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# Classical Fisheries Theory and Inland (Floodplain) Fisheries Management; Is there Need for a Paradigm Shift? Lessons from the Okavango Delta, Botswana

**Mosepele K***

*Senior Research Scholar- Fisheries Biologist , Research Services and Training, Botswana*

***Corresponding author:** Senior Research Scholar - Fisheries Biologist , Research Services and Training, Botswana, Tel: + 267 75054735; E-mail: mosepelek@gmail.com

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## Abstract

This paper reviews the fisheries management question of inland (floodplain) systems in the developing world and proposes a paradigm shift in approach. Inland fisheries management is largely based on classical fisheries formulations derived on temperate freshwater and marine single-stock fisheries. The basic models to manage inland fisheries are based on steady state equilibrium models. However, inland, flood-pulsed fisheries are dynamic and driven by external factors which are incongruent with the classical approach. Therefore, adopting this management approach in inland, flood-pulsed fisheries has created a management conundrum because of the obvious fundamental differences that exist between these two systems. Marine fisheries contribute to the macroeconomic growth of fishing countries, inland fisheries from developing countries are largely focused on recreational activities, while inland (floodplain) fisheries are key sources of food and nutrition security for marginalized riparian communities in the developing world. This review also uses lessons from the Okavango Delta fishery to illustrate the uniqueness of floodplain fisheries and the management questions therein. One key debate highlighted in this review is that inland fisheries are a livelihood of the last resort for poor (and sometimes malnourished) communities. Management should therefore mainstream this value into management interventions, especially since a sustainable utilization of this resource can assist developing countries to achieve some of the MDG's. The paper concludes with an argument of the need for a paradigm shift in inland fisheries management, where key factors such as enhanced data collection, co-management regimes based on "real" democratic principles constitute some of the germane attributes of fisheries management plans.

**Keywords:** Flood pulse; Classical fisheries management; Okavango Delta; Floodplain fisheries

## Introduction

Fisheries management theory, based on single-species exploitation [1]) is replete with "theoretical" equilibrium models that have been used to manage global (marine) fisheries (e.g. [2-4]). These models used the concept of maximum sustainable yield (MSY) as the foundation of the fisheries management paradigm. The MSY assumes a state steady, constant parameter system [1,5-8]. One of the basic tenets of this concept was the development of mesh size regulations, as an attempt to exploit a fishery at its maximum sustainable level [9]. The main management philosophical construct has always focused on internal drivers (e.g. fishing effort) as the main agents of change that need to be managed to attain sustainable fish utilization [3,8,10]. The classical management paradigm has always neglected external drivers (e.g. flooding, nutrients, etc.), primarily because they can't be managed [10]. Fisheries theories were developed in relatively static temperate, single species marine [11] and freshwater [12] fisheries but were tropicalized [13] into comparatively dynamic inland, flood-pulsed multi-species fisheries. Several classical overfishing scenarios were also developed based on fisheries theory [14]. These include growth overfishing [15], recruitment overfishing [16], biological overfishing [17], economic overfishing [18] and ecosystem overfishing [19]. These concepts also contributed to, and entrenched the classical fisheries management paradigm in inland (floodplain fisheries). The dichotomies created by these conflicting paradigms (i.e. marine vs. inland freshwater fisheries) have created a fisheries management dilemma, in floodplain fisheries.

Tropical floodplain fisheries are characterized by diverse species assemblages, diverse fishing gears, and diverse threats [20-22] driven primarily by the seasonal flood pulse in floodplain systems [23-25]. While these fisheries are significantly different from marine fisheries in form and structure [10], management interventions, premised on "over-exploitation" [26,27] have adopted classical fisheries management paradigms, ostensibly to ensure sustainable utilization [10]. These interventions were borne on the back of development projects that were implemented in these fisheries, to secure livelihoods of the socio-economically marginalized riparian communities. While marine fisheries contribute significantly to national GDP growth of fishing countries (FAO, 1951[28]), floodplain fisheries are a major source of food and nutrition security for the rural poor [29], though full-time commercial food fisheries have disappeared from most "developed" countries [30]. Floodplain fisheries from developing countries are also significantly different from those of the developed world [30]. Floodplain fisheries from developed countries place more emphasis on recreational value, while those from developing countries are valued for their food value. This is the fundamental distinction between these two fisheries, which should be reflected in their management approaches. If managed sustainably, these fisheries can contribute towards African countries' achievement of the MDG's [31], including those of developing countries in Asia and South America.

