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REVIEW

Analysis of Fish Health Status in Terms of Sustainability of Aquaculture in Turkey-A SWOT Analysis

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Abstract

The sustainability of activities for the production of food or other industrial products in natural areas all over the world is perhaps one of the most important problems. In order to ensure sustainability in the aquaculture sector, all components of the sector should be synchronized. In this review, fish health status, which is an important component of the aquaculture sector in Turkey has been analysed in terms of sustainability. The article primarily discusses a brief history of Turkey's aquaculture industry and also the diseases reported from fish in the country were mentioned. In addition, other components of aquaculture sector were announced except for fish health. In this first section, information about fish health related public and private stakeholders is given. In the second part of the article, a large SWOT analysis of fish health was performed. Finally, recommendations and measures for fish health managements were presented for the sustainability of aquaculture in Turkey.

Introduction

Turkey is a country with wide hinterland and a unique geographical position whereby Asia meets Europe. Moreover, Turkey’s location on the geography is such that its three sides are surrounded by sea. This allows the country to forge social and commercial relationships primarily with the adjacent countries and the countries with borders. Recent changes in the country’s economy and application of advanced technology in various sectors in addition to the advantages of communication era have enabled faster developments in the aquaculture sector, similar to several others, and made it possible to increase the market share of the sector. However, such developmental trends have also brought forth the issues related to fast growth and increasing capacities. The present review briefly mentions historical development of the aquaculture sector, and mentions diseases, which are the most important problem related to production, along with the forthcoming opportunities and potential threats in the Turkish aquaculture sector.

Aquaculture Sector in Turkey

Background

In the 1970s, Turkey’s population was 35 million (Yılmaz, 2015) and the total seafood production accounted for 184 thousand tons. However, this value only represented capture fishery, since the aquaculture production was not included in the statistics until 1984. The first formal record of aquaculture production was published in 1984, as 2.226 tones. Nevertheless, it is well known that Turkey’s aquaculture production dates back to a decade earlier. The first attempt of the country’s

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aquaculture production started in the early 1970s with the farming of common carp (*Cyprinus carpio*) and rainbow trout (*Oncorhynchus mykiss*) (Demir, 2011). World aquaculture history, on the other hand, dates back to an ancient era (Nash, 2011). Turkey began its aquaculture production much later regardless of the availability of aquatic resources as compared to other countries. Species diversification increased with the farming of European seabass (*Dicentrarchus labrax*) and gilthead seabream (*Sparus aurata*) in mid 1980s and aquaculture production reached 5,782 and 60,000 tonnes by the 1990 and early 2000, respectively. The current population of Turkey has exceeded 85 million and aquaculture production is almost equal to fisheries production. According to state statistics, the seafood production that was achieved in 2,308 registered aquaculture facilities in 2017 was 276,502 tons while the seafood caught from wild stocks via fishing activities was 354,318 tons (Kop, 2018).

Components of the Aquaculture Sector

Species of Interest (Cultured Species)

Rainbow trout (*Oncorhynchus mykiss*) stands out among the cultured fresh water species. Brook trout (Salvelinus fontinalis), which originates from North America, has also been the subject of research as an alternative species. Brown trout (*Salmo trutta*) are also cultured in Turkey.

Other fresh water species like Nile tilapia (*Oreochromis niloticus*), common carp (*Cyprinus carpio*), and wels catfish (*Silurus glanis*) are subjects of research by both government research institutes and the private sector.

Attempts on Sturgeon culture (three species; Acipenser gueldenstaedtii, A. stellatus, and Huso huso) were accelerated by 2000s. Presently, a fish farmer in Adana (central south) produces fresh fish and caviar of Sturgeon (A. gueldenstaedtii and A. baerii), while a few other farmers maintain stocks of sturgeon, mainly for fattening, provided by governmental research institutes and/or universities in Black sea region. The production of sturgeon culture has not reached the required numbers to be included in statistics, yet.

