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Review Article

Aquaculture Health Management Practices in Zambia: Status, Challenges and Proposed Biosecurity Measures

Oliver J. Hasimuna[1,2]*, Sahya Maulu[3,4], Joseph Mphande[5]

[1]Ministry of Fisheries and Livestock, Department of Fisheries, Solwezi Aquaculture Research Station, Solwezi, Zambia; [2]The Copperbelt University, Department of Zoology and Aquatic Sciences, Kitwe, Zambia; [3]Centre for Innovative Approach Zambia (CIAZ), Lusaka, Zambia; [4]Nanjing Agricultural University, Wuxi Fisheries College, Wuxi, P.R. China; [5]Ministry of Fisheries and Livestock, Department of Fisheries, Ndola, Zambia

ABSTRACT

Aquaculture is an important industry in Zambia which is contributing to economic development, food security and employment in the country. Significant increase in aquaculture production has been recorded recently, although its full potential is still far from being realized. Because of this, efforts are being made by the Zambian government to make the industry a more viable venture to expand its production. As these efforts continue to make a positive impact, and aquaculture production continue to increase, diseases of aquatic animals are likely to emerge and threaten the sustainability of the industry. Here, we review the status and challenges associated with aquaculture health management practices in Zambia as well as proposed biosecurity measures farmers may adopt to minimize the likelihood of fish disease outbreaks. The paper has established that despite the country having been spared from aquaculture diseases so far, there is lack of appropriate measures to prevent and control disease outbreaks. Overall, aquaculture producers in Zambia may benefit significantly from adopting available biosecurity measures to prevent disease outbreaks in their enterprises.

Keywords: Biosecurity; Sub-Sahara Africa; Fish diseases; Pathogens; Aquatic animal health; Zambia

INTRODUCTION

Aquaculture represents the fastest growing food producing industry globally, driving local economies and providing employment for many people in Zambia and the Sub–Sahara Africa Region [1]. However, disease among aquaculture stock is one of the greatest threats to the growth of sustainable aquaculture industries worldwide and no aquaculture has escaped this reality. As aquaculture becomes more intensive in the Sub-Sahara Africa region, new diseases are likely to emerge, and old diseases will appear in new locations. As such, several fish health experts have continued to research and propose ways of ensuring that outbreaks and spreading of diseases is prevented and/or minimized. The need for good quality and quantity aquaculture produce in the world today demands for proper aquatic animal health and diseases management practice that are sustainable. There is a general consensus however, that fish disease prevention is far better than managing the outbreaks [2]. This can be achieved through implementation of health practices aimed at preventing diseases at farm, national and regional levels.

Aquaculture in Zambia has continued to expand in the recent years and this calls for improved health management practices to sustain this growth. Currently, Zambia is among the leading aquaculture producers in the sub-Saharan African countries [3] with huge potential to significantly expand its current production. This potential exists in form of abundant natural resources, human labor and political will. Moreover, the industry has recently witnessed increased private investments, comprising mainly of large-scale commercial aquaculture producers. As a result of this, large-scale production is currently contributing the largest proportion (at least 71%) to national fish production [2]. However, sustaining the country's fish production requires improvement in current aquaculture practices as well as developing novel technologies [2]. A better understanding of the health management practices currently being applied in Zambia's aquaculture industry is a significant progress in efforts aimed at identifying practices for sustainable development. Hence, the present paper seeks to review the aquaculture health management practices in Zambia. The paper further, identifies the major challenges existing as well as proposing

Correspondence to: Oliver J. Hasimuna, Ministry of Fisheries and Livestock, Department of Fisheries, Solwezi Aquaculture Research Station, Solwezi, Zambia, Tel: +260977343533; E-mail: oliverhasimuna@gmail.com; oliverhasimuna@yahoo.com

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some of the measures aimed at improving the health management practices in the industry. The paper combines both primary data through a survey of various fish farms in the country and secondary data through relevant published articles.

LITERATURE REVIEW

Status

In Zambia, aquaculture health practices are not clearly defined, and according to Maulu et al. [2], the emphasis has been on the application of biosecurity measures that seeks to prevent disease outbreaks, although they are poorly reported. This is probably because the country has not yet experienced serious disease outbreaks in aquaculture [2]. However, different levels of production ranging from extensive to intensive are likely to have different capacity to apply health management practices. Therefore, it seems reasonable to define them based on the level of production. Previous reports have shown that aquaculture production in Zambia is narrowly categorized into small-scale and large-scale producers [2,3]. Additionally, the national Department of Fisheries (DoF) operates public aquaculture stations for research and development purposes. Such stations too have own health management practices for minimizing or completely eliminating disease outbreaks.

