Chapter 4
Fishing and Aquaculture Practice in the Ponds of the Indian Sundarbans

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Abstract Though agriculture continues to be the predominant livelihood option for the millions residing within the Indian Sundarban Biosphere Reserve (SBR), inland fishing has lately emerged as a promising and viable option to alleviate the financial status of the grossly impoverished population of this region. Ponds and rearing of fishes in those ponds are integral components of the daily life of the people of Sundarbans. However, fishes are grown in most of the household ponds for self-consumption, and extensively without much investment. Aquaculture operations, on the other hand, require substantial scientific intervention to commercialize the fish yield and get a handsome return against the time and labor input. The present chapter collated the knowledge acquired so far in this domain, from the perspective of SBR. The fish diversity and the aquaculture management practices are detailed in a nutshell. The salient features and the typical characteristics of the ponds of the SBR are also discussed. This chapter also identifies the basic threats and challenges that the aquaculture farms of this region are facing at present. Overall, this chapter gives a brief overview of the inland fish farming practice and the attitude of the local inhabitants towards this promising sector of earning revenues.

Keywords Household ponds · Aquaculture ponds · Freshwater aquaculture · Brackishwater aquaculture · Fish diversity · Pond management practices · Threats to fish farming

4.1 Introduction

The Sundarban Biosphere Reserve (SBR), which is renowned for being the largest single tract of contiguous mangrove forest, is also home to more than four million people in the Indian counterpart (Mitra et al. 2021). The population density in the transition zone of the SBR is substantially high, and agriculture is the principal livelihood option for most of the people who live in this region (Ghosh and Mistri

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2020). Besides agriculture, apiculture, the collection of forest resources like fuelwood and other non-timber forest produce (NTFPs) comprise another means of livelihood (De and Das 2021). However, another livelihood option that has been traditionally practiced by many in the SBR since time immemorial is fishing and fish rearing (Kumaran et al. 2020). The adjacency of the open oceanic regions of the Bay of Bengal made capture fisheries a viable source of income for many (Dutta et al. 2021). However, offshore fishing requires substantial capital investment and it is not a feasible option for the impoverished and marginalized section of the society. Though offshore fishing engages hundreds and thousands as laborers, it is not a suitable option for the millions to earn a secure livelihood. Moreover, the recent past has witnessed uncertain turnovers from offshore fishing mostly due to practicing unsustainable means of fishing (Suresh et al. 2021). However, fishing in open estuarine waters with small country boats by an individual or a small group of people is a very common sight in the SBR. According to Das and Manadal (2016), in the forest fringe areas of the SBR, more than 20% of the population practices this type of fishing. These people mainly go for various types of finfish, shellfish, prawn seed, and prawn seed collection. A substantial number of women in this fringe area are professional fishers. Women often set sail with small boats and fish not only in the open estuaries but also enters the forest creeks (Sundaray et al. 2019). Women with no boats are often seen walking in the intertidal zones and they collect small fish and prawn seeds with bag nets or bare hands. However, these practices have considerable risk as occasional human-animal conflict and casualties due to crocodile and tiger attacks are reported from this region (Paul 2020).

Inland fishing is traditionally practiced in the local household ponds throughout the rural setup of India and the Indian Sundarbans is no exception. In the SBR, ponds are an integral part of almost all households. The soil dug out from a portion of the land is used to make the Kucha houses or shelter for cattle and thus, it serves a two-way purpose by creating a means of water availability and raw construction material (Mandal et al. 2015). Rainwater is usually stored in these ponds. The monsoon rain fills these ponds during the rainy season from June to September. The stored water is used for multiple purposes throughout the year and especially during the dry months. Bathing and washing utensils are some of the common household activities that utilize pond water. Irrigation in agricultural plots or household agriculture also finds its use. Almost all the household ponds are also used to rear fishes of various types. The local people introduce fingerlings of various species and rely on natural photosynthetic processes for the fishes to grow. This type of fish rearing is only conducted for subsistence and local consumption (Mandal et al. 2015). However, in the recent past commercial aquaculture practice to grow fishes have gained significant popularity in this region (Kumaran et al. 2020). Fish is an extremely common and, at the same time, a popular cuisine among the Bengali community (Das Chaudhuri 2019). Thus, the demand for fishes in this region is never-ending. Given the uncertainty witnessed in the field of capture fisheries and the risk of fishing in forested estuaries, aquaculture emerged as one of the potent options within the SBR (Sundaray et al. 2019; Kumaran et al. 2020). The introduction of aquaculture, especially amongst the marginalized section of Asia and Africa, was meant to act as a relief from the burden of poverty

and a means of earning a decent livelihood (Ahmed and Lorica 2002; Mwaijande and Lugendo 2015). The people of Sundarbn have also lately realized the potential of aquaculture practice in providing an alternate livelihood and self-reliance (Kumaran et al. 2020).