Globally, floodplain fisheries are a key livelihood resource, particularly in Africa, Asia and South America. They are a major source of employment and food for the poor communities [21,26] and contribute to the economic development of many African rural economies [32]. These fisheries are also the mainstay of livelihoods in Asia and South America. The fisheries of the Yala swamp (in Kenya's coastal area of Lake Victoria) are a major source of income to its riparian community, and income derived from fishing is estimated to be four times the agricultural income [33]. Generally, African inland fisheries provide employment to several people [20]. Bangladeshi floodplain fisheries provide an essential source of protein and income seasonally, which underpin the livelihoods of the riparian communities [34]. The Mekong River, which covers several countries in South-East Asia [35], contains the world's largest inland fishery [20]. The Mekong contributes directly to food security of riparian communities in its system [35], is a major source of protein and micro-nutrients to 22 million people in Cambodia and Laos [20] and is a key livelihood resource for the nearly 70 million people in the Lower Mekong River Basin [36]. Subsistence fishing in the Amazon is an important source of animal protein for the riparian community of this river system [37], where this fishery and related activities provides employment for a substantial number of people in the central Amazon floodplains [38]. Inland fisheries in the developing world are therefore a key livelihood resource whose management determines where the next meal is coming from for the socio-economically marginalized riparian communities.

Understanding the biology and ecology of freshwater systems is critical towards a comprehensive management of floodplain fisheries. Most classical fisheries models are theoretical formulations (e.g. [9, 15]), without any firm basis on empirical observations. Therefore, there is need for a paradigmatic shift, at least in floodplain fisheries, to ensure sustainable utilization of the fish resources. Because of their dynamicity and heterogeneity at both spatial and temporal scales, floodplain fisheries management needs to be approached from a basic understanding of ecosystem ecology of freshwater systems. The major concept underpinning (inland) floodplain fisheries management is the flood pulse concept [23,25,36], which suggests that floodplains are the major areas of production in flood-pulsed systems [23]. The food-web dynamic created by the seasonal flood pulse regulates fish species interactions with their prey in floodplains [39]. Ultimately, this creates a dynamic aquatic-terrestrial interface that makes floodplains some of the most productive systems globally. This characteristic flood pulse regulates energy storage in fish [40], due to the food-web dynamic created by seasonal flooding. Moreover, seasonal flooding also regulates spawning and recruitment of floodplain fish species [41]. Therefore, Junk [36] argues that sustainable development should include the maintenance of the natural flood regime in floodplain systems to ensure sustained fish production. This suggests that external drivers (e.g. flooding), are major drivers of change, which then nullifies assumptions for classical management approaches in floodplain fisheries.

Diverse management approaches have been implemented to manage inland fisheries, ranging from top-down approaches (e.g. [30]) to co-management regimes (e.g. [42,43]). Top-down strategies are based on classical approaches which involve input and output controls [44], which are essentially effort and mesh regulations. According to Pauly [45], classical management approaches are premised on the assumption that fishers are in a "social and financial" position to either comply or implement these measures. However, this is not the case in the developing world, where the challenges of putting food on the table daily are sometimes insurmountable. The fundamental philosophy behind community based fisheries management is that a holistic management of fisheries enhances benefits gained from the resource and encourages sustainability [46]. Chuenpagdee and Jentoft [47], however, highlight that the success of co-management initiatives also depends on pre-implementation stages of the co-management process. Ultimately, co-management is seen as a sustainable response to (classical) fisheries management failure, which has been predominantly based on top down control measures [42]. According to Pauly [48,49], the major fisheries management objective in small scale inland fisheries is to stem the tide of Malthusian over-fishing. This Malthusian overfishing occurs when poor fishers, without any alternative livelihood strategies, continue fishing even when the resources are severely depleted [48]. In this scenario, women, who would have migrated to urban areas in search of employment, subsidise men fishers through remittances. It can be argued, therefore, that Malthusian overfishing, premised on Hardin's [50], "tragedy of the commons" thesis is one of the drivers of fisheries management paradigms in inland fisheries.

This review analyses the Okavango Delta fishery using the framework developed by the preceding literature, to highlight the nature and character of this fishery and its fish community. It is envisaged that this will highlight the dynamicity of floodplain fisheries, and illustrate that dynamic fisheries theory modeling is incompatible with floodplain fisheries management.

