The Development of a Web-Based App for Fish Farmers and Government Extension Officers

Report to the

WATER RESEARCH COMMISSION

by

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WRC Report No. 2820/1/21

January 2022

Obtainable from:
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The publication of this report emanates from a project entitled: *Developing a smartphone App for small-scale fish farmers and government aquaculture extension officers to deliver an existing WRC Aquaculture Manual for small-scale farmers* (WRC Project **K5/2820//4**)

ISBN 978-0-6392-0310-2
Printed in the Republic of South Africa

EXECUTIVE SUMMARY

Globally, and in Africa, the aquaculture sector is growing. The high demand for fish and the decline in wild caught fisheries has created an environment for the aquaculture sector to develop. Although there is potential for growth of the aquaculture sector in South Africa, it is not only very small, but has in fact declined. The reasons for this anomaly are probably not singular, but rather a combination of many factors. Two reasons that could be contributing to the low aquaculture production for South Africa are the technical capabilities of small-scale farmers (and extension officers) and the planning and management of the sector.

To assist in the development of the technical capabilities of small-scale farmers, Rhodes University (on a WRC research project) developed a manual for small-scale farmers in 2010. The manual was designed to provide a broad-based technical base for both farmers and the extension officers. However, the limitations of having a printed manual (such as cost and the fact that many small-scale farmers have limited literacy) provided the basis for developing a web-based App version of the manual. In this research project, a web-based App was developed with input from small-scale farmers from the Thohoyandou region of Limpopo. The App is named Buna Africa (or in short, Buna). *Buna* means “harvest” in Sepedi. Buna carried the original 2010 version of the manual and a revised version that was suited more for a digital platform. This digital version was condensed to make it “less wordy”. However, to ensure that the technical capabilities of the manual were not lost, links were provided to other websites so that if a user wanted to investigate a certain topic further they could then follow on by selecting the relevant links. This was also done to ensure that the App in itself does not require much data when a farmer logs into it. Furthermore, for each chapter of the manual, relevant YouTube videos were linked. For example, a farmer could read about spawning tilapia and/or watch a demonstration video on YouTube about spawning tilapia. To assist farmers calculate approximate expected yields from their ponds (for tilapia), or to determine the optimal weight of their fish (for a given age), a “production calculator” was built into the App. These important growth parameters would greatly assist farmers to benchmark the farms’ production levels. Another important feature in the App is an instant messaging system that farmers and extension officers can use to communicate and share information.

Another important feature of the App is that it enables farmers to submit farm production data to their extension officers. The type of production data that farmers submit can be determined by the requirements of the extension officers. This data is critical, not only for the extension officers, but also for the provincial and national aquaculture managers.

Reliable farm production data, which currently is not available (particularly for small-scale farmers), should be the basis of policy and management decisions. Farm production data will be available to the extension officers and those at province and national levels, through a spreadsheet embedded into the App or can be viewed visually on google maps. It is also required by the FAO that member countries submit their production data to them on a yearly basis.

In the development and field testing of the Buna App, 18 farmers were visited in the Vhembe District of Limpopo Province, 14 agreed to participate in testing the App and providing their feedback. 64.3% were male and 35.7% were female. Of the farmers surveyed, 64.3% were older than 50 years and only 21.4% were younger than 35 years. It was encouraging that 78% of the farmers expressed that Buna could be an effective App that could help them increase production. However literacy amongst the farmers is an issue, as 14.3% of the farmers were illiterate.

It is proposed that the next phase of the App is to pilot it. It would be necessary to test the App in “real world” conditions and to get small-scale farmers to use it as part of their farm operations (and to get feedback at that level as well). It is also proposed that during the piloting phase there would also be engagement with the Department of Environment, Forestry and Fisheries (DEFF) to develop a framework for the App to be adopted by DEFF on completion of the pilot phase. Buna has the potential to become the “go to” tool to assist farmers to increase production and for government to manage the sector, not only in South Africa, but the SADC region as a whole.

Future research areas to develop Buna further include: determining how the use of Buna translates into increased production at the farm level, the inclusion of a fish component, improving the visual layout of Buna, updating the training manual, expanding the features of the production calculators.

With regards to recommendations to making expanding and securing the use of Buna, two pathways are proposed. The first would be to engage with DEFF and to secure their support in taking up Buna as a tool that they would use in developing and managing aquaculture in the country. In this option, DEFF would in turn be using Buna when they engage with the various provincial departments of agriculture. Buna was designed and developed with the needs of DEFF in mind, and as such, Buna can greatly assist this department in fulfilling its mandate to support farmers. Furthermore, DEFF was involved in the development of Buna (as a Reference Member of the project). The second pathway would be to engage with

SADC to get their support to roll out Buna to its member countries. The issues that small-scale farmers in South Africa face are similar to those that farmers in the SADC region are facing, therefore Buna could also play an important role in assisting these farmers. SADC is made up of 16 countries, so this would be an important area in which Buna could be established.

Digital technology will increasingly become central to the development of the world. The Covid-19 Pandemic has clearly demonstrated that individuals or entities that are on the wrong side of the digital divide will find it increasingly difficult to participate in the economy. In countries like India, hundreds of thousands of fish farmers use Apps to increase production and trade. In South Africa, the use of digital technology in aquaculture is still very new, but it is the future, and it would be in the interests of both the farmers and government to embrace this progression and to use it for their benefit.

ACKNOWLEDGEMENTS

The research team would like to thank the Water Research Commission for funding this research. This research began before the Covid-19 pandemic, when including small-scale farmers into the fourth industrial revolution (digital) did not seem to be a high priority. It was only after the pandemic that it emerged how important it was to be connected and to have access to digital resources. Therefore, the foresight by the Water Research Commission to fund this research is greatly appreciated.

The input from small-scale farmers in the Venda region of Limpopo Province, who were always ready to engage with us and contribute towards the design and development of the App, is greatly appreciated. The enthusiasm and commitment of these small-scale farmers is humbling and a sign that, if provided adequate support, they will take this sector forward. We also acknowledge the support and assistance of the Limpopo Department of Agriculture and Rural Development (DARD), in particular Mr Jacky Phosa, Mr Solomon Ramakhumise and Ms Refiloe Thobejane. The project team also acknowledges the valuable input of the Reference Group members in guiding the research.

Acknowledgements are also due to Mr Serge Raemaekers from Abalobi, especially during the initial phases of the research project, Mr Rogan Field for assisting in developing the contents of the App and in the field, and Mr Anton Redelinghuys for all of the IT development of the App.

We are also greatly indebted to Ms LS Mothapo and her supervisor, Mr Johan Theron from the University of Limpopo (Aquaculture Research Unit), for conducting field work in demonstrating the App to small-scale farmers in the Vhembe District of Limpopo Province.

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List of Abbreviations

ADZ	Aquaculture Development Zone
ARC	Agriculture Research Council
BRICS	Brazil, Russia, India, China & South Africa
CAADP	Comprehensive Africa Agriculture Development Programme
DARD	(Limpopo) Department of Agriculture & Rural Development
DEFF	Department of Environment, Forestry and Fisheries
DTI	Department of Trade and Industry
ECMA	European Computer Manufactures Association
FAO	Food & Agriculture Organisation
FCR	Food Conversation Ratio
GIFT	Genetically Improved Farm Tilapia
HTML	Hyper Text Markup Language
IoT	Internet of Things
NEPAD	New Partnership for Africa Development
OIE	World Organisation for Animal Health
RBAC	Role Based Access Control
SADC	Southern African Development Community
SARNISSA	Sustainable Aquaculture Research Network in Sub Sahara Africa
SEO	Search Engine Optimization
SSL	Secure Socket Layers
WFC	World Fish Centre
WRC	Water Research Commission
4IR	Fourth Industrial Revolution

1 CHAPTER 1 BACKGROUND AND INTRODUCTION

1.1 Global Perspective

Globally, aquaculture has been the fastest growing animal production sector (www.fao.org). Annual global aquaculture production (82.1 million tons) is now almost on par with wild caught fisheries (96.4 million tons), and it is expected to supersede fisheries as fish stocks decline. This is related to the increase in consumption of fish, from 9.0 kg live weight (per person per year) in 1961 to 20.5 kg in 2018. This equates to an increase of 1.5% per year (FAO, 2020).

Another factor in the steady increase in global aquaculture production is the technology drive that is propelling this sector. Aquaculture is heavily dependent on technology, even when performed by small-scale farmers. Over the years there have been significant investments made by both governments and the private sector, such as developing the protocols for new species to be farmed (which then opens new markets), developing better genetics (improved growth rates), improving the quality of feeds and making them more affordable. All of these factors have not only helped to increase production, but also to reduce the input costs.

What is also important to bear here is that this technology, once developed, is then transferred to the fish farmers. Fish farmers have become far more aware of the need to apply the best and latest technology to increase their production. An example of this increased awareness is an informal network of African fish farmers called the Sustainable Aquaculture Research Network in Sub Sahara Africa (SARNISSA)[1]. This is an email network made up of about 3 400 members that connects fish farmers across Africa. Through email and Facebook, they share information and assist each other to resolve issues. In these conversations it is abundantly clear that small-scale farmers in Africa are always seeking more effective and efficient methods to increase production.

1.2 Overview of Small-Scale Aquaculture in South Africa

Even though aquaculture has been growing year on year on the global scale, South Africa's aquaculture production sector has been disappointing. The estimated production for 2017, as indicated in the DEFF 2018 Aquaculture Yearbook was 5,588 tons, a drop of 7% from the previous year (DEFF 2018 Aquaculture Year Book). In comparison, during the same period, Egypt produced over a million tons of fish. From the DEFF data it is not possible to

[1] https://www.sarnissa.stir.ac.uk/?page_id=4

determine what the contribution of the small-scale farmers to South Africa's total production was, however, a good indicator would be the tilapia sector as virtually most tilapia farmers could be classified as small-scale farmers (even those based in Gauteng Province). The DEFF data indicates that the total production of tilapia for 2017 was 402 tons across 81 farms in the country. This equates to an average of 13.6 kg of tilapia production per farm / day. This figure is exceptionally low and it requires DEFF to examine whether their current strategies are working.

The data in the DEFF aquaculture yearbook may also not be as accurate as required. For example, in the yearbook it states that there are 18 tilapia fish farms in Limpopo Province. However, when this was compared to the list of tilapia farms provided by the Limpopo Department of Agriculture to the report authors, the Limpopo list is made up of 78 farmers. While it is accepted that some of the farms on the provincial list may be inactive farms, it nevertheless points to a larger issue. This being that there are no set protocols or even pathways for information/data (that South Africa is mandated to provide) to flow from the fish farmer, to the province, to DEFF and finally to agencies such as the FAO.

- While it is acknowledged that South Africa's temperate climate has a significant impact on production, especially for warmwater species such as tilapia (when grown in ponds), production figures still do not explain why, in areas such as in the northern region of Limpopo Province where there is an abundance of water and a warm climate, aquaculture has not taken off. It is therefore possible then that the reasons could rather be structural. In the study conducted by Rouhani and Britz (2004), the report identifies some of these structural issues. These include: The lack of technical capacity of the fish farmers
- The lack of capacity of the government extension officers
- A gap between national goals, provincial plans and the fish farmers at the grassroots level

Even though the commercial aquaculture sector in South Africa is still relatively small, there are still significant differences between, for example, a commercial abalone farmer in the Western Cape Province and a small-scale tilapia farmer in Limpopo Province. The commercial fish farmers would be technically very strong, have established links with academic institutions to conduct on-site research and development to improve production and these farmers would have established lines of communication with both the provincial department of agriculture and the Department of Environment, Forestry and Fisheries (DEFF). In contrast, the small-scale farmer in Limpopo would have limited technical

capabilities, almost no direct contact with academic institutions and possibly limited contact with the provincial administration and DEFF.

The lack of technical skills of the farmers (and for that matter the provincial extension officers), is an issue that one cannot overemphasise as to how important it is, when it comes to the production and performance of the farmer. If a small-scale fish farmer, after having done all of the hard work of digging a pond by hand, cannot estimate the yield of that pond, or to determine how much to feed the fish, then at the fundamental level, this farmer will not have a chance to succeed. Further to this, if the farmer cannot then turn to the local extension officer for this fundamental technical support, then it is clear that the farmer will not be able to succeed. Coupled to this issue, is that often the extension officers and their managers may have limited technical skills and they themselves are in need of training and support.