The scope of aquaculture in India has a promising future, and already at present, India ranks second after China (the largest aquaculture industry in the world) accounting for 6% of the global total aquaculture produce (FAO 2016). Owing to a diverse landscape and geomorphological setting, India offers significant potential for carrying out both freshwater and brackish water aquaculture. Both these types of aquaculture are prevalent in the SBR. Followed by the state of Andhra Pradesh, West Bengal ranks second in terms of aquaculture production within the country and it involves an estimated 3.2 million people in this sector. Within West Bengal, SBR plays the most crucial role in aquaculture production. Singh et al. (2010) estimated that almost two million people from the SBR are directly or indirectly engaged with fishing activities. These observations indicate that the SBR is witnessing a paradigm shift from agriculture to aquaculture and such radical change can play a crucial role in alleviating socio-economic conditions of a large section of this coastal community. However, it is also feared at the same time that the effect of unsustainable and indiscriminate conversion of land to aquaculture can lead to severe consequences in this ecosystem (Halder et al. 2021).

4.2 Salient Features of Aquaculture Ponds in SBR

Various types of aquaculture practice are prevalent in the SBR, which includes freshwater monoculture, brackishwater monoculture, fresh and brackishwater composite culture or mixed culture, rice-shrimp mixed farming, etc. The aquaculture operations are mostly handled by men and their income lies around Rs. 50,000 per annum (Dubey et al. 2016). Inland aquaculture is practiced in the SBR since time immemorial and most of the present practitioners inherited the farms from their ancestors. However, in the recent past, a substantial rate of conversion of agricultural lands to aquaculture farms is witnessed (DasGupta et al. 2019). A comparatively better income and lesser risk than traditional agriculture (due to erratic rainfall and climate variability) are the principal reasons behind this large-scale conversion to aquaculture (Sarkhel 2015). They mostly rely on their traditional knowledge when it comes to fish farming (Abraham et al. 2010). Though efforts from the government as well as non-government sectors to disseminate the knowledge of the modern scientific advancements in this domain to the fish farmers exist, in reality, it is scarcely implemented due to lack of coordination (Dubey et al. 2016). It is also worth mentioning that the people of SBR seldom carry out aquaculture exclusively throughout the year. Most of these people practice fish farming as an additional source of income, keeping other livelihood options intact (Dubey et al. 2016).

According to Dubey et al. (2016) farming of finfish and shellfish, both are popular in the SBR. Almost three out of four ponds in the SBR practice freshwater aquaculture. One of four ponds practices both freshwater and brackishwater aquaculture in SBR. In the present date, polyculture is mostly preferred by the fish farmers of SBR (Biswas et al. 2019). Most of the aquaculture ponds are perennial (≈70%), while the rest are seasonal (≈30%). Inlets and outlets are maintained in almost half of the ponds whereas it is absent in the other half. In the case of freshwater aquacultures, mainly rainwater is utilized to practice fish farming; however, several ponds use a mixture of rainwater and groundwater. Brackishwater aquacultures are mostly practiced in the island peripheries, where the estuarine water of varying salinity is allowed to enter the ponds (Shyne Anand et al. 2018). Very few of the ponds in SBR have additional nursery ponds or grow-out ponds (Dubey et al. 2016). However, at present, the number of ponds with the grow-out facility is increasing. In the present date, the majority of the fish farmers purchase juvenile fish stock from hatcheries (Dubey et al. 2016).

