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A Review on the Effect of Pandemic on Aquaculture Production: A Case Study of Covid-19 in Nigeria

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ABSTRACT: *Coronavirus 2019 was a global health concern that left most countries in a state of severe economic meltdown, most countries are still trying to bounce back economically. Scientific research has been done on the virus and its impact on various sectors but that of the Nigerian aquaculture industry has being missing. This paves the way for this review to consider the impact of the pandemic to fish farmers on the influence of the coronavirus on their activities, the challenges they faced during the period of the virus, and the strategies adopted to mitigate the impact of the virus. The review will look at cross sectional surveys carried out by the Nigeria government. During the pandemic, majority of fish farmers perceived demand decline, high cost of production, fish being more expensive, and reduction of manpower on the farm due to lockdown orders from the government. Reduction in walk-in customers to the farm was revealed as the major challenge posed by the pandemic, while the inability to get technical support as least. On coping strategies adopted, it was revealed that farmers have resorted to the development of their own feed. The COVID-19 has led to disruption of aquaculture practices worldwide. The pandemic has adversely affected the aquaculture input supply of fish stocking and feeding, which, in turn, has impacted aquaculture production. Moreover, the COVID-19 crisis has adverse effects on value addition to aquaculture products, through the restrictions of seafood marketing and exporting. Aquatic food production is vulnerable to the effects of COVID-19 outbreak; hence, adaptation strategies must be developed to cope with the challenges. Although, a handful of fish farmers were involved in small scale feed production to cushion the effect of high cost of commercial feed and fish-marketable-size cost production.*

KEYWORDS: pandemic disease, aquatic food production, aquaculture, fisher folk, feed production, lockdown

INTRODUCTION

The novel Coronavirus disease 2019 (COVID-19) from the family coronaviridae (subfamily Orthocoronavirinae), a single-stranded RNA virus measuring 80 to 120nm in diameter is broadly distributed in mammals (Sharma *et al.*, 2020). The virus was first reported in December 2019 in Wuhan, China (Wu *et al.*, 2020). It was declared a public health emergency of international concern on 30 January 2020, and as a pandemic on 11 March 2020 by World Health Organisation. The virus primarily spread through close contact

and small droplets produced when infected patients cough, sneeze or talk (WHO. 2020; CCDCP. 2020). The virus spread to 110 countries, with an estimated 11 million people infected as of 2 June 2020. Africa recorded its first case on 14 February 2020 in Egypt and Nigeria on the 27 February 2020 (Gilbert and Gubar, 2020). The advent of the virus has led to a global health crisis, which has disrupted the economic system, security, and health of many countries. As some countries try to return to normality, the full economic impact of the virus is yet to be ascertained.

Aquaculture is a fast-growing agro-industrial activity with the potential to outpace population growth (Van der Merwe, 2015). The fish farming sector production has expanded by 12 times at an annual average of 8.8% (FAO. 2009). In 2012, FAO estimated that the total production of farmed fish stood at $119 billion from the over 300 farmed fish species worldwide. The world distribution of aquaculture shows that Asia, mainly China, contributes about 90% of the total aquaculture production output, with only 1% from Africa. In Nigeria, aquaculture has been considered as an alternative to the declining capture fisheries, accounting for 85,000 metric tons in 2010 (Akinrotimi *et al.,* 2011), and with demand for its output growing with increasing population. Although, COVID-19 does not directly affect fishes. It has however an indirect impact on the aquaculture sector through altering demand and supply patterns, logistical problem, reduction in the level of livelihood of fish farmers, and the serious health and food security consequence for people who depend on fish for their animal protein and essential micronutrients (Grema *et al.,* 2020).

COVID-19 which emerged from China, the major fish producer in the world will be the most hard-hit, hence all countries it export fish product to including Nigeria. In Nigeria, it is expected that on the supply side, the country will be hit by the shortage of labour that will because due to lockdown restriction. Access to input and output market is also expected to be hindered by the restriction on movement and also the loss of food resulting from the disruption of the aquaculture value chain. Whiles, on the demand side, it is expected that demand for aquaculture products which is generally inelastic will cause price hikes. The resulting impact will be the shift of fish consumers to other protein products like beans, eggs, and meat. Most data on COVID-19 has paid attention to the socioeconomic, and economic impact of COVID-19 at the expense of the impact of COVID-19 on aquaculture in Africa and the world. This paper further contributes to our understanding on real effects COVID-19 has placed on aquaculture farmers and pathways that could help to mitigate such effects in foreseeable future.