## Classical Fisheries Management Theory

Classical fisheries management is premised on a single stock paradigm which essentially argues that the productivity of a stock is a function of its size and its reproductive potential [51]. Subsequently, it is argued that the basic objective of fisheries management is to exploit this stock at a level where its reproductive ability is equal to its natural mortality [9,51], through mesh regulations/ selective fishing [9]. Therefore, the classical approach to fisheries management necessitates the need to estimate growth and mortality parameters from exploited populations [51,52], which are then used as input parameters to estimate MSY [53], which is the key objective of fisheries management [54]. This fisheries management philosophy is codified in Beverton and Holt's [55] yield-per-recruit model which is a major seminal work in fisheries literature [13]. Over time, regulations were gradually introduced to manage fisheries resources to achieve optimum utilization (i.e. maximum sustainable yield) of the fish resources. According to Pauly [45]), some of these include reducing fishing effort, mesh regulations, closed fishing seasons, and fishing gear restrictions. Welcomme [56]) defines these as technical measures (e.g. mesh and gear limitations, closed seasons, etc), input controls (e.g. licensing to control effort and access, ownership, etc), and output controls (e.g. quotas, size limits on fish landed, etc). These classical regulations have subsequently been assiduously implemented in floodplain fisheries [57,58].

Several management approaches, based on the classical paradigm, have been developed to manage fisheries resources globally. Because one of the premises of classical fisheries management is Hardin's [50] Tragedy of the Common's scenario, the basic approach to mitigate against this has been to privatize fisheries resources. Subsequently, Pauly [59]) proposes individual transferable quotas (ITQ) as an alternative approach to privatize the commons, ostensibly to inculcate a conservation ethic in exploitation regimes. Other classical management approaches to safeguard fish resources include the delineation of fish refuges, known as marine protected areas [59-61] which are essentially meant to act as game reserves or national parks

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used in wildlife management. Other approaches include the ecosystem approach [62], multi-species models [63-65], dynamic system models [60]. The fundamental question that this paper highlights then, is whether these approaches are relevant towards management of floodplain fisheries, when the very premise of classical approaches, that of a "constant parameter system [52]", are nullified?

## Lessons of Fisheries Management; the Okavango Delta

### Hydrology and limnology

The Okavango Delta (Figure 1) is a flood-pulsed inland floodplain system that receives water annually from the Angolan highlands [65]. Generally, seasonal floods peak in the panhandle in April (see Figure 2) and are lowest towards the end of the year. There are also strong inter-annual variations in flooding in the delta (Figure 1), and generally no two years have similar hydrographs. This flood pulse is out of phase with the rainy season [66] and peaks during the cold winter months when biological production is low [67]. Maximum flooded area is observed between August and October (Figure 2), several months after peak discharge. The floods flow the delta in a pulse that reaches Mohembo (Figure 1) in December/ January and only reaches the distal ends of the delta in July, several months later [68]. Different floodplain classes exist in the Delta due to different hydrological characteristics [69]. Floodplains that are permanently flooded are classified as permanent floodplains and are characterized by permanent marsh vegetation communities; regularly flooded seasonal floodplains (4-8 months of the year) are characterized by seasonal marsh vegetation communities; occasionally flooded seasonal floodplains (1-4 months of the year) are characterized by flooded grasslands vegetation communities; while floodplains that only receive water at high floods (and flood for less than 2 months) are characterized by forbland/ grassland vegetation communities. Similarly, there are strong intra-annual variations in water chemistry in the panhandle. Mladenov et al. [70-71], observed that DOC in the Delta is flood pulse driven, originating from the terrestrial environment. This terrestrial origin of DOC is a classic illustration of the existence of the flood pulse in the Delta's hydrology and limnology.