Generally, small-scale aquaculture producers in Zambia do not have well-established health management practices for their fish. The common practices observed include water quality management, farm and culture facility disinfection, observing reasonable stocking densities and caring for culture facilities surrounding to avoid any possible vectors of diseases [2]. Disinfection of the farm and culture facilities is usually the main health management practice employed to prevent the outbreak of fish diseases. The aim is to destroy potential pathogens, and this is achieved by applying certain chemicals for a specified period of time. The application of chemicals is often followed by drying period. However, specific information regarding the application of these practices is still unclear. Our survey in the Southern, Luapula, Lusaka, Copperbelt and North-western provinces of Zambia showed that a few of the small-scale fish farmers were only focusing on clearing and fencing their culture facilities to get rid of foreign organisms and objects that may possibly transmit pathogens. Surprisingly, some of the farmers were collecting fish seeds from the wild and directly stocking them into their ponds which presented a serious threat to health management of the fish farm. Furthermore, some of the common biosecurity measures were poorly observed, for example, the majority of the farmers were not disinfecting their culture facilities and quarantining the fish prior to stocking. This was primarily due to lack of adequate technical knowledge on the proper farm management practices as the country lacked adequate fisheries/aquaculture extension services [2]. Moreover, although some fish farming consultants were available in the country, most small-scale farmers could not afford the associated charges. This was however, justifiable because of low investment costs in their production, leading to low profits [3].

Contrary to small-scale producers, most of the large-scale producers in Zambia observed some level of well-established biosecurity measures for their aquaculture production. For example, a survey of some major large-scale aquaculture producers in the country revealed that a few of them were applying common measures such as foot and wheel bath facilities, aquaculture farm fencing, quarantine facilities, water filtering and disinfection practices. According to Kaminski et al. [4], some of the large-scale producers, mainly private investors simultaneously operate hatchery facilities while others operate hatcheries as separate systems. Our survey of some major hatchery operators in Southern, Lusaka, Northern and Central provinces showed that some of the hatchery operators had better basic biosecurity measures such as foot and wheel bath, disinfection of hatchery facilities and equipment, treatment of water sources, and restricting entry of foreign organisms and substances in culture facilities. For some of the producers, such as Yalelo Limited in Siavonga district of Southern province and Kafue fisheries in Lusaka province, have well prepared foot and wheel bath facilities installed at the entrance of farm premises for disinfection purposes. This prevents the entrance of potential pathogens into the fish farm from other sources. Studies have shown that although fish, pathogens and the environment always co-exists, any alteration in the environment that is unfavorable for the fish weakens their immune system thereby causing disease outbreaks [2]. According to the findings of Hasimuna et al. [5], the majority of the large-scale aquaculture producers in the Southern province of Zambia were stocking their fish at relatively high stocking densities. Such high densities potentially increase competition for resources and space in a culture facility among the fish resulting into increased stress levels which makes the fish more vulnerable to diseases such as streptococcus.

In government aquaculture research stations, a few measures are currently being observed. A visit at some research stations on the Central, Copperbelt, Luapula, Lusaka, Muchinga, Northern, North-western, Southern, and Western provinces revealed that only about 30% of the total surveyed were observing foot and wheel bath. Furthermore, most of them were operating tilapia hatching facilities for fingerling production and dissemination to fish farming communities, particularly small-scale farmers and for research purposes. The majority of these farms were simply observing simple biosecurity measures such as clearing of farm premises, water filtering, disinfection of culture facilities and equipment, water quality monitoring and control.

Challenges

Although Zambia has never had a serious disease outbreak in aquaculture, it is clear that the country's current status regarding aquaculture health management practices is not well prepared to handle any possible outbreak. Moreover, the country's regulatory body lacks fish diseases diagnostic facilities and experts [2]. Our survey of many fish farms around the country revealed that aquaculture in Zambia is facing several challenges related to health management practices which makes the country highly vulnerable to possible disease outbreaks. This therefore, is a serious economic threat among the producers. Some of the most notable challenges observed are discussed below.

