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Opinion

Application of traditional ecological knowledge in the management and sustainability of fisheries in East Africa: a long-neglected strategy?

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Abstract

Management and sustainability of fisheries has been guided by theories and models derived from modern ecological science. Traditional ecological knowledge (TEK) has been ignored in all spheres of decision-making for management and sustainability of fisheries in East Africa. TEK guided African communities in the way they associated and interacted with the natural environment around them. Spiritual rituals, religious practices, social taboos and sacred animal totems guided the peoples on how and when to utilize the available natural resources. In the advent of modern scientific knowledge, the African traditional knowledge quickly faded away and is generally seen as irrelevant. Today the potential of TEK in the management and sustainability of fisheries in East Africa has not been realized and its status and future is unknown. TEK should be complementary to modern scientific knowledge in the management and sustainability of fisheries. This paper therefore focuses on the potential application of TEK in the management and sustainability of fisheries in East Africa and the issues that impede its application.

The primary goal of fisheries management is to ensure the perpetuation of self-sustaining stocks of indigenous aquatic species and, where possible to allow their sustainable use (Olver et al., 1995). Decisions which govern the use of fisheries resources should be societal, where viewpoints from multiple stakeholders are balanced against potential costs and benefits of various resource uses (Scrimgeour & Wicklum, 1996). It has been claimed for a long time that rational fisheries management is the only universal solution for a sustainable use of fish stocks. Most management policies derive from the concepts of equilibrium population dynamics and stock assessment, and aim to achieve a level of fishing effort at which the stock or population is conserved at its level of maximum yield, i.e., maintaining maximum sustainable yield (MSY). Failure to determine accurately the levels of effort or access needed to conserve fish stocks and controlling fishing activities, coupled with the increasing population food demands, have complicated the application of modern management principles in fisheries. With the minimal success of the currently used fisheries management principles in achieving the MSY, incorporation of traditional ecological knowledge (TEK) in fisheries management could provide an alternative or synergism to modern scientific principles. For the purpose of this paper, TEK is "a cumulative body of knowledge and beliefs, handed down through generations by cultural transmission, about the relationship of living beings (including human beings) with one another and with their environment (Berkes, 1993)". It therefore combines various disciplines such as biology, linguistics, social sciences and any other disciplines that help the beings to interact, perceive and live within the environment and use its resources. The potential of TEK in the management and sustainability of fisheries resources in East Africa has not been realized, although it has been recognized elsewhere (Eythorsson, 1993). Its status

and future in the sustainable use of fisheries is also unknown. In this paper I present opinions on the potential applications of TEK in the management and sustainability of fisheries by people with a fishing culture in East Africa.

Man has associated with water systems since time immemorial and most, if not all, world famous civilizations were associated with water systems. Through this association, man has developed traditions and knowledge about the water systems and also technologies to exploit the resources therein. Consequently, a wealth of ecological knowledge on the utilization and management of fisheries is expected to have evolved especially where fish has been a source of livelihood over generations. In African communities, spiritual rituals, religious practices, social taboos and sacred animal totems dictated how and when natural resources were to be utilized. These approaches were, in most cases, dissimilar to the modern approaches.

Many development initiatives have failed because of the high level of technology and infrastructure which usually require expensive maintenance and high skill levels to operate (Andrew et al., 2000). For fisheries to be sustainable in rural areas, TEK, including skills, technology and infrastructure that are already locally available should be utilized as much as possible. Until the middle of the 20th century, African inland fisheries were traditionally pursued with a variety of locally fabricated gear such as harpoons, baskets, spears, traps and seine nets among others. Traditional fishing methods were adapted to the diversity of fish capture possibilities under particular environmental conditions, although inadequacy in technology limited the extent of exploitation of the resources. However, with the introduction and spread of new fishing technologies, many traditional practices became or are rapidly becoming obsolete. As a result, modern technology has eclipsed traditional technology and fishing communities have abandoned their traditional technologies for the modern ones. Although traditional fisheries equipment took time to make and were less efficient in capturing fish, they caught adequate fish for the subsistence demands and for the small village population. With subsequent population increase, it meant more fish were to be caught without regard to the fish populations. Consequently, commercialisation of fisheries occurred, and commercial gears were introduced which often resulted to a huge catch of unwanted species, leading to overexploitation of resources. This scenario raises the issue of whether we should not reverse the trend by borrowing strategies from TEK. The main problem faced by many modern fishers is the question of operationalizing what TEK can contribute and how. Further, the question also remains as to how scientific knowledge and TEK can be integrated and whether such integration is desirable in the first place. Due to lack of information and data on these questions, I opine that each of these two sciences has some contribution to make in the management of fisheries and it is worthwhile to examine these contributions, merge them, and produce hybrid fisheries management and sustainability strategies. Western science should not be a replacement for TEK since we can still learn a great deal from it in terms of technologies and management of fisheries. In most cases, the control policy of resource management is based on scientific knowledge and generalized ecological knowledge.