Although European seabass (*Dicentrarchus labrax*) and gilthead seabream (*Sparus aurata*) dominate the marine aquaculture production based on market demand, culture protocols have been developed for 18 alternative species. They are blue-spotted seabream (*Pagrus caeruleostictus*), red-banded seabream (*Pagrus auriga*), common seabream (*Pagrus pagrus*), brown meagre (*Sciaena umbra*), turbot (*Psetta maxima*), black tail bream (*Diplodus vulgaris*), Pandora (*Pagellus erythrinus*), white grouper (*Epinephelus aeneus*), stripped seabream (*Lithognathus mormyrus*), Shi drum (*Umbrina cirrosa*), white seabream (*Diplodus sargus sargus*), meagre (*Argyrosomus regius*), common dentex (*Dentex dentex*), sharpsnout seabream (*Diplodus puntazzo*), greater amberjack (*Seriola dumerilli*), Mediterranean mussel (*Mytilus galloprovincialis*), green tiger prawn (*Penaeus semisulcatus*), Kuruma prawn (*Penaeus japonicus*). The capture based tuna aquaculture, that involves farming and fattening, is also readily applied in the Mediterranean Sea (RTMFA, 2018; Mylonas, *et al.,* 2010).

Feed (Nutrition)

All components of the aquaculture sector struggle to develop at the same pace. However, factors like government incentives toward higher aquaculture production, availability of sector representatives from higher education departments, research in institutions and universities, as well as the Turkish economic stability have been helpful in the elimination of problems associated with sustainable growth. The Turkish aquaculture sector has faced issues related to quality, quantity, and cost of commercial fish feed from the beginning. The commercial fish feed production, in particular, was 40,646 tonnes in the year 2000 when aquaculture was considered to be a promising business, reaching up to 184,810 tonnes in 2010 (Demir, 2011). The most recent commercial fish feed production has been reported as 513,000 tonnes in 2017. Almost twice of the raw material is required, in the form of fish meal and fish oil, in order to produce required commercial fish feed for the increasing capacities of the aquaculture sector. This makes some of the raw materials to be imported, in other words, it increases dependency on the international market for commercial fish feed resulting in high production cost. Although, an increase in the capacity and technology of commercial fish feed companies has contributed to the sector by means of fulfilling the dietary need of species of interest and hence maximized performance.

Qualified Manpower (Expert) and Technical Staff

During the early 1970s, the required manpower for aquaculture was obtained from those outside of the sector but later on, qualified manpower with required skills, particularly with a degree in agricultural engineering and veterinary field, became essential. It took almost 20 years for those outside of aquaculture engineering (or fisheries, Aquatic sciences and zoology) to gain expertise in fish breeding and aquaculture, to apply their knowledge and/or experiences to fish breeding and more importantly to create awareness on official levels. Hydrobiology Research Institute (HRI) of Istanbul University was the first research institution that is devoted to scientific research activities related to aquaculture sector since the late 1960s. HRI carried out hatching of fish eggs imported from Germany and Austria and released the juveniles in to Iznik lake, thus constituting the first record of hatching and stocking

(Yurtoğlu 2017). Fisheries and Marine Science departments were established in the 1980s. The establisment of the department resulted in the graduation of skilful aquaculture engineers. At present there are 16 Faculties of Fisheries (one of these Faculties is Facuty of Aquatic sciences), 5 Department of Fisheries in the Agriculture Faculties and 3 Faculties of Marine Science Departments, providing equipped engineers and technical staff based on industry's demand. These faculties offer expertise on various subjects including fish welfare, nutrition, biotechnology, genetics, and sustainable aquaculture techniques. Skillful graduates from such faculties are currently leading the Turkish aquaculture sector, comprising of both governmental departments and private companies.