Objectives of the review are on:

i) The effects of COVID-19 pandemic on aquaculture production in Nigeria.
ii) Government mitigation approach on COVID-19 pandemic on aquaculture produce and products in Nigeria.

AQUACULTURE

Aquaculture, which is farming of seaweeds, crustaceans, bivalves, and fish, is a fast-growing sector of the food production industry in most economies around the world (Cai and Leung, 2017). The rapid growth has been

captured to be between 10- 15% over the last decade (Brugère*et al.*, 2019). Pauly and Zeller (2017) reported that aquaculture growth between 1996 and 2001 was 10.8million tons increase in production. The rapid growth of the sector according to Cisneros-Montemayor and Vincent (2016) is due to the growing population of the world, and the increasing demand for fish and fish products. The traditional catch system (capture fisheries) has failed to meet the growing demand, hence the improved growth of aquaculture. The growth pattern reported by Pauly and Zeller (2017) revealed that aquaculture was fast growing among developing countries at a rate of 10% as against 3.7% in developed countries. In Nigeria, aquaculture after a series of failed attempts, has gain ground as the country moves to meet its projected annual 1.5 million tons of fish demand. Aquaculture accounted for 43,950 tons in 2004 of the total fish production of the country (Eriegha and Ekokotu, 2017). This has led to the realization of aquaculture as a potential to diversifying farmer livelihood and income. The system of aquaculture production practiced in the country uses mostly earthen ponds, while ponds, raceways, vets and tanks are also gradually gaining popularity. Urban and peri-urban areas of the country due to the scarcity of land and growing problem of urbanization have led to the development and usage of recirculatory aquaculture systems (Haldén*et al.*, 2014). Small scale fish farms account for 70% of fish produce under aquaculture as the small scale farms vary from commercial subsistence to non-commercial subsistence farming (Kawarazuka, 2010). The most farmed fish species in Nigeria are the North African catfish, African bony tongue, and Nile Tilapia by small scale; thus, O. niloticus, C. gariepinus, and H. bidorsalis by medium scale. Large scale combines the small scale and medium farmed fish with Gymnarchus, Atlanticus, Heterobranchus spp., Hybrid catfish, common carp, Aba, Flathead mullet among others.

CHALLENGES FACED BY AQUACULTURE SECTOR IN NIGERIA

Nigeria with its estimated 1.75 million hectares of suitable sites for the development of aquaculture is still far from achieving its full potential (Adewumi, 2015). A sector that was developed with the hope of making the country self-sufficient in its fish production, based on its high reliability in return on investment and low capital intensity relative to capture fisheries, is yet to be felt (Nchuchuwe and Adejuwon, 2012).

The sector as it currently stands is underdeveloped despite it being a large source of livelihood to fish farmers and people that derive their livelihoods in coastal areas of the country. Aquaculture's contribution to the total fish production in Nigeria is insignificant. They attributed this to the monoculture (farming only catfish) nature of the Nigerian aquaculture sector. Therefore, the challenges of catfish tend to hinder the production capacity and aquaculture development of the country (Adeoye and Elegunde, 2012). The country has to find ways to overcome its annual 1.5 million tons of fish deficit. Morgan *et al.* (2017), observed that the disruption of the production process has led to a large time of farms failing to attain profitability status. These disruptions in the production process may come as a result of the delay in the delivery of fish seeds (fingerlings) and even products like feed, and among others. Financial risk situation of farming makes loan acquisition difficult for farmers, forcing them to reduce to small scale production. The inadequate technology and technical knowledge in fish farming production are some of the initial challenges fish farmers face. The genesis of these problems is the result of poor implementation government policies toward the sector.

