Addressing Accessibility of Online Platforms for Low-Literacy Users in Small-Scale Aquaculture

Report to the
Water Research Commission

by

A Haese[3], Q Rouhani[1], N Mabasa[1], B Trollope[2], C van Zyl[2] & P Chisenga[4]
[1] Rhodes University
[2] University of Johannesburg
[3] University of Pretoria
[4] Buna Africa

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“We must develop a comprehensive and globally shared view of how technology is affecting our lives and reshaping our economic, social, cultural, and human environments. There has never been a time of greater promise, or greater peril.”

- **Klaus Schwab**, *Founder and Executive Chairman*, World Economic Forum

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EXECUTIVE SUMMARY

Globally, the aquaculture sector contributes approximately half of total fish production. It is now the largest animal production sector. In Africa, aquaculture is also growing and developing, and the nature of the sector is also changing. In the 70s, and 80s, aquaculture was largely driven by international donor agencies as a subsistence activity. This is no longer the case; fish farmers in Africa are motivated by production and profit – like the rest of the world.

With this shift in African aquaculture, which is now commercially orientated, farmers want information and services in real time. With this shift, digitisation efforts are needed to improve productivity and efficiency and contribute to the sustainability of the aquaculture sector. Digital technologies are being employed across various value chain stages, from hatcheries and processing to marketing and distribution. These technologies are being employed for functions such as data collection, monitoring and control, marketing, capacity building, extension services and governance. Present digital solutions are fragmented; there is, therefore, a need for a single digital platform to provide a “one-stop” solution for fish farmers.

To meet the needs of fish farmers in South Africa, Rhodes University in 2021 developed an aquaculture online platform, called Buna Africa. Buna had two objectives; firstly is was to provide technical support and services to farmers in real time, and secondly, it was to provide a digital pathway for farmers to submit their production data to government. While the rationale for providing technical support to farmers is clear, the rationale for them submitting their production data is not always apparent. In a world where data is the new currency, the importance of aquaculture production data cannot be underestimated. Without reliable production data, government’s ability to make informed policy decisions and manage and develop the sector increasingly diminishes.

In 2021, when Buna was developed, the priority was on the functionality and stability of the platform. It was however recognised that many small-scale farmers who are largely in rural areas may have low digital literacy. Therefore, their ability to use Buna effectively and to its full potential was questioned. Therefore the primary objective of this research study was to design the User Interface (UI) and User Experience (UX) of Buna in a way that users with low digital literacy could effectively engage with this platform. Recognising that the success of Buna Africa is dependent on farmers being able using this platform it therefore became critical to undertake this research. This research study was an intersection between aquaculture, design, and software development.

The scope of the project was to engage with small-scale fish farmers in the Thohoyandou area (Limpopo Province). These farmers were selected as the research group had previously worked with them in the development of Buna itself, therefore they were familiar to the platform. Through participatory action research principals, farmers inputs were incorporated into the design of Buna.

The Buna Africa project aims to integrate fish farmers into the Fourth Industrial Revolution (4IR) through a digital platform tailored to their needs. Recognizing the importance of skills development in aquaculture, particularly for small-scale farmers, the project seeks to enhance farmers' understanding of fish production and improve their productivity and profitability. However, many fish farmers reside in under-resourced rural areas, and also have low literacy levels and/or digital skills, highlighting the need for accessible knowledge and information. To address this challenge, an interdisciplinary project was initiated involving collaboration between the Department of Ichthyology and Fisheries Science at Rhodes University, Graphic Design at the University of Johannesburg, and Information Design at the University of Pretoria. The primary objective is to enhance the Buna platform's UI design and scientific information.

The research explored user and stakeholder perceptions of Buna, identifies necessary formats for easy access to the platform, and investigates design improvements to facilitate engagement and understanding of its content. Recognising the importance of designing for users with low literacy, the project employed participatory design methodologies to ensure the platform is inclusive and user-friendly. Additionally, the project explored how participatory design can empower local communities to actively participate in the 4IR, positioning Buna as a case study for strengths-based community engagement in digital development.

