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Building fish farmers' resilience during and after epidemics and pandemics: Insights for Uganda

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Abstract
In the recent years, Uganda has experienced a number of epidemics and pandemics that have affected its agricultural sector. These include viral diseases such as Ebola, MonkeyPox (M-pox), Covid-19, and Acute Hemorrhagic Conjunctivitis commonly known as red-eye disease. These viral infections are highly contagious and often require avoidance of crowding and restricted movement of affected persons and communities in order to curb their spread. Herein, we focus on how the aquaculture sector in Uganda has been affected by such contagious infections, and propose measures that can be taken to promote sustainable aquaculture production during and after epidemics and pandemics.

Keywords: Contagious, disaster, Hazzard, aquaculture, fish farming

1. Introduction
Fish is a key animal protein source for about 50% of the people in Uganda [1]. It is one of the commodities considered for improving food and nutrition security in the National Development Programme III of Uganda [2]. By 2019, there were about 12,000 active fish farmers in Uganda, and annually, there are new entrants into fish farming [3]. Aquaculture production has grown from about 2000 metric tons annually in the year 2000 to about 138,000 metric tons by 2023 [3]. This makes Uganda the third highest aquaculture producers in Africa, after Egypt and Nigeria [4]. The fish is mainly for domestic consumption and some is sold to regional markets in Rwanda, southern Sudan, Eastern Congo and Kenya [3]. With growing human population in Uganda at about 2-3% per annum, the demand for fish is estimated to reach 1,700,000 metric tons annually by 2025 [5]. To address the gap in fish supply, the government of Uganda has set a target to sustainably produce 1,000,000 metric tons of fish from aquaculture annually [5]. This requires enhanced aquaculture productivity and improved performance of the aquaculture value chain [6].
However, in the recent years, Uganda has experienced incidences of epidemics such as outbreak of Ebola, Monkey-Pox (M-Pox), and Acute Hemorrhagic Conjunctivitis commonly called "Red-eye," as well as the Covid-19 pandemic which have negatively affected the aquaculture value chain [7, 8, 9, 10,11, 12]. These diseases are of Public Health Concern because they are highly contagious and deadly. During their outbreaks, there have been incidences of restricted movement of people to control the spread of the diseases and this disrupts many sectors including the aquaculture value chain, affecting the supply of farmed fish for domestic consumption and trade [13, 14]. However, fish is nutrient-dense containing high proportions of protein, micronutrients, fatty acids, and it is key in contributing to good health during and after epidemics and pandemics [13; 15, 16]. A restriction on the movement of people further limits physical delivery of extension services, aquaculture inputs and financial services to farmers [13, 17]. However, access to extension advice, quality inputs, fish markets and finances all need to be readily available for fish farmers as bundled services [18, 19]. This is because access to extension advice, quality inputs, fish markets and finances directly or indirectly affect each other [20].
The national lockdown to curb the spread of covid-19 virus, banned inter-district movements, and border restrictions slowed access to aquaculture inputs especially quality fish feed for feeding the fish and seed for stocking production units [21]. In addition, public transport was

banned, and yet most small-scale fish farmers rely on public transport to transport fish to the market [13]. This affected fish sells. Urban areas faced challenges accessing fresh foods like fish [20], and market prices increased making many urban dwellers fail to afford food fish [13]. Furthermore, closure of public markets in rural areas led to high costs incurred by farmers while continuing to grow the fish as they wait for opportunity to sell the fish at their farms [20]. These circumstances lead to some farmers dropping out of fish farming. The situation could have probably been controlled if farmers preserved their fish by freezing it. However, most fish farmers do not have facilities to freeze their fish to limit postharvest losses [6].

