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National Academy of Agricultural Sciences

Uniform Policy for Fish Disease Diagnosis and Quarantine

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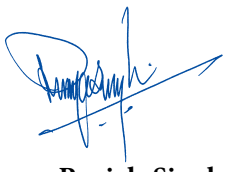
Preface

India ranks third in the total fisheries and second in aquaculture production in the world. There has been a paradigm shift from marine dominated fisheries to a scenario where inland fisheries has now emerged as a major contributor to the overall fish production in the country. In the inland sector, aquaculture contributes about 90% of the total production. The blue economy policy for doubling fish production within a short span of time aims to diversify species and production systems with an impetus towards industrial or high density aquaculture. This has led to more incidences of diseases with serious threat to the environment. However, the incidence of dreaded diseases like acute *hepato-pancreatic necrosis*, *koi virus herpes* and *spring viraemia* have not been reported from India, although the outbreak has been reported from neighbouring countries like Bangladesh and China. This could be due to inadequate surveillance and reporting system *in situ* or the disease or related mortalities are going unnoticed due to lack of appropriate diagnostics at the point of occurrence. It is also possible that these pathogens/diseases are truly not present in Indian aquaculture. This necessiate a country-wide targeted surveillance mechanism for aquatic animal health management encompassing disease diagnostics and quarantine.

Against this background, NAAS organized a policy workshop to review diagnostic procedures and quarantine measures applied globally with special emphasis on Indian scenario to identify the major gaps and formulate a policy to strengthen and streamline the diagnostics and quarantine system in Indian aquaculture. The write-up "***Uniform Policy for Fish Disease Diagnosis and Quarantine***" presents the much needed new policy initiatives/directions in the form of recommendations in order to protect, maintain and improve the fish health to achieve the goal of higher productivity and sustainability. On behalf of Academy, I compliment the Resource Person Dr P.K. Sahoo and other experts for their valuable efforts in developing the policy brief. My thanks are also due to Dr J.K. Jena, DDG (Fisheries) and Secretary NAAS for his valuable inputs as well as Dr V.K. Bhatia and Dr Kusumakar Sharma for their editorial support. I am hopeful that this document will be useful to all Fellowship and stakeholders.



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Uniform Policy for Fish Disease Diagnosis and Quarantine

1.0 Preamble

Indian fisheries and aquaculture has made a great stride during the past few decades. The export revenue from the sector has touched INR 45,106.89 crore (US$ 7.08 billion) , which is about 0.91% of the National Gross Domestic Product (GDP) and 5.23% to the agriculture GDP during 2017-18 (www.nfdb.gov.in). The total fish production of the country during 2017-18 was 12.60 million metric tonne (MMT). Currently, India ranks third in the total fisheries and second in aquaculture production in the world. The historical scenario of Indian fisheries reveals a paradigm shift from marine dominated fisheries to inland fisheries as a major contributor to the overall fish production in the country. In the inland sector, aquaculture contributes about 90% of the total production. Enhancement of aquaculture production through intensification results in an increased level of stress in fishes from high stocking density beyond the carrying capacity of a pond, and use of many growth enhancers and chemicals that ultimately make the fishes more susceptible to different diseases as well as introduction of newer diseases through cross border trade. Further, the blue economy policy for doubling fish production within a short span of time aims at species and system diversification with more impetus towards industrial or high density aquaculture. These developments would alternatively pose serious threat to the environment along with water contamination and scarcity, thus leading to more incidences of diseases. In the recent past, the freshwater aquaculture sector has witnessed introduction of few exotic species viz., Pangas (*Pangasius hypophthalmus*) and Pacu (*Piaractus brachypomus*), besides several wild and ornamental fishes, without knowing the pathogens they carry. Many of the dreaded diseases, although being reported in neighbouring countries, have not been reported from India (*e.g. acute hepato-pancreatic necrosis disease in shrimps in Bangladesh, koi herpes virus disease and spring viraemia of carp virus disease in China in carp farming, etc.*). The major reasons for this may be either disease or related mortalities are going unnoticed due to lack of appropriate diagnostics at the point of occurrence or the present surveillance system in the country is not adequate to identify these diseases along with poor *in situ* reporting system. On the other hand, it is also likely that these pathogens/ diseases are truly not present in Indian aquaculture. However, it requires a large-scale, country-wide, active/targeted surveillance mechanism to prove this point beyond doubt. Against this background, the policy workshop addressed all the critical aspects of aquatic animal health management comprising disease diagnostics and quarantine. The workshop reviewed all the existing diagnostic and quarantine measures applied globally with special emphasis on Indian scenario and attempted to identify the major gaps so that inputs can be given to formulate a uniform policy to strengthen and streamline the diagnostics in aquaculture and aquatic animal quarantine system in the country.