This project used a qualitative research approach, employing participatory design, design thinking, and human-centered design principles. Participatory design, rooted in Scandinavian research, explores tacit knowledge, enabling mutual learning among participants. It involves users and designers in collective reflection and action, ensuring designs are practical, usable, and culturally relevant. Design thinking, popularised by Stanford's d.school is a human-centred innovation approach emphasizing empathy, creativity, and rationality. It involves iterative modes like empathy, defining, ideating, prototyping, and testing to develop solutions.

The research team comprised aquaculture specialists and graphic designers, and engaged with fish farmers and one extension officer to improve the Buna platform's accessibility and engagement. Through participatory sessions, including focus groups and site visits, feedback was collected on the platform's usability and relevance to daily business practices. The iterative design process involved developing low to high-fidelity prototypes, integrating user feedback, and refining the platform's design and functionality. Data analysis methods included transcription, document analysis, and thematic analysis to comprehensively understand user needs and experiences.

Ethical clearance and informed consent were obtained from all participants. The project aimed to empower users by incorporating their insights into the platform's design, fostering a sense of ownership and community engagement. By leveraging participatory design methods, the project sought to create a platform that addresses the unique needs of small-scale fish farmers, contributing to sustainable and inclusive digital solutions in aquaculture.

The ongoing development of the Buna platform, designed to aid small-scale fish farmers, has seen significant improvements based on farmer feedback. Farmers' tacit knowledge has been pivotal in shaping the platform's tools for maximum accessibility, notably seen in the calculator tool's evolution and instructional videos' creation.

Key findings emphasise the value farmers place on technical information access and community building within the platform. The platform's potential to facilitate positive communication between farmers and officials was also highlighted. Farmers expressed interest in customising content, signalling the importance of co-designed solutions tailored to local needs.

The main finding from this project is that the participatory design process underscores the importance of user engagement in developing platforms that address diverse user needs. Looking ahead, we propose leveraging participation design methods to empower communities in the African context, ensuring that digital solutions are developed with, rather than for, the communities they serve. This approach fosters sustainable, inclusive development driven by community input, promoting culturally relevant solutions that empower users in the Fourth Industrial Revolution.

The innovation that this research study centred around was how to develop appropriate UI and UX for users with low digital literacy. As digitisation becomes increasingly adopted within the aquaculture sector, the findings of research study will have far reaching implications. Central to this research study is the innovation within Buna. Many of the functions in Buna offer novel solutions to challenges that have persisted in the aquaculture sector. This study also provided innovative ways to solve a central question, how to make digital platforms accessible to users with low digital skills. Through UI, graphics and some AI, this study was able to address this question

The study proposes future research into the following areas. Developing a function in Buna that connects farmers to fish traders. A function that enables farmers to manage their water quality. The ability for farmers to create their own content, this is important as farmers also have a knowledge base. Developing a function that connects farmers to researchers. Cross cutting all of these proposed research topics is the inclusion of Artificial Intelligence (AI) in Buna. The capabilities of AI is constantly increasingly and it is clear that it is possibly becoming the most important innovation in this digital revolution. Therefore, the inclusion of AI in Buna in a logical growth path for this platform to remain relevant to the sector.

The new knowledge this research project has created is in relation to the use of digital platforms to support small-scale fish farmers and in the design of UI and UX in making these platforms accessible to farmers with low digital literacy.

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Focus Group Members

Dr SN Hlophe-Ginindza	: Water Research Commission (Chairperson)
Prof. NS Mpandeli	: Water Research Commission
Dr L Nhamo	: Water Research Commission
Ms Mpho Kapari	: Water Research Commission
Dr Chantal Ramcharan-Kotze	: Water Research Commission
Dr C Fouche	: Department of Forestry, Fisheries, and the Environment
Dr H Hlungwani	: Department of Forestry, Fisheries, and the Environment
Dr Esau Mbokane	: Department of Forestry, Fisheries & the Environment
Mr K Sankar	: Operation Phakisa of the Department of Forestry, Fisheries, and the Environment
Prof. Mafaniso Hara	: University of the Western Cape (PLAAS)
Dr Joseph Sara	: University of Limpopo

Project Team

Mr Q Rouhani	: Rhodes University (Project Leader)
Dr N Mabasa	: Rhodes University
Dr A Haese	: University of Pretoria
Ms C Van Zyl	: University of Johannesburg
Ms B Trollope	: University of Johannesburg