There is also an information gap between the small-scale farmers, the provincial head office of the Department of Agriculture and DEFF. It would not be uncommon for the provincial department of agriculture not to have any information beyond the names of the farmers and where the farms are located. So vital farm statistics, such as production figures, would not be available to the provincial department of agriculture head office. Furthermore, it would not be uncommon for DEFF not to even know of the existence of the farm / farmer, let alone the production of the farm (information which DEFF is required to submit yearly to the FAO).

While DEFF has prioritised aquaculture in South Africa, with initiatives such as the Aquaculture Bill (which has been recalled by the Minister for reasons that are unclear), and provided funding for fish farmers in partnership with the Department of Trade and Industry (DTI) (Aquaculture Development Enhancement Project) and Operation Phakisa, these initiatives, as important as they are, have not really reached the rural small-scale farmer.

1.3 The WRC / Rhodes University Training Manual of 2010

In 2010, Rhodes University in collaboration with the Water Research Commission (WRC), developed the first manual specifically with the aim of providing technical support to small-scale farmers and to provincial aquaculture extension officers. The manual (A Manual for Rural Freshwater Aquaculture, TT 463/P/10) was designed to be technical in nature, in that it was to provide the user with the necessary information to assist with making informed decisions.

The manual was largely written for tilapia pond culture (as this is the most common type of farming practised by small-scale farmers), although it did also include information on other species and types of farming. The manual was not designed to provide in-depth detailed information on one particular area of aquaculture, but rather to assist the fish farmer to have a broad / general understanding of the basic principles of aquaculture. It was designed to enable the fish farmer to have enough knowledge for day-to-day operations. To meet this objective, the manual covered a wide range of topics, from fish health, water quality, feeding the fish, animal husbandry to the transportation of the fish. The manual included pictures, graphs, drawings and text. The manual was written in a way that was easy to read, as the authors were conscious that this manual was intended for small-scale farmers and extension officers.

The manual was well received both by farmers and extension officers, and it was well used. A number of training courses were held using the manual, and the authors had reports that extension officers had used it in the field. The WRC had to reprint the manual at least three times, due to the demand. The manual was also used beyond the borders of South Africa.

1.4 The Strengths and Weaknesses of the Manual

Although the manual was used in many training courses, it had its strengths and weaknesses. This was to be expected when developing a resource that would be used by a number of different users, over a wide area.

1.4.1 The strengths of the manual

- The manual provided technical information that was relevant to small-scale farmers and extension officers.
- The manual included images (some of which were in colour), diagrams and graphs to make it easier for the reader to engage with the topic.
- The manual was available for free when requested from the WRC. The only fee was cost of postage if it was to be mailed outside the country.

1.4.2 The weaknesses of the manual

- Although the manual was free, it was expensive for the WRC to print (as it included colour photographs and was printed on glossy paper). It was also not feasible that the WRC was expected to carry the costs of keeping the manual in circulation.

- The cost of updating the manual was also expensive, as any changes had printing implications, which was expensive. Aquaculture is a rapidly evolving sector, with new information and technologies being developed all the time. Therefore, keeping up with these changes in a printed, manual format presented logistical and financial implications.
- Although the manual tried to make use of as many pictures, graphs and diagrams, it still needed a level of literacy on the part of the fish farmer to effectively use it.
- Manuals are not interactive. There is a limit to what can be printed on the page.
- The manual was developed in 2010. How information is presented and expected to be presented a decade later, with all of the advances in digital information is not the same. It is evident that the age of using a printed manual to get technical information is closing. Almost all information is now being presented in a digital manner, and this expectation is not only limited to people in the urban centres. Smart phones have now become ubiquitous, even in rural areas, and with that, even rural farmers are increasingly becoming comfortable with using digital platforms.

1.5 The Need to Develop an App for the Manual

The evolution of the manual, to make it accessible by means of an App, was a natural and organic progression. It was broadly driven by two main factors:

- **Responding towards a digital migration.** Worldwide, there has been a shift from information being presented in the conventional printed format to being digital. This digitisation of information seems to have crossed into all spheres of life and across all socio-economic groups. An "every day" example of how information is being digitised is in the decline of printed newspapers in favour of online platforms. For example, in the United States, the number of people employed by newspaper companies dropped by nearly 47% from 2008 to 2018 and dropped in revenues by nearly 62% over the same period[2]. Small-scale farmers, even though they are rural, are also increasingly become part of this migration. It is nowadays common to find a small-scale farmer in a rural setting with a smart phone. Thus, it was inevitable that the aquaculture manual would have to be presented in a digital format, namely an App. This would also mean that the manual could be updated regularly (at low cost), reach a much wider group of people and would be interactive. Digitising the manual would also provide the user a much richer experience in using it.

[2] https://www.pewresearch.org/fact-tank/2020/02/14/fast-facts-about-the-newspaper-industrys-financial-struggles/

- **Conveying farm production data back to government**. The App also fulfilled another important consideration. It was not only designed to provide technical information to the small-scale farmer (to assist the farmer to increase production), but equally important, it was designed to convey production data from the farmer back to government. Within the South African context this has never been done before. This criterion was in response to a critical issue facing government, as currently there do not appear to be any system in place that reliably convey production data from the farmer back to the provincial Departments of Agriculture and to DEFF (and ultimately to the FAO; an obligation on every member country). Without production data to guide policy makers and aquaculture planners within government, interventions could miss the mark. Plans must be based on evidence and, until this is undertaken, the sector will continue to underperform.

1.6 The COVID-19 Pandemic

When South Africa entered a lockdown on 27 March 2020, due to the Covid-19 pandemic, it was evident that we had entered a new reality. Apart from the dire and direct health crisis this pandemic presented the country, it was also clear that all South Africans would now be required to do things differently and even to re-direct their current activities to meet this new challenge. It is therefore also important to describe how this research project is responding to the demands set by the pandemic.

- **Increasing food production**. The core objective of the App is to assist small-scale farmers to increase production. The FAO has already issued dire warnings about looming famines due to disruptions to food production due to the pandemic. The FAO is also urging all governments to take the necessary measures not only to safe guard existing food production pipelines, but where they can, to also increase production.
- **Accelerating the Fourth Industrial Revolution (4IR)**. One of the consequences of the pandemic has been the disruption to just about every aspect of our daily lives. When South Africa entered the Lockdown (Level 5) on 27th of March 2020, it became evident that companies, institutions and individuals who had access to the internet and online services, could continue (with some adjustments) and those who had no (or limited) access found themselves excluded. The pandemic made it very evident how important it was to ensure that everybody had access to the internet and was part of the 4IR. This App should be seen as a step in the process to close the digital divide and to ensure that even small-scale farmers in rural areas can also benefit from the services that technology can provide.

1.7 The use of Apps and the Internet of Things (IoT) in aquaculture

It is without question, that Apps and in general, the internet of things (IoT) – defined as the connection of everyday of things that make use of the internet to collect and exchange data, using software and sensors that have been embedded within it (Cisco, 2018) – has fundamentally changed how we conduct just about every aspect of life. This includes fish farming. The majority of fish farmers are small-scale farmers located in rural areas, facing unprecedented challenges, and needing access to information and technical support to be able to have a viable operation (World Bank, 2013). In a world that is so interconnected for farmers to be sustainable and able to compete, they will need access to information (Adomi *et al.,* 2003).

Mobile phones are no longer just a tool for telephonic communications. Amongst many other things, they also serve as tools to increase economic benefits and to enhance trade and production (Aker and Mbiti, 2010). To take this further, Muto and Yamano (2009), determined that in areas that had mobile phone coverage (bearing in mind for many rural communities the main connection to the internet is through mobile devices), farmers were able to increase their profitability by 10%.

In South Africa, it seems that Buna Africa, is possibly the first online platform / web-based App that deals directly with the needs of fish farmers, therefore there is not much information on this topic. However, one could view how India has embraced the IoTs to develop its aquaculture (and fisheries) sector. Furthermore, South Africa and India are both members of BRICS (Brazil, Russia, India, China and South Africa). BRICS member countries share an economic understanding with common economic objectives and a striving to cooperate with each other.

In India, the first App for fisheries and Aquaculture was developed as recently as 2015 (Dhenuvakonda & Sharma, 2020). To date there are 30 Apps, of which 12 are geared towards aquaculture and nine each for fisheries and marketing. However, this needs to be seen in context. Globally, India is the second biggest producer of aquaculture products and fisheries products (Dhenuvakonda & Sharma, 2020). Similar to the South African government's Operation Phakisa, a national programme to leverage the marine economy as a catalyst to create jobs and economic development, the Indian government, through its "Blue Revolution" programme, has identified the fisheries and aquaculture sector to create jobs and economic development (Dhenuvakonda & Sharma, 2020).

Of the 30 Apps in India (related to aquaculture and fisheries), 15 of them (50%) have been funded by the Indian government (Dhenuvakonda & Sharma, 2020). In South Africa, Buna Africa was funded by the WRC, which derives its funding from the State by means of a water usage levy. Apps in India are used by farmers and fishers and these Apps are largely focused on market information, fish disease, news, machinery and production ((Dhenuvakonda & Sharma, 2020). The top three popular Apps each have downloads of over 10,000 users (Dhenuvakonda & Sharma, 2020).

What is also important to consider is that India is digitising faster than any other country and approximately 40% of the country has internet subscription (Dhenuvakonda & Sharma, 2020). This is a formidable statistic, considering the population of India is 1.4 billion people (as compared to South Africa, which has a population of 59 million). A possible driver for the growth of App usage in India is the relative cost of data, compared to data in South Africa. In India, the average mobile data usage per month is 8.3 GB (Dhenuvakonda & Sharma, 2020). In South Africa, on the Vodacom platform, the average monthly data usage, using smart phones and smart devices was approximately 1.8GB in 2019 (Business Tech, 2019).

India is a relevant example of how Apps and the IoT are being used to promote and develop the aquaculture (and fisheries) sector. As data becomes more affordable, internet coverage expands, download and upload speeds increase, and it is then inevitable that farmers will increasingly turn towards Apps and the IoT as tools to develop their businesses. It is estimated that globally, by the year 2025, there would be 75 billion devices that will be part of the IoT (Statista, 2019). In South Africa, although Buna Africa is the first web-based App that engages with fish farmers, the India experience indicates that this this is the direction of growth and development.

1.8 Conclusion

Globally aquaculture is the fastest growing animal production sector in the world (www.fao.org). The increase in demand for fish, due to an ever-increasing world population and the greater awareness of the health benefits of eating fish, has seen the consumption of fish (per capita) rise from 9.0 kg live weight in 1961 to 20.5 kg in 2017. This equates to an annual increase of 1.5% (FAO, 2020). The growth of the aquaculture sector has also been supported by significant investment in research and development, which has translated to a greater number of species being farmed with increasing efficiency in production, making aquaculture more profitable.

In South Africa, the aquaculture sector is still in its nascent stages. The estimated production for 2017, as indicated in the DEFF, 2018 Aquaculture Yearbook was 5,588 tons, a drop of 7% from the previous year (DEFF, 2018 Aquaculture Year Book). One of the issues facing DEFF is that there is very little farm information data available (such production figures) that reaches the department (or, for that matter, the relevant provincial departments of agriculture). This is a challenge for DEFF as, without this information, effective planning and monitoring of the sector cannot take place. Furthermore, for many small-scale farmers, their technical levels are low, and as such they are unable to achieve the potential of their farms. This is an issue that government is aware of.

To assist in the technical growth and development of small-scale farmers, in 2010 Rhodes University, through a WRC-funded project, developed a technical manual aimed at these farmers. The manual was developed in the “FAO style”. This included many illustrations and diagrams and supporting text that was easy to read. The manual was used both as a support / reference tool for the farmers but also to train farmers and extension officers. However, the manual, in printed format, has its shortcomings. It was expensive to print, and once printed it could not be updated. Furthermore, with the advance of digital technology, it was clear that an online platform / App was the next logical progression of the manual. It was on this basis that, in 2018, the WRC awarded Rhodes University a research project to develop a web-based App as a platform for the manual.

On 27 March 2020, South Africa declared a national state of disaster due to the Covid-19 global pandemic and entered a lockdown. Apart from the direct health issues related to Covid-19, it quickly became apparent how significant the digital divide in South Africa is. Individual or communities without access to the IoT found themselves isolated and unable to participate effectively in the mainstream economy. The relevance of developing a web-based App for the manual became even more clear and relevant.

The use of Apps and the IoT in developing aquaculture has been happening in other parts of the world, like India, successfully. Apps are used by hundreds of thousands of farmers, to assist them to increase their production, to manage fish health and to find markets for their products. With the development of technology and ever increasing cell phone coverage, farmers will increasingly use this technology to develop their farms and grow their businesses.