2.0 Current Scenario of Disease Problems in Indian vis-a-vis World Aquaculture

2.1 Disease problems and losses there-in

Diseases are the major bottleneck in the way of higher aquaculture production. The risk of disease outbreaks is increasing day by day due to on-going intensification of fish farming. Hence, the major

task of the fish health expert is early detection and management of diseases. The climate change also can be a key player in the disease outbreak (s). There may be an increase or decrease in the intensity of certain endemic diseases or emergence of new diseases in new geographical areas (Sahoo and Paul, 2017). The aquaculture sector has faced many devastating diseases from time to time like White Spot Disease (WSD) of shrimp. It caused pandemic infection in the world, and its presence and economic impact are being felt in most of the countries. Because of the outbreak of WSD, the culture of *Penaeus monodon* has been reduced drastically throughout the world. Similarly, White Tail Disease (WTD) has devastated the culture of *Macrobrachium rosenbergii*. It is estimated that the diseases account for 10-15% of the production cost world-wide (Sahoo and Saurabh, 2018).

The economic losses due to diseases in Indian aquaculture are not properly estimated. However, a few sporadic survey reports are indicative of disease related losses to the Indian aquaculture sector. An earlier survey confined to Andhra Pradesh, India, indicated an annual loss of Rs. 40 million due to diseases. The same study found that an average of 10% of the production cost was spent on disease treatment. Further, the study recorded disease incidences of parasitic, bacterial and fungal infections being 70%, 27.5% and 2.5%, respectively in freshwater aquaculture (Gopal Rao *et al.,* 1992). In a carp culture farm in Mandi, Himachal Pradesh, the economic loss due to argulosis was estimated to be Rs. 67,102 (US$ 1428) per ha per year, after taking into account the factors like mortality, reduced growth rate and costs associated with drug application (Sahoo *et al.,* 2012). Similarly, a loss to the tune of Rs 29,524.40 (US$ 615) per ha per year due to argulosis, an ectoparasitic disease from carp culture ponds, was also recorded in a study conducted during 2008-2011 (Sahoo *et al.,* 2013). In freshwater prawn industry, the import of infected seeds of freshwater prawn from neighboring countries to India led to the introduction and spread of white tail disease in prawns. This disease became one of the important factors to cripple the freshwater prawn industry in India, causing high mortalities and huge economic losses. The annual economic losses due to shrimp diseases have been estimated to be Rs. 1022 crores (Kalaimani *et al*., 2013) and the losses only due to white spot disease have been reported to be around Rs. 700-800 crores (TANUVAS, 2011). There is no continuous flow of information to assess the accurate disease related losses in the country mainly due to non-availability of suitable diagnostics, facilities to carry out proper diagnosis at the state level and the policy there-in.

India is witnessing growing emergence of newer pathogens reported elsewhere in the world earlier (Fig. 1). It is quite difficult to predict the new disease or pathogen, which would emerge in the future that may lead to complete collapse of the sector or a species. Although the country witnessed tremendous growth in shrimp aquaculture sector after the introduction of specific pathogen free *Penaeus vannamei* following the collapse of *P. monodon* farming due to infection with White Spot Syndrome Virus (WSSV), the former species is also now experiencing a similar setback. Hence, it is important to adopt a policy to strengthen or develop HRD in fish disease diagnosis and prevent the spread of transboundary pathogens after their initial entry.

2.2 Status of fish disease diagnosis and reporting procedures in the country

Although Indian aquaculture contributes significantly to the world fish basket, the progress made in fish disease research is meager in terms of availability of commercial diagnostic products at the farmers'

