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Evaluation of low cost cage construction materials in el-Rahad Lake northern Kordofan - Sudan

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Abstract
An experiment was conducted by using "Canna" stick *Oxytenanthera abyssinica* as a locally available material for fish cages construction and to evaluate the benefits and performance in the water body of El-Rahad Lake "Torda" in Northern Kordofan-Sudan. Stalks plant of "Canna" were shaped the frame of three fish cages of 1.2×1.2×1.2m in size (fish cages type "A"), compared with another set of three fish cages with the same size made of iron frame considered as a control cage type (fish cages type "B")."El-Taror" shine (Aeschynomeneela phroxylon) used as a floaters in both cage types. The results of the study showed that the possibility of using "Canna" for external frameworks of fish cages and a validity of "Canna" sticks in water in good condition for more than 70 days, as the study indicated a well efficiency of "Canna" sticks in carrying the changing of the environmental factors as winds, waves, water currents, relative humidity, solar radiation during the study period, with the necessity of a good hedge in installed sticks of "Canna" together. Moreover, the study showed a significant low cost (P<0.05) of constructing fish cage from "Canna" sticks and "El-Taror" shine as a locally available material (200SP), compared with the cost of construction of iron made cage frame (310SP). The study notes the wonders of the local fishermen and residents in the region with the idea of owning a small fish cage made from locally available materials to breed and produce tilapia fishes.

Keywords: Fish cage, construction materials, wooden materials, metal materials, low cost benefits

1. Introduction
Fisheries and aquaculture make crucial contributions to the world's wellbeing and prosperity [1]. In the last five decades, world fish food supply has outplaced global population growth, and today fish constitutes an important source of nutritious food and animal protein for much of the world's population. Today, Fish farming is the world's fastest growing sector of food production, currently accounting for nearly 44.1 percent of total production from capture fisheries and aquaculture in 2014, up from 42.1 percent in 2012 [1].
Cage culture is an important technology to increase fish production. A widespread and profitable culture of fish in cages has already been developed successfully in Asia, Europe and America. This technique in South-East Asia first started from late 1800s, since then, many countries in this area were practicing cage culture in freshwater and marine environments, including open sea, estuaries, lakes, reservoirs, ponds and river [2].
Cage culture Technologies has grown rapidly during the past decades and is presently undergoing swift changes in response to pressures from globalization and an escalating worldwide global demand for aquatic products. There has been a move toward clustering existing cages as well as toward the development and use of more intensive cage-farming systems. In Africa, fish culture production increased by 56 percent in volume and more than 100 percent in value between 2003 and 2007 [3]. This growth was due to increasing prices for aquatic products along with the emergence and spread of small and medium enterprises, and to a significant investment in cage culture accompanied by the expansion of larger commercial ventures, some producing high-value commodities for overseas markets [3].
Fish culture by using existing water resources with confines fish inside some type of mesh enclosure been practiced since before. The mesh retains the fish, making it easier to feed, observe and harvest. The mesh also allows the water to pass freely between the fish and surrounding water resource, thus maintaining good water quality and removing wastes [4].
Today fish cage culture is receiving more attention by both researchers and commercial producers.

Factors such as increasing consumption of fish, some declining wild fish stocks, and a poor farm economy have produced a strong interest in fish production in cages [5].

The advantages and disadvantages of fish cage culture is adjudged by its comparative performance with other land based culture systems in terms of level of technology required for construction, ease of management, adaptability, quality of the fish reared, resource use, social implications, and economic performance [6].

Globally, fish cage frames have been constructed from wood, polyvinyl chloride (PVC) pipe or galvanized iron with flotation provided by Styrofoam, PVC pipe or plastic bottles[7]. Generally in Africa, fish cages built from locally available materials and stocked with local fish that are fed local feeds are used for tilapia culture [8].

Weather and shelter are important considerations in determining the suitability of a site for cage culture as they could have impact on both the cage structure and enclosed fish [9]. Cage made from a locally available material such as reed or bamboo and nettings enable poor people to breed fish, providing families with a protein-rich diet and a way to generate vital income [9]. Also fish cage frames made from bamboo poles is cheaper and readily available, easy to maintain and replace, easily to dispose, and has no threats to the environment [10].

In North Kordofan state, the supply of fish currently depends largely on the other states and very little production from local water sources. The local water sources are not efficiently utilized in fish farming. So fish cage system within the water bodies seems to be the most suitable culture system for North Kordofan.

