POLICY PAPER

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Reservoir Fisheries Development in India: Management and Policy Options

NATIONAL ACADEMY OF AGRICULTURAL SCIENCES, NEW DELHI

May 2016

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CITATION : NAAS 2016. **Reservoir Fisheries Development in India: Management and Policy Options**. Policy Paper No. 78, National Academy of Agricultural Sciences, New Delhi: 20 p.

EXECUTIVE COUNCIL 2016

Published by Mr H.C. Pathak, Executive Secretary, on behalf of
NATIONAL ACADEMY OF AGRICULTURAL SCIENCES
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Preface

Reservoirs are an essential component of most irrigation systems and together with those built for flood control and power generation, retain a large volume of water. As per available information, India has 19,370 reservoirs with an estimated 3.1 million hectares of surface areas at FRL, categorised as large, medium and small on the basis of area.

These reservoirs, apart from providing services for which created, also play an important role in fish production and contribute significantly to livelihoods of communities along their shores. There is widespread recognition that the fisheries potential of most of these greatly exceeds current use, provided that environmentally and socially sustainable management systems can be developed and adopted. Present average fish production from these reservoirs in the country ranges between 12-50 kg / ha that is much below the potential. The productivity or development benefits from reservoir fisheries can be enhanced through a number of approaches, *viz*., ecosystem-based management, implementing established fishery regulations and by enhancement interventions coupled with enabling policy support.

Considerable work has been carried out in the country to understand ecosystem functions, improve the fish production from reservoirs and a number of successful case studies and models where production has increased 3-4 folds are available. However, we have not been able to harness the benefits adequately across the country due to various policy and technology implementation challenges.

Keeping this in view, the National Academy of Agricultural Sciences organized on September 19, 2014 a Brainstorming Session on *Reservoir Fisheries Development in India: Policy and Management Options* to indentify strategy in research, policy and development programmes with aim to promote and improve the reservoir fisheries productivity for sustainable development and livelihoods.

The Academy appreciates the efforts of Dr. W.S. Lakra, former Director, CIFE, Mumbai and his team in convening this Brainstorming Session. Grateful thanks are due to Resource Persons, Reviewers and Editors of the policy paper. The Policy Paper is an output of the above deliberations and the Academy gratefully acknowledge the contributions of the Convener, the distinguished participants, reviewers, and other Editors of the Policy Paper.

S. Ayyappan
President

Reservoir Fisheries Development in India: Management and Policy Options

1. PREAMBLE

India is the second largest producer of fish in the world contributing to 5.43% of global fish production as of 2012-13. India is also a major producer of fish through aquaculture and ranks second in the world after China. The total fish production during 2013-14 was 9.58 million tons (4.2 million tons in 1991-92) with a contribution of 6.14 million tons from inland sector (1.71 million tons in 1991-92) and 3.44 million tons from marine sector (2.45 million tons in 1991-92). As evident, of the marine and inland sectors, the latter is growing at a faster rate with nearly two third share in India's total fish production. With Rs. 96,824 crores as value of output from fisheries sector at current price (2013-14), fisheries sector contributes about 1 percent to the overall GDP and 5.15% to the agricultural GDP. Exports of fish products aggregated to 9,83,756 tons in volume and was valued at Rs.30,213 crores during 2013-14 registering a growth of 6% in volume and 60% in value over the past year (DAHDF, 2015).

The recent scenario of Indian fisheries reveals a paradigm shift from marine dominated fisheries to a scenario where inland fisheries especially fresh water aquaculture has emerged as a major contributor to the overall fish production in the country. In this context, reservoir fisheries development assumes significance for following reasons: marine capture fisheries are fast approaching a plateau and the inland open water ecosystems overtime are fast getting degraded due to accelerated habitat modifications. The aquaculture development projects are comparatively more capital intensive and of late are facing many environmental concerns. In view of these issues and considering the enormous resource size and untapped production potential, the reservoirs have become the focus of future fisheries development plans in India.

Ironically, reservoir fisheries is sometimes characterised as a sleeping giant due to its vast but *underutilized* potential. Estimates suggest that presently reservoir fish production is only a fraction of their potential. For instance, to the projected fish production of 12.27 million ton in India by 2020-21, the reservoirs are expected to contribute about 2 million tonnes *i.e.* 16% (Ayyappan, 2011). Sugunan (2007) further argues that reservoir fisheries has many comparative advantages as compared to other fish production systems. It is reasoned that in terms of cost of production, aquaculture requires about Rs.10,000 crore to produce 1 million ton of fish whereas the fish production from reservoirs requires a far less investment. Socially also it is considered to be more equitable as the profit is shared by the larger fisher community depending on the reservoir fishery leading to

improvement in their income levels while in aquaculture the returns are realised only by a single or a small group of investor / farmer(s). In the immediate future, it is estimated that *nearly half of the projected demand of 3 million tons of additional fish by the end of XII Plan may have to come from the reservoirs.* Thus, national efforts to enhance fish production from India have to rely heavily on reservoirs (Ayyappan *et al.*, 2011).