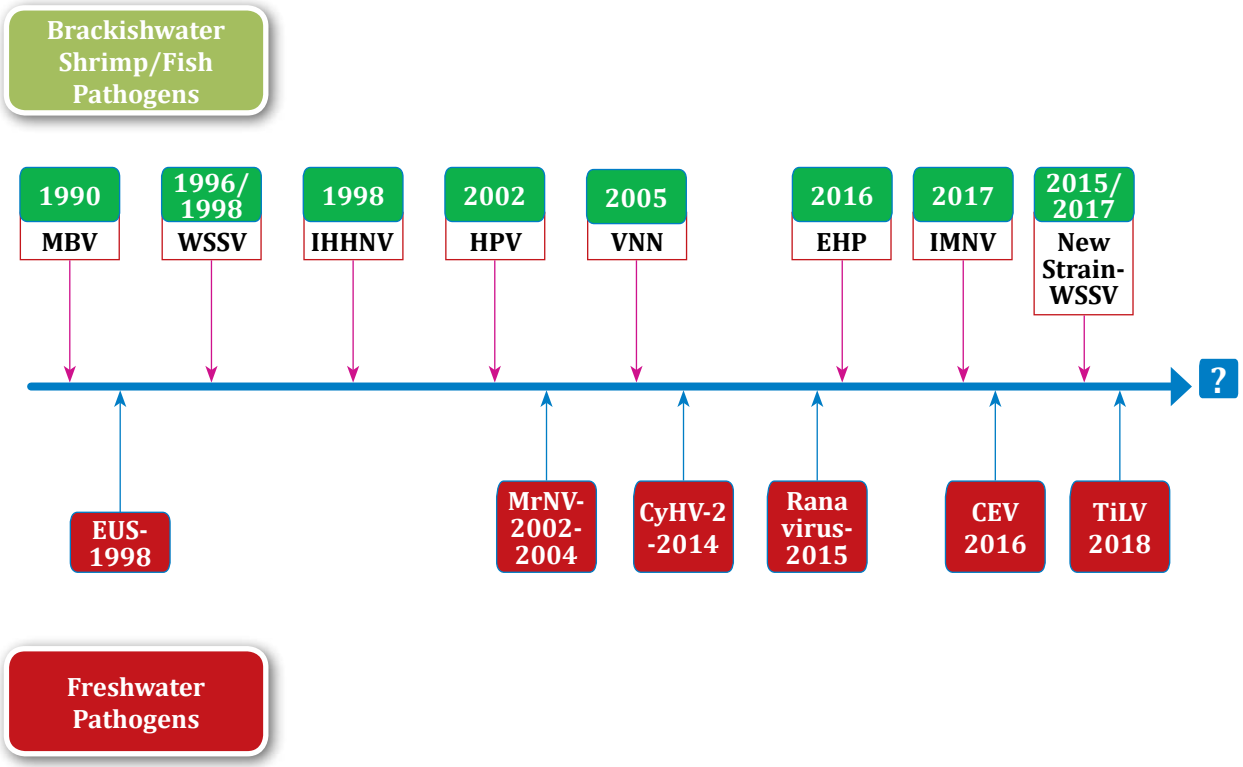

Fig. 1. [MBV: Monodon Baculo Virus (Ramaswamy *et al.*, 1995); WSSV: White Spot Syndrome Virus (Sahul Hameed *et al.*, 1998); IHHNV: Infectious Hypodermal Haematopoeitic Necrosis Virus (Ruby *et al.*, 1998); HPV: Hepatopancreatic Parvovirus (Manivannan *et al.*, 2002); VNN: Viral Nervous Necrosis (Azad *et al.*, 2005); EHP: Enterocytozoon Hepatopenaei (Rajendran *et al.*, 2016); IMNV: Infectious Myonecrosis Virus (Sahul Hameed *et al.*, 2017); EUS: Epizootic Ulcerative Syndrome (Kumar *et al.*, 1991); *Mr* NV: *Macrobrachium rosenbergii* Nodavirus (Tripathy *et al.*, 2006); CyHV-2: Cyprinid Herpes Virus-2 (Sahoo *et al.*, 2016); Ranavirus (George *et al.*, 2015); CEV: Carp Edema Virus (Swaminathan *et al.*, 2016); TiLV: Tilapia Lake Virus (Behera *et al.*, 2017)]

doorstep. A large number of diagnostics are being developed for various fish diseases by different institutes of the Indian Council of Agricultural Research (ICAR) and Fisheries Colleges, but majority of these are for use in the laboratories and need validation. For example, ICAR-Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar has developed both ELISA and PCR based diagnostics for most of the important bacterial diseases of finfish (e.g. *Aeromonas hydrophila*, *Edwardsiella tarda* and *Pseudomonas* sp.). ICAR-Central Institute of Fisheries Education (CIFE), Mumbai has developed latex agglutination kits for various bacterial fish pathogens, besides developing quantitative real-time PCR assays for four DNA viruses infecting shrimp. ICAR-CIFA has also developed PCR-based markers for species identification of *Argulus* prevalent in carp culture. Similarly, the researchers have developed diagnostics for Acute Hepatopancreatic Necrosis Disease (AHPND) and microsporidean infections of shrimp. College of Fisheries, Mangalore has developed diagnostic kits for field-level diagnosis of *White Spot Syndrome Virus* (WSSV) and *Aphanomyces invadans*. However, majority of the diagnostic kits are being imported from overseas that are used by the private diagnostic laboratories for various testing purposes and for farm-level diagnosis. Therefore, it is now imperative to develop and commercialize kits for important and emerging diseases that can be used by the farmers on pond-site. This would

facilitate quick, cheaper and easy farm-level diagnosis, and would be one of the important steps for disease management in aquaculture systems. Further, there exists an obvious disparity in the quality as well as reliability of the existing diagnostics. There is a need to develop a strategy for validation of diagnostics developed by different R&D institutes.