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LIST OF ABBREVIATIONS

4IR	Fourth Industrial Revolution
AgriSETA	Agricultural Sector Education Training Authority
AI	Artificial Intelligence
API	Application Programming Interface
AWS	Amazon Web Services
BFH	Buna Fish Health
CSS	Cascading Style Sheets
DFFE	Department of Forestry, Fisheries & Environment
DIFS	Department of Ichthyology and Fisheries Science
DO	Dissolved Oxygen
FAO	Food and Agriculture Organization of the United Nations
HTML	HyperText Markup Language
ICT	Information and Communication Technologies
IoT	Internet of Things
RFP	Rural Fisheries Programme
SADC	Southern African Development Community
SARNISSA	Sustainable Aquaculture Research Networks in Sub-Saharan Africa
UI	User Interface
UJ	University of Johannesburg
UNESCO	United Nations Educational, Scientific and Cultural Organization
UX	User Experience
WOAH	World Organisation for Animal Health
WRC	Water Research Commission

1. CHAPTER 1: INTRODUCTION

1.1 Background and Context

According to the Food and Agriculture Organization (FAO) of the United Nations, aquaculture is the fastest-growing animal production sector (www.fao.org). This sector is expected to continue expanding due to the increasing demand for fish. However, aquaculture production is not evenly distributed across the globe. In 2020, Asia accounted for 70% of all global fisheries and aquaculture production, while Africa accounted for only 7%, despite the continent's favourable conditions (FAO, 2022).

One potential explanation for the notable contrast in fish production levels between Africa and Asia may lie in the varying technical capabilities of fish farmers (Rouhani and Britz, 2004). Aquaculture demands a high level of technical proficiency for success, necessitating farmers to possess adequate skills and training. Addressing this issue, the Agricultural Sector Education Training Authority (AgriSETA) in its 2021 report underscores the significance of skill development within the aquaculture sub-sector for the years 2020-2021. The report delineates several significant challenges impeding the growth of aquaculture, including restrictive regulations, limited land accessibility, skill deficiencies, financial constraints, disjointed marketing strategies, and competition from low-cost fish imports (AgriSETA, 2021). These barriers serve as obstacles to the expansion of the sub-sector. Moreover, the report underscores the pivotal role of training initiatives in overcoming these challenges by identifying scarce skills, bridging training disparities, and enhancing the competencies of aquaculture professionals. This emphasis on capacity-building endeavours aims to unlock the sector's latent potential, foster job creation, and bolster support services (AgriSETA, 2021).

Capacity building should also take into consideration the Fourth Industrial Revolution (4IR) a term which encompasses various technologies anticipated to revolutionize people's lifestyles, professions, and recreational activities (Schwab, 2017). Technologies falling within the ambit of 4IR include the Internet of Things (IoT), robotics, artificial intelligence (AI), autonomous vehicles, and 3D printing. Graham (2016 in Cowie *et al*., 2022) notes that although each of these technologies holds significant power individually, their combined integration is anticipated to cause substantial changes in people's daily lives, and ultimately sets it apart from the previous digital revolution.

The increasing use of digital technologies in Africa promises an opportunity to transform the aquaculture industry, improve efficiency and increase the use of sustainable and best practices (AUDA-NEPAD, 2022; FAO, 2022). Digitisation is the use of digital technologies and data-based approaches to improve productivity, efficiency and sustainability of the aquaculture industry (Aghaji *et al*., 2023). It is easy to see how the aforementioned capacity building requirements could be improved through digital intervention, though, for example online training platforms, by providing easy access to

information and ways to connect fish farmers to other networks of practice. As such aquaculture digitisation promises to be a way in which the sector can be moved forward.

There are however challenges that would need to be addressed before its potential can be fully realised. One of the biggest challenges facing digitisation in Africa is poor internet connectivity, especially in rural areas. Many small-scale aquaculture farmers reside in rural areas might be excluded from digitisation efforts (Hinrichsen *et al*., 2022). Compounding this issue, is limited electricity and access to digital technologies in rural areas. To ensure that small scale farmers in rural areas are included in these efforts, there needs to be greater effort by government to include these communities into the 4IR.