In order to deliberate on various challenges facing reservoir fisheries development in India and come out with pragmatic action points, the National Academy of Agricultural Sciences sponsored the organization of a 'Brain Storming Session on Reservoir Fisheries Development in India: Policy and Management Options' at NASC Complex, New Delhi on 19th September 2014.

2. RESOURCE STATUS, PRODUCTION AND PRODUCTIVITY

Reservoirs are the ***single largest inland fisheries resource,*** covering more than 1% of the country's land surface, in terms of resource size. Though primarily created for irrigation, power generation and other water management purposes, these water bodies have become the prime inland water resource for harnessing fishery. The reservoirs are defined as man-made impoundments created by diverting surface flow, by erecting a dam of any description across a river, stream or any water course. Though several classifications exist, according to the widely used official classification (Srivastva et al 1985; Sarma 1990) reservoirs as per area are categorized as small (<1000 ha), medium (1,000 to 5,000 ha) and large (>5000 ha) for the purpose of fisheries management. According to Handbook of Fisheries Statistics published by Department of Animal Husbandry, Dairying and Fisheries, the estimated cumulative area under reservoirs is 29,07,000 ha (DAHDF, 2011). However, earlier detailed studies report 19,370 number of reservoirs spread over 15 states with an estimated 31,53,366 ha surface area at full capacity (area at FRL) of which small reservoirs constitute 14,85,557 ha (47%), while medium and large reservoirs occupy 5,07,298 ha (16%) and 11,60,511 ha (37%), respectively (Sugunan, 1995; Ayyappan *et al*., 2011). According to National Wetland Atlas, the total reservoir area in the country is estimated at 24,81,987 ha, using the remotely sensed data (NWAI, 2011). It implies that some classification related issues for reservoirs and wetlands remain to be resolved. The CIFRI under its CGIAR project "Challenge Program on Water and Food" during 2008 prepared an inventory of 691 reservoirs in Indian part of Indo-Gangetic-Basin states and revised the reservoir inventory status in some of the Indian states (Katiha *et al*. 2007). However, the reservoir number and area along the lines of agreed typology need a relook since many changes would have occurred by way of addition of new waterbodies and reduction in the area of existing reservoirs, etc. during the last three decades.

Based on the earlier estimates of fish yields from 422 reservoirs, in small, medium and large reservoirs (Sugunan, 1995) reports average production of 49.50 kg/ha, 12.30 kg/ha and 11.43 kg/ha, respectively from these categories of reservoirs. Applying this per unit production level, at national scale, fish production from small, medium and large reservoirs could be 74,129 tonnes, 6,488 tonnes and 13,033 tonnes, respectively totaling to 93,650 tones. But, with reported potential yield of 500, 250 and 100 kg/ha for small, medium and large reservoirs, respectively, the corresponding production could be 7,43,000, 1,27,000 and 1,16,000 tonnes. Cumulatively this would boost up the present production of all reservoirs to nearly a million tons, a tenfold increase (Ayyappan *et al.,* 2011).

According to CIFRI's impact assessment of NFDB's Reservoir Fisheries Development Program implemented in 20 States covering nearly 2000 reservoirs, the average yield from small reservoirs has increased to 110 kg/ha (Sugunan 2014). However, this is still low as compared to reported fish production from other countries such as China (743 kg/ha), Sri Lanka (300 kg/ha) and Indonesia (177 kg/ha) though one has to account for the differential species composition in each country, average size of waterbodies and the intensity of management. This improved per unit production is a positive sign and many States have reportedly achieved impressive gains in yield through this seed stocking program launched for reservoirs by NFDB (Sharma, *et al*, 2011).

Many reasons / factors have been attributed to low fish yields from our reservoirs. On the whole, these factors can be put into three broad set of challenges. The first one is ***Technology related challenges,*** the second ***Management Challenges*** and third ***Policy and Governance challenges.*** These are discussed in some detail hereunder.

3. TECHNOLOGICAL CHALLENGES AND OPTIONS

Reservoirs are generally managed for fisheries enhancement by adopting species enhancement, culture-based fisheries, or other forms of enhancements, depending on the bio-physical nature of the water body. In a culture-based fishery, stocking is done with the aim of recapturing a substantial part of the stocked fish. This is possible only in relatively shallow reservoirs that are conducive to operation of fishing gear and with low predator pressure. Larger reservoirs are not amenable to culture-based fisheries due to many reasons mainly because stocking to recapture becomes uneconomic. In such reservoirs, aim of stocking shall be to establish a breeding population that eventually forms a basis for future sustainable fishery. But, considering that more than 70% of the total 1.5 million ha of small reservoirs in India are amenable for culture-based fisheries, a significant increase in production can be achieved from these water bodies by adopting scientific principles of culture-based fisheries. One of the main reasons for low productivity of these reservoirs is either lack of, or inadequate application of technical knowledge in fisheries management.