For these purposes therefore, the objective of this study was designed to evaluate the cost effectiveness of using "Canna" as a locally available material to construct low cost fish cage in El-Rahad Lake against metal materials.

2. Materials and Methods

This study were conducted in El-Rahad lake "Torda", located in latitude 12° 44' N, longitude 30°38' E, about 253km west the White Nile River in North Kordofan state (Sudan), maximum water depth is 6m, surface area reached 3500ha, storage volume 85million m³, surrounded by fruit gardens. This "Torda" is considered to be the biggest surface water basin in the state (Image I).

Image 1: A Satellite image of El-Rahad Lake, North Kordofan (Sudan) 12° 42'N 30° 41'E showing the cages positioning in El-Rahad Lake.

In fish cage design, one factor that seriously affecting profit margins for cage enterprises is the performance of the materials used in frame and netting in order to reduce costs and avoid material failure. Dry stick of "Canna" *Oxytenanthera abyssinica*, which is rigid, light and available on local markets were used to make three floating fish cage frame of 1.2×1.2×1.2m in diameter [11], this frames was joined together by metallic wire to made a design of small fish cages (fish cage type "A"), another three small fish cage of an iron frame with the same size above had been made as a standard cages (fish cage type "B"). The two types of cages were formed outside using polyethylene net with a mesh size of 15mm. The iron cage frame had been painted with normal white iron paint (Table I, II). All cages were installed in 1.3-1.4 meter as a water column depth, about 25meter from the shore using a sacks (4 sacks for every cage) full with a stones weight 6-8kg as a sinkers (anchors), which tethered to the cage frame with a thick plastic ropes [11].

"El-Taror" shins *Aeschynomeneela phroxylon* [Image -1] is a water plant grow naturally in El-Rahad lake shore nearly 1.5-2.5m in height uses as a fish cage floaters (buoyancy), which had been fixed in two opposite top sides of every cage. About 40cm is the distance of every cage from the bottom [12, 9]. The two types of cages were placed in an open site about 25m from the shore to determine their duration (life span) and performance. The effect of some environmental factors was recorded after first twenty days, forty days and by the end of the experimental period. The structure cost for the two types of fish cages was accounted. The reaction of the fishermen and population toward the small fish cages were notice.

Hydrodynamic factors and physiochemical measurements (water and air temperature, pH, humidity, wind speed and water current) were taken with digital field equipment's and from the nearest meteorology station.

Table 1: Different Materials Uses in Fish Cages Type "A" ("Canna" Fish Cage), and Its Cost

Materials	***Amount/cage***	***Unit cost *(SP)***	***Total cost/cage(SP)***
Canna stick frame (1.2m length)	20 pieces	2.5	***50***
Iron wire mooring	½ kg	10	***10***
Polyethylene net	8 m²	10/meter²	***80***
Sinker (stones)	4 pieces	2.5	***10***
Floaters ("Taror" sticks)	8 pieces	1.25	***10***
Thick plastic rope	10 meter	1per meter	***10***
Crafting cost/cage		30	***30***

*SP= Sudanese pound= 0.1$

Table 2: Different Materials Uses in Fish Cages Type "B" (Iron-Made Cage), and Its Cost

Materials	*Amount per cage*	*Unit cost *(SP)*	*Total cost/cage *(SP)*
Iron made frame (1.2m length)	12 pieces	10	***120***
Polyethylene net	8 m²	10/meter²	***80***
Sinker (stones)	4 pieces	2.5	***10***
Floaters ("Taror" pole)	8 pieces	1.25	***10***
Paint tin	2	15	***30***
Nylon thread	10 meter	1	***10***
Crafting cost/cage		50	***50***

*SP= Sudanese pound= 0.1$

3. Results

This study was carried out in a lentic water body called El-Rahad northern Kordofan – Western Sudan from March 1 to May 10, 2014. A total of six fish cage of 1.2×1.2×1.2m, among them three fish cage of "Canna" stick frame-made (fish cage type "A"), and three fish cage of iron frame (fish cage type "B") had been made and placing in water. After first thirty days of the experiment the following indication were noticed; Quite and constant in hydrodynamic and environmental physiochemical factors; wind speed (11-28Km/h), relative humidity (4-11%) and water current speed (>5mile/h). Temperature ranges between 22-23 °C and 22-36°C for both water and air respectively during this period, which is within the normal ranges (Table III). Little amount of rust was seen in iron frame fish cages (fish cages type "B"). From April 1 until May 10, the some observations were noticed such as both types of fish cages were in good floating conditions in water surface, except some increment in the amount of rust seen in iron-made cages. Since sharp fluctuations in environmental conditions during rainy season, surface waves disturbances in the "Torda" and high speed wind was noticed and tearing nets were found in more than one site in cage netting in both types of cages (types "A" and "B"). Rust effects disperse in many places in iron frame cages, and the disintegration of some parts of the iron frame conjunctivitis. Throughout this period, “Canna” frame cages are in good situation generally.