Beyond the epidemics and pandemics, there is still need to strengthen farmer access to extension advice, quality inputs, fish markets and finances [6, 22]. Poor access to extension services is occasioned by the high ratio of farmer to extension worker of 1:1800 as opposed to the global level of 1:500 as well as in adequate government funding to enable extension workers to effectively carry out farmer field visits to guide farmers [22, 23]. Most farmers do not get adequate advice due to irregular or no visits from extension staff [24, 25]. Besides, most aquaculture technologies and innovations that are being disseminated are not customized to the technical capability, resource capacity, and needs of different categories of fish farmers, such as small-scale, medium scale, commercial farmers [24]. This arises from the weak interface between research, extension and farmers [22, 26]. In addition, aquaculture inputs (feed, seed and equipment) for enhancing fish performance have mainly been traded in major urban areas, especially central Uganda, making the inputs inaccessible to many farmers in rural areas. Furthermore, some small-holder farmers cannot afford some traded inputs. This calls for researchers to develop innovations affordable for smallholder fish farmers using low-cost resources present at smallholder fish farmers' farms / localities. Most fish farmers are also not well linked to fish markets. The farmers generally do not have access to information on existing or potential fish markets, market requirements, marketing strategies and value addition [20, 27]. There is need to mobilise and organise fish farmers into marketing groups to facilitate bulking production and marketing of farmed fish and negotiating for better fish selling prices [20]. While regional aquaculture producer groups and Uganda Aquaculture Cooperative Union exist with the mandate to support aquaculture producers, promote best aquaculture practices, and help the aquaculture sector adapt to climate change, the organisations are not effectively operating and need capacity building [28, 29]. Credit access by fish farmers, especially small-scale farmers, is minimal because farmers lack collateral [6]. There is need to train smallholder farmers on financial literacy and how to run aquaculture as a business [24, 27].

Climate change and variability are also impacting aquaculture productivity and profitability in Uganda [30, 31, 32]. Floods do affect supply, transport and distribution channels of farmed fish to the markets. Floods cut-off transport routes making it challenging for farmers to access fish markets and buy aquaculture inputs. Fish buyers also fail to access some fish farms to buy fish. Prolonged drought and low rainfall cause lake water levels to recede exposing breeding and nursery areas of small pelagic fish. This affects reproductive success of pelagic fish, threatening restoration of their populations and sustainable supply, and yet pelagic fish like silver fish (*Rastrineobola argentea*) are used as a key protein source in aquaculture feed. Small holder farmers are more vulnerable to the challenges detailed above. Uganda has over 20,000 fish farmers of which about 12,000-16,000 are small-scale subsistence fish farmers mostly living in rural areas [3, 17].

The purpose of the review is to highlight approaches that could enable fish farmers (small-scale, medium scale and commercial farmers), private sector, and farmer groups/producer organisations to safely, cost effectively and timely access extension support, inputs, fish markets and finances that they can use to improve and sustain aquaculture production and profitability. This is expected to contribute towards resilience of fish farmers during and after epidemics, pandemics and other natural hazards, in order to sustain aquaculture production. This would significantly contribute towards increased fish production and income generation for improved food security and poverty reduction.

2. Proposed intervention

2.1 Overview of digital (electronic) technology

Given that during epidemics and pandemics crowding and movement of people are normally restricted, we recommend adopting approaches that enable fish farmers' to ably access extension services, inputs, fish markets and financial services with minimal health risks during and after epidemics and pandemics.

Studies on crop production by farmers in developing countries like Bangladesh, and India show that farmers' access to advisory services, inputs, markets and financial services can be improved using digital technology through phones, tablets, or watches connected to broad area network and/or internet [33]. The digital technology enabled fast and cost-effective transfer of information to several farmers, thereby maximizing impact. similarly, in Kenya the use of digitalised approach to give agricultural advice to smallholder sugarcane farmers increased their yields by 11.5% [34]. A study in central Uganda and also noted that mobile phone-based extension delivery enabled more regular and intense interaction of farmers with extension agents and other service providers [25]. Given these benefits, we recommend replicating the digital innovations among fish farmers in Uganda during and after epidemics and pandemics, in order to improve delivery of extension advice, input supply, fish marketing and access to finance. The digital extension service would complement the conventional physical delivery of extension because in some instances there is need for physical visits to farmers [35, 36]. In Ghana, fish farmers that received aquaculture information from both digital tools and extension agents realised the best fish harvests and returns in investment [37].

2.2 Opportunities/enablers for digital technology adoption in Uganda

According to Uganda Communications Commission (UCC), by 2019, about 81% of the people in Uganda accessed telephone services, 50% accessed internet, with 1% growth rate in internet subscriptions [38]. Phone users and sellers were increasing in both urban and rural areas. By 2023, 77% of the population in Uganda were covered by 3G and 31% by 4G mobile broadband signal, while 53% of the country's geography were covered by 3G and 24% by 4G [39]. Government through the private telecom companies, continue to put in place strategies to increase the coverage. The amount of data consumed by telecom subscribers also increased from 1.6 gigabytes (GB) in December 2022 to 1.7 GB by March

2023 [40]. Internet subscriptions increased to 59% per 100 Ugandans in March 2023 from 57% per 100 Ugandans in December 2022, representing a 2% rise [40]. Each household in Uganda was reported to have at least one phone. Rural electrification was also improving with each trading centers having either solar power or hydroelectricity where cellphones can be charged. Some rural households have their own solar power for lighting purposes.