One of the strategies used in inland fisheries management was the restriction of access to fish resources. According to Berkes & Kislalioglu (1991), where local communities of fishermen can control access to fishing space and enforce regulations, exploitation levels can be managed. This strategy was practised in traditional societies where some fishermen in the fishing villages around major lakes and rivers had 'personal' spots where they traditionally set their nets. These were protected 'inheritance banks' taken over from their father and/or grandfather. The fishermen knew the spots very well and could resist any attempt to destroy them. In other situations, restricted access and harvesting of the resources was controlled by the local people through supervision of the allowable techniques, setting opening dates for different fisheries, and by according fishing rights to outsiders as practised by people in the Malian Niger valley (Fay, 1989a,b). Because of the restricted access and control, the fisheries were well protected from overexploitation and since they provided livelihood, the people had a sense of responsibility. However, with the emergence of the common property resources enlightenment, too

many outsiders are getting into fishing and are also using motors which have destroyed the fishing spots. Further, the personal fishing spots have also been destroyed by government interference where commercial fishing is licensed without consulting the traditional communities. These large companies infringe the boundary and the community-evolved rules on the utilization of the aquatic resources. More destructive gears have been introduced, including explosive fishing and trawl net, which are more effective than the traditional fishing gears. All these changes have led to acute over-fishing, where takes of fish species are beyond the rate at which the spawning stock biomass is replenishing the stock (Todd & Ritchie, 2000).

TEK is not necessarily true in the same way that scientific knowledge is not necessarily true. Like scientific knowledge, local knowledge is based on accumulated empirical data, and the local people register ecological change as deviations from a known normal situation. For instance, a local fisherman, who is familiar with a lake or river, will react spontaneously to fisheries observations that deviate from the usual pattern. He will be observant to qualitative changes and signs that indicate that something unusual is happening. He will interpret such signs within the context of his experience and traditional knowledge, and discuss his interpretations with fellow fishermen. This obviously makes a quick response to environmental occurrences, thus contrasting scientific approach where methodical observations and collection of quantitative data are needed. The ability to predict where fish is to be found in time and space is probably the most important knowledge for a fisherman. Traditionally, local communities around lakes and rivers kept their fishing gears (e.g., spears, traditional fishing baskets, etc.) off the spawning grounds for some time to allow fish to spawn undisturbed. They often monitored year-to-year changes in the sizes of some of the fish aggregations and reduced their exploitation pressure in periods when stocks were seen to be low, thus sustainably maintaining the fish populations. Some traditional societies practised Mare Clausum approach where some seasons are closed and no fishing rather than Mare Liberum (Kalland, 1990). Locations of rare or endangered fish species and fish aggregations were more likely to be identified by local resource users than by outside researchers doing inventories. In areas where there is flexibility in resource use, allowing switching from one resource to another during the times of no fishing, may serve as a strategy for sustainable harvesting and build up of the fish population. Poor fishing seasons may be compensated for with, for instance, more intensive hunting. Such flexibility is dependent on knowledge about possible substitutes for scarce resources. With the now unpredictable or stochastic climatic patterns, substitutes for the aquatic resources are rare. There is need to revisit fisheries management principles with a view to explore how substitutes could be provided to reduce pressure on fisheries.

The local knowledge of the tidal cycles and how the cycles affected productivity of various submerged microenvironments was used to devise capture strategies and select fishing gear for various times of the year. This specialized knowledge, which originated from the fishers' long-term association with the aquatic ecosystem, is the main factor that has allowed them to subsist in their fishery, irrespective of the invasion by technologically more sophisticated commercial fishers who lack such specialized knowledge. The lack of this knowledge by commercial fishers has led to depletion of fishery resources, destruction of fishing gears, and increased fishing effort. Knowledge possessed by the local aquatic resource users can also be invaluable in recording the spatial distribution of living and non-living resources and amenities by mapping the distribution of fish schools. This is especially important in the regions where recorded knowledge of local environments is poor. Local knowledge also hastens surveying and mapping of fish schools. What people know about their environment, and how they categorize this knowledge, will obviously have an impact on what they do to their environment. TEK may be utilized to suggest mitigative measures which could help to avoid or reduce inadvertent long and short-term damage to the ecosystem and traditional culture.