The technical expertise of the laboratory technicians plays a crucial role. In this regard, harmonization of the diagnostic tools through ring testing and intensive training to the technical manpower and finally the accreditation of disease diagnostic laboratories need to be undertaken. Further, existing diagnostic laboratories in the public sector need to be further strengthened and modernized so that sufficient referral laboratories are created in different parts of the country.

2.3 Scenario on aquaculture quarantine and certification

India has a large aquatic animal import-export business. Over the last few years, the country is facing a growing problem of incursion of exotic pathogens along with introduction of new /exotic species. Currently, the only quarantine facility available in India is located at Neelankarai, Chennai. The main focus of this quarantine centre is to facilitate a regulated importation of non-native *Penaeus vannamei* into India. However, recently few states like Andhra Pradesh and Karnataka are establishing quarantine facilities for either ornamentals or brackishwater species through Marine Products Export Development Authority (MPEDA) or under PPP mode. There are also huge numbers of ornamental fishes being imported to the country without proper quarantine, which needs to be given priority to impose strict rules of their introduction. Seed certification and farm to farm movement of fishes should be subjected to proper quarantine for better management of fish health and reduction in pathogen spread. At present, there is no mechanism in the country to address the problem of introduction of pathogens through live feed and preventing the spread of diseases from one region to other region of the country.

Currently, private parties are being given permission by the Ministry of Agriculture and Farmers Welfare on a case-to-case basis based on species to be imported and to practice on farm quarantine. Further, there is also equal amount of demand from private parties to establish quarantine for freshwater fish import from neighbouring countries, e.g. Sunrise Agro & Seeds, Kolkata to import large varieties of fish from Bangladesh. However, the case-to-case decision would be a nuisance to the system without any specific policy.

Based on volume of aquatic animal trade and type of aquatic animals, there is a need to establish quarantine facilities in different regions. Further, there will be requirement of manpower and technical knowhow for operating the quarantine facilities and testing of the consignments.

3.0 Issues and Concerns in Fish Health Management

As diseases are the most important limiting factor in aquaculture production, health management of farmed fishes assumes significance. However, health management is highly complex, and formulation and implementation of best management practices involves significant intervention in terms of research & development, training, extension and ultimately an enabling policy. Some of the significant issues pertaining to this aspect are highlighted as follows:

3.1 Similar clinical signs with different etiological agents: confusion in diagnosis and treatment measures

Gross clinical signs in most of the fish diseases are very similar, and include gill or skin lesions. There are several types of pathogens that are known to affect gills. These include parasites (e.g. *Dactylogyrus, Trichodina*, *Myxosporeans*, etc.), viruses (*koi herpes virus*, *carp edema virus*, *cyprinid herpes virus-2* etc.), bacteria (*Flavobacterium* spp., *Aeromonas* spp., *Pseudomonas* spp., etc.) and fungi (*Branchiomyces* spp.). These produce similar gill lesions with more or less identical clinical signs, thereby resulting in difficulties in disease diagnosis. If misdiagnosed, it can lead to ineffective treatment regimens. In most of the cases, farmers apply several drugs and chemicals without having the knowledge of the actual causal agents to save the crop, which ultimately can affect the entire production system and food chain, and ultimately result in economic losses to the farmers.

3.2 Disadvantages in developing sero-diagnosis for major bacterial pathogens *vs* environmental contaminants

Opportunistic bacterial pathogens are part of normal flora of water and their continuous exposure to healthy fish leads to development of antibodies in the host. These antibodies hinder with sero-diagnosis at the time of disease outbreaks. Further, many of viral infections in tropical environment occur as co-infections with other bacteria and thus make the diagnosis difficult. The antigen sharing and cross reactivity among genus or species of microbes are equally important while developing diagnosis test at field level. There is no clear cut-off antibody titre established for diagnosing prevalence of any of the pathogens in the system. Further, in '*Manual of Diagnostic Tests for Aquatic Animals (2018)*', sero-diagnosis has not been recommended as method of diagnosis for any of the diseases. It has been reported also that sero-diagnosis in crustaceans is questionable in the absence of antibody production. Hence, strong research for its application in field level is the need of the hour.