Secondly, land which is the paramount resource to the start of fish farms is readily available. Though readily available, the land acquisition systems variation of the country varies and these lands sometimes are litigated

(Adeogun *et al.,* 2007). The location of the land also determines how the land will be used and the type of fish farming to be adopted by a farmer. Farmers who stay along swampy areas are more likely to adopt earthen ponds. Famakinwa *et al.* (2017) opined that land availability for fish farming is entangled with variables such as population, the land tenure system, development of the country, and level of technology. Therefore, as population increases, land for agriculture are traded off for accommodation, meaning that the number of fish ponds will have to be limited to fit the land area. Land tenure systems ownership and rights, other than that which is based on outright purchase by a farmer or investor, will imply that after a farmer's leases or rent is over, the farmer will have to sell the ponds or destroy them. This is so because the land reverts to the owner per the status under which it was acquired by the farmer or investor. This in most cases, makes the use of earthen pond difficult as most rented and leased lands use plastic tanks to cultivate and produce fishes for targeted markets in Nigeria.

Furthermore, water, which is the home and backbone of the aquaculture system is overly polluted by mining activities and industrial waste. Olowosegun et al. (2005); Omitoyin and Tosan (2012) reported that water and water bodies in major part of Nigeria are highly toxic due to the release of waste into them by industries and the oil exploration, spillage and dredging of oil companies. The polluted nature of water and viable water bodies make the aquaculture production sector unattractive in these areas, especially in and around the Delta and River states of Nigeria. However, those who still practice aquaculture have to treat the water, especially shared water flows, before they can use it for production. This leads to high production costs to the fish farmer. Lastly, marketing and distribution channels are ineffective in the country. Oluwatayo and Adedeji (2019) noted that the transportation system for fish and fish products to be made available to markets (consumers) is bad, as output goes wasted in most cases. Due to the perishability of fish, the few that gets to the market sometimes becomes unsold or sold at a lower price, since consumers are not willing to pay a high price for produce that are near their shelf live. This makes the business of producing and venturing into aquaculture difficult and unattractive to the productive hands, farmers and investors in Nigeria.

Other challenges identified by other researchers include the shortage of inputs (fingerlings and feed), inadequate knowledge resulting in poor management practices, inadequate funding, theft, and direct involvement of government in production (Lam et al., 2012). Use of poor quality seeds, inadequate information, high cost of feeds, traditional techniques, small-size holdings, poor infrastructural facilities, and low capital investment are also factors reported to be limiting the growth of aquaculture sector in Nigeria (Ugwumba and Chukwuji, 2010; Adewumi, 2015; Adebayo and Daramola, 2013).

PREVENTIVE MEASURE FOR FUTURE OUTBREAK OF SUCH TYPE OF VIRUSES

Citizen-centered policy in the cities: narrow sidewalks and crowded public spaces should be taken care and steps should be taken to widen them (social distancing), so that people can maintain distance between each other and nevertheless, health policing by enforcing social distancing in social gatherings, e.g. churches, banks, markets, clubs, etc. Better public transportation: fare free public transport system should be boosted. It will help in improving environmental conditions, reducing vehicles miles, helping lower income communities to use transit, also help in pandemic times as it will help in keeping social distancing between driver and passengers. Cycling can be promoted to help in solving both the problems. Better natural surrounding: more parks and small

gardens should be encouraged near the houses or residential areas to provide fresh air and provide exercise areas (maintaining social distancing) during the lockdown periods, if such pandemic occur in the future. Building infrastructure: as during pandemic mostly people are being encouraged for work from home, so need for more capacity building has decreased. High capacity building can be discouraged in future, putting loss burden on environment and on owners (Amy, 2020).