Lack of knowledge due to inadequate extension services: Our survey showed that the majority of the fish farmers in Zambia especially small-scale ones, lacked basic knowledge regarding possible outbreak of fish diseases, transmission, prevention and control measures. This challenge is being worsened by inadequate extension services that has affected many other facets

of the Zambian aquaculture industry [2]. Some of the farmers were practicing aquaculture based on indigenous knowledge as passed on by parents. Some of them were learning from fellow fish farmers through information sharing. A few lucky ones were once taught by government extension workers and/ or non-governmental organizations and other volunteers within the community. However, this kind of information sharing that lacks scientific support is usually void of some important elements of knowledge. In most cases, these farmers do not know how to properly disinfect their culture facilities and equipment, doses of disinfection agents, as well as various ways through which fish diseases may be transmitted from one culture facility to another, among others. Further, because Zambia's aquaculture has not had serious fish disease outbreaks [2], the majority of the farmers know very little about fish diseases.

Poor entry and exit control measures against fish and other organisms: The majority of the aquaculture farms in Zambia are open with free entry and exit of organisms and substances that may potentially transmit or lead to fish disease outbreaks. They mostly lack proper security to monitor the operations. For example, our survey at several farms around the country showed that, the majority of the small-scale farms are not fenced to prevent the entry of some organisms such as otters, monitor lizards, and even human beings that may be vectors of some pathogens. Furthermore, most of the fish ponds are surrounded by long grass which may pave way to snakes, monitor lizards, tortoises, and otters' entry into the fish ponds. Such organisms may carry with them different pathogens that threatens fish health. In the case of ponds located near streams or other water bodies, fish may escape to the wild, threatening the health of wild fishes. For large-scale aquaculture producers, especially those operating in cages, it is very common for cultured fish to escape into the wild. This poses a very serious threat to fish disease transmission. As reported by Hasimuna et al. [5], aquaculture production in Zambia is dominated by cage aquaculture, therefore, any disease outbreak due to disease transmission through fish escapes from cultured fish to wild fish and vice versa may have a huge impact on the country's aquaculture industry. More also, the environmental degradation that results from cage aquaculture has a potential to lead to proliferation of disease causing pathogens. Furthermore, with the likely increase in aquaculture operations through cages, pens and ponds around the country due to good government policies favouring aquaculture, this challenge is likely to increase.

Lack of proper diagnostic tools: Generally, Zambia's aquaculture industry and managing institutions do not have appropriate fish diseases diagnostic tools which makes the industry even more vulnerable. According to Maulu et al. [2], the country currently relies on diagnostic practices in some public universities, particularly the University of Zambia, for diagnosis and handling of fish disease outbreaks. However, these institutions often lack some key tools as they are not usually meant for fish diagnosis. This challenge is exacerbated by lack of fish health experts which remain one of the major challenges facing the Zambian aquaculture industry. The use of proper and adequate diagnostic tools is very crucial for accurate identification of specific pathogens in order to provide appropriate treatment and development of vaccines. Unfortunately, Zambia is still limited to the use of traditional diagnostic tools [2].

Exotic fish species introduction: The introduction of exotic fish species in fisheries and aquaculture continues to be one of the major threats to sustainable fish production systems globally. Exotic species introduction has generally been associated with loss of genetic diversity of local species, and fish disease outbreaks and transmission [6,7]. Currently, Zambia do not have a strict policy that regulates the introduction of exotic fish species by both the public and private players in the aquaculture industry. Although the Fisheries Act No. 22 of 2011 provides the Department of Fisheries a provision to regulate exotic fish introductions. The stated Act further gives power to the Director of Fisheries to reject or approve applications made to his/her office for any possible introduction of exotic aquaculture species. The decision is dependent on the possible impacts that the proposed species may have or may not have on the local species and the environment as a whole. Because of this flexibility in the law where someone has to write to the Director for approval leaves room where one may decide to introduce the species without applying to the Director. As a consequence, the private sector remains the major medium through which exotic aquaculture species are introduced in Zambia. This has the ability to seriously affect the aquaculture industry production and sustainability, as well as food security of the country.