In conclusion, TEK exists among lacustrine communities in East Africa. It is a tangible aspect of a way of life that can lead to sustainable use of fisheries resources. I have summarized some of the potential applications of TEK in Table 1. The future of TEK in East Africa is uncertain. Such knowledge should be recorded and evaluated by

Table 1. Potential applications of traditional ecological knowledge in fisheries

1. Pollution and ecotoxicology
   Washing dirt hands with cow dung material or toxic materials is forbidden. If you do, fish will disappear (Anon., personal communication). This combines modern science as well as traditional beliefs. Local eutrophication occurs in such circumstances but the local communities do not interpret the occurrence as such. The existence of clean, undamaged environments is critical to sustainability. The biological processes that underlie sustainability require good substrate, adequate water supply, suitable thermal characteristics and good water quality (Olver et al., 1995).
2. Lunar rhythms and fishing
   (a) Fishing is preferable during the crescent moon phase; when the moon sets no fish: if you do catch any fish during this time, it will be small-sized fish.
   (b) No fishing during full moon, very small-sized fish present.
   (c) During waning moon, diurnal fishing is more preferred to nocturnal fishing. In diurnal fishing large fish are caught.
   The above beliefs involve ecological phenomenon of diel vertical migration (dvm) of zooplankton which occurs as a result of changes in light intensity and energy base shifts, i.e., food availability.
3. Daily weather predictions, seasons and fishing schedules
   (a) The fishing conditions in the lake could be estimated by cloud conditions. In cloudy nights, the lake water is cold and few large fish are caught. This phenomenon is also related to light intensity and the shifting of fish food through the dvm of zooplankton, a source of food for fish.
   (b) In the rain season (i.e., April–May) people have intense urge to fish since there is a high probability of getting fish. This is observed in some Lake Victoria riparian communities.
   (c) The fishermen put their feet into the water; if the water is warm, more fish of mixed sizes are believed to be present; when the water is cold, less fish. Nutrient input increases during the rains which leads to high productivity and therefore more food for fish. Rain seasons are also breeding seasons for most fish.
   (d) In some parts of Lake Victoria (Port Victoria and Sigulu Island areas), morning hours have gentle winds, waves are gentler and currents are benign. Locals believe that the spirits of the lake are in a stupor. In the afternoon hours, raging, heaving waves are stirred by swishing winds. The explanation given is that the lake spirits are waking up and they will be completely awake and wild by around 1500 h. This implies that the best time for fishing would be in the morning hours. These observations have also been reported elsewhere (Hobson, 2003).
4. Traditional technology, selection of gear, and techniques
   (a) The traditional fishing gears (e.g., baskets) are very effective during nights without moonlight and catch plenty of fish. This technology is disappearing rapidly in favour of modern technology. The market economy by means of fish trading with outside markets led to change in the methods of fishing and fishing gears. The main purpose of traditional fishing was for household consumption. This rarely led to over-fishing. Traditionally, non-destructive types of gear (e.g., hook and line versus spear/harpoon) were rotated to meet the availability of fish species available in different seasons.
   (b) Knowledge of tidal cycles by the coastal people and how the cycles affect the productivity of various submerged microenvironments was used to devise capture strategies and select fishing gear for various times of the lunar day, month and year.
   (c) Mouthfuls of brackish water in estuaries gave clues about what fish species was present; head submergence in water helped in listening to the clicking of shrimps in order to determine whether they were holding fast in the sea grasses along the estuarine floor or moving in the water column (McGoodwin, 1990).
5. Spawning and aggregations of fish
   (a) Locals can tell precisely the months and lunar periods as well as the precise locations of spawning aggregations of fish. Stock sustainability requires that the number of adult fish escaping harvest (i.e., spawner escapement) be sufficient to maintain the reproductive output of the stock (Olver et al., 1995). As spawner escapement tends toward zero, the risk to stock sustainability increases rapidly. Traditionally, locals knew the consequences of fishing during spawning; they kept the nets off the spawning grounds for some time, allowing the fish to spawn undisturbed.