Very often reservoirs are arbitrarily stocked with inappropriate seed material leading to wastage of resources and sub-optimal growth of fish stocks.

Central Inland Fisheries Research Institute (CIFRI) and other sister institutions have carried out commendable research in understanding the ecological functions and biology of fishes from reservoirs and developed technological packages / scientific protocols for improving their fish production. Some of the interventions / suggestions are:

3.1. Stock Enhancement

State Fisheries Departments and the technology transfer system often require unambiguous and simple prescription of technological packages and management strategies with reference to species mix, stocking density, cage culture guidelines, etc. so as to ensure high adoption rate (Vass *et al.*, 2009). However, such prescriptions are often challenging considering the diversity of resources in terms of size, hydrographic profile, trophic level and status of potential productivity in each category of reservoirs. For example, the utility of following an uniform stocking density for all small reservoirs (size < 1000 ha) for culture based management. Instead, it may be appropriate to sub-group them for the purpose of implementing appropriate stocking density and enhancement strategy. Hence, there is a need for generating more scientific knowledge for stock enhancement strategies for different kinds of reservoirs with choice of species, stocking density, harvesting pattern, etc. after accounting for all relevant factors. Application of Lorenzen population dynamic model) in Thirumoorthy reservoir in Tamil Nadu and Kanhiraphuza reservoir in Kerala has resulted in impressive productivity gains (CIFRI, 2014). The research gap in this respect needs to be bridged. Various States report adopting stocking density @500 fingerlings/ha in case of large reservoir and @1000 fingerlings/ha in case of small and medium reservoir under the NFDB program, and have registered increased average fish yield of 85 kg/ha / year during 2013-14 (Jharkhand, 2014). The total average annual fingerling stocking increased from 30 lakhs during 2001-2006 to 250 lakhs during 2007-2013, this nearly 8 fold increase in stocking in the case of reservoirs in Karnataka, resulted in noticeable increase in fish production (Ramakrishna, 2014).

However, until more detailed scientific studies are available questions remain as to whether the production could be doubled mainly by stocking, in a complex reservoir ecosystem under diverse ecological conditions.

3.2. Cage Culture

Cage culture in reservoirs, raising fish in enclosure within an ecosystem, is a promising new technology. In this context a significant success story indicated in the Box 1, has been extended with NFDB's funding support in several States. It has demonstrated the potential for

enhancing fish production in reservoirs. Success stories of cage culture in many reservoirs across many States both in public sector (Jharkhand, Chattisgarh, Karnataka, Odisha, Maharashtra, Uttar Pradesh and Madhya Pradesh) and private Sector (Maharashtra and Madhya Pradesh) have already started emerging, most of them with support from NFDB and National Mission on Protein Supplements (NMPS) scheme. CIFRI's demonstration of fingerling production in low cost cages in reservoirs in Uttar Pradesh and Madhya Pradesh and CIFE's community based cage and pen culture demonstrations in Dimbhe reservoir of Maharashtra have provided valid information to refine the technology. Two such success stories are given in Box 1 and 2.

The requirement of developing a complete package of practices for cage culture and their dissemination across States is need of the hour. Selection of right species combination for cage culture in reservoirs keeping in mind both the health of ecosystem and the market demand of species is one of the crucial issues. Delimitation of area for cage culture and appropriate stocking density should be based on the study of carrying capacity of the reservoirs. One of the widely shared concern is the need for detailed study of environmental aspects, before undertaking cage culture on large scale, so as not to repeat the mistakes committed during extensive spread of coastal aquaculture in early 1990s.

Box1: Raising of fingerlings in low cost cages in reservoirs

Availability of appropriate fish seed in time and space is the main constraint in reservoir fishery development. To overcome this problem, *in situ* raising of fingerlings from fry (18 mm average length) in enclosures was demonstrated successfully in Dahod reservoir in Madhya Pradesh and Pahuj reservoir in Uttar Pradesh. The enclosures were low cost nylon net cages suspended in bamboo frame. The fingerlings raised in cages were stocked in the reservoirs. The results are widely acclaimed in India and abroad under CPWF project (Vass *et al*., 2008 and Bene *et al*., 2009).

Trials in Dahod reservoir in M.P.

(i) Grass carp and Common carp

A battery of eight cages was installed in the reservoir with each cage of 5 m x 3 m x 3 m in dimension. The cages were stocked with 90,000 fry of 20-22 m in size (*C. idella*–54,000, *C. carpio*–36,000). After a rearing period of 105 days 45,240 fingerlings (survival–50%) were released into the reservoir with *C. idella* achieving a size range of 70-96 mm in length and 5.0-11.0 g in weight, while *C. carpio*, grew to a size range of 85-112 mm in length and 19-26 g in weight. Another trial with 13 cages also revealed similar results.