COVID-19 PANDEMIC AND AQUACULTURE

Coronavirus disease 2019 popularly known as COVID-19 is caused by severe acute respiratory syndrome coronavirus 2. A similar strain of the virus SARS-CoV-1, which was reported to have affected 8000 people in 2002-2003 (Surico and Galeotti, 2020). A study in February 2020 revealed that the virus is made of 96% DNA match between bat coronavirus and human through an intermediate host (Xu et al., 2020). The virus enters through the mouth, eyes, and nose, attaching itself to respiratory tracts through the production of a protein called ACE2. The virus has become a global pandemic with only a handful of countries exempted or without any cases. The actual magnitude of the spread is still unclear as global confirmed cases have already exceeded the 1million mark in less than a year. Although no research has proven that COVID-19 affects fish, it is the human component of aquaculture that raises concern for the sector. Precaution

Ahmed and Azra (2022) reviewed on aquaculture production and value chains in the COVID-19 Pandemic. They stated that COVID-19-pandemic–precautions-related to: lockdowns, social distancing, supply chain disruptions, and transport restrictions; affects seafood production, food distribution, marketing; consumption and disruption of aquaculture practices worldwide. They stressed that the pandemic has adversely affected the aquaculture input supply of fish stocking and feeding; seafood marketing and exporting to its peak. They also suggested that adaptive strategies must be developed to cope with the challenges and opined that an urgent need for collaboration among key stakeholders to rebuild the supply chain of inputs and fish marketing for sustainable aquaculture practices; International agencies, donors, government and non-governmental organizations, researchers, and policymakers need to develop policies to support aquaculture production and supply chains to salvage the COVID-19 effects on aquaculture production and its value chains forthwith.

In Nigeria, the pandemic is expected to have serious consequences on the country's aquaculture directly and indirectly. Indirectly, Nigeria's underdeveloped health sector will mean an immense pressure on aquaculture. This will imply that the number of the labour force will drop as the infrastructure at the health sector cannot hold the likely number of infected persons. UNDP (2020) reports that the likely fall in labour will lead to a serious economic and fiscal crisis which is happening already, there is untold hardship and hunger in the globe. GDP growth has already fallen to -1.58% mainly from oil prices decline by 55%. As the outbreak continues to intensify, the countries services, trade, and financial sectors will fall along with the falling GDP as the sector continues 30% to GDP.

For the aquaculture sector, this will mean that farms are likely to lose their workforces especially commercial farms that need a larger number of labour. This will also mean that farms will have to reduce their production capacity to hold the available workforce. Marketing of the end product of fish farming (fish at all stages of growth) cannot be done as the country has adopted policies of lockdown, the ban on interstate travel, and also a

ban on import and export. With this means restricting marketing, it expected that sales volume will fall greatly as market sizes will be reduced to the local market. This may be good for small farms in the short run but in the long run, be overshadowed by big ones. On consumption, it is expected that the fall in production level will mean price increase to help cushion losses made by farmers. Directly, the sector faces huge competition from other protein sources as the relative cost of other protein source are likely to be low to fish. It will be expected that the consumption pattern of consumers will shift to a cheaper source.

CONCLUSION

The global health crisis caused by COVID-19 has led to an unexpected effect on world economies with economies struggling to mitigate the effect of the pandemic (diseases, hardship and hunger). The Nigerian aquaculture sector is no exception to these difficulties. The pandemic has led to increased cost of input, raw material, market inaccessibility and the reduction of walk-in customers to farms. This is as a result of some policies taken by the government, like measures restricting movement and the closure of the country's borders.
This review was carried out to find out the extent of the impact of COVID-19 on the Nigeria aquaculture, and the adaptation strategies farmers are undertaking to mitigate its impact. The article is to review researchers' core objectives to identified the socioeconomic characteristics of fish farmers in Nigeria, examined the perception of fish farmers on the influence of COVID-19 on aquaculture, identified challenges faced by fish farmers during COVID-19 and coping strategies adopted to mitigate the impact of COVID-19 in the sector. It is true that researchers reported a significant difference in the relationship between socioeconomic characteristics of fish farmers. They also revealed that fish farmers perceived that COVID-19 has led to the decline in the demand of fish purchase and cost of fish inputs were increased and a reduction of manpower on the farm due to the lockdown protocol were further observed; as well as farmers also revealed that the cost of fish is more expensive during the COVID-19 period. Furthermore, they revealed that the major challenge faced by fish farmers during the COVID-19 period was the reduction in walk-in customers to the farmers. This has made farmers to develop their own feed and also taking advantage of the government reduced interest rate policy to reduce the impact on their activities.