4.3 Pond Management and Farming Practices

A suite of pond management strategies is adopted by local people of SBR for their household ponds, specifically for the aquaculture ponds. Dewatering of ponds is one such common strategy often implemented for household as well as aquaculture ponds. The fresh initiation of the cycle of an aquaculture production often begins with dewatering the entire pond, followed by sun-drying (Biswas et al. 2019). This effort enables the pond managers to carve out the pond shape properly before allowing the waters to refill the ponds and remove any unwanted weeds and shrubs. The anaerobic soil bottoms get rejuvenated to some extent through this practice. This practice is occasionally carried out in household ponds as well. The pond owners often mentioned that sometimes they feel the entire water needs to be drained out. They rely on their traditional knowledge and experience in deciding the time of dewatering. A foul odor and blackish-green color are some of the indicators that compel the dewatering of household ponds. Removal of bottom sediment from the ponds is also a common practice in the SBR (Dubey et al. 2016). This practice is mostly seen in the aquaculture ponds are scarcely in the household ponds. The aquaculture ponds accumulate substantial organic loads and detritus material in the pond bottom (Kalous et al. 2012). Bottom feeders like some prawns can collect their food resources from such deposited materials (Moraes-Valenti and Valenti 2010; Franchini et al. 2020); however, an excess of such materials in the pond bottom often lead to undesirable consequences. Bottom sediment removal is often practiced in the presence of water but mostly takes place when the ponds are dewatered. The presence of excess organic detritus makes the pond bottom extremely anoxic (Musyoka 2016), which in turn favors some anaerobic bacterial communities to reduce sulfate to hydrogen sulfide and this leads to foul odor and pungent gas ebullition (Antony and Philip 2006). Accumulation of hydrogen sulfide levels beyond a certain threshold affects the respiratory

process of several fishes and indirectly incurs various diseases (Jasmin et al. 2020). De-weeding is another technique that is quite prevalent in the SBR. Removal of unnecessary weeds from the ponds leads to better functioning of the ponds (Rahman et al. 2011). Besides, the above-mentioned management practices, lime treatment, and compost manure application are two of the most common practices observed in both the household ponds and aquaculture ponds. Lime treatment is carried out for multifarious purposes. Maintaining the pH of the water column is the prime objective of lime treatment (Chanda et al. 2019). Calcium is known to play a crucial role in the bone development of fishes (Fontagné et al. 2009) which comes into the aquaculture system through lime treatment. Lime treatment is done in two ways in the ponds of SBR. Sometimes, when the ponds are de-watered solid lime (powdered) is applied to the bottom soil and allowed to sun-dry. Besides, a lime slurry is sprayed throughout the pond when the pond remains filled with water. Again in this perspective, the fishermen use their traditional knowledge to decide the time and magnitude of lime required for their ponds to perform well in terms of fish production. Occasionally potash alum is mixed with lime and applied to the water body. The alum is known to play a disease preventive role (Anderson 1992), as well as, it acts as a coagulating agent and facilitates the deposition of unwanted suspended particles, which in turn, enhances the clarity of the water column (Igwegbe and Onukwuli 2019). Even in the present date, a substantial number of fish farmers rely upon manure to fertilize their ponds, which includes vermicompost, farmyard, and many other types, like cow dung, and oilseed cakes (Ghosh et al. 2019). According to Dubey et al. (2016), 30% of the fish farmers practice single stocking, i.e., they stock the fish once in a cycle and harvest altogether at once. However, the majority of the fish farmers practice multiple stockings, i.e., they stock the fish at regular intervals and periodically harvest depending on the size and shape attained by the fishes or species (in the case of polyculture). Fish seeds can be broadly categorized into three types, namely the fries, the hatchlings, and the fingerlings. Dubey et al. (2016) observed that fingerlings are the most popular followed by the fries, and the hatchlings are the least used. A sizable number of farmers also prefer a mixture of all three types. The fish stocking density varies largely depending on the fishes being cultured; however, the stocking combination has some prominent preferences. The Indian carps and Tilapia are the most preferred couple followed by the minor carps mixture. A substantial number of fish farmers do not provide any external fish and rely on the natural photosynthetic process for the fishes to grow; whereas a large number of people use natural items like rice bran and oil cakes as fish feed (Dubey et al. 2016). Those with a higher tenacity to commercialize the fish produce purchase fish feeds available in the market and apply them in the ponds to amplify the fish growth. Feeding intervals vary from daily to weekly depending on the type of fish being farmed and the particular farmer's traditional knowledge.