3.3 Cost effectiveness, validation and quality control of diagnostics

The cost effectiveness of the diagnostics developed is a matter of great concern from the point of view of both scientists and policymakers. As diagnosis based on clinical signs is not feasible and sero-diagnosis is not a gold standard, aqua diagnostics laboratories have to depend on molecular methods of diagnosis, which make diagnosis costly and do not discriminate between viable and non-viable organisms. Many of the state laboratories are mostly looking into water quality assessment and clinical/post-mortem based diagnosis. Further, the diagnostic tools developed by various organizations need quality control system and validation by qualified or referral laboratories.

3.4 Lack of diagnostic laboratories

Unlike veterinary and human diseases, the diagnostic laboratories involved in diagnosis of fish diseases are very few, and even most of the State Fisheries Departments do not deal specifically with disease diagnosis. Recently, Andhra Pradesh and Telangana are coming out with a proposal for establishment of disease diagnosis laboratory in every district of the states with the financial and technical support of National Fisheries Development Board (NFDB) and different ICAR institutes,

respectively. It will be pertinent to mention that only a few of the Fisheries Colleges are adequately equipped to diagnose the disease epizootics and in very few laboratories the facilities for isolation of viruses are available.

3.5 Lack of interest from private sector to set up diagnostic laboratories

Although there are a few diagnostic laboratories in shrimp farming sector, but the scenario in freshwater aquaculture sector is totally different. Unlike developed countries, none of the private entities are interested to set up diagnostic laboratories for freshwater fish diseases. One of the major reasons is lack of policy of mandatory checking of farms for any presence of disease/pathogens. The lack of awareness and availability of cost effective and sensitive diagnostics are also of equal concern.

3.6 Lack of professionals in the field

In the field of fish disease diagnosis, there is a dearth of specialists at the farm/ground level. Although there are 28 Fisheries Colleges in India, which offer Bachelors in Fisheries Science (B.F.Sc.) degree, but credit hours allotted in the curriculum for fish health aspects are inadequate. This prevents the students in getting a strong footing in fish diseases diagnosis. For an effective field-level disease management, qualified and trained manpower is imperative. However, lack of significant number of private players in the area of disease management is a matter of concern. Moreover, graduates with Degree in Fisheries Sciences are not given any weightage in selection for appointment in State Fisheries Departments in many states.

3.7 Large number of quacks in the sector

Omni-presence of quacks is really a major concern in the sector. In Andhra Pradesh, every farm is being supervised by so called technicians, whose technical standing is really questionable as far as disease diagnosis and treatment are concerned. A number of medicines/formulations are being used/ suggested by them without knowing their compositions or mode of action or cause of the problem. Often, they also act as agents of fake companies. Recently, ICAR has initiated All India Network Project on Fish Health that focuses mainly on enlisting the drugs and chemicals used by the farmers in aquaculture. This would pave a long way to help in cataloging all the drugs/chemicals/formulations/ products used in aquaculture for evolving an effective and corrective policy to facilitate the judicious use of these products. However, list also needs to focus on withdrawal period of each drug to bring awareness among farming community for their judicious field applications.

3.8 Arbitrary use of chemicals, pesticides and drugs

Arbitrary use of chemicals, pesticides and drugs are mainly associated with the inappropriate diagnosis with a hope of getting better return quickly. Antibiotics are freely being used in the sector for any given problem in the culture conditions by some farmers that results in irreversible environmental degradation, besides drug resistance and residual concerns. Nearly 70-80% of the drug used in aquaculture ends up in the environment (Hernandez, 2005). There are also very few approved drugs available for use in disease outbreak conditions. In such a scenario, farmers are using several

drugs and chemicals without properly knowing the dose and safety issues thus causing environmental, social and economic loss. The wide diversity in species cultured, unawareness of pharmacokinetics for different species cultured and their biology pose further concern.

Only a few antimicrobial drugs have been approved by the U.S. Food and Drug Administration (USFDA) for use in aquaculture. Coastal Aquaculture Authority (CAA) has banned 20 antibiotics from using in shrimp aquaculture. However, there are no such regulations in place for freshwater aquaculture. Use of antibiotics and its withdrawal period has not been studied in Indian context, although there are some studies for the temperate species. The report for off-target effect of drugs and chemicals used in aquaculture is very limited. It is important to have a policy on aqua-drugs use alongwith the user guidelines. As many antibiotics are banned, many companies are marketing antibiotics in the name of growth promoters without proper label. The major concern here is prior use of antibiotics leading to difficulty in bacterial disease diagnosis.