Regulations

Aquaculturists are obliged to follow the regulations of several countries, by means of associations and organizations, as well as of the ones where they carry out the aquaculture activities. Aquaculture and fisheries sectors are regulated by the Law number:1380, which was enacted in the year 1971. This law sets a framework covering the responsibilities of aquaculture activities and is updated based on legal requirements and regulations regarding the environmental impact of aquaculture activities, fish health management, disease control, export-import, and government incentives (Bahadır *et al.*, 2011). This legislation was amended in 2007 to comply with to EU regulations with a specific focus on the site selection and again in 2009 for fish welfare and monitoring of fish farms. Furthermore, Turkey has adopted the EU Common Fisheries Policy (CFP) as a part of the harmonization process in 1983 (Çelikkale, Düzgüneş & Okumuş, 1999).

Diseases

Fish diseases are considered to be the most important problems and play a significant role in aquaculture industry. In Turkey, the first records of a fish disease are mainly about fish parasites reported by both local and foreign scientists. For example, a protozoan parasite Mucophilus cyprinid from common carp (*Cyprinus carpio*) were identified in 1965 (Koç, 1965). The identification of bacterial fish diseases started around the 1980s following identification of parasitic diseases. The first records of bacterial diseases are Aeromonas hydrophila, isolated from rainbow trout (*Oncorhynchus mykiss*) (Baran *et al*., 1980), and Pseudomonas sp. from pike-perch (*Stizostedion lucioperca*) (Timur & Timur, 1985). The first record of the viral fish pathogen was Infectious Pancreatic Necrosis (IPN) isolated from rainbow trout in the 2000s (Candan, 2002). The identification of quality (resistant strains) and the quantity of fish pathogens is steadily increasing due to the intensification of aquaculture practices and the availability of fish health management experts enabling their straightforward identification. A review of bacterial and viral fish pathogens reported the presence of 48 bacterial and 5 viral fish pathogens in total from 112 independent studies carried out in Turkey (Öztürk & Altınok, 2014). About 79 species were identified between the years 2003 and 2009 in Turkey (Kayış *et al.*, 2009).

Government Agencies in Charge of Fish Disease

Prophylactic control methods avoid the occurrence of fish disease both in natural water bodies and aquaculture environments. Chemical treatments are both harmful and expensive, so it is important to apply control mechanisms and monitor fish health regularly. Surveys are the initial phase in fish disease research that unveils the natural course of diseases (Lasee, 1995). As prophylaxis and surveys involve regular monitoring, resulting in data need to be kept in a library format so that it is readily available to aquaculturists. However, a lack of coordination and/or communication exists among the governmental bodies and research institutions regardless of accessible technical infrastructure, qualified man-power, and experts on specific subjects. Among these agencies are several agencies of government that provide services for fish disease but most of them operate under the Ministry of Agriculture and Forestry. Among these agencies are, Veterinary Control Research Institutes (VCRI), Central Fisheries Research Institutes (SUMAE), foundations such as universities and related faculties; Fisheries and Aquaculture Faculties and Marine Science Faculties operating under Higher Education Departments (HED). Even though these agencies are well distributed within the country (with an exception of Southeastern Anatolian region) (Figure 1), the fish farmers (private sector representatives) are not connected to any of them. All fish farmers come under the responsibility of provincial organization of the Ministry of Agriculture and Forestry.

Veterinary Control Research Institutes

The VCRI operate many activities of research, diagnosis, and control, training and production of vaccines and field tests. Their responsibilities involve applying nationally and/or internationally verified methods with utmost confidentiality and ensuring fast and accurate diagnosis of diseases and/or residual analysis of all sorts of animals kept for breeding. These operations do not have any expertise in fish disease, in particular, however, some of the residual trace element tests are routinely applied to import/export fish. Fish farmers may apply for this service if required, as the results are legally valid but their expertise is limited to fish diagnosis and fish pathogen detection. Some veterinary schools also cover aquatic pathobiology by