The shift from subsistence to more commercial farming in recent years prompts both farmers and government administrations in Africa to implement more efficient systems in terms of data collection and record keeping (AgriSETA, 2021, Avadí *et al*., 2022). As the industry continues to grow more efficient systems for data collection need to be employed (Fonda *et al*., 2021). This will help government to make data-based decisions with regard to providing access to land, water and fish health and welfare services. The data will also help government with informing policy, legislation and management of the sector. Aquaculture digitisation would therefore serve both farmers and government.

Despite connectivity issues, and the fact that many rural areas of South Africa remain underserved (Mubangizi, 2023), South Africa is still in the process of improving its technological infrastructure and lowering costs of data and mobile devices, combined with widespread connection availability through services such as free inner-city Wi-Fi[1], mean that the developments of solutions to meet the needs of South African fish farmers is a worthy endeavour. Given the ongoing progress in digital technology and the increasing prevalence of smartphone usage – especially in South Africa, it is imperative to explore mobile-focused solutions to promote broader, more democratic development of digital solutions. According to Jones and Hafner (2002), digital texts and screens consistently incorporate multiple modes of information, including audio, video, and interactive hyperlinks, a capability unavailable in analogue media technologies. This convergence, combined with the widespread adoption of smartphones worldwide, underscores the necessity for cities to ensure the digital integration of citizens into the broader societal framework (De Waal, 2014). Digitisation of aquaculture in Africa aims to be a way to equalise the continent to the rest of the world. For fish farmers, the use of digital technologies may be a way to help improve productivity and reduce running costs. Coupled

1 The South African government has shared its intentions to set up free public Wi-Fi hotspots in low-income and rural areas. The former communication minister, Khumbudzo Nthsavheni, highlighted the significance of digital inclusivity and acknowledged that data has become as vital as water and electricity in our homes (Illidge, 2022).

with the general growth of aquaculture on the continent, digitisation can help accelerate this positively and empoweringly. This is what Buna Africa set out to achieve.

1.2 Buna Africa, the Development of an Online Aquaculture Platform

In 2010, The Rural Fisheries Programme (RFP) of the Department of Ichthyology and Fisheries Science (DIFS) of Rhodes University (South Africa) developed an aquaculture manual (A Manual for Rural Freshwater Aquaculture (TT463/P/10)) that was aimed to provide technical support for small-scale fish farmers. It was recognised that many fish farmers lacked technical knowledge and support services, which hindered their ability to increase production and grow.

The manual was used widely by farmers and, by extension, officers as a resource, not just in South Africa but in the wider Southern African Development Community (SADC) region. The manual included technical information relevant to small-scale fish farmers, and it was also presented in a way that was easy for farmers to engage with. The manual was presented similarly to the FAO training manual. In as much as the manual was useful, it had limitations. Printing the manual in full colour was expensive, and it needed many revisions as new information became available. This was also costly. Furthermore, with the growth of the internet, farmers, like the rest of society, shifted away from “hard copies” to “soft copies”. Therefore, in 2017, the RFP successfully proposed to the Water Research Commission (WRC) to develop an online platform through which farmers could access this manual. The advantage of using an online platform is that the manual is easily accessible, it can be updated regularly, and it would not incur the printing costs associated with releasing subsequent, updated versions. This platform was called Buna Africa (www.bunaafrica.org). Buna, in Sepedi, means *to harvest*.

Buna Africa started as an online manual for fish farmers but has since expanded to offer more features to enhance its benefits. The objective of Buna is to address two challenges facing the aquaculture sector:

1. To develop a platform that would provide fish farmers with services and functions that would enable the farmer to increase production, reduce transactional costs and become more successful. To develop a digital ecosystem for farmers that was easy to use, intuitive and evolving with the needs of the farmers.
2. To provide a pathway for farmers to submit their production data to the government. The dearth of production data that many governments face is a serious constraint when developing policy, management, and development plans for the sector. Without production data, such as where the farmers are located and what they are producing, it becomes very difficult for policymakers to make informed decisions.

What differentiates Buna from other online platforms in the aquaculture sector is its ability to create a conduit between farmers and government officials. This two-pronged solution, which is to provide services to farmers and also for farmers to submit their production data, is a first of its kind.