(ii) Indian major carps

Separately in a three cage set, 36,000 Indian Major Carp fry of 30-34 mm size (*L. rohita: C. catla: C. mrigala* in a ratio of 5: 2: 3) were stocked. After a rearing period of 150 days, 23,322 fingerlings (survival–64.7%) were recovered and stocked in the reservoir. The stocking size and weight for different species was: *C. catla*: 90-150 mm and 19-32 g, *L. rohita*: 88-160 mm and 15-28 g and *C. mrigala* 82-130 mm and 12-23 g.

Trials at Pahuj reservoir in U.P.

In Pahuj reservoir one battery of eight cages (size 5 m x 3 m x 3 m) was installed and 100,000 fry (*C. idella* 74% and *C. carpio* 26%) were stocked. The length of fry at release was 16-28 mm. After a growing period of 145 days, 62,400 (survival–62.4%) fingerlings were released into the reservoir. During this period *C. idella* achieved a size of a 65-96 mm in length and 4 12 g in weight. In case of *C. carpio* the size attained was 74-115 mm in length and in 12-22 g in weight.

The cost per fingerling was Rs 0.40/-, which was much below the market rate, thus eliminating the transportation cost of seed and transit mortality.

(Das, A.K. et al, 2009)

Box 2: Cage Culture in Reservoirs of Jharkhand for fish production

An innovative cage culture program in different reservoirs is under implementation in Jharkhand State. As of March 2014, 1226 number of cages are operational in Jharkhand reservoirs. Of these, 150 are modular cages with dimension of 6m x 4m x 4m costing Rs.1,30,000/- each and 1076 are made of G.I. pipe (HDPE drum) cages with dimension of 6m x 4m x 4m costing Rs.75,000/- each. With predominantly *Pangasius* as candidate fish species in cages, the average production of 3.5 - 5 tons / cage has been recorded, though a maximum production of 9.2 tons was reported in Chandil reservoir with a stocking rate of 6400 number of Pangasius / cage. The cages are being operated by different co-operative societies as per the guidelines so as to sustain the program in the long run. The “Cage Rakshaks” take care of the day-to-day maintenance and security of the cages. Department of Fisheries (DoF) has provided Rs. 20/kg during the first cycle which was reduced to Rs.8-9/kg subsequently as back end subsidy. In order to minimize the production cost, DoF jointly with Co-operative Department has established in Chandil reservoir a feed mill costing Rs.40 lakhs, with average daily feed production capacity of 1-2 tonnes, while raw materials for feed like Corn and Soya are sourced with the help of nearby Krishi Vigyan Kendra. Ninety six pick-up vans have been distributed

to societies to ease transportation of fish and marketing. The programme is executed by the State Department in collaboration with ICAR and NFDB. While the pond raised *Pangasius* is sold @Rs.60/kg in the Howrah market, the *Pangasius* raised from cages in Jharkhand reservoir is sold at Rs.80/kg. However, in order to scale up this production system, the market expansion, processing and value addition becomes necessary.

(Ref. Director of Fisheries, Govt of Jharkhand, 2014)

For the success of stock enhancement and cage culture in reservoirs the demand for adequate number, size and quality of seed needs to be met. While the role of government and developmental agencies should be limited to act as facilitators, the hatcheries in private sector should be encouraged / incentivized to meet this seed demand. The stakeholder community of reservoir fishery needs to be convinced / demonstrated, about the importance of right kind of seed stocking to improve productivity, so that it becomes voluntary and sustainable activity.

3.3. Pond Culture in Reservoir Periphery

The practice of making temporary fish ponds along the reservoir periphery as well as in places where the water recedes within reservoirs especially in summer is not uncommon. Odisha has taken an initiative to encourage fishers to take up pond culture practice in such marginal area in the reservoirs. This practice has started picking up and has given very encouraging results in places like Hirakud. Other States may consider this option, though the issues of ownership, licensing, etc. needs to be sorted out with respective Irrigation / Water Resources Departments.

4. Management Challenges

It has been increasingly realized that not only the complexity of technology comes in the way of achieving higher production from Indian reservoirs, the *lack of and inadequacies in the present policy environment and institutional framework* (which subsumes the type of management regime) has also limited, the optimal reservoir fishery development so far.

For instance, profit obtained in aquaculture ventures is 'return on investment' made by an entrepreneur, investor or a group of individuals. On the contrary, (under a good governance regime), the benefits due to increased fish production obtained in the reservoir, in an ideal situation, are shared by a large number of fishers - the key stakeholders. This highlights the need for putting in place appropriate governance regimes in reservoirs through appropriate policy and institutional framework.