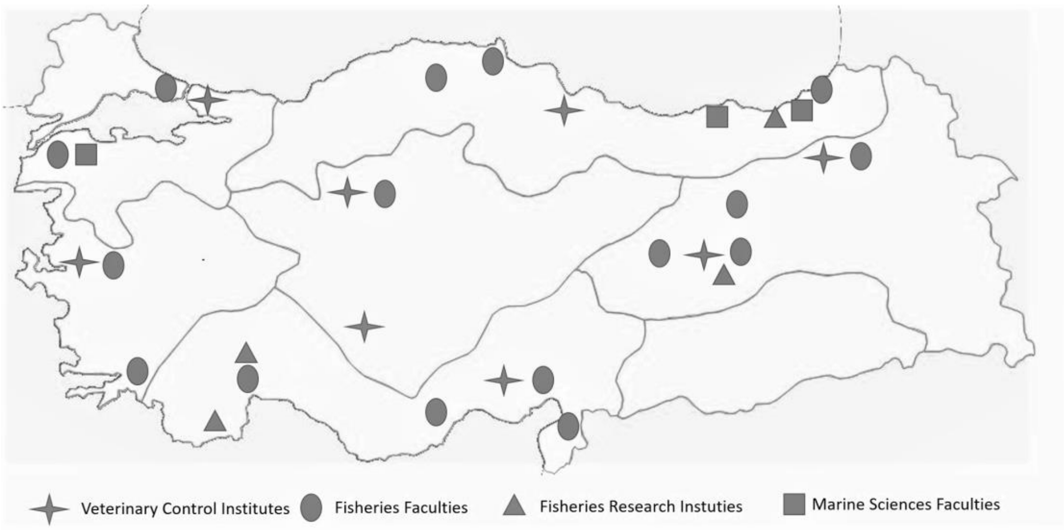

Figure 1. Distribution of governmental agencies in charge of fish disease.

carrying out education and research simultaneously and these departments are akin to the aquaculture department of fisheries faculties.

Fisheries Research Institutes

Although limited in numbers, these government agencies are geographically broader in their operations. Their responsibilities involve executing industry-applied research projects that cover both fisheries and aquaculture, as well as holding national and international level scientific meetings in order to provide an opportunity for knowledge and technology transfer. These institutes like the VCRI do not handle fish farmer's cases related to diseases. Nevertheless, aquatic fish health departments operate under these agencies and provide service to fish farmers when needed.

Educational and Research Institutions

Turkey's higher education departments carry out both education (teaching) and research simultaneously. Faculty of Fisheries and Faculty of Marine Science are well distributed in the country (Figure 1) and they produce skilled BSc, MSc and PhD graduates and aquaculture engineers. Researchers from these universities have reported the majority of the fish diseases (Öztürk & Altınok, 2014), because of which the fish health management experts of universities are mostly consulted in the case of disease outbreak.

Provincial Directorate of Ministry of Agriculture and Forestry

These are the main official agencies in charge of all agricultural activities as well as processes of prevention and control and are located in every city of Turkey. Fish farmers directly come under the responsibility of these agencies in the province where aquaculture activities are carried out and they control project approvals, fish transfers and movements and government incentives. However, these agencies are the least efficient in fish health management in terms of both technical infrastructures and qualified or expert man-power. In other words, one of the most competent fish health departments of Turkey is unsatisfactory in performance.

Private Organizations in Charge of Fish Diseases

The Turkish aquaculture sector has developed steadily with increasing demand and exportation, thereby positively affecting the product quantity as well as the quality.

Considering the advances that have been made in offshore caging systems, feed technology, and processing technology, the resulting developments in fish health is slower. No private company specifically provides services only in fish disease, but cooperate with companies with larger production volumes and professional visions have established their own fish disease laboratories for rapid identification of fish pathogens.