In the design of Buna, it is recognised that for fish farmers to submit their production data to the government, in return, it would be necessary to provide services to farmers. Otherwise, farmers would not be incentivised to submit their production data. This is an essential and often overlooked factor by the government. Fish farmers need to see that if they are required to submit their production data to the government, in return, there should be an exchange for some form of tangible services and benefits. Buna does that; it provides fish farmers who use this platform several services and functions. Data is the “new currency”, and its importance cannot be overlooked or understated. Without (production) data, governments cannot plan and develop the sector and effectively operate in the dark. Therefore, this component of Buna will always be prioritised for development and refinement. It is important to mention that when farmers submit their production data, it is not “lost” to them. All data that farmers submit can also be seen and accessed by the farmers. The farmers can also use this data, therefore, be also used by the farmers to evaluate their production and manage their business.

Some of the main features in Buna1 included:

- Access various aquaculture manuals, including the 2010 Rhodes University / WRC manual.
- Links to YouTube videos on aquaculture topics relevant to African fish farmers.
- Real-time messaging system similar to "WhatsApp" connects farmers and extension officers with the potential for themed chat groups.
- Weather service integrated into Buna, displaying forecasts and current conditions based on farm location.
- Posting relevant information and documentation such as funding calls and government notifications.
- Inbuilt fish production calculator for Nile tilapia, with plans to expand to other species.
- Service providers list their offerings on Buna, allowing farmers to connect directly.
- Buna Fish Health (BFH) facilitates diagnostics and connects fish farmers with state vets and laboratories.
- Farmers submit real-time production data to government officials, visible on Google Maps.
- Government officials can export production data from Buna for further analysis.

1.3 Problem Identification

There has been a global effort to incorporate fish farmers into the Fourth Industrial Revolution (4IR). In countries like India, numerous dedicated apps have been developed for fish farmers and fishers, with over 30 available apps (Dhenuvakonda and Sharma, 2020). Buna Africa aims to fulfil a similar role on the African continent. As noted earlier, the focus on skills development in this sector, as

highlighted by AgriSETA (2019), emphasises the importance of training existing small-scale farmers to enhance their understanding of fish biology. This training aims to improve the productivity and profitability of their businesses. To avoid complications resulting from unsound advice, agriculture extension officers must possess adequate knowledge of aqua farming, as they often serve as the primary point of contact for freshwater farmers with limited resources (AgriSETA, 2019). Many fish farmers reside in under-resourced rural areas. Access to knowledge and information is crucial for empowering such communities (Rahman and Fukuda, 2015). AgriSETA (2019) emphasises the significance of getting the basics right in pond farming to avoid being stuck in a cycle of low productivity.

However, the initial development team recognised the need for improved access and comprehension of Buna's content among farmers with low literacy and limited digital platform experience. According to the United Nations Educational, Scientific and Cultural Organization (UNESCO), literacy extends beyond traditional skills like reading and writing. It is now viewed as a means of identification, understanding, interpretation, creation, and communication in a digitally driven-and information-rich world (Khuluvhe, 2021). recognised Computer literacy has been recognised and promoted in South Africa as a form of literacy since at least 2014 (Walton, 2014). Additionally, the use of multimodal ensembles[2], such as smartphones, is becoming more prevalent in everyday digital communication (Taylor, 2023).

To address this, an interdisciplinary project involving collaboration between the DIFS at Rhodes University, Graphic Design at the University of Johannesburg, and Information Design at the University of Pretoria was initiated, with the primary objective to enhance both the user interface design and scientific information of the platform. User Interface design refers to creating visual and interactive features within software or digital platforms. Its purpose is to improve user experience and usability by developing interfaces that are visually appealing, easy to navigate, and encourage engagement. Key emphasising UI design elements include emphasising user-friendliness, presenting information, ensuring consistency across design components, and being responsive to user input. (Interaction Design Foundation, 2023a).

The research explored the following aspects of the Buna platform:

1. *User and stakeholder perceptions*: Assessing Buna's current perceptions regarding its ease of use, accessibility, and understandability.
2. *Required formats*: Identifying the necessary formats to enable easy access to the Buna platform.

[2] A multimodal "ensemble" refers to a text incorporating various modes, including painting, illustration, photography, written language, diagrams, and visual design elements (Serafini, 2010).

3. *Design improvements*: Investigating how the User Interface of Buna can be enhanced to facilitate easier access, engagement, and understanding of its content.