2 CHAPTER 2 DEVELOPING BUNA AFRICA, A WEB-BASED APP FOR SMALL SCALE FARMERS

Buna Africa (also referred to as Buna in this document) is a web-based App that was developed as a tool for small-scale farmers to increase production. Buna was also designed to allow farmers to submit farm production data to their extension officers, to enable these extension officers to manage the sector. The data from Buna could also be accessed by provincial and national government aquaculture managers, to assist them in making policy and strategic management decisions.

2.1 The Engagement with Abalobi (an App for Marine Small-Scale Fishers)

The process to develop the App began by engaging with the developers of Abalobi, an App designed for small-scale fishers in the marine sector. Even though later on in the project an independent App developer was brought in on the project, this initial engagement with Abalobi was relevant, and as such is being reported on.

Abalobi is an App (http://abalobi.info) that was developed in South Africa as a tool for small-scale marine fishers. The primary objectives of Abalobi are to promote networking, empower small-scale fishers, align with international guidelines, encourage transparency, develop best practises and share knowledge. Some of the core functions of Abalobi include catching log and analytics, communication, data sharing and export, personal accountant, a safety at sea system and providing an info hub for the fishers.

Many of the features in the Abalobi App are open source, which means that they can be used by third parties without payment or copyright infringements. There is still a fair amount of technical skill required to stitch the various components together and to ensure that the functions they perform are synched and that the user can navigate through it with ease. The Abalobi App did serve as an interesting model to use, however due to budget considerations it was decided that an independent IT developer be brought on board to assist in the developing of Buna Africa.

2.2 The “Wire Frame”

A wire frame is essentially a draft plan of the App. This includes the proposed features of the App and some of its functionalities. The wire frame developed for Buna Africa (Figures 1-5) served as a starting point for the IT developer to work from. In the development of Buna Africa, the App progressed in appearance and functionality, which was to be expected.

As the project team received input from the farmers interviewed and the project reference group, changes were made.

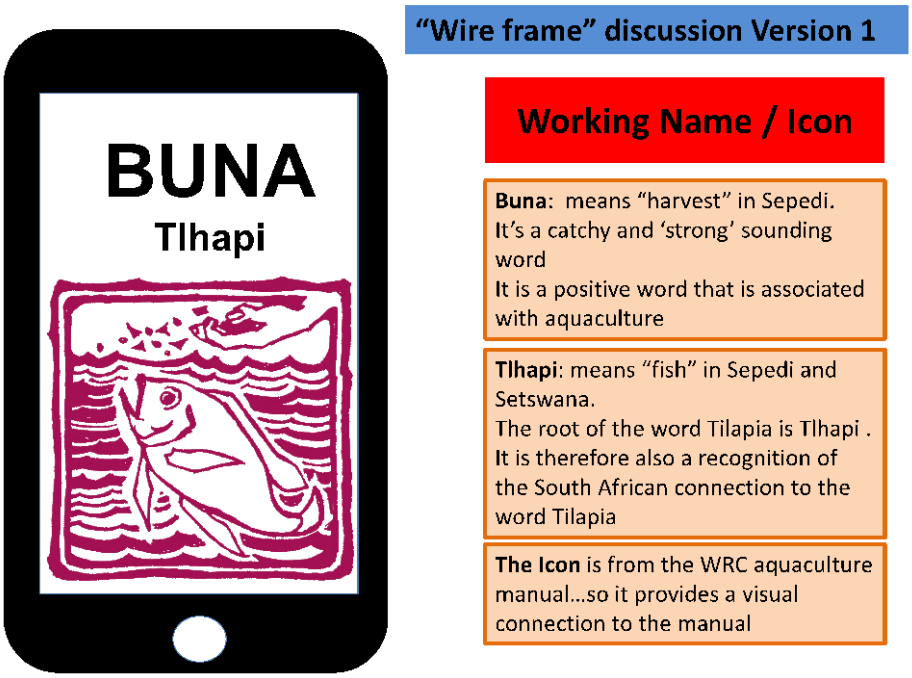

Figure 1. *The wire frame for the App.*

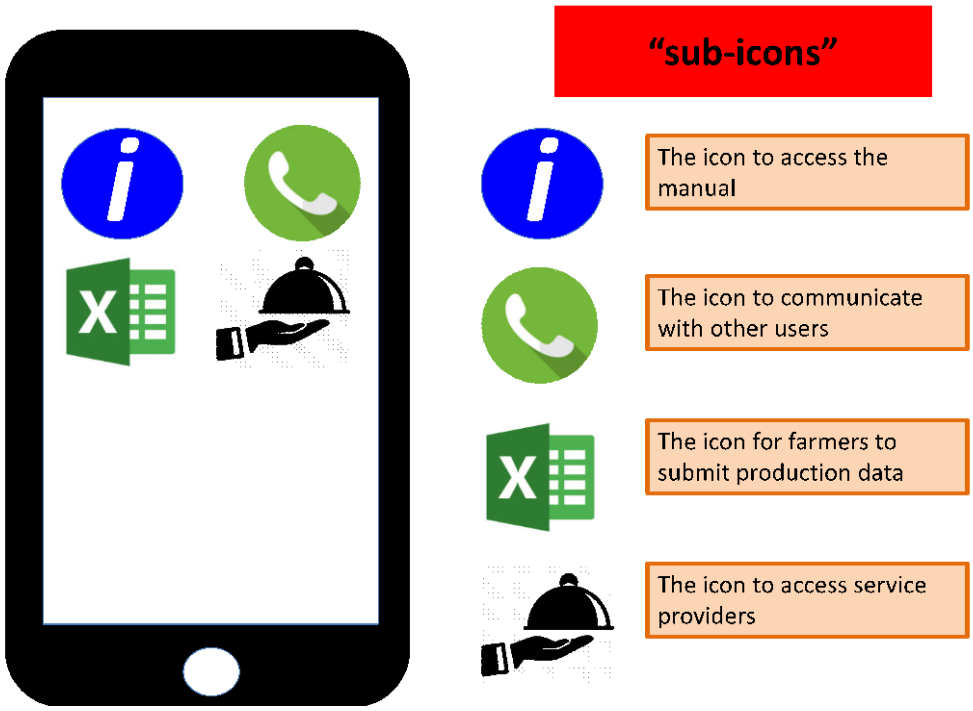

Figure 2. *The sub icons for the wire frame.*

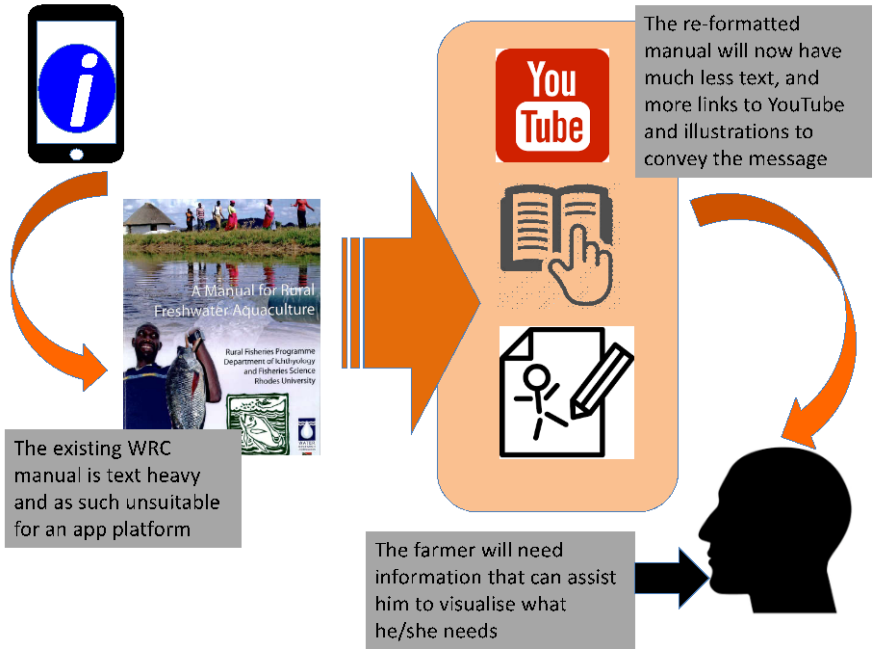

Figure 3. *The wire frame for the App, relating to the manual selection.*

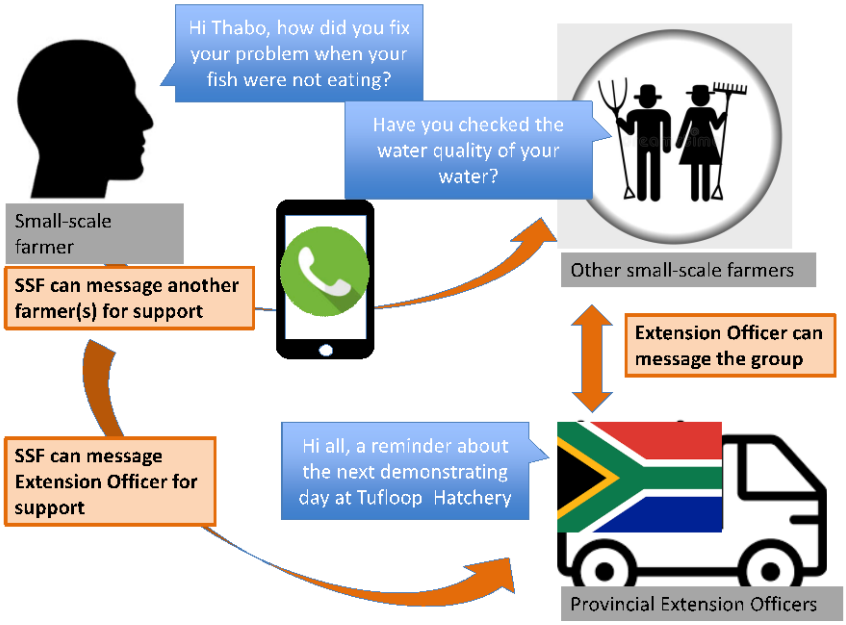

Figure 4. *The wire frame for the App, relating to the selection on developing an instant messaging system that farmers can use.*

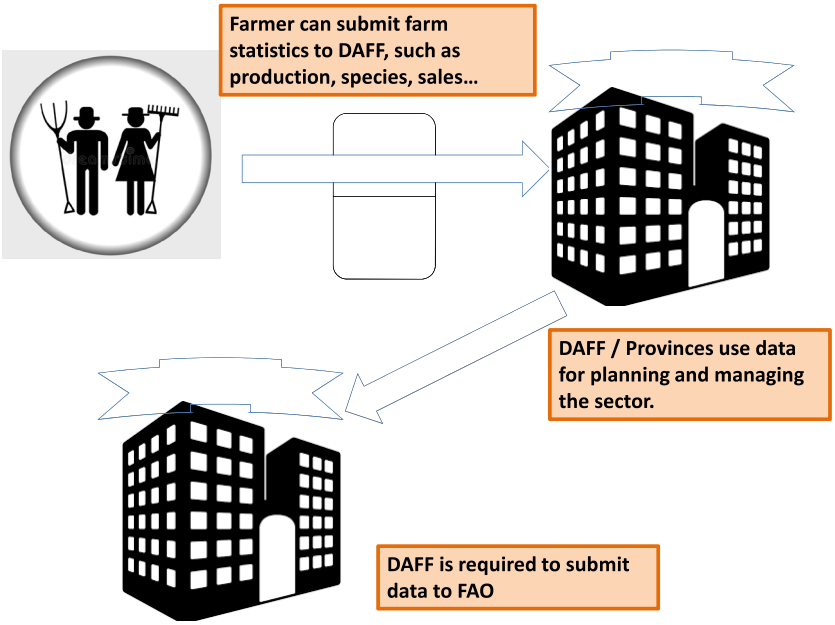

Figure 5. *The wire frame for the App, relating to how farm production data flows from the farmer to the DEFF and ultimately to the FAO.*

2.3 Building the App

In building the App, it had to have the following capabilities:

1. To be able to provide the re-written manual in electronic format to the user on a device, with emphasis being placed on providing a solution which uses minimal data as most of the end users are primarily on the lower income scale and data is at a premium for them.
2. Pictures and videos are not automatically displayed and will only be visible when clicked on, so as to conserve data for the user.
3. To provide an interface for the user to be able to do calculations based on certain criteria and display the result in the device browser.
4. To provide an interface for farmers to upload data to a database.
5. To provide a communication platform between users via an in-App messaging module.
6. To provide a list of service providers.
7. To provide a way for farmers to contact service providers.
8. To provide an interface for extension officers to view the collected data.
9. To provide an interface for content management for any content which needs to be updated or which may change.