4.4 Freshwater and Brackishwater Species

The Sundarbans host a wide variety of fishes in the estuaries, creeks, and near-shore waters of the Bay of Bengal. Dubey et al. (2015) recorded 62 freshwater fish species, out of which 8% belonged to the endangered and critically endangered category. The admixture of freshwater and saline water in and around the intricate network of waterways of Sundarbans provides a suitable habitat for an array of both freshwater and marine fishes (Gopal and Chauhan 2006). The adjacency of the vast mangrove stretch provides a suitable shelter and acts as a nursing ground for these fishes (Dutta et al. 2016). Several anadromous fishes that spend most of their life cycle in the marine water proceed towards the estuarine reaches during spawning (Giri et al. 2020), whereas several freshwater fishes and prawns that usually inhabit the freshwaters access the estuaries during spawning (Sundaray et al. 2019). Thus, this unique eco-region acts as an abode for all types of fishes, which enhances the fish diversity of this region. This high ichthyofaunal abundance in the estuaries is reflected in the inland fishing scenario as well (Fig. 4.1). The Indian major carps (*Catla catla*, *Labeo rohita*, and *Cirrhinus mrigala*) still dominate freshwater aquaculture; however, several minor carps (*Labeo bata*, *Labeo calbasu*, etc.) are also cultivated throughout the SBR. Tilapia (*Oreochromis niloticus*, *Oreochromis mossambicus*) is still a very popular choice among many fish farmers (Fig. 4.2). Compared to freshwater finfishes, options for freshwater shellfishes are very few, out of which, *Macrobrachium rosenbergii* is farmed by many, especially during the rainy season (Sundaray et al. 2019) (Fig. 4.3). Brackishwater finfishes like *Mystus gulio* and *Lates calcarifer* are occasionally farmed (Fig. 4.4); however, among the brackishwater

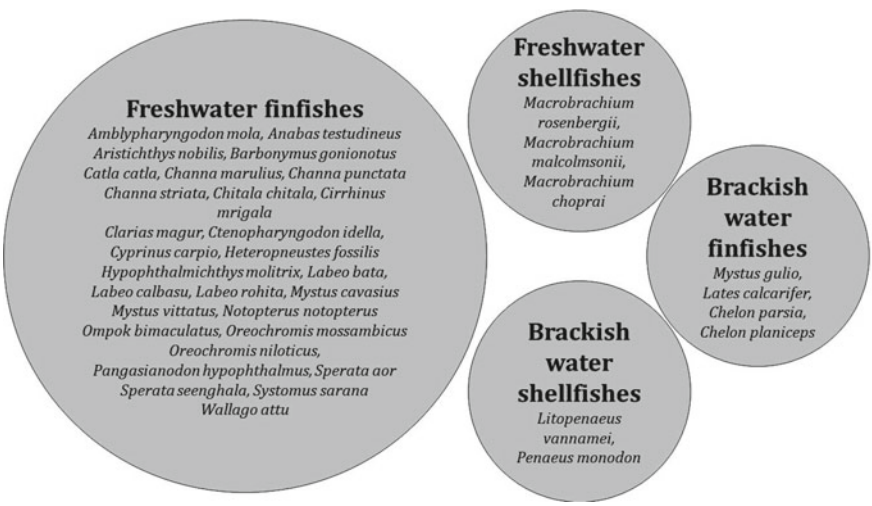

Fig. 4.1 The dominant fish species farmed in the aquacultures of SBR

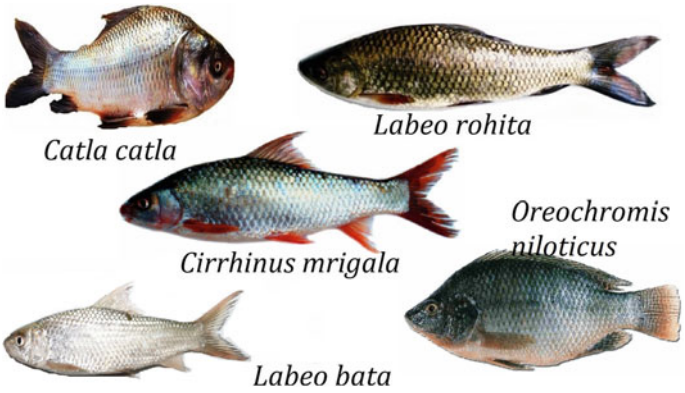

Fig. 4.2 The images of few dominant freshwater finfishes which are grown through aquaculture farming in the SBR