Literature reveals that designing for users with low literacy is a balancing act between designing for their needs without alienating more technologically skilled individuals. Participatory design methodologies are recommended as being an effective means of designing digital solutions. More broadly, the project also investigated how participatory design can be viewed as a strengths-based and proactive way to engage with and involve local communities in developing systems that will allow them to actively participate in 4IR using this as a case study.

1.4 Aims, Objectives and Research Questions

The project aimed to use participatory design to improve the access, engagement and understanding of the Buna platform.

The following research questions guided this research project's participatory section:

- What are the Buna platform's current user and stakeholder perceptions regarding ease of use, accessibility, and understandability?
- What online formats are required to allow easy access to the Buna platform?
- How can the design of the Buna platform allow for easier access to, engagement with and understanding of its content?

Members from Rhodes University, the University of Pretoria, and the University of Johannesburg formed part of the research team but were also viewed as stakeholders in the participatory design process, as they developed the Buna platform or acted as designers in the project. As such, the project included three key stakeholder groups: fish farmers and one extension officer (users); aquaculture specialists (from Rhodes University); and graphic designers, or the ‘design team’ (from the Universities of Pretoria and Johannesburg). The aquaculture specialists constituted the team that developed the Buna platform.

2. CHAPTER 2: LITERATURE REVIEW

This literature review is linked with the digitisation/the use of digital technologies for aquaculture in Africa.

2.1 The Use of Digital Technologies in Aquaculture

In the process of digitisation, different digital technologies used in different aspects of aquaculture are combined. These fields include production, farm management, financial services, marketing, research, and development (FAO, 2022; Obiero *et al*., 2017). The expansion of aquaculture is growing in Africa due to favourable climates, abundant water resources, entrenched fish consumption traditions in certain communities, and aquaculture expertise. However, persistent challenges such as low productivity, limited market access, and sustainability concerns (Madibana *et al*., 2020; Adeleke *et al*., 2021) underscore the need for innovative solutions. Harnessing digital technologies presents a promising avenue for overcoming these hurdles and unlocking the full potential of the aquaculture sector.

2.2 Initiatives Driving Aquaculture Innovation in Sub-Saharan Africa

As aquaculture blends traditional methods with new digital technologies, the industry has opportunities to boost productivity, sustainability, and market reach. Areas of aquaculture that can benefit from digitization include data collection, management and analysis, on-farm monitoring and control, market access, financial services, capacity building, information sharing and governance. There have been multiple initiatives towards digitising and creating platforms in Africa to promote technological advancements, economic growth, food security, and access to information. Some noteworthy digitisation initiatives and platforms that can be utilised in aquaculture are:

2.2.1 General African socio-economic initiatives

- Smart Africa Initiative and Africa 50

The Smart Africa Initiative (https://smartafrica.org/) is an innovative, collaborative effort among African leaders to accelerate the continent's socio-economic development through increased and affordable access to information and communication technologies (ICT).

Africa50 (https://www.africa50.com/) was developed by collaborating with African governments and the African Development Bank, aiming to bridge the gap between infrastructure funding and medium to large development projects. It supports projects related to water, ICT, energy, and transport, which could all contribute to agriculture and aquaculture growth.

Both these initiatives have the potential to contribute to digitizing different sectors of agriculture in Africa, as well as aquaculture.

2.2.2 e-Government strategies

The South African government is currently implementing e-government to deliver services (Jakoet-Salie, 2020). Tanzania has also attempted to use ICT to enhance the delivery of government services and broaden service availability to people (e-GA, 2012). The successful implementation of e-government strategies can be leveraged to simplify ease of access to policy, licencing and permit applications for aquaculture farmers.

2.2.3 Digital hubs and innovation centres

African cities such as Nairobi, Kenya, and Lagos, Nigeria, have digital businesses and innovation centres to support young entrepreneurs and technology start-ups (Business insider Africa, 2023). Such centres offer support mentorship, resources and funding for young entrepreneurs in many sectors like aquaculture.

2.2.4 Aquaculture specific initiatives

- SARNISSA

Channels for communication and information sharing that have been employed for aquaculture. Channels such as the EU-funded Sustainable Aquaculture Research Networks in Sub-Saharan Africa (SARNISSA), which aims to build a sustainable aquaculture network between Africa and Europe (LEAP4FNSSA, 2023). It shares news, media, publications, videos, employment and investment opportunities in aquaculture in English and French, reaching a wider audience.