RECOMMENDATIONS

They therefore conclude that fish farming and its related activities are submerged in various degrees of shocks. These shocks are either from within the aquaculture sector or spill-overs from national shocks from to the emergence of the COVID-19 pandemic. Hence, government and stakeholders in reducing such shocks, should consider a holistic approach to national policies on aquaculture and best practices of pandemic mitigation.

It is discovered that fish farmers and other stakeholders engaged in aquaculture in Nigeria should begin considering multiple supply chains for aquaculture products in an attempt to reduce shocks such as those exposed by COVID-19.

Fish farmers should also consider other marketing approaches like online marketing (it was painfully observed that some buyers/customers were scammed during this period by fake online fish products; fish feed and drugs sellers) and contract farming to create direct market avenues for their products.
The government and private sector stakeholders in aquaculture in Nigeria should invest in the local production of fish feed and other fish farming inputs to reduce the cost of fish farming and also create lucrative jobs in the sector.

Lastly, the government of Nigeria should continue with its reduced lending rate and subsidies to cushion fish farmers entering into the post-COVID-19 fish farming season.
The government should establish clinics and hospitals for fisher folk and fish farmers in the flood plains, rivers and creeks for better productivity.

REFERENCES

Abraham, T. J., Sil, S. K. and Vineetha, P. (2010). A comparative study of the aquaculture practices adopted by fish farmers in Andhra Pradesh and West Bengal. Indian Journal of Fisheries, 57(3), 41-48.

Adagunodo, T. A., Sunmonu, L. A., Oladejo, O. P., Hammed, O. S., Oyeyemi, K. D. and Kayode, O. T. (2018). Site characterization of Ayetoro housing scheme, Oyo, Nigeria. In IOP Conference Series: Earth and Environmental Science, 173(1), 12-31.

Adebayo, O. O. and Daramola, O. A. (2013). Economic analysis of catfish (Clarias gariepinus) production in Ibadan metropolis. Journal of Agriculture and Food Sciences, 1(7), 128-134. Retrieved from http://www.resjournals.org/JAFS

Adeogun, A. O., Popoola, K. O., Oduola, A. O., Olakiigbe, A. K. and Awolola, S. T. (2017). High level of DDT resistance and reduced susceptibility to deltamethrin in Anopheles gambiae, Anopheles coluzzi, and Anopheles arabiensis from Urban Communities in Oyo State, South-West Nigeria. Journal of Mosquito Research, 7(16), 125-133.

Adeoye, A. O. and Elegunde, A. F. (2012). Impacts of external business environment on organizational performance in the food and beverage industry in Nigeria. British Journal of Arts and Social Sciences, 6(2), 194-201. Retrieved from http://www.bjournal.co.uk/BJASS.aspx

Adewumi, A. A. (2015). Aquaculture in Nigeria: Sustainability issues and challenges. Direct Resource Journal of Agriculture and Food Science, 3(12), 223-231. Retrieved from https://directresearchpublisher.org/drjafs/ abstract/aquaculture-in-nigeria-sustainability-issues-and-challenges.

Ahmed, N. and Azra, M. N. (2022). Aquaculture Production and Value Chains in the COVID-19 Pandemic. Food, Health, and the Environment (KeNachmanAndD Love, SectionEditors), Current Environmental Health Reports.https://doi.org/10.1007/s40572-022-00364-6, 9:423–435.

Akinrotimi, O. A., Abu, O. M. G. and Aranyo, A. A. (2011). Environmental friendly aquaculture key to sustainable fish farming development in Nigeria. Continental Journal of Fisheries and Aquatic Science, 5(2), 17-31. Retrieved from http://hdl.handle.net/1834/24296.

Amy, T. (2020). Covid-19 provides lessons on climate adaptation. News from Earth Institute.

Brugère, C., Aguilar-Manjarrez, J., Beveridge, M. C. and Soto, D. (2019). The ecosystem approach to aquaculture 10 years on a critical review and consideration of its future role in blue growth. Reviews in Aquaculture, 11(3), 493-514.

Cai, J. and Leung, P. (2017). Short-term projection of global fish demand and supply gaps. Rome, Italy: FAO.