The most significant effort that private organizations have undertaken is the development of vaccines for bacterial fish pathogens and provision of services for fish health management. Currently, vaccines are being developed for Yersiniosis, Vibriosis, and Streptococcosis bacteria, effectively commercialized home products for aquaculture companies. Since fish farmers prefer fish vaccines, a new area that needs qualified man-power and technical has emerged.

SWOT Analysis of Fish Welfare in Turkey

This review discusses, the current situation of the aquaculture sector and all components of the industry that affects fish health. From this point onwards, the review will cover the strengths and weaknesses of the sector along with the discussion pertaining to the threats that can be faced and opportunities that this sector will create.

Strengths

Skilled Staff and Technical Infrastructure

The number of experts for fish health management is considerably high in Turkey. Researchers working in universities from the higher education department, personnel working at the governmental agencies as well as private companies, are all capable of prompt detection, identification, and diagnosis of fish pathogens. They can also suggest the correct prophylactic control mechanisms needed to be implemented at the aquaculture sites. Technical infrastructure for assisting such processes is readily available and the fish pathogens are routinely identified by the means of phenotypic, histologic, serologic, and molecular tools. In this context, Turkey is in a well-equipped position.

Using of Vaccination Against Fish Pathogens

Fish farmers have been convinced to use fish vaccines during the last decade, resulting in a considerable decrease in the outbreak of fish diseases. For example, the prevalence of Yersiniosis has significantly decreased. The use of fish vaccines has been widespread in the eastern Black Sea region of Turkey. Yersinia ruckeri that used to be frequently isolated from bacterial monitoring of this region (Lasee, 1995; Balta *et al*., 2016) has been either isolated or rarely isolated in the recent years (Kayış *et al*., 2017; Bingöl, 2018). Besides, the widespread use of fish vaccines has reduced the unnecessary use of antibiotics in fish farms.

Formal and Commercial Obligations on Fish Health Management

The existence of legislation on “prevention of animal disease and control program for animal transfers” that is practiced by the Ministry of Agriculture and Forestry is a statutory authority on the fish farmers. Furthermore, the additional compulsory criteria for exportation encourage farmers to employ better health management strategies in their farms.

Weaknesses

Conflict of Authorization and Competence

Provincial Directorate of Ministry of Agriculture and Forestry is the main official agency with a direct authority on aquaculturist, having supervisory as well as penalty power on fish farmers. However, these agencies are the least efficient in fish health management with respect to both technical infrastructure and skilled personnel, because of which the monitoring of fish farms cannot be carried out effectively. Besides, there is an additional conflict of interest with the occupational authorization of fish health experts employed in governmental departments. In Turkey, veterinarians are the authorized occupational group in regards to fish diseases whereas the graduates of Fisheries and Aquaculture Faculties, aquaculture engineers, as well as those from Marine Science departments, fisheries technology engineers, are not authorized in fish health. This not only creates a conflict of interest among the graduates of aquaculture related departments but also hinders the efficient control and monitoring of fish diseases.

Control of Fish Distribution

Aquaculture industry of Turkey is not just limited to fish production for human consumption across domestic and international markets but the ornamental fish industry is also an important sector. In Turkey, the value of ornamental fish that was imported reached up to 1.97 million $ in the year 2013 (Tolon & Emiroğlu, 2014). Pathogen free certificates for imported animals, of both ornamental fish and trout eggs that are routinely transferred abroad, are of utmost importance but official authorities do not necessarily require certificates in this regard. Similarly, the provincial directorate of the Ministry of Agriculture and Forestry holds the responsibility of domestic fish transfers but does not effectively control it. Therefore, legal regulations are not effectively followed for fish transfers and import to Turkey.

The Lack of Certified Aquatic Products

Specific pathogen free fish eggs (QTL-®IPN, QTL-®FLAVO) can be made readily available. After a long-term follow-up, the individuals resistant to pathogens can be obtained and the eggs obtained from such parents can be safely sent even to very distant areas. Thus contamination of diseases can be prevented and a fresh start can be offered to fish farmers. Unfortunately, Turkey does not have any SPF hatchery setup available at present.