3.9 Lack of proper diagnosis and data on economic loss

It is high time to scale down the economic impact of diseases to the production system and how it can be bartered through scientific involvement. Although there are some pilot studies related to economic loss estimation, but a robust and reliable methodology is the need of the hour. Indiscriminate use of medications by farmers without proper diagnosis and lack of mechanism in place to assess the economic losses due to diseases are two serious issues, which are to be addressed with utmost priority. There exists no mechanism either at the state or central level for immediate disease reporting. Further, there is no ICT-based mechanism in place for farmers to reach out to the diagnostic centres for expert advice.

3.10 Surveillance

Surveillance programme for monitoring and controlling spread of diseases of national and international concern has become a primary requirement for effective health management and ultimately for sustainable aquaculture. The NFDB funded National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) is operational in 16 selected states of fisheries and aquaculture importance for last six years. In this mega project 29 different ICAR institutes, State and Central Fisheries Universities and State owned government institutes joined hands for both active and passive surveillance of fish and shellfishes. It is necessary to further strengthen and continue this program for better disease control in aquaculture. It would help in estimating the accurate loss due to various diseases and also benefit the country to prioritize the disease research.

3.11 Quarantine

Limited facility at the ports of entry is a big challenge for aquatic quarantine. The guideline is also not robust to address each individual species to specifically define the exact period of quarantine. Again some fish act as vectors to carry the pathogen instead of showing the disease symptoms and it remains a big challenge for pathologists while importing such fish species. With the advancement of transboundary trade, quarantine for GMOs should be specifically looked into while developing

guidelines. Currently, frozen products are being reported to carry pathogens and there needs to be a legal framework in-build in the system for their screening. The possibility of entry of pathogens through obscure algae, molluscs and insects while importing fish poses a big challenge to the industry as these are not routinely screened. The guidelines in quarantine need to be modified accordingly to address issues related to quarantine.

3.12 Need of a uniform policy

A uniform policy for fish disease diagnosis and quarantine is needed to address the following:

- Proficiency testing of laboratories involved in fish disease diagnosis,
- Validation of diagnostics available at Research Institutes and making them commercially viable at the government level,
- Emphasis to develop farmer friendly point-of-care diagnostic kits for diseases of national concern,
- Strengthening of mechanisms for transportation of diseased samples to the nearest diagnostic laboratories,
- Mandatory setting up of diagnostic laboratories in each aquaculture-advanced/targeted districts, preferably at each state headquarters, with adequate financial resources and trained manpower,
- Extension of human resource development and minimum facilities to all laboratories of ICAR Institutes and State Fisheries Colleges,
- Strengthening diagnostic facilities in each newly set-up state fishery colleges,
- Creation of adequate posts of Fish Pathologists in all the states,
- Mandatory screening of fish or shrimp by each farm in the recognized laboratories for serious pathogens during each culture operation,
- Creation of more aquatic quarantine facilities under PPP model,
- Formulation of guidelines for practicing as Fish Health Experts with minimum qualifications,
- More effective quarantine policy on methods/species of import and set-ups to address the demand of the entire country.

4.0 Fish Disease Diagnosis and Qurantine Initiatives and Existing Instrument

4.1 ICAR initiatives

There are eight ICAR fisheries research institutes in the country and all of them have well-developed diagnostic laboratory facilities to address most of the common as well as transboundary aquatic animal diseases. These are currently catering to the needs of the farmers and shrimp industry either through surveillance project mode or more often when need arises. ICAR is giving significant importance in

developing farmer-industry friendly diagnostics and also establishing agri-business incubation for easy commercialization of technologies. In this context, the technical backstopping by the scientists of the Institutes towards setting up quarantine facilities should not be ignored.