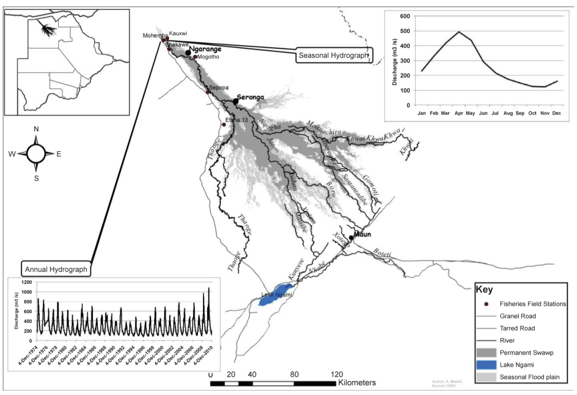


**Figure 1:** Map of the Okavango Delta showing some of the fishing villages around the panhandle. The map also illustrates a seasonal and annual hydrograph

The main channel waters of the Delta are oligotrophic, while those of floodplains range from oligotrophic and mesotrophic [72]. Conversely, lagoons in the Delta's seasonal floodplains are highly enriched, primarily from cattle dung [73] or large herbivore dung in the seasonally flooded floodplains [74], and hence support high fish biomass [73]. This high production in the seasonal floodplains agrees with Junk et al. [23] flood pulse concept (FPC) that seasonal flooding drives primary production in floodplains due to a dynamic interchange between terrestrial and aquatic habitats. A similar dynamic exists in the Delta where primary production is driven by the flood pulse [75] and zooplankton diversity in the seasonal floodplains is driven by the seasonal flood regime [74]. Seasonal floods also drive zooplankton production in temporary floodplains of the Okavango Delta [76]. Other studies have revealed that flooding frequency in the delta, especially in rarely flooded floodplains, is the major factor determining the diversity and viability of zooplankton [77], which is key food for juvenile fish.

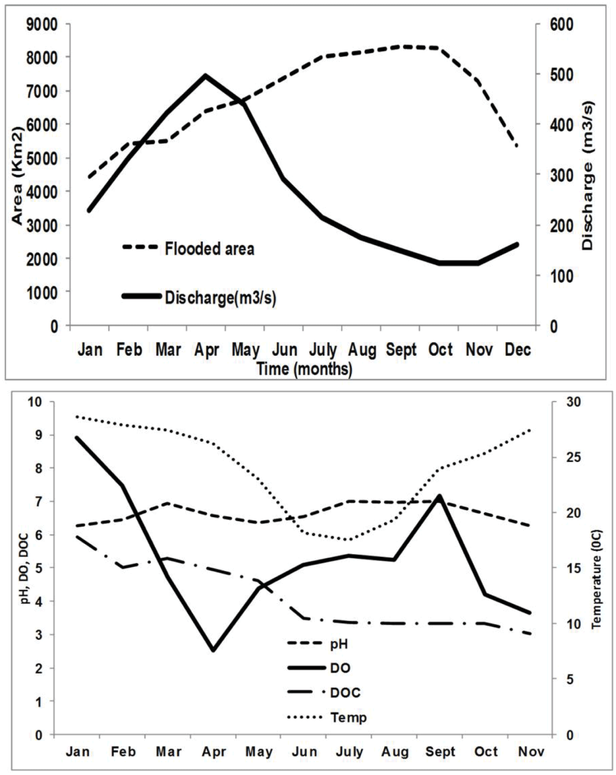


**Figure 2:** Hydro-chemical variations in the panhandle of the Okavango Delta

### Biology and ecology of fisheries:

There are 71 different fish species in the Okavango Delta [68] and range in size from small species like *Barbus haasianus* (maximum size is 32 mm SL) to large species like *Clarias gariepinus*, whose maximum size is 1.4 m SL [78]. The majority of fish species are insectivores (Table 1), which highlights the importance of insects/ aquatic macro-invertebrates in fish biomass production in the delta. This notwithstanding, the delta's fish species have a relatively plastic feeding behavior [79,80], because of the dynamic nature of the system.

*Schilbe intermedius* is one of the dominant species in the delta's fish community [79,81], possibly due to its opportunistic feeding ecology [79,81], where it also feeds on terrestrial food items, driven by the seasonal flood pulse [80]. Cichlids are the dominant family in the delta's fish community [81], and Mosepele [80] also found out that they have a plastic feeding behavior, where detritivorous species like *Oreochromis andersonii* were found to prey on fish under stressed conditions. Currently, there are no endemic and or introduced species in the Okavango delta [68], making the delta a relatively pristine environment. While the permanence and flow rate of water are the key variables regulating fish distribution in the system [68], habitat partitioning has resulted in variable life history strategies of similar species in the delta. Similar species have different growth rates from different parts of the delta [83]. Furthermore, Mosepele et al. [81] also observed habitat partitioning in fish species assemblages of the delta, where upper delta habitats have relatively higher species diversity than lower delta habitats [79].

