hyacinth is mixed with organic municipal waste, ash and soil, composted and sold to local farmers and market gardeners.

(ix) Animal fodder

Sun-dried water hyacinth plant mixed with cowpea and groundnut stubbles at 40 % inclusion level have been fed to growing West African Dwarf goats with good results (Dada, 2002). In China, pig farmers boil chopped water hyacinth with vegetable waste, rice bran, copra cake and salt to make a suitable feed for swine. In Malaysia, fresh water hyacinth is cooked with rice bran and fishmeal and mixed with copra meal as feed for pigs, ducks and pond fish. However, the high water and mineral content mean that it is not suited to all animals.

(x) Fish feed

The Chinese grass carp is a fast growing fish which eats aquatic plants. It eats submerged or floating plants, including water hyacinth, and will eat up to 18 – 40 % of its own body weight in a single day. It reaches up to 32 kg in weight (Gopal, 1987). Konyeme *et al.* (2006) used water hyacinth leaf meal as a fish feed to replace up to 40 % of fish meal in the diet of *Clarias gariepinus* fingerlings with no significant ($P>0.05$) difference in weight gain between the control and the test diets.

(xi) Feedstuff for livestock

Water hyacinth leaf meal has been found to be of nutritive value in the diet of eight-week Tegal ducks when fed whole and when fermented with *Aspergillus niger*; though fermentation with *Aspergillus niger* increased the crude protein digestibility, true metabolizable energy and nitrogen retention, but not for crude fibre digestibility, for the ducks.

Similarly, in a research study by Malik (2013), it was found that water hyacinth meal can be included up to 10 % in the diets of pullet chicks (replacing 50 % of wheat offal), without the addition of any exogenous enzymes, for optimum growth performance and nutrient utilization. Hence, a noxious weed that is a nuisance to everyone, with millions of Dollars spent every year towards its eradication can now be converted into an important feed resource for poultry.

Future prospects for water hyacinth

It is envisaged that in the future years ahead; this weed would be of immense use to the pharmaceutical industries. Also, it would be a vital resource in biotechnological research; for use in biofuel generation, as well as an essential material in the field of genetic engineering. For now, it could be termed a wonder plant whose full potential is yet to be realized. Hence, prospecting into the usage of water hyacinth could be a revenue earner to the economy of the country.

Conclusion

Water hyacinth is the world's most noxious aquatic weed species, spreading rapidly round the whole world due to its high prolificity. Despite causing great damages to aquatic ecology, tourism and the environment, it has a lot of economic potentials which when harnessed could contribute meaningfully to the economic development of the country. If efforts are made by both the government and private sector to develop more efficient ways of harvesting and processing the plant using technologies that are cheap, readily available to the local populace and are environmentally-friendly, it would be a great crop. Nigerian populace needs to be given more education and enlightenment on its practical uses so that its potentials will be fully harnessed.

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