Insufficient Self-Regulation

The main purpose of domestic aquaculture associations, which are 18 in total, is to increase the communication between fish farmers and governmental authorities. This is done to enhance the development of the aquaculture sector nationally and internationally as well as to ensure the sustainable use of environmental resources. Such associations, in theory, are expected to provide progress, communication, and employment;

however, they lack management strategies for identifying threats and finding solutions for potential drawbacks. Since active fish farmers with commercial concerns operate most of these associations, the association duties are only of the secondary importance to them. Although associations have authority over fish farmers, particularly for collaboration of fish health control mechanisms and fish transfer processes, they can be inefficient in putting it to practice thus leading to negligence in farm operations. These factors can cause serious economic losses, problems that cannot be fixed in short time (in the case of high mortality on brood stock fish), lack of assessment for new markets nationally and internationally, and can create bottlenecks for sustainable development of the aquaculture sector in a long term.

Opportunities

Government Incentives and Time of Change for Turkey

The economic change in Turkey was initiated around the year 2000 and the system of government was been updated in 2018. The statistics have reported a –9.5% growth rate with an inflation rate of 68.5% in 2001, whereas the growth rate reached up to +10.3 with a lower inflation rate of 6.4% in 2010 (Acar, 2013). Recently in 2017, the growth rate was recorded at 7.4%. All fish farmers get proper government support for aquatic production. In order to have stable economic balances, the relevant state units need to be very positive about the production and export of aquaculture, similar to other sectors. The government agencies in charge of aquaculture production have a resource incentive point of view for the import/export market. The previous system of governance has been updated to a presidential system, which allows quick decision making and application of new strategies in all domains. This may, in turn, enable stable government incentives in regards to fish welfare and encourage new investment opportunities.

Geographic Position and New Production Platforms

Cage systems are mainly used in intensified aquaculture operations that are adaptable to several fish farming sites such as lakes, dams for fresh water sites and sea cages for marine sites. The all year round production of rainbow trout is feasible in water reservoirs but such sites are more likely to be affected by the accumulation of organic material and bacterial biomass. Black sea, for instance, is not suitable for all year round production due to climate and physio-chemical parameters of water. Sea cages have nearly four months of fish-free time between June to September, due to the higher water temperature of 25 °C. This period gives the desired interval for the elimination of organic matters and bacterial biomass that potentially have a negative effect on fish transferred to cage sites. Black sea marine ecosystem is not used for high performance due to temperature effect.

Threats

Bacterial Resistance

Antibiotics are routinely used to treat bacterial infections all over the world (Juma & Karaman, 2015). The FDA (Food and Drug Administration) allows only the use of certain antibiotics namely sulfamerazine, oxytetracycline dihydrate, sulfadimethoxine/ormetoprim, and florfenicol, on fish pathogens globally. There are 35 licensed fish preparations of antibiotics, consisting of oxytetracycline, florfenicol, amoxicillin, trimethoprim/sulfadiazine, enrofloxacin, and oxolinic acid as active ingredients (Baydan, Yurdakök & Aydın, 2012). The use of these antibiotics causes bacterial resistance on the bacteria isolated from fish farms (Capkin *et al*., 2015). It is important to limit the unnecessary and overuse of antibiotics due to the fact that it leads to bacterial resistance, which will increase the cost of future fish health operations.

Pathogenic Contamination

The Turkish aquaculture industry has dynamic fish transfer operations wherein the routine transfers between the fresh water and marine sites are performed by the companies while live fish transfers (e.g., broodstock during spawning period and or juveniles) are common among fish farmers. Trout eggs produced by selective breeding, with focus on fast growth and fresh quality are imported and European seabass juveniles are routinely transferred to Blacks Sea in the north from the western and southern parts of the country. Pathogenic contamination risks are quite high in this scenario and once the aquatic environments are contaminated, it becomes difficult to eliminate the pathogens. Hence, a reduction in available aquatic resources will be confronted if aquaculture operations are not handled carefully.