| Feeding guild | Relative proportion (%) |
|---|---|
| Insectivores | 44 |
| Mixed predators | 29 |
| Omnivores | 8 |
| Piscivores | 7 |
| Molluscivores | 6 |
| Detritivores | 4 |
| Planktivores | 1 |
| Herbivores | 1 |

**Table 1:** Fish feeding guilds from the Okavango delta based on Skelton [78]

Several studies have shown that the flood pulse is a key driver in the delta's fish community [75,80, 84-86]. Similar fish species from different habitats in the Delta have different life history strategies [82, 87], which is driven primarily by differences in environmental conditions [85]. Furthermore, Mosepele et al. [80] showed that the seasonal flood pulse is the major driver of the feeding ecology of selected fish species from the Okavango Delta. Their study revealed that most fish species from the delta are opportunistic feeders whose diet is changed seasonally regulated by the seasonal flood pulse. In fact, the feeding rate of some fish species is driven by changes in either mean depth or discharge [80]. This study [80] revealed that fish diet varied between terrestrial and aquatic sources, depending on the seasonal hydrograph. At a larger time scale, years of low floods resulted in low fish biomass while years of high floods resulted in high fish biomass [75]. High flood years inundate rarely flooded floodplains which are massive engines of zooplankton production which is then grazed heavily by juvenile fish, especially cichlids [88]. Therefore, fish dynamics in the Delta are driven by the length of time water is present in the system and by the nature of its flow [84]. Subsequently, Linhoss et al. [86] developed a statistical model to show that the seasonal flood pulse is a major driver of fish population dynamics in the Okavango Delta.

## Exploitation regime of fisheries:

Fishers use different fishing gears to exploit the delta's diverse fish species assemblage [89-92], where fishers use different fishing gears to adapt to variations in fish catch ability [91]. Fishers also use indigenous knowledge to target their preferred species [93]. The three major exploitation regimes in the delta's fishery, which use different fishing gears, and exploit different fish species are subsistence [90], commercial [92] and recreational [94] fishing. The main species exploited by the small-scale commercial fishery are *Oreochromis andersonii, O. macrochir* and *Tilapia rendalli* [84,89], and these three species are also exploited by the artisanal fishery (i.e. using homemade fishing gear). However, different artisanal fishing gears exploit different fish species as shown in Table 2. Moreover, fishers of different ages using similar fishing gears exploit different strata of the delta's fish community, from small sized species to large sized individuals [89].

| C.p.u.e (nos/set) | Species richness | Mean fish size (mm) | Shannon's index (H') | Evenness (J') | Most important species |
|---|---|---|---|---|---|
| 3.8 | 22 | 38 | 2.26 | 0.73 | *A. johnstoni* |
| 4.8 | 43 | 259 | 2.29 | 0.61 | *Clarias spp* |
| 19 | 46 | 57 | 2.62 | 0.68 | *T. sparrmanii* |
| 21.1 | 24 | 261 | 2.31 | 0.73 | *O. andersonii* |
| 58.5 | 17 | 228 | 2.36 | 0.83 | *C. gariepinus* |

**Table 2:** Summary of catching efficiency (c.p.u.e), species diversity and the most important fish species per fishing gear used by subsistence fishers in the Delta where the most important species in the catch is determined by using the Index of Relative Importance (IRI) (Source: Mmopelwa et al. [91]) Note: 1 net set is defined as a 25 m long gill net set in the water overnight for 12 hours.

## Socio-economics and management of fisheries:

Fishing is a major livelihood activity in the Okavango Delta [87,90, 92,95-96], though characterized by conflict due to competing uses [87, 96]. Subsistence fisher households in the delta are mostly headed by female-headed households who are relatively poor and tend to depend on fish as a major s ource of food [90,95] and nutrition security [97]. Generally, subsistence fishers are women, have very little formal education, with an average household size of 7 people [94]. Apart from being a major source of food for poor households [91,95], fish is also a natural safety net and buffers those who are chronically ill, especially those who suffer from HIV/AIDS (mostly from HIV/AIDS illnesses) people against deterioration into chronic poverty [98] and for children (under the age of 5 years) during times of food scarcity [95]. Conversely, commercial fishing in the delta is a major source of rural income [99] which (i.e. income) at times exceeds agricultural (e.g. cattle) income [92]. Research has also shown that commercial fishers utilize indigenous traditional knowledge to target their preferred species in the delta, and have developed efficient fishing techniques compared to subsistence fishers [93].