10. To collect usage data from farmers to evaluate efficacy of the webApp usage.
11. To provide a richer visual experience to users who are not data-constrained, for example users who connect from a personal computer via a DSL line.

2.4 Technical Aspects for the Development of the App

The access to the site is provided by role based access control (RBAC). To enable RBAC it is necessary for new users to register on the App so that they can be allocated the correct security rights. For example, one would not want a farmer to access the supplier's module, whether purposefully or inadvertently, and then be able to offer goods for sale on the site. There are four different roles which users on the site fulfil:

a) Farmer: This user type has access to the following resources:
- Can view and interact with the training manual.
- Can view and communicate with suppliers via the in-App messaging system
- Can use the calculators
- Can send and receive messages to and from other users or suppliers.
- Can update their profile details as well as their farming operation details.

b) Supplier: This user has access to the following resources:
- Can view and interact with the training manual.
- Can view and communicate with suppliers via the in-App messaging system
- Can use the calculators
- Can send and receive messages to and from other users or suppliers.
- Can update their profile details as well as their supplier and business details.

c) Official: This user has access to the following resources:
- Can view and interact with the training manual.
- Can view and communicate with officials, suppliers as well as farmers via the in-App messaging system.
- Can use the calculators
- Can update their profile details.
- Can view and interact with data presented to them from the farmer's profiles.

d) Administrator: This user has access to the following resources:
- Has full access to the "front end" and "back end" of the system and can fully administer all aspects of the App, including adding and removing users.

The App uses logic to determine what type of device the user is connecting with and which role the user fulfils and then presents the correct version of the App for that particular user.

2.4.1 The registration process:

When a user registers to use the site, they need to indicate which type of user they wish to register as, i.e. farmer, supplier or official. Based on this choice, the user is then guided through a three-step process where data is collected from the user.

The following data is collected:
Farmer: Name, username, province, nearest town, email address, latitude and longitude of the farm, number of ponds and type of fish the farmer breeds.
During the registration process the App automatically attempts to determine the latitude and longitude of the user and uses this information as the indicator for the farm's location. Unfortunately, not all browsers are capable of providing this functionality and in some cases the user will need to enter the co-ordinates manually.
Supplier: Name, email address, business name, contact number
Official: Name, email address

The final step is the field-testing phase where selected users will use the webApp and make recommendations on information and usability of the App. These change requests will be implemented immediately so that end users can test them as quickly as possible.

Currently, the development version of the App is being hosted as a subdomain of the Midnightcoder Domain. Hosting is provided by Imaginet, and they will also provide the hosting infrastructure for the production environment.

Furthermore, to facilitate the functionality of the App, the IT specialist also included:

1. A very light "back end" framework which allows for fast page loading. This will be further enhanced once the final field-testing has been completed and the site moves to the production environment.
2. A very data-usage-aware structure to the "front end". The entire webApp has been designed to offer the best possible visual experience while minimizing data usage during browsing by allowing the user to make choices on which material they wish to interact with.
3. An uncomplicated, intuitive user interface to cater for people who may not be regular technology users.
4. Device and user aware logic to present the correct experience to the user, based on those criteria.

The final production version of the webApp will be hosted on infrastructure provided by Imaginet and will be secured by an SSL certificate, so the final URL for the site will be supported with an “https” prefix. This is important from a search engine optimization (SEO) point of view as some search engines, such as Google, penalize sites which are not secure or which are not responsive in design.

Responsive design is a means of coding the webApp so that it automatically scales correctly to the size of the device it is being viewed from, whether that device is a PC, laptop, tablet or smart phone.

2.4.2 The technical specifications of the web-based App

1. Coding elements: PHP v7.0, Javascript ECMAScript 2018, Bootstrap V4, MySQL V8.0 with MySQLi and MySQLi PHP directives, HTML5
2. Hosting environment: Linux

2.4.3 The site has been tested on the following devices

Samsung Galaxy Note 3 / S9 /S9+	Apple Ipad, iPhone 6/7/8/X
Microsoft Lumia	Xiaomi Redmi

2.4.4 The site has been tested on the following browsers

Firefox V67.0.1 (64-bit and 32-bit)	Opera
Google Chrome V75.0 (64-bit)	Internet Explorer 9

2.5 Accessing the web-based App

Users need to register on the site before they can fully access all areas of the site. The reason for this is that the App uses a role-based access control model, which means that information is displayed to the user based on their role and the only way for them to choose a role is to actually log in to the App.

To avoid hacking and spam on the site, the user will receive an email with a link to click on

as confirmation after registering. The site administrator will also receive an email when a user registers and can confirm the user on the user's behalf in cases where the user does not have an email address. (This process can be changed if we find it creates confusion.) After registration the user can log on using his/her credentials created during the registration process. Once logged on, the App uses logic to determine whether the user has chosen a role or not. If not, they will be prompted each time they log on but until they choose a role, they will not have full site functionality.

When they log on, they are taken through a 3-step process:

Step 1: Choose a role: Farmer, Supplier or Official

Step 2: Depending on the role, they are presented with a form to complete certain details, e.g. the farmer role needs to fill in the species of fish they farm with and the supplier needs to fill in the type of service they provide.

Step 3: They are logged on to the site and have access to all functionalities for their role.

The current working link to the site is URL: https://buna.africa/index.php

2.6 Developing the contents for the App

Developing the contents of the App, with regards to technical information that is of relevance to the fish farmer was focused into two main areas:

- **Developing a version of the 2010 manual that was relevant to an App format.** The manual that was developed in 2010 was text heavy. To make it relevant for an App format, each chapter was condensed (Figure 6, a freeze frame of a condensed chapter is shown). In this condensed version, key words are highlighted and they provide links to other relevant websites to provide the reader with an opportunity to further explore that particular subject area, if they wish. This feature was included as it provided the reader the choice to determine what they wanted to explore further, rather than presenting all of the information upfront. The motivation for this was primarily for two reasons. Firstly, it was important not to overload the user with a lot of information from the beginning. Secondly, the App designers were mindful not to develop an App that required a lot of data (which would have cost implications for the user). So, by the user determining how much information they wanted, they then also controlled how much data they were using.

  The condensed chapter also included links to YouTube videos related to the topic of that particular chapter. As much as possible, the YouTube videos selected will be African in origin, so as to be relevant to the small-scale farmer. A farmer in Limpopo

Province would probably relate more to a video about a farmer in Ghana than to a farmer in Norway.

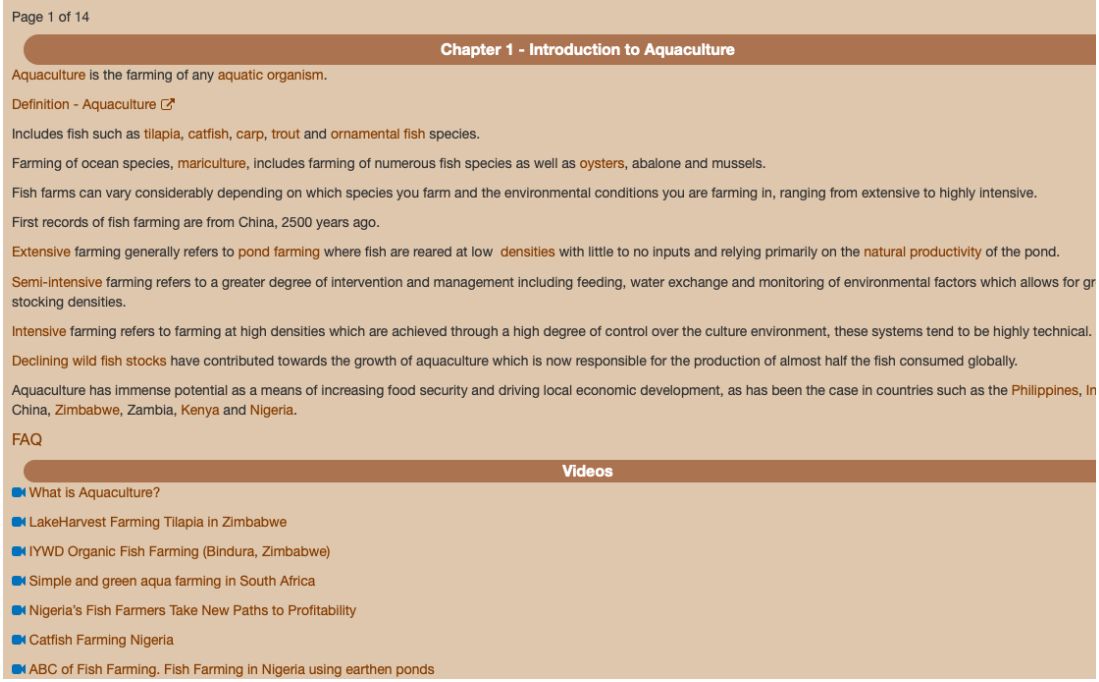

Figure 6. *A screen grab of the condensed manual (Chapter 1).*

To further enhance the experience of the farmer or user of the App, there are links embedded in the text that would allow the farmer to further research the subject matter and or the farmer could also click on a YouTube video on that subject matter.

- **Developing the production calculators**. One of the main issues facing small-scale fish farmers, and for that matter even the extension officers, is that they were not able to determine basic parameters for their farms. Farmers did not know how much yield they could expect from their ponds, how much they should be feeding their fish or even the growth rates of the fish in their ponds. These are basic parameters that every farmer should know as these calculations are the fundamentals of every fish farm. It is these parameters that determine if the farm is running at a loss or making a profit.

To address this issue, it was then determined that the App should include a feature that would assist the farmer to determine basic production parameters for their ponds. To achieve this, growth rates for tilapia from the available literature, were tabled and plotted out (Figure 7). These growth rates were also linked to length / weight correlations and the

recommended feeding regimes for fish. All of this information was formatted into an excel spreadsheet (Table 1) that is present in the ""back end"" of the App.

What is presented to the farmer on the App, is a page that is easy to engage with (see Figure 8) that for example allows the farmer to insert the age of the fish and the App would then calculate and determine what the weight for a fish of that age should be. The App can also assist the farmer to determine the yield of a pond (based on its size) and how much they should be feeding their fish.

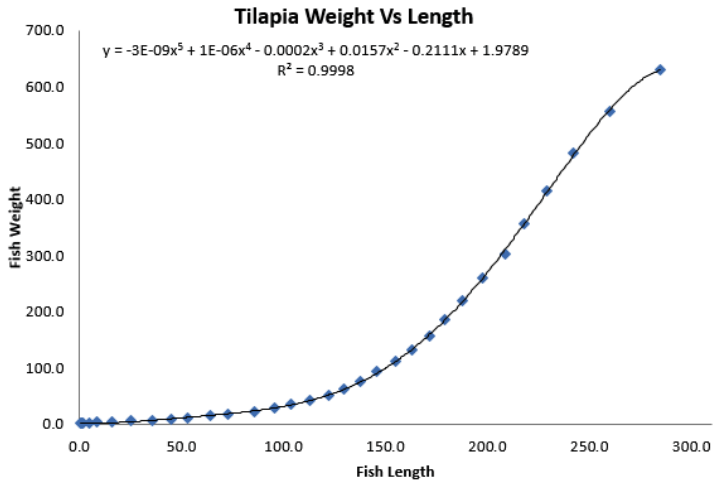

Figure 7. *Length/weight correlations for tilapia, embedded in the App.*

This graph is in the "back end" of the App. What the farmer interphases with is a page that allows him/her to insert the age of the fish and the App then calculates (using this graph) the size of the fish. The answer to the farmer's question is then displayed on the device (Arana et al., 2020; Bahnasawy et al., 2003; de Castro Silva et al., 2015; dos Santos et al., 2013; El-Sayed, 2013; FAO Aquaculture Feed and Fertilizer Resources Information System; Gibtan et al., 2008; Kembenya & Munguti, 2014; Towers, 2010).