4.1. Inappropriate Management Regimes

Diverse, sometimes contradictory types of management practices *i.e.* numerous procedures and processes of leasing and licensing of waterbodies (reservoirs) are followed across the States. They can all be categorised into three types of management models namely revenue-oriented management model, welfare-oriented management model and development-oriented management model. The existing practices in *almost all the States fall under the first two types of management models i.e. either revenue-oriented or welfare-oriented* and hardly relate to the ideal development-oriented model except in few cases.

The reservoirs in India are common property resources, generally managed based on community activity. Thus, organization of the community that manages the system plays a key role. Quite often, on account of inadequate awareness, empowerment and motivation, the community remains incoherent and disorganized whose members at times act at cross purposes. This not only weakens their ability to negotiate with the other sections of the society, but also make them easy prey to the unscrupulous elements like money lenders and middlemen. This is the bane of reservoir fisheries throughout the country. In isolated pockets, where the community is well organized and works under good institutional support in the form of effective cooperative societies, Self Help Groups (SHGs), etc. very high yield and equitable distribution of profit are reported (Sugunan, 2014; Mehta, 2014; and Ramakrishna, 2014).

Thus, the policy has to encourage *co-management regime* in reservoirs for sustainable utilization of reservoirs for fish production while maintaining the ecological balance and ensuring sustainable livelihoods for communities living on periphery of reservoirs. *Development oriented livelihood model* with appropriate leasing system, technological options, management practices, investments, community and stakeholders' involvement shall become integral part of policy.

5. POLICY AND GOVERNANCE CHALLENGES

There is absence of *comprehensive policy for use and development of reservoirs for fisheries* in India. Though many States, with large reservoir resources, like Tamil Nadu, Karnataka, Andhra Pradesh, Madhya Pradesh and Uttar Pradesh follow some *guidelines.* The reservoirs are managed by respective State Departments while Central Government has a larger role, especially in creating enabling policy environment for their optimal utilization. The average low productivity in reservoir largely attributed to inappropriate and ineffective fisheries policy and governance mechanisms, while basic technologies were available for long.

5.1. Scope and Objectives

Any exercise in developing the policy shall take into account the questions like *whether separate policies* are required for fisheries development in reservoirs, ponds / tanks and riverine systems *or single comprehensive policy* for all inland open water resources would suffice; whether it will confine to leasing policy or a broader fisheries development policy incorporating the various Management Options, Institutional Options, and Technological Options; and whether it would be applicable to only those owned/managed by fisheries department or for all water bodies under State ownership.

Overall Objectives: Policies shall have clearly defined goals and objectives that would provide inspiration, underscore priorities, and give appropriate directions so as to infuse life and pragmatism to various elements of the proposed policy. The template of objectives may be as follows:

i. To enhance the fish production and productivity through sustainable development of reservoir fisheries following ecosystem approach to management
ii. To protect the interests of *small scale fishers* and their livelihoods through education, capacity building, resource access rights and empowerment
iii. To conserve and propagate the endemic fish species in inland water bodies including reservoirs for their intrinsic as well as commercial values

5.2. Water Availability and Usage

Though water has multiple and increasingly competing usage namely for drinking needs, domestic usage, crop irrigation, fisheries / aquaculture, navigation, industry usage (both secondary and tertiary sectors), urban usage, etc., the recent water usage policy does not clearly recognize the minimal right to water for fisheries and aquaculture, and hence there is need for a comprehensive and equitable water policy that fairly balances the competing demands. *Non-consumptive nature of water usage in fisheries,* as the net intake or loss is very minimal, compared to crop irrigation and industrial usage, may be clearly recognized while deciding on water allocation for fisheries and aquaculture.

Thus, the present water usage policy needs amendments with enlarged scope that clearly recognizes the ***minimal right to water for fisheries and aquaculture*** as against the residual status being accorded now. Also, fisheries shall have ***a legitimate claim and due rights in reservoir development***. The policy shall ***envisage a regulated market for water in the long term to balance the competing demands*** that could pave the way for efficient and effective use of public water resources while minimizing the conflicts. It will be a win-win situation as it would significantly promote fisheries activities in potential

areas thus improving the livelihood and nutritional security while minimizing conflict among multiple stakeholders. Water usage is a cross-sectoral issue and hence deserves cross-sectoral dialogue for its long term resolution.

5.3. Multiple ownership and management

All the reservoirs, natural lakes and wetlands, majority of irrigation tanks, flood plains and village ponds across the country are under the *public domain* and have potential for fisheries development. The ***pattern of multiple ownership*** - village ponds by PRIs, temple ponds / tanks by Religious Endowment Department / Temple trusts, some ponds and tanks by DoF, some by Irrigation Department, some by Department of Forests, some by Revenue Department, some flood plains by a large number of individuals – ***and the lack of coordination and conflicting interests among them*** are responsible for poor utilisation of (*only 45% of the available 6.1 million ha) of suitable waterbodies* for fisheries and aquaculture.