- Farm management systems

The use of sensors and IoT devices in an aquaculture setting to monitor and record data associated with water quality parameters such as ammonia, pH, temperature and dissolved oxygen can help in analysing this data so that it can used to optimise growth conditions for fish. Systems such as those developed to remotely monitor water acidity, temperature, and turbidity levels using IoT have shown temperature monitoring success rates of up to 97.66% and acid base monitoring of 94.92% (Bachtiar *et al*., 2022). Other IoT systems are able to measure water quality parameters as well as fish growth in real-time, and give more accurate results than those obtained using hand-held probes (Rosaline and Sathyalakshimi, 2019). The use of these systems can also assist in detecting the early signs of disease and disease outbreaks. Real-time monitoring of water quality facilitates the implementation of

appropriate intervention strategies to minimize stress on fish, thereby reducing the likelihood of disease outbreaks and ultimately enhancing productivity (Rastegari *et al*., 2023).

Digital tools and devices can also be useful for farmers in tracking feeding schedules, fish growth rates and the overall performance of their farms (Rosaline and Sathyalakshimi, 2019). Data analytics tools can provide more information on patterns and trends, which can help farmers make data-driven decisions to improve performance. Smart, automated feeding systems are currently being used in many farms, such as those used for offshore at OceanFarmITS (Karningsih *et al*., 2021), and intelligent feeding based on machine vision (Zhang *et al*., 2023). The increase in these implementations will further assist in adjusting feeding systems based on real time data. This will help to improve feed efficiency and reduce feed costs for farmers. Using remote sensors that record and report real-time data allows farmers to make quick decisions and respond to issues, reducing risk.

Several digital technologies have been developed to improve the efficiency of day-to-day operations even in Africa. One of the examples is Kenyan farmers using internet-based sensors to monitor water temperatures in their cage farms. This software allows them to care for and feed their fish in Lake Victoria (Scidev.net 2019) more efficiently.

Applications such as AquaRech are used to send feeding instructions to farmers to help make their feeding schedules more efficient. Approximately 30 000 fish farmers across Kenya have used this application (Orozco, 2022).

The African aquaculture sector can greatly benefit from using and integrating digital technologies into conventional processes. Addressing issues related to digital literacy, access to information, and access to finance will be key in ensuring that the potential of digitisation is fully realised in African aquaculture.

- Financial inclusion efforts

The creation of inclusive digital payment and financing system can help to improve the financial access of most farmers, regardless of type and size of their operation. Systems such as mobile money and digital banking, which are currently being used in countries such as Uganda and Nigeria (World Bank, 2021), can help facilitate transactions. These systems enable users to send, receive and store money using mobile devices (AZA finance, 2024). This reduces the reliance on the use of cash and formal banking systems, facilitating the inclusion of those who were previously excluded. Over 60% of Africans have no access to banks and the use of mobile money services such as M-Pesa, Orange Money, MTN Mobile Money, and Airtel Money gives millions of Africans access to financial services that were out of reach for them, especially those in rural areas (AZA finance, 2024). In South

Africa, the Abalobi app attempts to fill the gap in small-scale fisheries and catalyse financial inclusion (https://fishwithastory.org/). This successful use of these platforms and implementation of others like them will have a positive impact on small scale aquaculture farming in rural areas of Africa.

Several efforts and initiatives have been implemented to improve financial inclusion through digital technologies. These include services such as M-Pesa in Kenya and mobile money in Uganda, Kenya, and Ghana, which are currently being successfully used by populations that previously had no access to such financial services (World Bank, 2020).

- Markets

Digital technologies can also help track the journey of aquaculture products from farm to market, similar to the system developed and used in China (Gao *et al*., 2019). These systems help to increase transparency, as well as identify and address issues that may arise in the supply chain. They can also be useful in optimising inventory, reducing waste, and ensuring that products are delivered timeously to marketplaces.

2.3 Designing Digitisation

Adib (2023) states that, Bottom of Form
“Designing is the art of creating something that is both functional and visually appealing. We design to communicate, express ourselves, and solve problems. Designing helps us to create products that are more efficient, effective, and user-friendly”. Design permeates every aspect of our lives. Whether consciously aware of it or not, it shapes our communication methods, decisions, and behaviour. Owen (2006) states that “Where the scientist sifts facts to discover patterns and insights, the designer invents new patterns and concepts to address facts and possibilities” … “the values of design tend to be ones associated with human needs and environmental needs created by or resulting from human actions”.