Table 1. *The length / weight / age / feeding ratios embedded in the "back end" of the App. This Excel spreadsheet is what drives the production calculators. The farmer interphases with a "simple" page that allows him/her, for example, to insert the age of a fish and the App then calculates what the weight should be (Arana et al., 2020; Bahnasawy et al., 2003; de Castro Silva et al., 2015; dos Santos et al., 2013; El-Sayed, 2013; FAO Aquaculture Feed and Fertilizer Resources Information System; Gibtan et al., 2008; Kembenya & Munguti, 2014; Towers, 2010).*

Age (Months)	Weeks	Length (mm)	Weight (g)	Feed % BM	Feed/fish/day (g)
0	0	0.05	0.0	5.0%	0.001
	1	1	0.1	4.5%	0.002
	2	2	1.0	4.5%	0.045
	3	5	2.0	4.0%	0.080
1	4	9	3.0	4.0%	0.120
	5	13	5.0	4.0%	0.200
	6	17	7.5	4.0%	0.300
	7	22	10.0	4.0%	0.400
2	8	27	12.5	4.0%	0.500
	9	32	15.0	4.0%	0.600
	10	38	17.5	4.0%	0.700
	11	44	20.0	3.8%	0.760
3	12	50	25.0	3.8%	0.950
	13	57	30.0	3.8%	1.140
	14	64	35.0	3.8%	1.330
	15	70	40.0	3.5%	1.400
4	16	77	50.0	3.5%	1.750
	17	86	64.0	3.5%	2.240
	18	94	72.0	3.5%	2.520
	19	102	84.0	3.2%	2.688
5	20	111	98.0	3.2%	3.136
	21	118	110.0	3.2%	3.520
	22	124	124.0	3.2%	3.968
	23	130	138.0	3.0%	4.140
6	24	138	152.0	3.0%	4.560
	25	144	168.0	3.0%	5.040
	26	152	182.0	3.0%	5.460
	27	158	200.0	1.5%	3.000
7	28	166	220.0	1.5%	3.300
	29	174	240.0	1.5%	3.600
	30	182	260.0	1.5%	3.900
	31	188	280.0	1.5%	4.200
8	32	196	300.0	1.5%	4.500
	33	205	325.0	1.5%	4.875
	34	214	350.0	1.5%	5.250
	35	222	380.0	1.3%	4.940
9	36	230	410.0	1.3%	5.330
	37	238	440.0	1.3%	5.720
	38	248	470.0	1.3%	6.110
	39	256	500.0	1.0%	5.000
10	40	262	525.0	1.0%	5.250
	41	268	550.0	1.0%	5.500
	42	275	575.0	0.8%	4.600
	43	282	600.0	0.8%	4.800

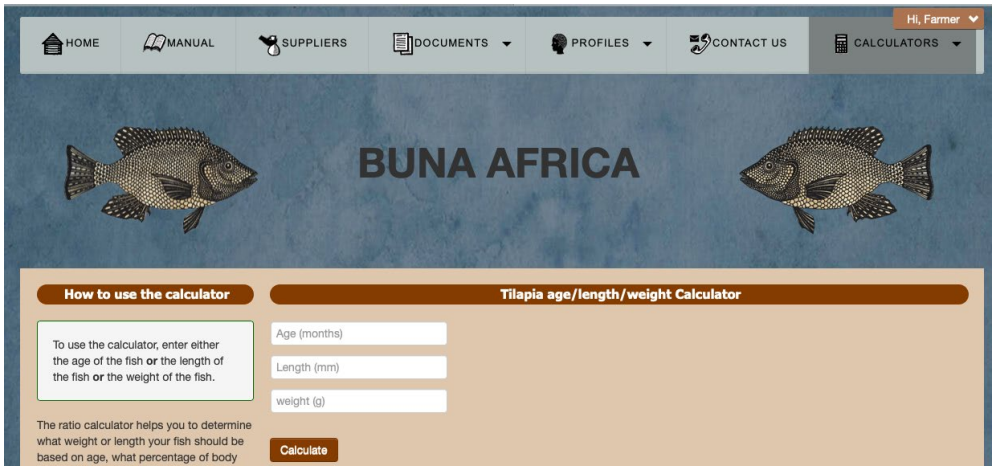

Figure 8. *A screen grab of the production calculator.*

To use this feature, all that the farmer needs to do, for example, is to insert the age of the fish and the App would then calculate and display what the ideal weight of the fish should be. The farmer is not required to interact with the "back end" spreadsheets or graphs.

2.7 Conclusion

The development of Buna began with the "wire-frame". The wire frame is a conceptual design of the proposed web-based App and it is used to guide the App builder (the IT specialist). Once the wire frame was designed and approved, the IT person could then start the process of writing the code to function the App. Apps have a "front end" which is what the user experiences and interfaces with and then there is the "back end" which is the code to function the working of the App.

Buna was designed to serve two main objectives, to assist farmers to increase production and to provide a tool for government officials to obtain farm data (that would assist them to manage and develop the sector.) To assist farmers to increase production, a number of features were incorporated into the App. The main thrust was the delivery of the manual. In addition to the original manual of 2010, an abridged version was also included. This step was taken as the original version of the manual was text heavy and it would not have been easy to navigate using a small handheld device. To assist the farmers to increase production, Buna also provides the farmers with a production "calculator". A farmer can now provide the dimensions of his pond and determine the approximate yield of the pond, and if the farmer input the age of the fish, the calculator can then determine what the average weight and length of the fish should be. Another issue that hampers the growth and development of farmers is the need for information on where to source essential materials for the farm (such as feed and fingerlings). To respond to this need, the App includes a

platform to allow service providers to list their products. Farmers can then search for a particular product and if listed, Buna will then direct them to the service provider. Buna also has an instant messaging service, similar to WhatsApp. Farmers registered on Buna can then message each other in real time and share information. Through the App farmers are easily able to communicate with each other, thus assisting them to solve problems they may face and therefore increase their production.

An important feature of Buna is that farmers can submit their monthly production data (e.g. how many fish they harvest, and the species they sell). The farmer logs into Buna and fills out a monthly form. The data field that the farmer completes can be set, depending on what data government requires. Farm production data is relevant to government officials as this data would typically be used to develop and manage the sector. Over time, the data can be used to look for trends or even to make projections. This could be a useful tool for government as presently there does not appear to be a functional process that conveys farm data to a central point in so that it can be analysed. Another feature on Buna is that some of the farm production data is displayed on a Google Earth map. This visualisation of the data will assist government officials to know where the farms are located.

3 CHAPTER 3 TESTING THE APP

3.1 Field Testing the App / the methodology

In developing the App, it was important that the farmers, who would have been a primary target for this technology were part of the process, and that there input was considered. To achieve this, two process were taken. Rhodes University met with farmers for their input, as well as a Hons student from Limpopo University (Ms LS Mothapo) from the Aquaculture Research Unit also engaged with farmers (under the supervision of Mr Johan Theron). In both of these processes, very similar methods were approached. Details are presented below.

3.1.1 Rhodes university engagement with the fish farmers

To reach the farmers, The Limpopo Department of Agriculture and Rural Development was contacted (Mr Jacky Phosa). The Department, then identified a cluster of farmers in the Vhembe District that they felt would be relevant to participate in the process to develop the App. The Department then requested that we engage with the District Extension Officer to work out the finer details and logistics of our site visit. The District Extension Officer identified three (3) farmers for the team from Rhodes University to visit and engage with. The farmers that the District Extension Officer identified were the situated in and around Thohoyandou, Limpopo Province.

A questionnaire was developed (see appendix 1) that guided the discussion between the research team and the farmers. Though the questionnaire was in English, the District Extension Officer not only assisted with the translation but also in the facilitation of the engagements. It was evident that the District Extension Officer and the farmers that were being engaged with had known each other over many years and as such they trusted each other. This greatly facilitated the engagement as the farmers seemed comfortable to engage with us (based on the trust they had with the District Extension officer).

The field trials of the App were held from 15-17 October 2019. Each farmer was engaged with separately (except for the group meeting that was hosted by the ARC). The farmers were presented with the Rhodes University Ethic Clearance Certificate), a consent form and an attendance register. All of the interviews were held in the presence of the assigned Extension Officer, Mr Solomon Ntsieni Ramakhumisa (from the Thohoyandou Office). The extension officer also assisted in translation (when required).

Meeting 1: Presentation at an ARC workshop

Concurrent to our field trip in Thohoyandou, the Agriculture Research Council (ARC) had organised a workshop for all of the fish farmers in the northern region of Limpopo (Figure 9). The ARC workshop was held at a municipal hall in Thohoyandou and approximately 30 farmers attended it. We were kindly allocated a slot to make a presentation on the App (the App was presented live by a data projector on a screen).

Figure 9. *The fish farmers who participated in the ARC workshop.*

The ARC team allowed the Rhodes University team to make a presentation on the App to the farmers; this was greatly appreciated.

It was good for the project to make a presentation to such a large group of fish farmers. The App was very well received and many of the farmers wanted to know when they could use it. One of the features that fish farmers liked the most was the link to the many YouTube videos. They were really excited to watch fish farmers in other African countries farm fish in similar environments to their own. Also, some of the farmers had never seen how tilapia breed, and this was really exciting for them.

Due to the large group present, it was not possible to get more “one-on-one” time with the farmers, but it was evident that they really liked the App and what it could do for them.

Meeting 2: Mr Nemutamba (fish farmer)

Mr Nemutamba is a well know fish farmer in Thohoyandou. Although he had recently been involved in a serious car accident and had lost his son, he was kind enough to invite us to his home so we could interview him. Mr Nemutamba was shown how the App works and he was very excited about the App. His main suggestion was that we should be holding aquaculture training courses, however aquaculture courses are not within the scope of this project.

Meeting 3: Mr Tobias Makhokha (fish farmer)

Mr Makhokha was taken through the App (Figure 10) and he was very interested in how it could help him become a better farmer, and when he could sign up. The feature on the App that most appealed to him were the videos. Seeing how tilapia spawned was of particular interest to him. He had previously seen small depressions at the bottom of his pond and when he saw the video, he realised that these depressions were in fact the nests that the male tilapia creates to attract female fish for spawning.

Figure 10. *Visiting the fish farmer Mr Makhokha in the accompaniment of extension officer Mr Ramakhumisani.*

From left to right, Rogan Field (Rhodes University), Tobias Makhokha (fish farmer) and Solomon Ramakhumisani (extension officer), during a farm visit to go through the App.

Meeting 4: Mr Jonas Netshituni (fish farmer)

Mr Netshituni is a lychee farmer (Figure 11) with small ponds that he uses to farm tilapia. We took him through the App and he was very interested in how it could assist him in becoming a better farmer. For him, being able to see where he could buy supplies (fish feed) was of interest. He was very positive about the App and was keen to use it when it becomes available.

Meeting 5: Mr Nemumvumoni Mafukasaga (fish farmer)

Mr Nemumvumoni has several ponds on his farm that he stocks with tilapia, and as such, he was very interested in the App. The videos on the App were of particular interest to him as well as the fish production calculators. He was pleased that he would be able to determine exactly how many fish he should expect per pond (depending on its size), at what rate they should grow and how much to feed them. These really are the basics of any farm operation. He too, was keen to know when he could have full access to the App.

Figure 11. *Research team meeting with small-scale fish farmers.*

Meeting the farmers on their farms was important, as we could test if we could receive cell phone coverage. We were able to connect to the App at all of the farms we visited.

3.1.2 Feedback from the famers

- **Production calculators.** The farmers had very positive feedback on the production calculators. They were interested in the idea that they could now be able to determine what the size of the fish should be in relation to the age of the fish. This was something new to them, as prior to this, as they did not have access to this type of information. The relations between age and length and weight had not been explained before and now with Buna they could visualise this relationship. The fish calculator also assists the farmers to determine how much to feed the fish. This feature of the calculator was also greatly appreciated as they could now be able to manage their feed stock. The farmers also realised that if they over fed the fish, they would be losing money. So, this feature of the App would help them become more business efficient.
- **The YouTube videos.** The YouTube videos, which were linked to the training manual was possibly what excited the farmers the most. For a small-scale farmer in Vhembe District to watch a farmer in Ghana spawn the same species of fish that he is working with, in similar farming conditions, is a very powerful way to capacitate and train farmers. Many aspects of aquaculture are abstract (such as water quality), but for farmers to then watch another farmer in another part of Africa discuss it, makes it real. It is clear that going forward, this section of Buna will need to be built up.
- **The messaging system.** All the farmers we interviewed had access to a smart phone, so they were very familiar with instant messaging systems such as SMS and WhatsApp. So, the inclusion of a messaging system within Buna, was a feature that they recognised and well understood. However, recognising now that they could be connected to farmers across the country and to their respective extension officers –

through Buna – was new to them. They understood how this connection could benefit them, as now they would be able to engage with other farmers and share information and assist each other.

- **The training manual.** The small-scale farmers had positive feedback on the training manual (both the original version of 2010 and the abridged for Buna). The farmers appreciated the technical information in the manual and how this could assist them to increase production. The farmers were familiar with the original manual (of 2010) and as such the abridged version on Buna was something they could relate to.
- **Translation of Buna.** The farmers we engaged with, English was not their first language, and as such the research team had to depend on the extension officer to provide translation. For Buna to really become a tool that will be used by small-scale farmers, across the provinces, it will have to be translated in the relevant language of that area. This is an issue that DEFF and the relevant provincial departments of agriculture will need to take up.