Collaborative Use of Coastal Area and Rehabilitation Issues

The issues related to the collaborative use of the coastal area and the rehabilitation of such environments have been topics of ongoing debate countrywide. Civil construction work carried out for building dams, bridges, hydroelectric power plants (HEPP) and the gravel and sand companies adjacent to water reservoirs and their operational processes, as a long term stressor, constitute threats to the aquatic environments and cause a reduction in available ecosystems for aquaculture production. Hydroelectric power plants are examples by which habitat degradation of aquatic species and reduction in available resources for aquaculture can be observed. In total, 596 HPPs are actively operating, of which, 83 are under construction and decisions have been made for 639 new HPP for which the construction work has not yet been initiated (Yaman & Haşıl, 2018). This is evidence of the threat that can be faced by the aquaculture sector in near future.

Supply of Certified Production Material

Uncontrolled live material transfers for producing high quality seeds from abroad and different locations within the country poses pathogenic and genetic contamination risks. The availability of certified eggs with pedigree information in the domestic market will surely be advantageous in terms of international competitiveness. This is of prime importance for the development of the rainbow trout industry in Turkey, which has the second highest production volume after Iran. The lack of certified egg supply is a threat for sustainable development of the industry.

Sustainability

The escapees from fish farms are considered as a threat for wild populations; it creates predation pressure and competition for prey, potential transfer of disease causing agents from farmed to wild stocks, concerns like alteration of the genetic composition of wild fish due to mixing with farmed ones which are likely to be disadvantageous in natural conditions.

Conclusions and Recommendations

This review is the short answer to the following question, what is done about fish health for sustainable aquaculture in Turkey? In this respect, the aquaculture industry of Turkey possesses promising advantages with available resources nevertheless serious threats may be faced, not at present but likely in the future. The most prominent result of the present analysis is that there is a need to assess the future of aquaculture industry carefully, by focusing on fish diseases using more scientific methods, in order to eliminate threats and embrace the advantages that industry holds.

The actions that can be taken for the future of the aquaculture industry in the context of fish welfare are as follows:

(I) First of all, authority and competence balance need to be established by laws and regulations. Diversification of authorized personnel working under the responsibility of the Ministry of Agriculture and Forestry needs to be allocated. Engineers of aquaculture and fisheries technology need to be educated about fish health instead of relying solely on veterinarians in this regard. Once the desired diversification is introduced, in-service training needs to be organized so as to ensure competence and skill set of new attendees. There is a need to bring established senior researchers and authorized personnel together so that strength of their expertise can be utilized.

(II) The second most important step that requires action is the establishment of a fish disease database; which has a login requirement from every fish farmer and strictly controls actions such as fish transfers and quarantine. This system might help in reducing the contamination of fish pathogens and prevent the spread of diseases.

(III) It is of prime significance to produce domestically certified aquatic products, thus minimizing and eliminating the foreign source dependency of Turkey. Actions need to be taken to produce SPF domestic certified products in accordance with the industry demand in order to support sustainable growth of the aquaculture industry and to eliminate pathogenic contamination of foreign origin.

(IV) Vaccination must be done according to the activity calendar of other animals present in the culture. In this regard, vaccination in aquaculture needs to be obligatory thereby minimizing the use of antibiotics and preventing fish diseases.

(V) Protection of aquatic environments is a prerequisite for healthy and sustainable production of fish. Therefore, protection of water bodies is of primary importance not only for the aquaculture industry but also from the environmental point of view in regard to sustainable use of resources. All aforementioned precautions will help in protecting the present condition of the Turkish aquaculture sector by eliminating potential threats and help in embracing new opportunities.

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