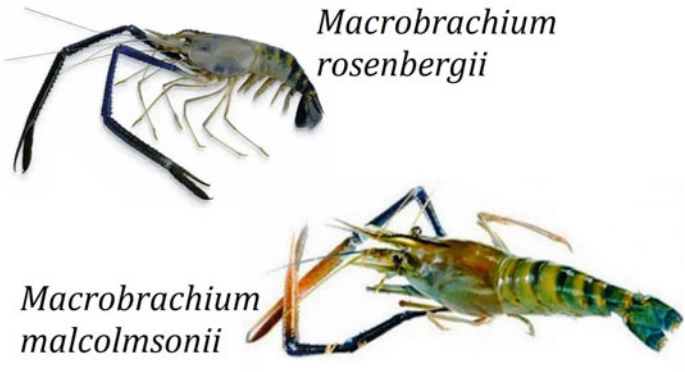

Fig. 4.3 The images of the dominant freshwater shellfishes which are grown through aquaculture farming in the SBR

shellfishes, the exotic *Litopenaeus vannamei* is at present outplaying the indigenous *Penaeus monodon* (Fig. 4.5).

4.5 Challenges and Threats to Aquaculture Fishing

4.5.1 Serious Lack of Scientific Intervention

Sundaray et al. (2019) emphasized that there exists a serious lack of coordination among the fish farmers remotely based in the different islands of Sundarban. A significant number of fish farmers have no idea about the modern scientific breakthroughs

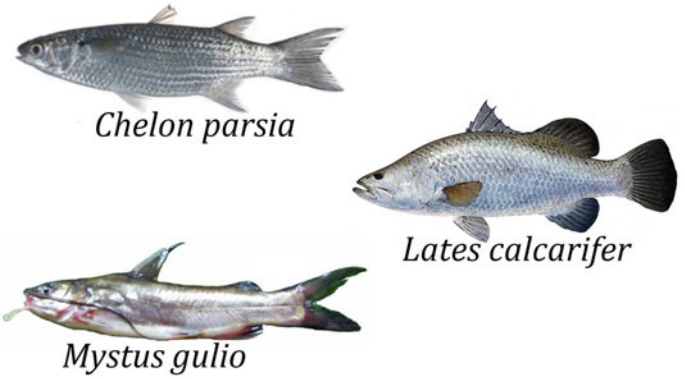

Fig. 4.4 The images of few dominant brackishwater finfishes which are grown through aquaculture farming in the SBR

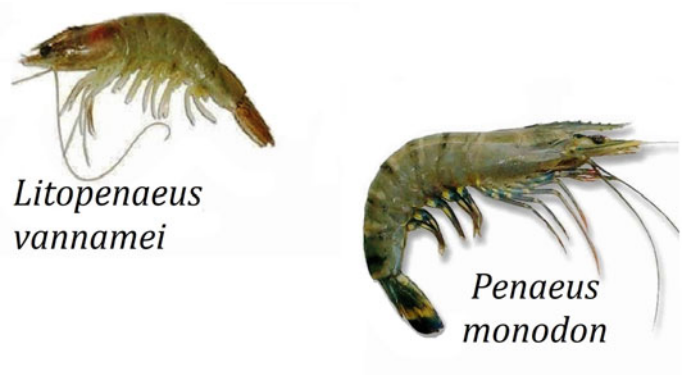

Fig. 4.5 The images of the dominant brackishwater shellfishes which are grown through aquaculture farming in the SBR

in the domain of aqua-farming. Their traditional knowledge is not up to the mark to enhance the yield of the fish to that extent, which can be commercially profitable. Inadequate pond management strategies, absence of fish feed and fertilizers bar the fish farmers of SBR from getting the expected return, even when this unique eco-region has a huge potential in terms of aquaculture farming. Sundaray et al. (2019) also stressed that the fish farmers of this region are not all aware of the fish nursing and rearing, and purchase the fish seeds from external markets. This lack of knowledge or proper intent incurs heavy financial losses to the fish farmers or reduces the profit margin.