Chinese Center for Disease Control and Prevention. (2020). Distribution of new coronavirus pneumonia. Retrieved July 20, 2020, from http://2019ncov.chinacdc.cn/2019-nCoV

Cisneros-Montemayor, A. M. and Vincent, A. C. (2016). Science, society, and flagship species: Social and political history as keys to conservation outcomes in the Gulf of California. Ecology and Society, 21(2).

Consultative Group on International Agricultural Research. (2020). WorldFish discussed COVID-19 impact with Nigerian aquaculture community. Retrieved from https://fish.cgiar.org/news-and-updates/news/worldfish- discussed-covid-19-impacts-nigerian-aquaculture-community

Eriegha, O. J. and Ekokotu, P. A. (2017). Factors affecting feed intake in cultured fish species: A review. Animal Research International, 14(2), 2697-2709.

Famakinwa, M., Agboola, A. F., Alabi, D. L. and Ogunjimi, S. I. (2017). Factors Associated with Land Accessibility among Rural Dwellers in Osun State, Nigeria. Middle-East Journal of Scientific Research, 25(3), 528-535.

FAO. (2009). Aquaculture (Technical Paper, No. 523). Rome, Italy: UNEP/FAO.

FAO. (2020). How is COVID-19 affecting the fisheries and aquaculture food systems. Rome, Italy: FAO.

Fisheries Committee for the West Central Gulf of Guinea. (2020). Nigeria: Addressing impact of COVID-19 on fish. Retrieved from https://fcwc-fish.org/other-news/nigeria-addressing-impact-of-covid-19-on-fish

Gilbert, S. M. and Gubar, S. (2020). The madwoman in the attic: The woman writer and the nineteenth-century literary imagination. Connecticut, USA: Yale University Press. https://doi.org/10.2307/j.ctvxkn74x

Grema, H. A., Jacob, K., Mohammed, B. and Umaru, O. H. (2020). Understanding Fish Production and Marketing Systems in North-western Nigeria and Identification of Potential Food safety Risks Using Value Chain Framework. Preventive Veterinary Medicine, 181(105038), 1-30.

Haldén, A. N., Lindberg, J. E. and Masembe, C. (2014). Aquaculture—A fast growing food production sector. SLU Glob, 4(1), 42-45.

Ifejika, P. I., Akinbile, L. A., Ifejika, L. I. and Olajide, J. O. (2018). The Socio-economic effects on adoption of aquaculture technology among fish farmers in anambra state, Nigeria. Journal of Agricultural Extension, 11(01), 74-86.

Kawarazuka, N. (2010). The contribution of fish intake, aquaculture, and small-scale fisheries to improving nutrition: a literature review (The WorldFish Center Working Paper No. 2106). Penang, Malaysia: The WorldFish Center.

Lam, V. W., Cheung, W. W., Swartz, W. and Sumaila, U. R. (2012). Climate change impacts on fisheries in West Africa: Implications for economic, food and nutritional security. African Journal of Marine Science, 34(1), 103-117.

Makinde, A. F. K. (2014). 4 The Evolution of the Independent sharīʿa Panel in Osun State, South-West Nigeria. Sharīʿa in Africa Today, 15(1), 71-101.

Morgan, M., Terry, G., Rajaratnam, S. and Pant, J. (2017). Socio-cultural dynamics shaping the potential of aquaculture to deliver development outcomes. Reviews in Aquaculture, 9(4), 317-325.

National Population Commission (2006). The Nigeria Population Census 2006. Lagos, Nigeria: National Bureau of Statistics.

Nchuchuwe, F. F. and Adejuwon, K. D. (2012). The challenges of agriculture and rural development in Africa: the case of Nigeria. International Journal of Academic Research in Progressive Education and Development, 1(3), 45-61.

Olaoye, O. J., Ezeri, G. N. O., Akegbejo-Samsons, Y., Awotunde, J. M. and Ojebiyi, W. G. (2016). Dynamics of the adoption of improved aquaculture technologies among fish farmers in Lagos State, Nigeria. Croatian Journal of Fisheries, 74(2), 56-70.