3.1.3 Observations by the research team

During the interview process, the research team made some observations. These are listed below:

- **Using Buna**. For all of the farmers interviewed, it was clear that navigating through Buna was something new to them; the farmers would not have normally spent many hours of the day on their smart phones, online and using the internet. Using an online platform was something that was relatively new to them and it was as such clear that they would need many hours of contact time to train them so that they would be comfortable to using an online platform such as Buna. This point is part of a larger issue, which is about bringing the fourth industrial revolution (4IR) to rural communities. It also maybe a consideration, that when seeking new farmers into the sector, to recruit the youth as they would use platforms such as Buna effortlessly.
- **The cost of data**. Even though farmers expressed that they would use Buna, and pay for the airtime to use it (if it assisted them to increase production), one cannot escape from the relatively high cost of using Buna. The observation made was that farmers were on pre-paid contracts and were very mindful of the cost of data and that they did not always have money to purchase data. Therefore, the cost of data will become a consideration for the farmers when using Buna.
- **Cell phone coverage**. Even though in the Vhembe District there seemed to be good cell phone coverage, including at the fish farms that the project team visited, it needs to be noted that internet speed was not high. Even though, there are efforts by the

cell phone companies such as Vodacom and MTN to rollout high speed internet connection, at present the speed is low. Using low speed internet can be frustrating and as such it may deter the farmers from using online platforms such as Buna. This is an issue that DEFF will need to take up with the national government to put pressure on internet providers to invest in infrastructure, in rural areas, so as to bring the 4IR to all.

3.2 Demonstration site visits to small-scale fish farmers conducted by the University of Limpopo

In the fieldwork conducted by Ms Mothapo, fish farmers in the Vhembe District (Figure 12), were selected (Table 2) for site visits by the Limpopo Department of Agriculture and Rural Development (Mothapo, 2021). Two site visits were conducted in December 2020. In the first site visit, the farmers were provided with a PowerPoint presentation on the App (how it works and the functions). The demonstrations were done in the presence of the Limpopo Department of Agriculture and Rural Development officials. It should also be noted that the team from Limpopo University observed all the necessary Covid-19 regulations when engaging with the farmers. The farmers were then encouraged to use Buna for the next two weeks, after which the farmers were interviewed for their feedback, by means of a questionnaire (Appendix II). During the two week period, while the farmers were testing the App, the researchers from Limpopo University were in touch with the farmers (through a WhatsApp group) to assist them in case they experienced difficulties.

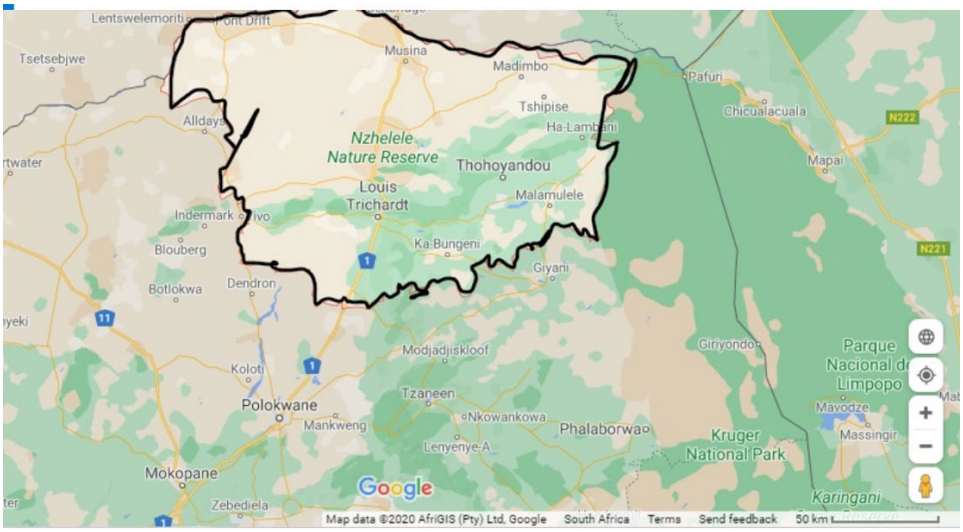

Figure 12. *Vhembe District in Limpopo Province where site visits to fish farmers were conducted (Mothapo, 2021).*

To analyse the data of the farmers' questionnaire, "data was entered into an IBM Statistical Package for Social Science Data (SPSS) editor spreadsheet and thereafter organised and reviewed. The collected data was analysed using the Descriptive Statistic of the SPSS Version 26 computer programme. The data was analysed by descriptive analysis which uses means, minimum and maximum values, standard deviations, and frequencies" (Mothapo, 2021).

Table 2. *Fish farmers in the Vhembe District visited by Limpopo University (Mothapo, 2021).*

Municipality	**Selected Farmers**	**Village**	**Contact details**	**Distance**
Makhado	Khashane S	Mukondeni	0826765912	Mukondeni to Bungeni 14.3 km
	Chabalala E	Bungeni	0821756155	
	Tshikovhele E	Bungeni	0767353277	
	Mufamadi E	Masia	071188630	M to Masia 34 km
Musina	Mudau E	Nancefield	0728489999	
	Moyo T	Nancefield	0763765699	Nancefield to Campbell – 6.2 km
	Moyana E	Campbell	0727884661	
	Ndzadza F	Campbell	0795801604	
	Nemunzhele	Matswale	0827533683	Nancefield to Matswale 7.7 km
Thulamela	Nemanuvhuni J	Lwamondo	082689668	
	Mufunwa	Lwamondo	0795950010/0835967281	
	Ramadzela T	Mapate	0722413225	Lwamondo to Mapate – 4.2 km
	Netshituni J	Phiphidi		Lwamondo to Phiphidi 23.8 km
	Denga T	Phiphidi		
	Makhoka	Muledani	0765967281	Lwamondo to Muledani 22.4 km
Mutale	Makhura I	Tengwe	0721290749	
	Seani C	Tshitande	0733430322	
	Modau J	Pile	0722060182	Thengwe to Pile 1.8 km

3.2.1 Results

“Of the 18 farmers who attended the first meetings when the App was being introduced, 14 farmers attempted to go through Buna Africa App (shown in Table 3) and 4 did not. According to Pandey (2012) the socio-economic status (factors such as age, education, etc.) of the fish farmers plays an important role in the response of the farmers to develop new technologies which is why preparing the socio-economic profile of the fish farmers was important to explain the possible reasons for their issues. From the 14 farmers who used the App 64.3% were males and 35.7% were females. This is because according to Haugen and Brandth (2015) male farmers are more productive than female farmers as a result of access to farm labour, tools, extension services and financing for their farms. Table 5 shows the average percentage of the farmers and it was found to be 61.10% for males and 39% for females.

A better understanding of age in determining level of economic and social participation is important when it comes to targeting interventions (Pandey, 2012). If more youth (younger than 25 years) and middle group (35-50 years) are involved it could infer that fish farming practices for farmers could succeed as a result of attracting the younger generation. Based on the results on Table 4, 64.3% of the farmers were older than 50 years with only 14.3% in the middle age group and 21.4% younger than 35. This explains why most of them struggled with going through the App and led to them not being satisfied with the App as they felt they were too old for this kind of technology and that this App should be introduced to the younger generations since they are computer literate and respond fast to changes and advances in technology. The older farmers felt if they were to use the Buna App, they needed more workshops and meetings with people who can show them step by step how to navigate through it. Another socio-economic factor which affected the farmers was level of education.

Education is an important factor which determines the understanding and adopting to the fish farming technologies by the fish farmers. Table 3 also shows that 14.3% of the farmers were not literate and 85.7% were literate with 50% of the farmers having middle school education (secondary school education) and 35.7% having tertiary level education and these were the ones who understood English. Out of the 64.3% who could not understand English, some could only understand a little English which was very challenging since the App only uses one language. The average of the farmers who were illiterate was 13.9%, those with secondary education was 55.33% and those with tertiary education was 3.67% as shown in Table 6. That is why most farmers felt the App should be available in multiple

languages including their home language, i.e. Tshivenda. Since most of these farmers have a secondary education and they are over 50 years they are not very technologically advanced which meant navigating through the App was another challenge for them.

Since the results were based on a first-time experience there were a lot of challenges that the farmers faced when they tried to use the Buna Africa App. All the farmers had access to smartphones. The main challenge was logging into the site when using a phone. This is because the App has not yet reached full functionality when using a phone. The only farmers who managed to access the App to its full potential were those who were using laptops and only 35.7% farmers had access to laptops and 64.3% did not have access (Table 3). This means less than 50% of the farmers managed to get full functionality of the App. Their results came from the little information they received from the presentation and the one which is not fully functional when using their phones. The farmers rely on data, none of them have access to Wi-Fi and data is expensive therefore even for the farmers who are using laptops to access the Buna App they struggle to use the App. In some areas, e.g. Matswale there is poor network connection (the network reception was very bad) for some networks which led to the farmers not being able access internet and log in to the site.

Even though most of the farmers did not manage to get full access and functionality of the App, based on the little information they got during presentations and when they were trying to use it 78.6% of the farmers thought the App could be an effective tool to use in order to increase production on their farms (Table 7). The farmers were pleased to have been introduced to a tool that was going to give them access to information to help solve their challenges regarding fish farming since their biggest challenge is lack of information. They were happy to know the App was going to be useful to them in terms of increasing production in their farms. They were also impressed with the fact that it was going to be easier for them to connect with other farmers and government support and most importantly, the App was going to make them accessible. The small percentage of the farmers 21.4% thought it will not be effective for them. Table 6 also shows the average of the farmers who thought the App is effective to increase production. This was because of age and level of education. The other reason was that of first-time experience of the App, they could not conclude about it since they needed more time to go through it to understand it better." (Mothapo, 2021).

Table 3. *Farmers and Government officials who used the Buna App.*

The table shows their Gender, Age, the highest level of Education and whether they own a smartphone (the tool used to access the Buna App) (Mothapho, 2021).

	Farmer number	**Gender**	**Age**	**Education**	**Own a smartphone**
Musina	1	Male	>50	Secondary	Yes
	2	Male	>50	Secondary	Yes
	3	Female	<35	Diploma	Yes
	4	Female	35-45	Secondary	Yes
	5	Female	>50	Primary	No
	6	Female	<35	Secondary	Yes
Makhado	7	Male	>50	Primary	Yes
	8	Female	>50	Diploma	Yes
	9	Male	>50	Secondary	Yes
	10	Female	<35	Degree	Yes
Thulamela	11	Male	>50	Secondary	Yes
	12	Male	>50	Secondary	Yes
	13	Male	>50	Secondary	Yes
	14	Male	35-50	Degree	Yes

According to Table 2, of the 14 farmers who went through the App, 6 were from Musina, 4 from Makhado and 4 from Thulamela. From the participants, there were 8 male farmers and 6 females. The table also shows that 8 of the farmers were over 50 years old, 2 were between 35-50 and 4 were less than 35years. All the farmers had access to smartphones except only 1 female. 8 farmers had secondary education as their highest level of education, 2 with primary education and 4 had tertiary education.

***Table 4**. Frequency and percentage table (Mothapo, 2021).*

Measure	**Items**	**Frequency (No)**	**Percentage (%)**
Gender	Male	9	64.3
	Female	5	35.7
Age	Younger than 35	3	21.4
	35-50	2	14.3
	Older than 50	9	64.3
Education	Primary	2	14.3
	Secondary	7	50
	Tertiary	5	35.7
Understand English	Yes	5	35.7
	No	9	64.3
Laptop Access	Yes	5	35.7
	No	9	64.3
Fish farming only source of income?	Yes	3	21.4
	No	11	78.6
Heard about Buna App before?	Yes	3	21.4
	No	11	78.6
Are you satisfied with this App?	Yes	5	35.7
	No	9	64.3
Is the App effective to increase production?	Yes	11	78.6
	No	3	21.4
How likely to recommend the App to others	Unlikely	1	7.1
	Likely	6	42.9
	Very likely	7	50.0

Table 3 shows different measures and questions that farmers were asked and their responses are recorded as frequencies and converted to percentages.

Table 5. *Descriptive Statistics for gender of the farmers (Mothapo, 2021).*

	N	Minimum	Maximum	Mean	Std. Deviation
Male	3	33%	100%	61.10%	34.708%
Female	2	0	67%	39.00%	34.828%
Valid N (listwise)	2				

The table shows the minimum, maximum, the mean and the standard deviation of the gender of the farmers. The average of the males was found to be 61.1 while the females was 34.828.