Continued on p. 5

Table 1. (Continued).

(b) Traditional peoples were able to monitor year-to-year changes in the stock sizes of some of the fish aggregations and reduced their exploitation pressure in periods when stocks are seen to be low, thus sustaining the fish population. They acknowledge natural temporal variation in productivity of the target population and of the ecosystem of which it is a part. Locals do not need to know and use formulae (e.g., maximum sustainable yield (MSY), optimal yield (OY), $F_{0.1}$, etc.) that have been developed in fisheries science for establishing defensible limits on exploitation (Parsons, 1993), to take decisions on fisheries issues.

(c) Locals have knowledge on the distribution of fish schools.

6. Location and identification of rare or endangered fish species

(a) They are more likely to be identified by local resource users than by outside researchers doing inventories. Traditional peoples are the first to notice any change in the availability of a certain fish species and will explain events in relation to occurrences in the environment. Vulnerable, threatened, and endangered species must be rigidly protected from all anthropogenic stresses (Olver et al., 1995). Any activity that risks their extinction should be proscribed.

7. Systems topography and traditional fishing spots

(a) Some fishermen have personal fishing spots and know when to expect fish. They know where and when certain fish species will probably turn up.

(b) Local fishermen know about the landscape on the lake or sea bottom so that they do not destroy their traditional equipment with sharp rocks.

8. Division of labour in fisheries

In traditional communities labour is divided according to gender and age as are the skills taught to a child. In fishing, for instance, fish identification is learnt by both boys and girls at an early age (2–6 years). The transfer of knowledge on fish identification could take up to 4 years or more and it is usually the father who teaches such an activity. Learning of the fishing activities in the lacustrine communities starts early. Boys and girls as young as 8 and 10 years, respectively, have been reported to take part in fishing activities in other parts of Africa (Van der Waal, 2000). But as the fishing activities become more complex (e.g., casting nets, using the harpoon/spear) the tasks are shifted to males only. Children (about 2 years) learn passively by watching the older people do the activity. This way the child grows with intense attachment to the environment that provides for his/her livelihood. This shows that gender issues are paramount in promoting the use of TEK in the sustainable use of fisheries resources.

people who possess an appropriate background in biology, ecology and resource management, and in the social sciences. Local traditional knowledge and local norms could supplement scientific knowledge in establishing ecologically sound and socially just management of fisheries. However, as applications of some scientific theories and models are detrimental to fisheries, so are some TEK applications. A taboo on harvesting of a fish species may put increased pressure on some other, more easily depleted species. Locally prescribed methods for improving fishing which focus on propitiating spirits or countering the effects of sorcery may divert attention from the real and sometimes correctable causes. Superstitions and myths can be taken for granted to conceal functional ecological concerns. To ensure sustainable use of fish stocks, those populations that can be exploited, and those that cannot, need to be identified. For instance, in the Western Indian Ocean, turtle products are believed to have aphrodisiac effect and are harvested indiscriminately, conflicting with conservation principles and sustainability. Traditionally, people around the lakes and along rivers have also used ichthyotoxins from plants (e.g., *Phytolacca* sp., *Tephrosia* sp.) to harvest fish (S.T. Kariuki, personal communication). This could be against the principles of resource management and sustainability since the bioactive products usually select the small-sized fish that are expected to recruit to the adult stock (Welcomme, 1979). The right to use ecological productivity does not bestow the right to abuse it. The consequent alteration to the productivity of natural ecosystems and the loss of surplus production from native stocks undermines sustainability. Whether TEK is an obstacle in fisheries development or not has not been documented in East Africa. The South African Xhosa cultural belief that ancestors resided beneath the water as the

'river people' or 'Abantu bomlambo' was not an obstacle in the development of aquaculture or fisheries (Van der Waal, 2000). Ways of integrating both traditional and scientific knowledge systems effectively to facilitate the management and sustainability of fisheries should therefore be sought. Because of conflict among the stakeholders, co-management as "the active participation in management of a resource by the community of all individuals and groups having some connection with, or interest in, that resource (Claridge, 1997)" would be more applicable for sustainability where villagers, and local and regional governments are involved. This could also be one of the strategies for integrating modern scientific and traditional knowledge in the management of fisheries in East Africa. It is more appropriate to upgrade, rehabilitate and adopt "indigenous" resource-management systems and merge with selected and tested resource management techniques of the industrialized countries to produce hybrid resource-management systems.

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