Lack of basic biosecurity measures: Our survey of most aquaculture farms in Zambia, particularly in Lusaka, North-Western, Copperbelt, Southern, Luapula, Eastern and Central Provinces revealed that the majority of the farms lack basic biosecurity measures such as foot and wheel bath, spray races, water testing kit, disinfection points, quarantine facilities and recording keeping documents for all the farm data. It is obvious that in the absence of such basic biosecurity measures, traceability of where a disease may have come from would prove futile. Lack of knowledge on the occurrence of fish diseases in aquaculture among the producers was considered the major factor behind this observation as it is traditionally believed that fish don't get sick. However, some respondents mentioned that they had seen fish with wool like structures and some with sores. The above mentioned biosecurity measures are regarded as basic requirements in the sense that they don't require much financial resources and can be applied even on small-scale fish farms. Strict observation of the basic biosecurity measures may significantly reduce the likelihood of fish disease outbreaks and transmissions. Small-scale farmers would especially benefit from utilizing available basic measures, since in case of disease outbreaks, they would be the most affected due to low capacity to control the outbreaks.

PROPOSED BIOSECURITY MEASURES

Fish diseases continue to be one of the greatest causes of economic loss for the industry in most countries, for example, it has accounted for millions of dollars in annual losses [8-10] from fish producers. There are several benefits of employing biosecurity in aquaculture farms and facilities. Biosecurity generally include a standardized set of scientific measures adopted and set to eliminate disease outbreaks from host and culture environments as well as limiting their spreading and establishment [11,12]. Observing good biosecurity measures will minimize the fish's exposure and susceptibility to disease causing pathogens, reduces economic losses from mortalities and helps firms to continue having a good reputation in the sector. Furthermore, it enhances food safety, protects the investments by preventing economic losses,

optimizing the health and immunity of fish stocks. The benefits are many and Zambian aquaculture producers must adopt proper biosecurity measures and subsequent implementation. Recently, international, national and farm-level biosecurity measures in aquaculture have become increasingly essential due to the need to control and prevent infectious diseases and their devastating economic consequences [13]. Before proposing any biosecurity measures, it is very crucial to understand the factors underlying disease outbreaks and transmission in an aquaculture operation [12]. This is because disease causing pathogens are always present in the aquatic environment where the stock is cultured and will only cause disease when the environment favours the pathogen unlike the stock under culture [2]. As such, sound biosecurity practices are a good guard against disease outbreaks in aquaculture. Figure 1 below gives an illustration of the relationship existing among fish (i.e. host), the environment and pathogen in every aquaculture facility.

In order to effectively manage the transmission of diseases there is need to understand the routes for disease transmission especially for developing aquaculture industries like those in Sub-Sahara Africa. These routes are divided mainly into three categories: onto, within and from the farm as suggested by Sub-Committee on Aquatic Animal Health (SCAAH) [14]. SCAAH [14] further stated that routes that can transmit diseases causing pathogens within the farm are just like those that can transmit the disease onto the farm but the focus is on transmission risk is for the spread of disease between different production and processing areas. Generally, not all facilities or ponds within the same farm are the same in terms of health levels. A very good example is the differences that exits between the health status of hatcheries and grow-out ponds, the later would have a higher health status. As such, consideration should be given to the risks of disease transmission between these areas of different health status. To lessen the effect of disease outbreaks, the risk of disease transmission between production areas should be considered [12]. Transmission of diseases can be summarized as shown in Figure 2. Therefore, the rule of thumb is that each production area must be managed independently to prevent a disease outbreak in one area spreading to all the other areas [14].

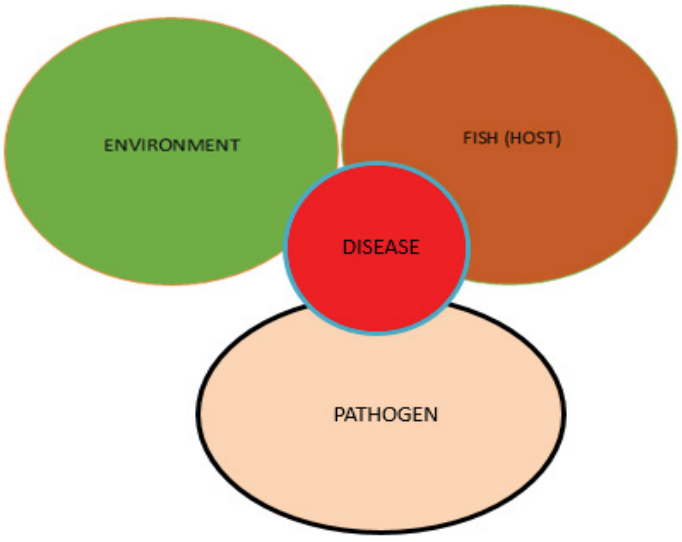
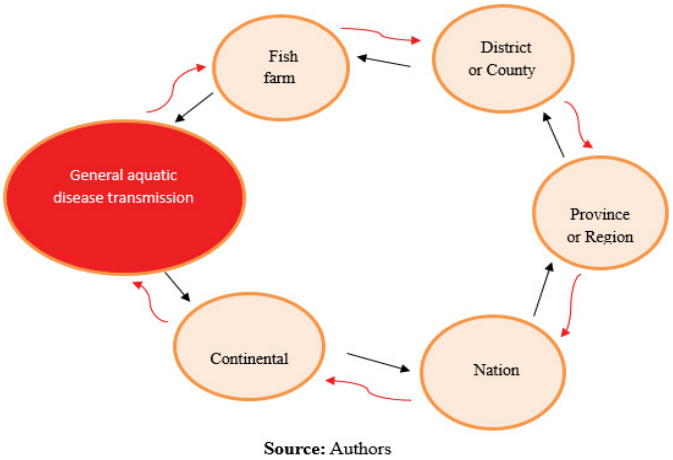