By 2019, there was a ratio of one mobile money service provider to 76 active registered mobile money subscribed users [38]. Registered mobile money accounts increased from 36.8 million in December 2022 to 37.3 million in March 2023, with 472,000 agents across the country [40].

Active pay Television subscribers also increased reaching 2.4 million in March 2023 from 2.3 million in December 2022 with at least 69% uptake of local television content [40].

The national infrastructure put in place by telecommunication companies and equipment owned by individuals (phones) puts Uganda in a good position for delivery of digital services such as extension advice, aquaculture input supply, fish marketing and finance access.

2.3 Proposed digital approaches for consideration in Uganda

2.3.1 Sending electronic messages /text using phones

Phones can be used by extension workers to send extension information to fish farmers in languages that they understand.

2.3.2 Digital applications for accessing bundled services

We also recommend adapting the use of mobile digital applications to delivery to farmers extension advice, aquaculture input supply, fish marketing and finance access as a bundle using the same digital application [33]. Existing digital applications could be utilized or new digital applications could be developed to meet specific needs. Digital applications mainly rely on the use of smart phones/tablets connected to the internet [33, 41].

In Uganda a digital mobile application called Agro Market Day contains extension advice on aquaculture management practices, information on aquaculture inputs and service providers, fish markets and financial service providers, and terms and conditions [42]. There is need to popularize the use of such mobile applications because few fish farmers and extension staff are aware of their use. The target users also need to be empowered with knowledge on how to use the tool to send and/or access information in the digital application using their phones.

Mobile digital applications offering bundled service need to be populated with information on fish farmers'-demand-driven needs derived through participatory data collection with the farmers and other stakeholders [43]. The data collected will need to be compiled, analysed, and used to develop guidelines on aquaculture technologies and management practices addressing the needs of farmers [41]. The guidelines should also be customised to resource capacity of different categories of fish farmers, such as small scale, medium scale and largescale. The information will need to be uploaded into the digital application along with information on aquaculture inputs and suppliers, fish markets and fish buyers, and financial service providers and their packages [41]. To make the information in the digital application scalable, it should be made accessible by farmers, input suppliers, fish traders, financial institutions, extension workers, policy makers, and other relevant stakeholders by giving them user rights. Digital profiles of the users of the application will therefore need to be registered on the mobile digital app to aid the target users of the digital app to access uploaded information and communication between themselves [33, 41]. The farmers can use the information on aquaculture technologies and management practices as a guide for farm planning and decision making to improve fish productivity and income generation. The guidelines should be updated routinely by the developers of the digital application [33]. The updates could include new aquaculture knowledge, technologies, innovations, inputs and service providers, fish marketing information, and financial services. Farmers and other stakeholders will need to be informed about the updates through SMS and the digital app. The digital application can also benefit government ministries by providing information on extent of adoption of aquaculture technologies and innovations, and effectiveness of existing policies [33, 41]. This will enable them to identify aquaculture aspects for further intervention and strengthening through enabling policies.

Where possible, farmers could be mobilised and organised into producer groups for bulk production and marketing of fish to sustain available markets.

Effectiveness of the mobile digital apps in delivering bundled services to farmers will need to be evaluated periodically by seeking users' opinions, and the findings used to improve on the operation of the mobile digital app to meet the needs of fish farmers and other stakeholders. There should be provision for users to seek clarification, hence, someone competent in aquaculture and communication skills has to be assigned to respond to users' inquiries/comments. The developers of the mobile application will also need to provide for data protection and confidentiality.

The mobile digital application could be operated in a public-private partnership mode to build synergies to sustain the operations of the app [41]. The public-private partnership could involve institutions with expertise in Information, communication and technology (ICT), aquaculture research, extension and financial service delivery, fish trade, communication and outreach services, policy development, project monitoring and evaluation. In order to run the digital application, there is a need to pay license fees to Uganda Communication Commission, however, a fees waiver could be negotiated as stipulated in the guide on Tax Incentives/Exemptions available to Investors in Uganda (www.ugandainvest.go.ug).