By the end of the study period, this outcome had been clear; the general situation for the fish cage with a "Canna" frame is best during whole study period, compare to the fish cage with the iron-made frame. Ability of the "Canna" stick cage frame against the hydrodynamic and environmental factors among the normal ranges and its existence in water. The efficient of "El-Taror" shins as floaters to hold the fish cages in both fish cage types (cage type "A" and type "B"). The efficient of plastic sacks full with a stones to be as sinkers (anchors) for the two samples of fish cage types. Carving and damages were seen in some parts of the polyethylene nets for some cages, specially the parts over water surface. Substantial variation in construction cost between the two types of cage materials; "Canna" frame (200SP), and iron-made frame (310SP) were observed (Table IV).

Numbers of species of water mollusks (bivalve-snails) and water arthropods (water crustacean) attached to the fish cage netting. Extra attention and care noticed from the fishermen and the local population to the stapes of making fish cages from locally available material and their functions.

Table 3: Main Factors Affected the Two Types of Fish Cages (Type "A" and "B") in the Field during the Experimental Period

Physiochemical factors	*Measurement range*	*Observation*
Water temperature	22-23 °C	*In normal range*
Air temperature	22-36 °C	*March& April is summer months, May start rainfall*
pH	7.1-8.4	*In normal test*
Water depth	1.4-1.5m	*About 25m. from the shore*
Hydrodynamic factors	Measurement range	*Observation*
Relative humidity	4-11%	*Very dry tell May,*
Water current speed	5 Km/h <	*Quite water surface, except in rainfall*
Wind speed	11-28Km/h	*South-east direction*

Table 4: Total Construction Cost, Duration and Main Observation Records in Both Fish Cage Type "A" and Type "B"

Fish Cage Material	*Duration (day)*	*Total Cost Per Cage *(SP)*	*Observation*
"Canna" frame (fish cage type "A")	More than 70 days	200	***In good condition during the experiment***
Iron made (fish cage type "B")	Less than 70 days	310	***Rust seen after a short period of time during the experiment***

*SP= Sudanese pound= 0.1$

4. Discussion

fish cage culture classified as the fastest aquaculture production systems growing in the world [13], and as Kordofan region suffer from a lack of water bodies, the increased production of fish inside/within the available water bodies is the most appropriate way to increase the production of fish in the areas of Kordofan; and considering the availability or the presence of a small fish cages made with local materials for breeding fingerlings or adding more weight for young fish is a method can be available to all fishermen in this water body aside from their work in the fishing, as well as the communities around even for women sector.

This study showed clearly the feasibility of using "Canna" sticks *O. abyssinica* which is locally available material and abundance for the construction of small fish cages characterized by good resistance to environmental factors as winds, waves, temperature, humidity and sun light as a recommended[9], for more than seventy days in the case of the development of these fish cages in places with greater protection could serve these cages for more than two seasons to breeding small tilapia fishes [12].

The use of local materials such as "Canna" sticks for making

cages is a traditional method of making fish cages, wherein commonly used and its applicability in many countries in Southeast of Asia and China [11], where they are making the fish cages frame from wood and bamboo. The study amid to determine the preference of "Canna" sticks *O. abyssinica* when compared with iron in the length of the period of validity, particularly as the paint that was used for iron coating material for normal corrosion-resistant, as well as found from the study that the cost of construction for the construction of fish cage from wooden materials such as "Canna" (200SP or 20$) is significantly lower than the cost construction for making fish cage out of the iron-made (310SP or 31$) in the same size.

5. Conclusion

In a conclusion, observation from the study revealed the possibility of introducing a number of available and cheap materials in the surrounding environment to create a fish cages such as "Canna", which used as a cage frame and "El-Taror" plant which were used as a floaters to the fish cages, of cost only (200SP or 20$) per fish cage in comparison to metal materials used otherwise.

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