Olowosegun, O. M., Olowosegun, T. and Mohammed, H. (2005). A review on the effect of water pollution onfish and the fishing industry of Nigeria. 2005 FISON Conference Proceedings. Port Harcourt, Nigeria: FISON.

Oluwatayo, I. B. and Adedeji, T. A. (2019). Comparative analysis of technical efficiency of catfish farms using different technologies in Lagos State, Nigeria: A Data Envelopment Analysis (DEA) approach. Agriculture and Food Security, 8(1), 1-9.

Omitoyin, S. A. and Tosan, F. B. (2012). Potential impacts of climate change on livelihood and food security of Artisanal Fisherfolks in Lagos State, Nigeria. Journal of Agricultural Science, 4(9), 20-30.

Pandey, D. K. and Upadhayay, A. D. (2012). Socio-economic profile of fish farmers of an adopted model aquaculture village: Kulubari, West Tripura. Indian Research Journal of Extension Education, 2(1), 55-58.

Pauly, D. and Zeller, D. (2017). Comments on FAOs state of world fisheries and aquaculture (SOFIA 2016). Marine Policy, 77, 176-181.

Salau, E. S., Lawee, A. Y., Luka, G. E. and Bello, D. (2014). Adoption of improved fisheries technologies by fish farmers in southern agricultural zone of Nasarawa State, Nigeria. Journal of Agricultural Extension and Rural Development, 6(11), 339-346.

Senten, J., Smith, M. A. and Engle, C. R. (2020). Impacts of COVID-19 on US aquaculture, aquaponics, and allied businesses. Journal of the World Aquaculture Society, 51(3), 574-591.

Sharma, S., Zhang, M.,Gao, J., Zhang, H. and Kota, S. H. (2020). Effect of restricted emissions during COVID-19 on air quality in India. Science of the Total Environment, 728(1), 138-878.

Sunny, A. R., Sazzad, S. A., Datta, G. C., Sarker, A. K., Ashrafuzzaman, M. and Prodhan, S. H. (2020). Assessing Impacts of COVID-19 on Aquatic Food System and Small Scale Fisheries in Bangladesh. Preprints.

Surico, P. and Galeotti, A. (2020). The economics of a pandemic: The case of Covid 19. Wheeler Institute for Business and Development, London Business School, London.

Ugwumba, C. O. A. and Chukwuji, C. O. (2010). The economics of catfish production in Anambra State, Nigeria: A profit function approach. Journal of Agriculture and Social Sciences, 6(4), 105-109.

Umeokeke, N. I., Okoruwa, V. O. and Adeyemo, T. A. (2017). Impact of electronic-wallet system on farmer's welfare in Oyo State, Nigeria. International Journal of Social Economics, 44(4), 474-490.

United Nation Development Programmme. (2020). COVID-19: Looming crisis in developing countries threatens to devastate economies and ramp up inequality. New York, USA: UNDP. Van Beijnen, J., and Yan, G. (2020). Five ways for fish farmers to survive Covid 19. The Fish Site. Retrieved from https://thefishsite.com/articles/five-ways for-fish farmers-to survive-covid-19

Van der Merwe, M. (2015). Integrating aquaculture with crop systems: An aquaponic enterprise project proposal for the Ntinga Multipurpose Co-operative in Philippi, South Africa (Doctoral dissertation, Stellenbosch University, Stellenbosch).

World Health Organization. (2020). WHO Director-Generals remarks at the media briefing on 2019-nCoV on 11 February 2020. Geneva: WHO.

Wu, C., Chen, X., Cai, Y., Zhou, X., Xu, S., Huang, H. and Song, J. (2020). Risk factors associated with acute respiratory distress syndrome and death in patients with coronavirus disease 2019 pneumonia in Wuhan, China. JAMA Internal Medicine, 180(7), 934-943.

Xu, J., Zhao, S., Teng, T., Abdalla, A. E., Zhu, W., Xie, L. and Guo, X. (2020). Systematic comparison of two animal-to-human transmitted human coronaviruses: SARS CoV-2 and SARS-CoV. Viruses, 12(2), 244-261.