2.3.3 Virtual Meeting Platforms

The use of virtual platforms could also facilitate extension and advisory service delivery during and after epidemics, pandemics and emergencies such as floods, among others. Some common virtual meeting platforms include skype, zoom, google meet and Microsoft teams [44]. They have provision for HD audio, video conferencing, raising hands when ones need to speak, muting, screen sharing, recording, and exchange of messaging among others. Virtual platforms can be installed in laptop computers, tablets, phones and/or watches and turned when a meeting is scheduled. The platforms have different set-up and mode of navigating through, but each of them has a user guide / tutorial to orient the users. However, persons with low ICT literacy level may face challenges navigating through the application and may need to be supported by competent persons. In addition, basic training on the use of the platforms may benefit fish farmers, extension workers and other stakeholders who are not

familiar/competent with navigating through the virtual meeting platforms.

According to AU-IBAR, the virtual meeting platforms could be made more effective by:

a) Providing for real-time automatic translation of speeches to other languages to enable communication with a wider audience from different parts of the country.
b) Providing for automatic background noise removal, hence, getting rid of distracting and unwanted sounds.
c) Incorporating mechanism for replacing distractive and unattractive backgrounds of the meeting attendees with simple and good-looking background.
d) Providing for everyone in the meeting to be seen at the same time, to create a feeling of a physical interaction.
e) Including vocal sounds to aid the conveners of the meeting as well as participants to obtain real-time help to adjust settings or enable features.
f) Include emoji designs in the applications to enable participants to send motion reactions during meetings, apart from raising their hands.

2.3.4 Social media platforms

Social media platforms such as whatsapp, you-tube, LinkedIn, and facebook are another mode of digital communication channel. They can enable extension workers to share information with farmers and other stakeholders, and provide advisory services [45, 46, 47, 48]. Whatsapp, LinkedIn, and facebook, have provision for forming a group(s) to reach several farmers concurrently. The group(s) also gives an opportunity from farmer-to-farmer exchange of ideas and experiences within a short time. However, care has to be taken when using information from social media because not everyone who posts messages has adequate technical knowledge in aquaculture. It will require a competent person to double check the messages shared and provide any necessary clarification.

2.3.5 Electronic newspapers and magazines

Newspaper sections dedicated for sharing information on agricultural production, television programmes, and magazines on agricultural production are also other sources of information dissemination [45, 46]. They are one of the traditional methods used for disseminating information in the agriculture sector. In cases of epidemics and pandemics, electronic versions of newspapers and magazines could also be considered.

2.3.6 Challenges and mitigation measures towards adoption of digital technology for extension service delivery

Potential barriers to adoption of digital farmer services include language barrier, digital literacy, gender gaps, cost of internet subscription and erratic broad area network and internet connectivity [41, 49] need to be mitigated. The information in the digital application needs to be provided in the key languages used in Uganda for more inclusive access. Fish farmers with low ICT literacy will need to be trained to access the digitalized services. Farmers that may not cope with the technology could be supported by production of information in audio-visual aids produced in different key local languages used in Uganda. This could include voice messages; video clips; visual farm tours; excursions to model farms for experience sharing; charts with information in pictorials form. In addition, virtual innovations centers could be established at strategic locations in selected districts to further benefit farmers with low literacy level. In case of disease outbreaks, Standard Operating Procedures need to be strictly followed at the innovation centres. Government and development partners could consider securing funding to support farmer groups with phones to access the digital information, and meet internet connectivity costs.

Uganda communications commission to engage telecommunication companies operating in Uganda to optimise their wide area network (WAN) over the geographical areas they are licenced to operate in Uganda.

3. Conclusion

Building a network of fish farmers, with agro input traders, fish buyers and financial institutions can enhance delivery of bundled services (extension advice, inputs, fish market and finances) to fish farmers. Extension workers and government agencies need to be availed reliable information from research for guiding farmers, and developing evidence-based enabling policies for promoting increased aquaculture production, fish supply and trade.

Through digital extension and advisory services, marginalized groups like people with disability, deaf, elderly, orphans, widows and women headed families who face difficulty moving long distances in search for aquaculture services will have easy access to extension advice, inputs, fish markets and finance.

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