4.2 DADF initiatives

The then Department of Animal Husbandry, Dairying and Fisheries (DADF), presently the Department of Fisheries, Ministry of Agriculture and Farmers Welfare, Govt. of India has funded a mega-programme on National Surveillance of Aquatic Animal Diseases (NSPAAD) through National Fisheries Development Board (NFDB), Hyderabad. It has given a major impetus to diagnose disease problems at the grass root level. This programme has generated a large pool of well-trained manpower for the country to face the challenge. As on date, this programme has detected a number of exotic diseases, viz., *tilapia lake virus* disease (Behera *et al*., 2017), infection with *Cyprinid herpesvirus-2* (Sahoo *et al*., 2016) and *carp edema virus* (Swaminathan *et al*., 2016), *Proteus mirabilis* infection in IMCs (Pattanayak *et al*., 2018), infectious *myonecrosis virus* (Sahul Hameed *et al*., 2017), *hepatopancreatic microsporidiosis* (Rajendran *et al*., 2016), *epitheliocystis* (Sood *et al*., (2017). Besides, it has also helped in knowing the distribution of endemic diseases. Further, the Ministry is the Nodal Agency to report the disease status to Network of Aquaculture Centres in Asia-Pacific (NACA) and World Organisation for Animal Health OIE twinning laboratories on quarterly basis. Besides, quarantine issues are being addressed by the Ministry on a case-to-case basis.

4.3 State initiatives

Some of the leading states do have diagnostic laboratories and these are mostly involved in testing the water quality parameters. Few leading aquaculture states have taken initiatives to establish quarantine facilities for ornamentals as well. However, lack of trained manpower at each of these places on a continuous basis remains a major concern.

4.4 Farmers readiness

Majority of the aquaculture farmers are undertaking small-scale fish farming. The sector is somewhat organized in case of shrimp farming. However, the fish farmers and the farming rather remain generally in unorganized sector. The leading farmers of the sector are largely confined to shrimp industry and to a some extent in carp farming. However, the economic issues and societal issues largely pull them back to undertake the scientific fish farming. One of the major concerns is lack of policy to address the issues faced by the sector.

5.0 Recommendations

- All laboratories involved in disease diagnosis in public and private sectors need to be accredited. A small body may be formed under the Department of Fisheries, Ministry of Agriculture and Farmers Welfare. This can help in deciding the criteria for accreditation and subsequently undertaking the accreditation.

- The existing diagnostic laboratories in all shrimp hatcheries need to be registered and entered into ring testing mechanism.
- One Central Disease Diagnosis Laboratory with 6 Regional Laboratories (8-10 trained manpower) need to be established with central funding. These laboratories need to be further linked to state level key laboratories either at State Agriculture Universities (SAUs) or at State Fisheries Departments (SFDs) as well as district laboratories.
- Sero-diagnosis with emphasis on antibody titre in fish in healthy and challenged conditions needs to be undertaken for developing sero-diagnosis.
- Sensitivity of diagnostic methods used for quarantine may be looked into for non-OIE listed pathogens.
- Institutionalization of the National Surveillance Programme with technical backstopping from ICAR institutes should be taken up to make the disease surveillance more effective and sustainable.
- Aquatic animal disease reporting should be further strengthened and should be made mandatory to meet the national and international requirements of aquatic animal farming and trade. The reporting is necessary to deal with the emerging, exotic and endemic diseases; to facilitate effective quarantine of aquatic animals and transboundary movement of aquatic animals.
- A regulatory framework has to be developed and implemented to ensure the quality standards and sustained functioning (state level, central level).
- An effective mechanism needs to be formulated for disease preparedness and emergency response by the regional laboratories and functions of each should be specified.
- Ensure industries/stakeholders participation in commercialization of diagnostics developed through R&D.
- Promote quarantine systems under PPP model region-wise, commodity wise or ecosystem-wise with fixed numbers of ports of entry.
- Import risk analysis of live aquatic animals including seed, their products, feed additives and evaluation of competent authority of the exporting country needs to be undertaken before approval of introduction proposal.
- Follow sampling and testing using internationally recognised protocols for trade purpose.
- Devise mechanism for formal and regular system of quarantine whereby the cost of quarantine is borne by the importer.
- Formulate the mechanism for regulating movement of live aquatic animals within the country.
- Revisit the list of diseases of national concern (exotic and endemic diseases) and organise brainstorming session for this purpose.

- Incorporation of rules and guidelines under the existing livestock importation act to strengthen the aquatic animal quarantine.

6. Proposed Strategy/Action Plan

6.1 General

Aquaculture authorities/industry/farmers need to realize the importance of fish disease diagnosis and its routine screening besides policy backdrop with regards to aquatic quarantine. All the efforts need to be directed to flag the issues involved at appropriate levels to realize the necessity of strong diagnosis back up and quarantine facilities in the country for multiple species at multiple ports of entries. Urgent action in this regard is to be initiated to bring out the National Policy and its effective implementation at the grass root level (**DAF/ICAR**).