In this scenario, multiple ownerships of public waterbodies ***shall be accepted as an inevitable fact*** under the increasingly decentralized democratic governance structure in India. However, a ***distinction shall be made between ownership and management rights*** of waterbodies. While respective agencies may continue to be the owner of those resources, the **leasing and management rights of all waterbodies for fisheries development** shall be **transferred and vested with Department of Fisheries**. The policy may provide for sharing of lease revenue among the owner agency and DOF.

5.4. Leasing and licensing issues

Leasing aim: The guiding principle shall be based on the balance between livelihood development and enhanced sustainable production. Revenue generated through leasing shall be utilized for maintenance and conservation of this highly diversified natural resource.

Lease period: The lease period shall be generally of long term (5-10 years). However, different lease periods based on size - long term for large water bodies (7-10 years) and short term (3-5 years) for small reservoirs - and requiring civil/renovation works needy to be evolved. Annual review shall be built into the leasing policy.

Prioritizing the lessee: The priority for leasing shall be in the following order: Fishers' co-ops jointly with private entrepreneurs, SHGs of fishers adjacent to water bodies, fishers' co-ops, individual fisher, private entrepreneurs, farmers, educated unemployed youth / fisheries graduates and corporate. Unsettled water bodies may be given to interested federations on long term lease.

Lease terms: The terms of lease, among others, shall include the following: mesh size regulation for IMC and exotic carps; fishing boats to be compulsorily registered with Fisheries Department; closed season to be followed; and only advanced fingerlings to be encouraged for stocking.

Minimum lease rent shall be determined through an objective, fair and transparent mechanism following a single window system. Ideally the minimum lease / rent amount shall not exceed 10% of total projected annual gross income of the lessee.

5.5. Conflict between livelihood concerns and environmental conservation

One of the major policy challenges is ***to reconcile the priorities of development and conservation.*** Several conflicts are evident between conservation of biodiversity and sustaining livelihoods of small scale fishers around ill managed common property resources across India. These are more evident in the case of aquatic resources (open waters, wetlands and even reservoirs) most of which are allegedly in different stages of degradation.

To name just few such instances around inland ecosystem are: Tawa Reservoir, a large reservoir on the Tawa River in central India (Hoshangabad District of Madhya Pradesh state), built in late 1970s, has been supporting the livelihood of small scale fishers, organised around one of the best working / model co-operatives for more than two decades. Fishing has been banned since 2006 as it formed the western boundary of newly created Satpura National Park and Bori Wildlife Sanctuary under the Wildlife Protection Act, 1972. The poor fishers, who were earlier evicted / displaced by the same irrigation Project, were deprived of their livelihoods once again in the name of conservation. The issue is sub-judice. Similar is the case with respect to Jeyakwadi Reservoir region, the largest reservoir in Maharashtra located in Aurangabad district and in few islands of Sundarbans in 24 Parganas district of West Bengal.

The assumption underlying these instances is the notion that conservation of biodiversity and fishers livelihood are inherently conflicting and can't go hand in hand. Regulatory frameworks need to be made more perceptive to the livelihoods needs of resource poor people who are long dependent on it, and whose optimal resource use does not threaten the biodiversity. While not treating livelihood development and conservation as mutually exclusive, the ecosystem-based fisheries management and improved fisher livelihoods shall become the central elements of any policy. Joint Forest Management (JFM) which protects rights of traditional forest dwellers as well as make them partners in biodiversity conservation can be a good model to start with.

5.6. Introduction and regulation of exotic species

It has been reported that there is paucity of adequate scientific data / studies on the impact of exotics on indigenous fish species and ecosystem (Lakra *et al*, 2008). Such a policy guideline shall encourage studying long term impact of introduction of exotics in different aquatic systems across India. A statutory body needs to be established for introduction, after a systematic study and wider consultation, as well as for continuous monitoring and regulation.

5.7. R&D Focus in Reservoir Fisheries

Sugunan (2000) considers that 'given the number & surface area of reservoirs in India and their importance in fishery development, research on this resource is very modest'. Only about 100 reservoirs (out of 19370) have been subjected to some form of studies so far focusing mainly on ecology & biology, little on socio-economics and governance (Sugunan, 2000). While CIFRI, CIFE and several traditional Universities have studied many more individual reservoirs, there is a need to consolidate the scattered information and find out research gaps and channel the findings to devise better management plans. Van Zwieten et al (2011) in a recent global review of reservoir fisheries echoed the same that 'there is a general paucity of data and lack of research on small scale inland lake and reservoir fisheries while there is significant amount of myths and misconceptions. They caution that management interventions would certainly fail 'without the necessary fundamental research'. Basic knowledge on food web structure and species (both native and exotic) interactions in reservoir ecosystem are necessary so as to provide the basis for optimal utilization of reservoir fisheries (only partial and incomplete information is available at present). Also, there is lack of adequate number of studies on appropriate craft and gears for harvesting fish from different types of reservoirs.