Fisheries management in the delta is based on a classical fisheries management approach, where fishing effort, mesh regulations, fishing season and fishing methods are the main elements of the management regime [100]. Due mostly to competing use value between (small-scale) commercial and recreational fishing in the delta, allegations of fish over-exploitation by commercial fishing created serious conflict in the fishery [87]. However, a fish stock assessment revealed that the fish stocks were still healthy [87,101,102] and that perceptions of over-exploitation were driven by a motive for exclusive access to the fish resource by recreational fishers [87,101]. Despite the obvious reliance on indigenous knowledge by commercial fishers, current government policy has not integrated this into natural resource management in the delta [103]. Moreover, the lack of a national fisheries policy [83,100] has always made it difficult to implement comprehensive management strategies which include gender equity in the fisheries sector [104]. This issue was also highlighted by Mosepele [96] who developed a co-management model for the Okavango delta fishery, with special emphasis on the role of women in the fishery. The co-management model developed for the delta does not have any legal foundation, and is based purely on people's willingness to comply [96]. The lack of a national fisheries policy, has compounded management concerns in this fishery, where critical elements like indigenous knowledge, gender equity and contribution of this fishery towards achievement of the MDG's have not been integrated into the management regime. Despite these drawbacks, a code of conduct is currently operational in the fishery, and was developed through consensus among the stakeholders, facilitated through an Okavango Management Fisheries Committee (OFMC). This committee was formed as part of the co-management regime that was developed in the fishery [96].

Among others, classical management approaches in the delta prohibit use of mosquito nets, drive fishing, and encourage use of larger meshed nets [105]. According to Mosepele [89], the major fish species exploited by mosquito nets are topminnows (Aplocheilichthys spp) which are consumed at the household level. These contribute a major source of high quality nutrients like zinc, calcium and amino acids, similar to some fisheries in Asia [106,107] which are critical micro-nutrients to women and children under the age of 5. Furthermore, Mosepele [93] has shown that drive fishing is a highly effective indigenous fishing method that small-scale commercial fishers use to target their preferred species. This fishing method exploits species like Tilapia rendalli, which are otherwise not exploited by other more conventional fishing methods [42,93]. Prohibiting some fishing methods, restricting certain fishing gears, and encouraging large meshed gill nets encourages selective fishing in a multi-species complex. Walsh [107] cautions that selective fishing drives the exploited fish population towards more r life history strategists, that it results in the loss of highly fecund (i.e. larger/ older) females, and this according to Harvey [108], may reduce the reproductive potential of exploited populations. Ultimately, selective fishing (by targeting larger sized individuals mostly) results in loss of resilience of exploited populations which may invariably result in their crash [109]. It is on this basis that Jul-Larsen [110] argues for a non-selective exploitation pattern in multi-species inland fisheries, primarily to protect the biodiversity of these fisheries. This is the non-selective fishing pattern that traditionally existed in the delta [88], before the advent of classical management approaches.

## Synthesis

Because of the multiple threats facing freshwater systems [20], inland fisheries management cannot be sector specific because they transcend the fisheries sector [96]. It was on this basis that a fisheries Code of Conduct was developed to alleviate conflicts that prevailed in the fishery. This code of conduct essentially integrated different management issues that affect the fisheries of the Okavango Delta. Another important management issue is what Pauly [45] terms the marginality of the inland fisheries, which he defines as their "geographic, socio-economic and political remoteness from decision makers in the major population centers". In his opinion, the socio-economic remoteness of these inland fisheries, which are small-scale in nature, is related to the relatively low incomes of their fishers and the fact that they belong to ethnic groups of low status. This is particularly relevant in systems such as the Okavango Delta where women are a major subsistence group that is generally marginalized in the prevailing management regime as observed by Ngwenya [103]. Therefore, there is need for a comprehensive management of floodplain fisheries which should be sensitive to issues of (ethnic and gender) equity. This marginalization is also manifest in lack of political power by these low socio-economic status groups [45]. Pauly [45,48] argues that marginalization creates Malthusian over-fishing, which is seen my some managers as ground for strict management regulations. Conversely, lessons from the Delta have shown that total fishing effort (defined as number of total fishers) is in constant flux, driven by changes in the macro-economic situation in the country [86]. According to Mosepele [86], more people enter the fishery when their livelihood opportunities are limited, but immediately move out when more opportunities are available elsewhere in the national economy. This preceding argument then calls for a paradigm shift in inland fisheries management. It is evident that inland fisheries management issues are much more complex than simply implementing either "input" or "output" controls in the fishery (i.e. based on the classical management paradigm), ostensibly to exploit the fishery optimally at the MSY.