Figure 1: Relationship existing among the environment, fish and pathogen in an aquaculture facility.



Source: Authors

Figure 2: The forward and backward transmission of aquatic disease.

Biosecurity measures that are based on a better understanding of various disease risk factors in an aquaculture farm may provide a more effective result. Some of the major risk factors that need to be seriously taken into consideration include animals, people, vehicles and other moving equipment, water and sediments, feed, and solid and liquid wastes. Therefore, biosecurity measures may be designed to address these risk factors.

Animals

when animals enter an aquaculture farm or facility, they pose significant risks of spreading the disease more especially if their health status is unknown or uncertain [11]. Both aquatic and terrestrial animals would act as vectors of the disease and examples include: broodstock, seed, eggs and animal products, wildlife, birds, pests, and scavengers [11]. Each fish farm should have a proper screening protocol for aquatic animal diseases for all in-coming stocks (fingerlings and broodstock) especially those from the wild. Whenever new stocks are introduced onto a farm, it is important to subject them to necessary quarantine procedures to ensure they are free from any possible diseases. Therefore, fish farmers must always have quarantine facilities at the farm. Furthermore, there is need to obtain healthy fish (fry, broodstock, juvenile, eggs, fingerling) from a reputable source and in a case of uncertainty in the health history of the fish obtained, tests should be done shortly upon reaching the new farm. Where possible, however, it is important to minimize importation of fish from other regions or countries as it can be one of the major source of diseases in a fish farm.

People

It is important to understand that people including workers, staffs from other farms, visitors, contractors and other members can present a significant risk of disease transmission onto the farm [11]. Therefore, measures to prevent them from bringing the pathogens or a disease should be employed if the enterprise is to be protected. Aquaculture producers in Zambia must ensure that people that enter the farm are treated as couriers of the disease and measures must be put in place to prevent diseases from coming into the farm through human beings.

Vehicles, vessels and other equipment

Vehicles that have been used for transportation of animals or other risk factors previously can bring pathogen onto the farm [11].

Vessels can act as a likely source for pathogen introduction when they have been used at other farms or have been in close contact with animals. Equipment that has been previously used in other farms or in contact with animals can also pose a significant disease risk and can transmit disease onto the farm. To manage the risk of spreading disease within the farm, arrangements should be in place. For example, use separate equipment for each production area (the equipment should be labelled and stored appropriately), have dedicated facilities in each production area for cleaning and disinfection of routinely used equipment and clean and disinfect equipment that must be used in multiple production units.

Water and sediments

Quality water is key to an aquaculture enterprise and it is often said that before you farm an aquatic organism you ought to farm the water [11]. This means that the water must have the required parameters necessary for the proper growth of fish without favouring the pathogens. Equally, the sediments have a bearing on the water especially in already used ponds. If the sediments are polluted, the water will significantly be affected within a short period of time. Therefore, water supply of a farm has a major influence on health of animal under culture and in semi-open system like cage culture in sea or lakes, water supply can be little controlled. In land-based culture nature of water supply, presence of contaminants considerably affects the risk of disease transmission onto the farm. It is therefore very important to ensure that water of appropriate quality is used in the culture of fish. Additionally, the movement of water within a farm should be considered to minimize the potential for diseases to spread between different production units or populations with different health status. This is particularly important to reduce the spread of an emerging disease. That is a more reason why series ponds are not encouraged because if one pond is affected there are higher chances that even other ponds that were not affected initially would also be affected due to water moving from one pond to another.