Table 6*. Descriptive Statistics for level of education of the farmers (Mothapo, 2021).*

	N	Minimum	Maximum	Mean	Std. Deviation
Primary	3	0	25%	13.9%	12.733%
Secondary	3	25%	75%	55.33%	26.652%
Tertiary	3	17%	50%	30.67%	17.214%
Valid N (listwise)	3				

Table 6 shows the mean, standard deviation, min and max values of level of education of the farmers. The table shows that more farmers had secondary school education with an average of 55.33% and the lowest was primary education with 13.9%.

Table 7*. Descriptive Statistics of the Effectiveness of the Buna App (Mothapo, 2021).*

	N	Minimum	Maximum	Mean	Std. Deviation
Effective	3	67%	100%	78%	19.53%
Not effective	3	0	33%	22%	19.053%
Valid N (listwise)	3				

The mean, standard deviation, min and max of the farmers who thought the Buna App was effective to increase production are shown in Table 7. The average of the farmers who thought the App was effective was 78%.

3.3 Input from Stakeholders to Refine the App

In the development of the App, there was input from a number of different stakeholders. This was required as the App would not only be used by farmers, but also by various government departments. The stakeholders engaged for input included:

***Small-scale farmers*:** The focus of the project team was the farmer, as the App was primarily designed to assist the farmers to increase production. Therefore, the farmers were consulted for input, not only before the App was developed, but also when the first draft was completed. The farmers provided important feedback, such as the inclusion of the YouTube videos. They felt this was important and it is clear that in future iterations of the App this feature will need to be expanded to include many more topics and possibly even to encourage the farmers to also include their own videos.

Government: It was also important that government officials had input into the development of the App. At the provincial level, presentations of the App were made to Limpopo and Mpumalanga Departments of Agriculture. At the National level, a presentation of the App was made to the Department of Environment, Forestry and Fisheries (DEFF). These Departments provided positive feedback on the App.

3.4 The Reference Group of the Water Research Commission

The Reference Group, which was composed of individuals with a wide range of skills and backgrounds, made many valuable inputs into the design of the App. For example, the inclusion of the production calculators precipitated from one of the discussions of the Reference Group. Even the layout of the App was changed due to feedback from the Reference Group. The Reference Group was a very important “sounding board” for the project team and it provided valuable advice and input.

3.5 Conclusion

Field testing Buna, getting input from the farmers was an important step in the development of the App. The testing of the App was conducted both by the research team from Rhodes University and a more in-depth fieldwork by a student (Ms Mothapo) from the Aquaculture Research Unit at the University of Limpopo.

In the study conducted by Ms Mothapo, 18 farmers in the Vhembe region of Limpopo Province were visited, of which 14 agreed to test the App. The site visits to the farmers were conducted in December 2020, and these visits were coordinated through the Limpopo Department of Agriculture and Rural Development. During the first visit, a PowerPoint

presentation of the App was made, with a follow up meeting of the farmers after two weeks. During these two weeks the farmers were encouraged to use Buna so that they could provide feedback. Furthermore, during this two week period, the researchers were in contact with the farmers (by forming WhatsApp groups) to assist them if they faced difficulty when using Buna.

Of the 14 farmers that agreed to use Buna, 64.3% were male and 35.7% were female. Of the farmers surveyed, 64.3% were older than 50 years and only 21.4% were younger than 35 years. This could be a factor that would need to be considered when promoting and rolling out Buna amongst small-scale farmers, as generally younger people are more likely to use and online or digital platforms.

Literacy is a factor, when using Buna or, for that matter, any App or online platform. 14.3% of the farmers interviewed were illiterate and proficiency in the English language was a factor. Buna is presented in English, therefore there will be a need in the near future to translate Buna into the language that the farmers use. This point of view was shared by the farmers.

The cost of data is still a concern for farmers as is poor network connectivity. This is an issue that is bigger than the research project and it will need to be addressed at the appropriate levels of government. With that, 78% of the farmers surveyed expressed that Buna could be an effective tool to assist them with increasing production.

Buna is a new digital technology platform designed to assist small-scale farmers to increase production. The majority of small-scale farmers are in rural areas, where generally the penetration of the 4IR has been low and slow. It is therefore understandable that the uptake of Buna will not be instantaneous. Government will need to support the process of rolling out the App, knowing that it will take time and there would need to be a structured programme to support the farmers during this process. Critical to this process would be the role of the government extension officers. They should also be trained in using Buna, and in turn they could train and support the farmers.

4 CHAPTER 4 DEVELOPING THE FINAL VERSION OF THE APP

4.1 Developing the final version of the App

The final version of the App was developed in May 2020. This was after input from the farmers and the Reference Group was included in the App. The App has three (3) landing pages. Farmers, government officials and suppliers (of aquaculture services) log into the App differently. The main features for the three different users include:

4.1.1 Farmers' landing page

- Access to the manual, both in the original version (of 2010) and in the format developed specifically for the App, which includes links to other websites and YouTube video's related to the chapter title that is being searched.
- Access to the production calculators that will enable the farmers to determine expected yields from their ponds. Currently the production calculators are only limited to tilapia (which is what most small-scale farmers are growing).
- Access to the instant messaging system between the farmers and the extension officers.
- Access to a database that would allow the farmer to locate service providers (such as feed producers, hatcheries and farm machinery).
- Access to newsletters (from the FAO) and other news articles to be posted on the App.
- Access to a weather site
- Access to Zoom.
- Enable the farmer to upload production data.

4.1.2 Government landing page

- The government landing page has a Google map of South Africa, and each farmer that is registered with the App is a "pin" on the map. When farmers register, they are required to provide their GPS co-ordinates. The government official can then have a "bird's eye" view of all of the registered farms.
- When the farmer uploads their production data (monthly), this information is saved into an Excel spreadsheet and it can be further analysed. Some of the data that the farmer uploads can then be linked to the "pin" on the map, to provide the government official with a brief summary of that particular farm. For example, it could list what species is being farmed and total production to date.

- The government official also has access to all of the other services on the App that the farmer has.

4.1.3 The supplier landing page

The supplier landing page is similar to the landing page of the farmer, but the only input that the supplier can upload is to update the supplier database. This would be to list the services they offer, their location and their contact details.

4.1.4 The layout of the App

An important input from the Reference Group was around the layout of the App. It was felt that the App needed more icons to assist the users to navigate their way around it.

The services of a graphic artist were secured and icons (Figure 12) for the various features of the App and even the chapters for the manual were developed. These icons should make it easier for the users to navigate their way around. The icons also make it friendlier for a person with limited literacy to select the various features of the App.

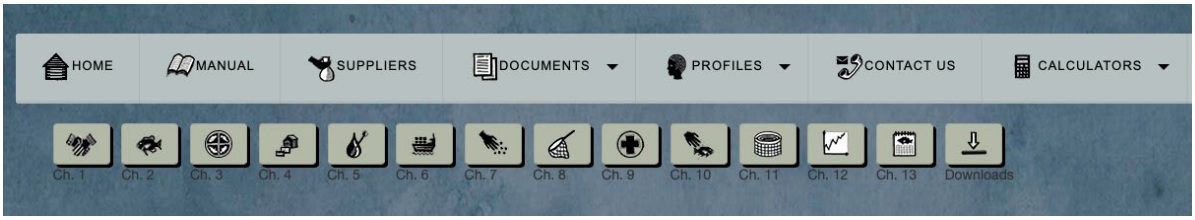

Figure 13. *Some of the icons developed for the App.*

Under the manual section, each chapter is represented by a relevant icon.

Soon after the lockdown started, it became evident that the App would also need a feature that would allow the farmers (and extension officers) not only to message each other, but also to allow them to meet virtually. The lockdown severely restricted travel and face-to-face meetings. To address this issue, in April of 2020, Zoom was embedded into the App. This was the last significant addition to the App. However, when indicating that the final version of the App has been developed, cognisance needs to be taken that technology is constantly evolving. Furthermore, the needs of the farmers are also constantly evolving and as such, the term “final” should be seen within the context of the research project and not in the broader development of the App.

4.2 Further Possible Iterations of the App

Aquaculture is driven by research and development. There will always be new information that is relevant to the farmer. Therefore, the contents of the App will always need to be updated on a regular basis. However, what changes in a more pronounced fashion is the method of conveying this information. For example, presently an App seems to be the most appropriate method for delivering this information to the farmer. Within a relatively short space of time, there could be new technology that would need to be considered. Currently there are possible iterations of the App that could be considered in the near future. These include:

- **Embedding Twitter and Instagram into the App**. One of the issues facing small-scale farmers is that they have limited pathways to advance their advocacy. The voice of the small-scale fish farmer in South Africa is not heard and it is important for the sector that farmers can articulate their views and project their voice. Twitter would greatly assist them to do so.
- **Creating a Facebook account for the App**. This will greatly increase the profile of the App, and it will also allow the farmers to use the Facebook account as a tool for their advocacy.
- **Expanding the production calculators to include other species of fish**. Presently the production calculator is limited to tilapia. It is envisaged that in the near future, the calculators could also be modelled to include trout and catfish.
- **Translating the App into other languages**. Presently the App is only available in English. For many small-scale farmers, English would not be their first language. There may be the need to translate the App into other languages, depending on which province / district is being targeted.

4.3 Research Gaps and Future Work to Further Develop the App

This App should be viewed not as a final destination, but rather as the beginning of a process that seeks to bring the fourth industrial revolution to small-scale fish farmers; a process to assist farmers to use technology, in all of its shapes and forms, to increase production.

The immediate research gaps and future work to further develop the App include:

- **Researching the impact of the App on production and management.** Developing the App was in important first step. However, the impact of the App to assist small-scale farmers to increase production and for government officials to better manage the sector would be an important research question. There is still a

lot of work to be done to better understand how and to what extent (and why) the farmers will use the App, and also equally important, how will government use the App to manage the sector and to make management decisions. This would be an important follow up research topic, as using Apps to solve these types of issues has not been done before in the South African aquaculture sector.

- **Including a fish health component into the App**. One of the biggest issues facing the sector is fish health. Fish health services is not accessible to many small-scale farmers, even though there may be state veterinarians who may be able to assist. Most of small-scale farmers are located in rural areas, geographically far from where state veterinarians may be stationed. Therefor the inclusion of a fish health component to the App could be beneficial to the farmer. The App could be designed to assist not only in providing relevant information to the farmer, but to also link the state vets into the App so they could provide advice in real time. It is proposed that this could be done with support of the World Organisation for Animal Health (OIE) and DEFF fish health specialists.
- **Further developing the visual layout of the App**. The visual layout of the App could be further improved. Many small-scale fish farmers in South Africa have limited literacy and, as such, there will be need to further develop the visual layout to make it even more friendly for these farmers. However, developing the graphics and visualisation to enhance the experience of users of limited literacy levels, is an area of specialisation. The project team has collaborated with the Graphics and Design Department of the University of Johannesburg, who specialise in this area, on a project relating to develop materials for small-scale fishers. It would be useful for further collaboration between the project team and the University of Johannesburg to continue to develop the visual layout of the App.
- **Updating the training manual**. The original manual that was developed in 2010 may need to be updated. This manual is presented on Buna. There have been a number of developments and new technologies in aquaculture since 2010 and as such, this new information will need to be included in the manual. In developing the new manual, it would be important to recognise that it would now be presented on an online platform, so the formatting and structure would need to recognise this.
- **Increasing the scope of the production "calculators"**. Presently, the production calculator is only for one species of fish. Further research could be undertaken to develop production calculators for different species of fish, not only for those farmed in South Africa, but also in the SADC regions. This would make Buna relevant to a much larger geographical area within SADC. Further to this, the scope of the

production calculators could be expanded to include a financial calculator. In this feature, the farmer would be able to input all of their income and expenditure. Buna would then be able to provide a financial statement to the farmers, monthly and annually. This feature would assist the farmers to determine their level of profitability and to identify where their major expenses are. With this knowledge, a farmer would then be able to determine which part of the farm operation would need to be streamlined. This type of data is of relevance to government as well. If they know what the major expenses are that a farmer faces, they can then make the necessary interventions to assist farmers to become more profitable.

- **Using Buna to manage ADZ's**. In recent years DEF has been promoting the concept of Aquaculture Development Zones (ADZ's). ADZ's are high priority aquaculture zones that DEFF promotes to meet certain economic and social objectives. The ADZ's are generally confined to a certain geographical area. Buna has a google map embedded in it, to assist DEFF to identify the location of farms. It would be an interesting research project to determine how Buna could be used to manage ADZ's.