6.2 Research

a. Presently, the research on sero-diagnosis for commercial applications is neglected. However, sero-diagnosis remains a cheap and user-friendly diagnosis system in terrestrial animals and human diseases. Hence, research needs to be undertaken for developing reliable serological assays to screen healthy and infected fish, particularly for endemic diseases. (**ICAR Institutes/SAUs**)

b. The National Referral Laboratories created under the National Surveillance Programme for three broad categories of aquatic diseases, viz., freshwater fish diseases, brackishwater fish diseases and OIE-listed/exotic pathogens, need to be accredited either at national or international level. They should conduct ring testing of targeted pathogens among the registered diagnostic laboratories. (**ICAR Institutes**)

c. The lead diagnostic laboratories in research Institutes or Universities need to emphasize upon developing very sensitive diagnostics for all transboundary pathogens for use during quarantine certification process (besides OIE protocols where the sensitivity is poor), particularly while analyzing risks associated with a commodity/species to be imported upon. Probably diagnostics based on e-DNA technology would be more powerful tool to address by analyzing not only aquatic organisms but also transported water along with it at the site of entry. (**ICAR Institutes/SAUs**)

d. There is long National list of pathogens/diseases, which was prepared after a workshop at ICAR-NBFGR, Lucknow. The list needs to be revisited again after a brainstorming session. (**ICAR Institutes**)

6.3 Capacity Building

a. Develop training modules on fish disease diagnosis and quarantine for states and others to be established with the help of central laboratories personnel for efficient diagnosis. Even the newly recruited researchers need to undergo such trainings. Different modules also need to be developed to sensitize aqua-quacks involved at the grass root level. (**ICAR Institutes**)

b. Awareness programmes need to be launched to sensitize fish farmers to report a disease problem to the nearest diagnostic laboratory and routine screening of the stock intermittently as a mandatory policy, thereby reducing disease related loss and spread of pathogens within the country. Nevertheless, the awareness campaign should target also the ornamental traders, shop owners, live feed industry, NGOs and SHGs associated with fish farming. (**State Fisheries Departments/KVKs**)

c. Intermittent sensitization among state fisheries officials on the policy and associated regulations with regard to disease diagnosis and quarantine to be made mandatory. (**MPEDA/DAF/ EIA/States**)

6.4 Financial support

a. Department of Fisheries (DoF), Govt. of India should establish one Central Diagnosis Laboratory in Centro de Diagnosticos Laboratoriais (CDDL) pattern with minimum 6 Regional Laboratories (with 8-10 trained manpower to address freshwater, brackishwater, marine water and coldwater systems, OIE reported and exotic pathogens) under central funding. These laboratories need to be further linked to each state level key laboratories (either at SAUs or at SFDs) and district level laboratories either established or to be established by each state in key aquaculture districts. The infrastructure support in terms of building and equipments with one year consumables as one time grant need to be extended by DoF either directly or through NFDB. However, the technical manpower needs to be part of the state machineries. (**DoF, NFDB**)

b. The National Surveillance Programme need to be institutionalized as a key organization for making surveillance, reporting and monitoring agency for the country. (**DoF, NFDB**)

c. All the aquaculture states should establish diagnosis laboratories in key aquaculture districts. (**Fisheries Departments of States**)

6.5 For planners and line departments

Aquatic animal disease diagnosis and reporting should be further widened, strengthened and be made mandatory to meet the national and international requirements of aquatic animal farming and trade to deal with the emerging, exotic and endemic diseases, and to facilitate effective quarantine of aquatic animals and transboundary movement of aquatic animals. It should be mandatory for all laboratories involved in disease diagnosis in public and private sectors to be accredited. A small body may be formed under the Ministry for accreditation. Further, the existing diagnosis laboratories in all shrimp hatcheries need to be registered and entered into ring testing mechanism. Diagnostic development and quarantine facilities need to be promoted under PPP model to address different ecosystems and commodities. Import risk analysis of live aquatic animals including seed, their products, and feed additives should undergo proper evaluation mechanism by competent authority before approval of introduction. The mechanism involved in each step should be globally acceptable to promote cross-border trade. Further, incorporation of rules and guidelines under the existing livestock importation act to strengthen the aquatic animal quarantine may be followed.

6.6 For farmers

The ultimate cooperation by each of the fish farms and farmers is key to success of any policy, although it is missioned towards the benefit of each farmer. The farmers need to be well trained and must respect to the national policy. They need to understand the importance of disease diagnosis and reporting, as even one farmer's silence or ignorance may lead to breakdown of whole industry of a country. Nevertheless, it must be ensured that the policy which is to be formulated should not become a regulatory burden on farmers in any way, which would hamper their livelihood. The farmers need to be proactive to go for registration of all farms at the state level or at any regulatory authority as governed by the Ministry.

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