Feed

Manufactured feed or raw materials can act as source of fish disease causing pathogens. There are serious concerns when feed is not handled or stored properly [11]. Feeds and feed ingredients are often sourced from aquatic environments and may present a risk of transmitting diseases. Different types of feed present different levels of disease risk. For example, live feeds such as rotifers, artemia and polychaetes and unprocessed whole aquatic animals may present a higher risk than commercially manufactured feeds and the risk of disease transmission. The disease status at the source of the feed or ingredients must be known. The focus areas are: whether pathogens of concern are present in the feed or feed ingredients, whether the feed or feed ingredients have been treated in a way to deactivate pathogens of concern and how feed is stored. In short, proper screening should be conducted on feed materials and ingredients. The biosecurity risks to your farm that are associated with feeds need to be considered and measures put in place to manage any unacceptable risks. For example, where live or unprocessed whole animals must be used as feeds, risks can be managed by sourcing feeds from disease free areas, by testing to ensure they are disease free or by treatment to inactivate pathogens.

Solid and liquid waste management

Solid and liquid wastes are usually generated in the aquaculture operations from various materials and equipment as such the disposal of these wastes is very vital in ensuring that diseases and pathogens are eliminated from the farm [15-17]. In order to ensure good maintenance of the farm, all the processes that have to do with waste management such as handling and treatment of waste materials, from the collection, transportation, and disposal of rubbish and sewage to the removal of infrastructure that is no longer serviceable and the management of biofouling are followed and well executed at all times [16]. Therefore, biosecurity measure must be applied in waste management to protect the investments made in aquaculture.

Good farm management practices

Good farm management practices requires employing knowledgeable and experienced farm workers to oversee production activities. In cases where this is not possible, the farm attendants must undergo necessarily training on good aquaculture management practices that ensures the protection of farm animals from disease invasion. The design and construction of aquaculture farms or facilities must be done in a way that will prevent risks of disease introduction, spread or leaving the farm easily. Stock health should be maintained by keeping stock stress to minimum level and maintaining optimum water quality. For example, water quality parameters should always be kept within the required range, and stocking density should be kept under normal based on the species being culture as well as the size of the culture facility. It is very important to keep records about the stock movements, in and out of the farm at all times so as to make it easier to trace the sources of disease in case of outbreaks. The use of basic biosecurity measures, such as foot dips and controlling the movement and access of people in the farm are crucial.

DISCUSSION AND CONCLUSION

The results unraveled that the aquaculture sector has continued to grow globally, as a result, the threat of infectious diseases to aquaculture production systems have risen also. This suggests that more disease causing pathogens are being identified and in some cases spreading to new locations. It is therefore evident that the risk of diseases in aquaculture production settings cannot be eliminated completely. It is also important to be arrive to the fact that biosecurity measures for an aquaculture production system will depend on a number of factors, including the type of facility, the purpose of the facility (e.g., stocking food fish), as well as the species and life stages reared. Therefore, there is no "one-size-fits-all" solution in aquaculture biosecurity. Identifying the biosecurity measures required involve the identification of risk areas for a facility and determining the necessary preventive measures to obtain the greatest cost-benefit. The use of biosecurity measures will help to prevent disease introduction and spread thereby protecting the fish and farm investments. Countries in Sub-Sahara Africa must act now and take measures of biosecurity implementation seriously.

RECOMMENDATIONS

The following are some of the steps or measure that can be taken by aqua farms and/or governments in the region to ensure that the

sector is protected from negative consequences of aquatic animal diseases:

- Governments in the region must enhance their efforts in training experts in aquatic animal health as a way of preparing for any unforeseen dire situations of fish disease out breaks in the region.
- Sub–Sahara Africa must develop entry, internal and exit level biosecurity measures for the various farms if the transmission of the fish diseases or pathogen are to be prevented from affecting the aquaculture enterprises and assure aquatic animal health.
- The region must adopt latest production technologies such as Re-circulation Aquaculture Systems (RAS) which assures disease prevention.
- Proper handling, sourcing of ingredients and storage must be prioritized in an effort to ensure quality of the feed is not compromised.
- Regular monitoring and surveillance practices should be implemented especially for the farms that have a higher production outputs.
- Audit should be conducted of on-farm biosecurity plans and their implementation on regular intervals.
- More research is needed to understand biosecurity measures that are being implemented in respective countries with special focus on hatcheries, grow-out, nurseries and cage culture facilities.
- There is need to develop standard protocol, legal framework and ensure their implementation.

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