4.5.2 Cyclonic Disasters

The Sundarbans is prone to the frequent occurrence of severe cyclonic storms. In the last three decades the intensity, as well as the frequency of these tropical cyclones, have increased manifold (Mandal and Hosaka 2020). The high wind velocity not only leads to the destruction of life and property, but massive storm-induced surges also ravage the rural areas (Sahana and Sajjad 2019). Breaching of embankments and saline water intrusion into the agricultural fields and ponds are some of the most inevitable events that follow after a cyclone passes through the SBR (Pramanik et al. 2021). Saline water floods most of the freshwater ponds and imposes a salinity shock to the present ichthyofaunal diversity leads to mass mortality of fishes (Sundaray et al. 2019). Moreover, extreme rainfall events lead to the overtopping of the ponds and most of the fishes leave the pond enclosures, which lead to substantial losses to fish farmers (Paul and Chatterjee 2019). Several fish farmers also claim that blown away materials like broken branches of trees and leaves due to the storm-passe leads to deterioration of the water quality of the ponds. These observations are very common in the case of household ponds, which are often associated with trees planted nearby.

4.5.3 Fish Diseases

Dubey et al. (2016) noted that many of the farmers of the SBR strongly believe that the fishes of this region do not suffer from any diseases and the same was advocated by Chand et al. (2012) due to the presence of salt in these waters, which kept several diseases at bay. However, with the changing climate and the recurrent climate extreme events like cyclone, droughts, and increase in the ambient temperature, several fish diseases have become prominent in this region (Sundaray et al. 2019). Epizootic ulcerative syndrome, fin and tail rot, malnutrition, dropsy, and parasitic outbreaks like Lernaeasis, Argulosis, and Myxoboliasis, along with fluke diseases like Gyrodatylosis and Dactylogyrosis, are some of the most common diseases among the finfishes of SBR (Dubey et al. 2016, 2017; Sundaray et al. 2019). The crustaceans on the other hand mostly suffer from white spots, fungal infection in shells, blackening of gills, and softening of shells (Dubey et al. 2016; Sundaray et al. 2019). These diseases were found to onset any time of the year; however, the beginning of the post-monsoon season till the winter end, is the most vulnerable time of the year for disease outbreak (Khan and Lilley 2002; MacRae et al. 2002). The monsoonal runoff-induced proliferation of industrial chemicals and pollutants in the ponds coupled with lowered immunity at this time of the year is held accountable for the susceptibility of diseases in the fishes (Bly et al. 1997).

4.5.4 Intrinsic Soil Character

The ponds of this SBR are earthen and the water stored within these enclosures remain in direct contact with the unearthed region. Mondal (2003) observed that the SBR comprises two types of soils, the Aridisols (which thrives in arid to semi-arid environments influenced by salinity) and the Alfisols (alluvium which experiences a steady humid environment). However, both of these types often encompass soils rich in acid-sulfate at varying depths. Though the ponds of SBR are mostly shallow, during unearthing these acid soil layers get exposed and come in direct contact with water (Sundaray et al. 2019). Direct exposure to such soils drastically reduces the pH of the entire water column. The local fishermen though recognize the problem but often due to a lack of proper lime treatment and other necessary measures that need to be implemented, the fishes die in numbers. Sundaray et al. (2019) observed that such effects of acid soils diminish over three to five years, and this accounts for substantial loss to the fish farmers.

4.6 Conclusion

Collating the very few existing pieces of literature on inland fishing in the Indian Sundarban Biosphere Reserve, it can be inferred that fish rearing and farming is integral to the lives of the local inhabitants of this region, however, in terms of commercialization of the aquaculture practice, it is still in infancy. Most of the households practice traditional extensive fishing in their ponds, and the fishes grown are meant for self-consumption. The aquaculture sector has seen tremendous growth in the last decade; however, technological intervention is yet to spread across the nooks and corners of this ecosystem. In the last decade, the Central Institute of Freshwater Aquaculture (CIFA) founded by the Indian Council of Agricultural Research (ICAR), New Delhi has taken several measures to properly educate the fish farmers regarding the scientific advancements of this domain; however, still, it is a long way to go to fetch the expected results. Many scholars believe that the multifarious challenges that the aquaculture and inland fishing sector of SBR experience in the present date can be handled by implementing proper management strategies, and that this sector can in the truest sense, alleviate the impoverished conditions of the majority of the population within the SBR.

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