Studies by Sugunan (2007), Katiha *et al* (2002, 2007, 2010), Ananthan and Dilip Kumar (2008), Ekka *et al.* (2013) clearly demonstrate how policy, regulations and institutions impact upon reservoir fisheries production and livelihoods. This needs to be addressed through adequate priority given to research on reservoir fisheries.

5.8. Reforms in Fisheries Cooperatives

Presently, the co-operative societies are plagued by economic inefficiencies, absence of democratic processes, mismanagement and misappropriation of benefits by the dominant few, lack of transparency and accountability thereby defeating the very purpose and advantages of cooperatives. Any policy has to be alive to the fact that active interventions are necessary to strengthen and restructure Fisheries Co-operative Societies in order to

make them as a democratic grass root level engine of fisheries development, and ensure equity of benefits particularly to their poor fisher members. The emerging institutional options of Producer Companies, SHGs, Farmers Field Schools, etc. need to be weighed properly for encouragement and promotion.

5.9. Markets and Infrastructure Development

Infrastructure: Adequate steps are to be taken to provide basic infrastructure in the existing irrigation projects, and inbuilt into the new projects, to facilitate fishing activities in the reservoir such as approach roads, fish landing centers, seed rearing units, etc. There should be minimal provision for seed production units and post-harvest landing infrastructure while transportation, distribution and strengthening of local markets need adequate attention. However, the infrastructure like cold storage, seed rearing units, etc. developed in 1990s around many of the reservoirs are in complete shambles due to disuse and lack of maintenance. Infrastructure development shall be absolutely need based and the primary stakeholders shall be made integral part of its development and continued management.

Markets and marketing: Banking upon the eco-friendly nature of fish produced from reservoirs and their existing consumer preference, the reservoir fish need to so labelled as to create brand value and attract premium price in all markets. The highly unorganised and inefficient domestic fish market structure, negligible private and public investments, lack of systematic and reliable market / price information, weakened marketing cooperatives and their federations are issues of concern in domestic fish markets. The marketing policy shall ensure that primary producer getting greater share in consumer rupee and consumer is assured of safe and quality fish at affordable price. For this, the policy shall encourage market reorganization and establishment of ***modern producer and user managed wholesale and retail fish markets.***

The recent ***NFDB funded programs on modernization of markets*** need to be assessed objectively so as to understand not only the extent of their impact on reservoir fisheries production and livelihoods but their differential success / failure in different States owing to the different governance arrangements across States. Such an exercise would provide a pointer to identify bottlenecks or key implementation issues and take corrective measures to increase the program effectiveness in future.

5.10. Service Delivery System and HRD

Extension and service delivery system is the crucial but weakest link between technology generation and client systems.

DoFs are to be reorganized wherein regulatory role shall become minimal and developmental role shall become the primary while the outlook shall be transformed from desk-oriented to field-oriented where fisheries co-management and participatory aquaculture extension would become major paradigms of extension. Also, the extension system shall be conceived of as providing bundle of services ranging from technical training and support, input mobilisation including credit and insurance, market facilitation, conflict resolution instead of just the transfer of technological package.

5.11. Data Inadequacies and Development Planning

Timely, complete, reliable and updated statistics on reservoir resource, on status of their utilisation, resource wise and species wise production and productivity levels, catch and fishing effort, status of Human Development (and extent of poverty) among fishers dependent on reservoir fisheries and market information is essential for formulation of relevant policies, programs and action plans. At present, the existing data on which plans and programs are made is either too old (nearly 30 years) or lack reliability and not collected appropriately by the States. Only crude estimations and approximations with wide margins of error form the basis of development planning and management.

Innovative mechanisms shall be devised wherein stakeholders / resource users volunteer to supply reliable data through CBOs / PRIs / NGOs. Measures have to be initiated for proper categorization, analysis, and wider dissemination of data thus generated and maintaining a computerised database for easy retrieval.

BOX 3: Karnataka's 'Travails with Reservoir Governance'

Karnataka has 82 reservoirs spread over an area of 2,63,000 ha constituting 47% of inland resources, the remaining 53% being the small and large irrigation tanks. Of these, about 90% reservoirs (238000 ha) are being utilised as of now for fisheries. Karnataka follows three pronged reservoir development strategies namely 'stock and harvest', 'cage and pen culture technology approach' and thirdly the 'Public-cooperative partnership (PCP) and public-private partnership (PPP) approach'.