Small scale fishers in the developing world are generally poor with few employment possibilities, whose families are also usually malnourished [111]. Therefore, inland fisheries management in the developing world should focus more on securing food in these fisheries, compared to the developed world where the focus is more on recreational values [30]. The basic argument here is that there are fewer alternatives for food in the developing world, especially high protein diet that fish provides in riparian communities. Essentially, top down management regimes cannot provide food and nutrition security for subsistence fishing households to whom fish is a key life and death resource [112]. Based on lessons learnt from the Okavango Delta, a co-management regime is recommended based on truly democratic principles [96]. This argument is based on the observation that fisheries are "non-excludable" but "subtractable" resources [43]. They [43] highlight that non-excludability means it is costly to either legally or physically exclude users from accessing the resource while "subtractability" means that users cannot jointly consume the resource. This is particularly critical because classical approaches to management of fisheries focus on control and command interventions which are invariably associated with high operational costs. Enforcing a closed fishing season in the Okavango Delta essentially diverts resources (human and financial) from more productive pursuits, to stop women basket fishers from harvesting a mere 90g of fish/ day (the efficiency of basket fishing as calculated by Mosepele et al. [88]. This is certainly an over-kill and not cost effective. Therefore, co-management in this management scenario is seen as a way of minimizing management costs [42]. This not to suggest however, that a co-management approach is a panacea to inland fisheries issues. What is important nonetheless, is that the people should have some element of participation in the decision making process of how the fisheries resource needs to be managed.

Inland fisheries management, especially in flood pulsed systems, determines access to food and nutrition of the last resort to socio-economically marginalized households. The value of these fisheries is much more critical in Africa, Asia and South America where the majority of the riparian communities exist under conditions of chronic poverty. These fisheries are also a critical entry point for state intervention into achievement of the MDG's in the developing world. As discussed above, inland fisheries management is a political exercise because it defines access to fisheries by excluding some people and including others [42]. It is therefore incumbent upon fisheries managers, policy makers and fisheries scientists to acknowledge this fact, that they hold the keys to political power that should be used effectively and efficiently for the benefit of the politically voiceless. Moreover, Welcomme et al. [21] highlights that the key management questions in inland (flood-pulsed) fisheries are predicated on environmental flows because of the multifaceted nature of these fisheries. Therefore, inadequate data collection systems that exist in these fisheries are a major hindrance to inland fisheries development [21]. Hence, there is need to expand monitoring efforts and management capacity in the developing world [113]. Obtaining catch and effort data in African (inland) fisheries is problematic [42], which provides a compelling argument to institute proper catch and effort monitoring strategies as part of a management regime. These data are needed to illustrate the "real" intrinsic value of these fisheries to policy makers. Lack of knowledge from these fisheries, compounds the management dilemma, where managers resort to classical management approaches, because these are easy to implement, but not necessarily to enforce. A shift in the paradigmatic approach to the inland fisheries management question, will allow managers and scientists to appreciate the intrinsic values of these fisheries to marginalized riparian communities.

## Conclusion

This review has shown that inland (floodplain) fisheries are diametrically opposite from marine fisheries. While marine fisheries are more focused on large industrial fisheries, the value of inland (floodplain) is more about putting food on the table for marginalized riparian communities. Furthermore, while marine fisheries management is focused more on theoretical formulations aimed at maximizing fish yield, inland (floodplain) fisheries management should focus more on the ecosystem approach because of the multiple threats they face. Classical management approaches, based on input and output controls, do not have any philosophical foundation in inland (floodplain) fisheries. A key management objective in inland (floodplain) fisheries should be to secure the food and nutrition security value of these resources for riparian communities. Another key management objective should be to enhance fishery dependent and fishery independent data collection systems because these are currently lacking in inland fisheries. Another major objective should be to enhance knowledge about the socio-economic value of these fisheries so that their values are mainstreamed into management. A key approach to inland (floodplain) fisheries management is co-management, as facilitated within the context of the Okavango Delta. These management objectives illustrated the need to shift paradigms in inland fisheries management, where a more holistic approach is required, so that the food value of these fisheries is maintained for posterity.

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