5 RECOMMENDATIONS

The App was developed for two primary purposes: to assist small-scale farmers to increase production and to provide a tool for government officials to make better management decisions (based on farm production data that the App would be providing). Using an App in South Africa's aquaculture sector is new. The recommendations to take this process forward are:

- **Rolling out a pilot phase**. The next logical step in developing Buna is to implement a pilot rollout phase. Although there was engagement and field trials with small-scale farmers during this research and development phase, it is not enough. If Buna is to become a national online platform to assist small scale farmers to increase production and to be used across all provinces by the various provincial departments of agriculture (and DEFF), there would need to be a dedicated and separate project to pilot the rollout of Buna. A stand-alone project to pilot the rollout of Buna would be relevant, as it would provide a structured process for Buna to be presented to various provincial departments of agriculture and for Buna to become integrated within their reporting and functioning structures. Currently Buna has not yet been formally adopted by a provincial department of agriculture (nor DEFF). If Buna is to become a national online platform tool, then this process is required. Furthermore, it needs to be recognised that government processes are slow. For Buna to become accepted and integrated by a government department, it requires a process. In the process to pilot Buna, this could then be one of the objectives of the project: to engage with various relevant government departments to initiate the process for Buna to be formally adopted. Another need to pilot Buna is to test the App over a longer period of time and at a larger scale. During the current research and development phase, this was not possible, due to resource and time constraints, and the primary objective was to develop Buna. Developing an App like Buna is complicated as it has many features and functions. It is only when Buna is rolled out over a longer time period and across a large area that it is possible areas that need to be strengthened can be identified. For example, one of the critical areas of Buna is the role of extension officers. When farmers fill out the monthly production forms that are then submitted via Buna to the relevant provincial / national department of agriculture, the data in the forms need to be "ground truthed". If farmers (for whatever reason) are not submitting reliable and accurate information, Buna as an App, cannot determine if the information is accurate. It requires an extension officer, who is on the ground and familiar with the farm in question, to verify that the information that the farmer has submitted is accurate. For this interaction to work (between the farmer, the

extension officer and Buna), requires a certain level of coordination, and this is precisely why a rolling out phase is required. Buna is essentially a “disruptor”. It is a deviation from how farmers, extension officer and their managers have operated and brings in a different way of reporting and managing the sector. As such, there is a need for a pilot project to rollout buna.

- **Continuing with the research and development of the App**. Buna is the first online platform in South Africa that is dedicated to the aquaculture sector. In other countries, such as India, this form of technology has already been used for a number of years. There is also no question that the growth and development of the aquaculture sector in South Africa will need to include the use of Apps and the IoT. One of the stark lessons of Covid-19 has been that individuals or entities on the wrong side of the digital divide will struggle to integrate into the main economy. As Buna is the first online platform in South Africa dedicated to aquaculture, there would be a need to ensure that there is a parallel and continuous process to enhance and develop Buna. The aquaculture sector and indeed the digital sector is not static. It is constantly changing and evolving, and as such Buna must also constantly evolve and develop not only to meet the demands of the farmers but also to incorporate new and improved technology in its operation. To expand on this point further, internationally the research field in aquaculture is exceptionally active and dynamic. There is constant research to improve the quality of feed, make it more affordable, improve the efficiencies of production, new genetics and so forth. All of this information needs to be packaged to the farmers in a way that is accessible to them. Therefore, how this information is presented to the farmer on an online platform in an accessible way, requires research and development. Furthermore, the IT technology around the development of online platforms is also constantly changing. Digital systems are always changing and to add to that complexity is that users are also have their preferences. For example, in recent years, Instagram has become very popular, therefore it could be entirely possible that at a certain point Buna may also have to incorporate Instagram. Considerations when developing Buna have been the cost of data and the fact that internet speed in rural areas is not always particularly fast. However, government has committed (by engaging with the private sector) to decrease the cost of data and increase the coverage of 4G / 5G accessible to a larger area of South Africa. With Covid-19 this need has been prioritised and when this happens it will open many new possibilities around the features and capabilities of Buna. To develop this would require ongoing research. Until such time as 4G / 5G becomes a reality in the rural areas, there is still research that could be undertaken to improve and develop the digital components of Buna.

- **Securing support from DEFF.** Buna has been designed and developed as a tool to assist small-scale farmers to increase production and for government to develop and manage and the sector. The use of Buna for the farmers is at no cost to the farmers. The majority of small-scale farmers are poor and as such if Buna was based on a subscription model, they would not be able to pay for it. However, running Buna has direct costs, such as hosting Buna on a server, ensuring that the security of Buna is maintained (hacking is a constant threat to all online applications), updating the contents, and the regular maintenance and operations of Buna. Therefore, to ensure the long-term viability and sustainability of Buna it would be important that DEFF adopts the App as a national online platform. By adopting and supporting Buna, DEFF in return would get a service. The farm production data that DEFF needs to manage and develop this sector would now be available. Presently there does not seem to be a pathway for the farm production data that DEFF needs to manage the sector, to reach it. Therefore, Buna fulfils a real need of DEFF. DEFF has been part of the process to develop Buna, as they have been part of the WRC Reference Group. They have been aware that an objective of the development of Buna has been to have it adopted by DEFF. There has already been engagement between Rhodes University, the WRC and DEFF to explore the pathway for DEFF to adopt Buna. However, these engagements have so far been inconclusive and to date there has not been any formal response from DEFF on the way forward. It is therefore recommended that a dedicated process between Rhodes University and the WRC be undertaken to achieve this objective. These types of engagements are generally not quick or straightforward, but will require a dedicated approach, that may need to be funded. The engagement may need to commence at an executive level and lead to getting support for Buna at a high level. Once this has been achieved the discussion can then be taken the senior managers at DEFF to determine the more practical details of how DEFF will function this decision. It is of strategic importance that Rhodes University and the WRC undertake this process together. Buna can become a leading online platform for small-scale fish farmers, not only in South Africa, but in the SADC region. Buna can showcase the ingenuity of South African researchers to develop technology that is relevant to the region. However, for Buna to be adopted in the SADC region, it would be important that it is also used by DEFF in South Africa.
- **Presenting Buna to SADC (Southern African Development Community).** The logical progression for the growth of Buna is for it to be adopted in the SADC region. Although the Buna App was developed in South Africa, it is applicable and relevant in the SADC region. The issues that both small-scale farmers and governments face is

cross-cutting across the region. Small-scale farmers across the SADC region have difficulty in accessing technical information so that they can increase production, they are often isolated from other farmers, and have limited contact with their extension officers. Furthermore, like in South Africa, farm data does not seem to reach provincial or national level government officials. Without this data, government's ability to plan and develop the sector is limited. It is therefore relevant that Buna is also presented to SADC. To achieve this, Rhodes University and the WRC could approach the International Affairs office within DEFF to facilitate this. Presently the South African government has delegated a DEFF fisheries and aquaculture specialist to SADC. The process to engage SADC through the DEFF would, however, require the support and commitment of DEFF at the highest level. When engaging with SADC (through DEFF) and trying to get their support to roll out Buna in the region, a number of protocols may need to be observed. It is therefore possible that this process would require a significant period of time to complete and possibly extra resources as a number of meetings may be required. Furthermore, building a partnership with SADC could also be a pathway to expand Buna to the continent. Through SADC, links could be made with New Partnership for Africa's Development (NEPAD), which is now part of the AU. Buna would be addressing some of the key issues identified by the NEPAD's Comprehensive Africa Agriculture Development Programme (CAADP) (with regards to assisting small-scale farmers grow and develop). A key partner to SADC in developing aquaculture in the region is the World Fish Centre (WFC). They would be the logical partner in this process. The WFC has developed a new strain of tilapia, known as the Genetically Improved Farm Tilapia (GIFT). This strain of tilapia is a fast grower with good feed conversation ratios (FCR). GIFT is used in Africa and as such this strain of fish could be included in the production calculators of Buna.

6 CONCLUSION

In 2010, Rhodes University, with funding from the WRC, developed a manual for small-scale fish farmers. The technical manual was aimed to provide both small-scale farmers, as well as the extension officers, with a broad technical base. The manual was used widely, both by farmers and by extension officers. The manual was also used as a training resource.

The manual, in its printed format, had limitations. It was expensive to print (as it included colour photographs), it was "text heavy" and once printed, further additions or information could not be included. Furthermore, to fully engage with the manual, it required a certain level of literacy and numeracy. On this basis, the research project to develop a web-based App around the manual was initiated.

The App made accessible to small-scale fish farmers not only the original manual developed in 2010, but also a condensed version of the manual (so that it easier to interact with on a hand-held device, like a smart phone). This condensed version had links to other websites (if the farmer wished to further research the subject matter they were searching) and links to relevant YouTube videos. For example, if the farmer was searching on how to spawn tilapia, they could read about it, or / and watch a YouTube video of a small-scale fish farmer demonstrating it.

The App also includes an inbuilt messaging system (like WhatsApp), to enable and encourage farmers to exchange ideas and to stay in touch with their local extension officers. Another prominent feature of the App was the inclusion of a "production calculator", currently limited for tilapia pond production. This feature allows a farmer to enter the age of the fish into the App, and the production calculator then calculates what the expected length and weight of the fish should be. This feature of the App, is possibly one of its most important components, as most small-scale farmers are not able to determine the growth rates of tilapia in their ponds, a basic parameter that every farmer should know.

The App was also designed to enable fish farmers to submit their monthly production data, which would then be accessible to provincial and national government officials. When a farmer chooses to participate to use the App, they would be required to provide the GPS co-ordinates for their farm. This information can then be accessed by government officials on a Google map and by means of an Excel spreadsheet. This monthly production data could assist government officials to monitor the sector and enable them to make policy and management decisions based on real time production data.

In the future, The App could be expanded to provide a more comprehensive portal to the farmers, and could include a section on fish health, and the App could also be made available in local languages. There could be further work to “soften” the appearance of the App, to make it visually more relatable to the users.

The App has potential to become an “every day” tool for small-scale fish farmers to increase production and for government officials to use the farm production data to make informed decisions with regards to management and policy decisions. However, for the App to realise this potential, it needs to be piloted. Developing and testing an App within a research and development phase is not the same as piloting in a “real world” scenario. To get buy-in from farmers and government, the App needs to be seen performing in “real life” conditions. Furthermore, the piloting phase should also be twinned with a process in which DEFF is involved and their participation should be linked to a process to determine how DEFF (after the pilot phase) would adopt the App as a national tool. For the future of the App, the role of DEFF would be a significant component.

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8 Appendix I: Questionnaire used by Rhodes University

Questionnaire Form

Section 1

Date	Location
Name of Government Extension Officer	Name of fish farmer
Number of person administering the questionnaire	Comments

Section 2

1) Describe your farming operation (e.g. how many years, species of fish, type of farm, production, sales)
2) What are some of the challenges you face (e.g. access to information / support, markets, access to feeds, access to markets, low production / high input costs)
3) What features in a smart phone App would be of use to use (e.g. contents, data costs, features of the App)
4) What are your thoughts on the App developed and how can it be improved (e.g. contents, data costs, features of the App)
5) Do you have any other comments / questions

9 Appendix II: Questionnaire used by the University of Limpopo

The purpose of this questionnaire is to gather all the information and answers from the farmers regarding the Buna Africa web-based App. Please read all the questions carefully. Your answers have worth for me and please keep your responses confidential.

1. Gender

A. Male B. Female

2. Age

A. younger than 35 B. 35-45Years old

C. 45-50 D. Older than 50

3. How well do you understand English?

A. I do not understand English. B. I understand a bit.

C. I understand English very well

4. How do you access internet?

A. Phone B. Other

If other, please state how _____

5. Do you have access to a laptop?

A. Yes B. No

6 .Is Aquaculture your only source of income?

A. Yes B. No

7. Have you heard about the Buna Africa web-based App before?

A. Yes B. No

If yes. Where have you heard about this App? _____

_____

8. What are some of your thoughts about the Buna Africa web-based App?

_____

_____

9. Would you say you are satisfied with this App?

A. Yes B. No

If yes, what are you satisfied about? _____

_____

If No, why are you not satisfied and what can be done to change those things?

_____

_____

10. Are the any other recommendations that you have or suggestions that you would like to make? _____

_____

11. Do you think this app can be a useful tool to provide fish farmers with technical information to increase production and to connect farmers to other farmers?

A. Yes B. No

Why? _____

_____

12. How likely are you to recommend this App to other farmers?

A. Unlikely B. Likely

C. Moderately likely D. Very likely

13. Is there anything that we have not touched on that you would like to know about this App?

_____

14. What are some of the challenges that you have experienced as a fish farmer while trying to access the App?

_____

_____

_____

_____