In the PPP / PCP modes, the partnership between fishermen private entrepreneur or cooperatives and DOF was established by following a transparent process. Reservoir development committees consisting of all the stakeholders have been set up for each reservoir. Here, the responsibilities of private partner / PCS are stocking of advanced fingerlings, payment of lease value, watch and ward, marketing & account keeping etc., while Department of Fisheries' job is to lease the reservoir, provide technical guidance and overall supervision. The fishermen individually had no investment to make but only

to fish and earn using his skill. The profit was shared between FCS / private partner and the fishers @50:50 ratio after paying for the lease value and expenses.

However, the experience of this PCP / PPP approach has been less than smooth as demonstrated by the of court cases (10 cases in Krishna Raja Sagar and 4 in Kabini reservoirs among others) that sprang up in its aftermath from the rival contractors and cooperatives, in most cases simply to derail the process as the new approach has been perceived to be changing the long established vested interests. It was commented that public private partnership (PPP) model that has been developed from infrastructure sector *i.e.* road and airport construction needs to be reworked in the context of management of natural common property resources like reservoirs so as to make it feasible. A viable model is yet to emerge for replication across States (Jt. Director (Inland Fisheries), Govt of Karnataka 2014).

6. RECOMMENDATIONS AND ACTION POINTS

- Reservoir fisheries has witnessed noticeable progress in recent years especially with NFDB funded stock enhancement program. It is recommended that a mission mode program on reservoir fisheries be launched after critical examination and review of ongoing stocking programs in reservoirs to make it scientifically more informed and self-sustainable.
- The ***reservoir number and area on the lines of agreed typology need urgent revision*** for two principal reasons: many changes have occurred by creation of new waterbodies and reduction in the area of existing reservoirs, etc. during the last three decades. It is also required to reconcile remote sensed estimates on wetland.
- Encouraging results have emerged from NFDB supported cage culture scheme, but it was felt that more clarity is required in terms of choice of candidate species for culture in different ecosystems, permissible reservoir area for installation of cages, low cost durable cage designs, feed alternatives, and developing complete package of practices to ensure large scale adoption. While economic viability and profitability shall always be the guiding factors, detailed policy and operational guidelines including EIA guidelines need to be framed within the larger ecosystem perspective to minimize externalities.
- ***Non-adoption of scientific management practices*** has been understood and accepted as one major reason for low reservoir productivity. It was recommended that there should be greater appreciation of policy and governance issues in improving reservoir fish production. It is emphasized that states should come out with their reservoir fisheries policies, incorporating the best practices followed in respective states.

- The policy has to encourage ***co-management regime in reservoirs*** for sustainable utilization of reservoirs for fish production while maintaining the ecological balance and ensuring sustainable livelihoods for communities living on periphery of reservoirs. ***Development oriented livelihood model*** with appropriate leasing system, technological options, management practices, investments, community and all stakeholder involvement shall become integral part of policy.
- A cross-sectoral dialogue among Departments of Fisheries, Agriculture, Water Resources, Planning, Environment and Forests is considered necessary to reconcile the competing demands for water use for different sectors ensuring water availability for fisheries ecology in reservoirs / rivers. It was also strongly felt that fishing governance of all reservoirs be transferred to State Fisheries Department while the custodian rights of reservoir may continue to lie with the concerned Department.
- The Model Bill on Inland Fisheries and Aquaculture circulated by DAHDF to State DoFs may provide the basis on which more enabling State specific policies, plans and regulatory mechanism shall be put in place. It shall be done through consultative mode and provide pragmatic blue prints for reservoir fisheries development.
- Fisheries cooperatives need serious reforms to make them professional and transparent while encouraging other institutional options like Producer Companies and SHGs in reservoir fisheries development. Ensuring capital needs for intensive stocking and cage culture programs in medium and large reservoirs is highly desirable.
- Large reservoirs (beyond 5000 ha), contribute about 37% (11,60,511 ha) to the total reservoir area of the country. In view of their individual vastness, they require huge initial investment for their fisheries development, which is practically not possible on part of Fishermen Cooperatives or Government Agencies. It is, thus, suggested that possibilities may be explored to lease some of them to private entrepreneurs for fisheries development with safeguards ensuring that 75% of labour employed for various fishery related activities would have to be hired local.
- Marketing policy shall ensure greater market price share to the fisher and safe and quality fish at affordable price to the consumer. Thus policy should encourage market reorganization and establishment of ***modern producer and user managed wholesale and retail fish markets.***
- Existing and new irrigation projects should have inbuilt critical infrastructure support such as fish landing center with approach roads and hatchery with seed rearing units. A separate strategy has to be prepared for fisheries development in newly created reservoirs with regard to fish stock enhancement.
- State DoFs need to be reorganized with ***minimal regulatory role but maximum developmental role.*** They need to be transformed from desk-oriented to field-oriented

responsibilities with delivery system conceived of providing ***bundle of services*** ranging from technical training and support, input mobilisation including credit and insurance, market facilitation, conflict resolution instead of just the transfer of technological package.

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