Design plays a pivotal role in the digitisation process. Digital solutions rely on interfaces for users to interact with. Such interfaces shape the user experience, product functionality, and overall effectiveness of a digital solution. Thoughtful design ensures that digital technologies are accessible.

As noted earlier, UI design enhances software or digital platforms by creating visually appealing, intuitive interfaces that facilitate efficient user interaction, drawing from principles in interaction design, visual design, and information architecture (useability.gov).

Martins (n.d.) writes that “The use of typography, symbols, colour, [sic] and other static and dynamic graphics are used to convey facts, concepts, and emotions. This makes up an information-oriented, systematic graphic design which helps people understand complex information. Successful visual

communication through information-oriented, systematic graphic design relies on some key principles of graphic design".

Designing and evaluating user interfaces is a complex task. The focus on UX demands user-centred processes that take considerable time and resources (Rossi *et al*., 2023). Key considerations in UI design include user-friendliness, clear information presentation, consistency in design elements, and responsiveness to user actions (Interaction Design Foundation, 2023a). The UI of a platform such as Buna becomes the first connection between stakeholders – in this case, farmers and government officials.

User interface is crucial for encouraging the initial adoption of new products. It improves usability, making it easier and more enjoyable for users to interact with a product or service. Efficient UI design enhances user productivity by simplifying tasks and reducing cognitive load across various digital platforms. Moreover, it plays a role in shaping brand perception, as visually appealing interfaces reinforce brand identity, while poorly designed ones may harm reputation. This is especially important when fostering liaison between users and government officials – as in the case of Buna. A well-crafted UI can attract and retain users, an important consideration for the longevity of a digital product or service. Additionally, an intuitive UI design minimises the need for extensive training and support, potentially reducing operational costs.

2.4 Artificial Intelligence in Aquaculture

Artificial Intelligence (AI) "involves programming that "facilitates recognition (images, languages, music, etc.) and decision making – without the need for human supervision" (Lutz, 2023). It is an exciting area offering much potential for digital solutions like Buna.

Regarding scientific value, Lutz (2023) states that "AI has become increasingly relevant in aquaculture research and production in recent years – with both start-ups and established companies developing new AI-based applications for the industry".

Artificial intelligence is currently being used in aquaculture for purposes such as water quality and fish behaviour monitoring (Lin *et al*., 2021), optimization of fish feeding (Capetillo-Contreras *et al*., 2024), as well as fish sorting and classification (Kuswantori *et al*., 2023)

Although generative AI is not a novel concept, its application in writing and design saw a significant increase in the year 2023. In graphic design, algorithms were utilised as early as 2017 to produce seven million distinct packaging designs for the Nutella Unica product line (Aouf, 2017). Marr (2023) writes that despite the promising nature of generative AI:

…there are challenges, too. One of the biggest will be balancing the ongoing need for true human creativity with the desire to create efficiency through automation. Sure, AI can throw out 100 designs a second, but can we be sure that they all express the creative and technical flair businesses want to put in front of their customers?

Additionally, in design, academic and industry research, ethical concerns regarding data ownership, authorship, and intellectual property rights still require resolution (Marr 2023).

Artificial Intelligence is still very much in its early stages of development, but it is a real consideration in the future design of digital solutions. unlock. What a powerful solution this branch of science can unlock remains to be seen. In the future, Buna will soon be looking at how to incorporate AI in Buna, as a tool that farmers can use directly to manage their farms and solve real life problems for them.

3. CHAPTER 3: RESEARCH METHODS

3.1 Research Approach and Design

The project used a qualitative research approach, using participatory design as a research design. Additionally, we employed design thinking and a human-centred design approach throughout the project. These are described below.

The Interaction Design Foundation (2023b) traces the origins of participatory design to the research conducted by Scandinavian scholars during the 1970s and 1980s, particularly focusing on human-computer interaction. Participatory design allows an exploration of tacit knowledge (Spinuzzi, 2005) – the implicit, unspoken, and often intuitive knowledge that individuals possess based on their experiences, insights, and expertise, which is difficult to formalize, articulate, or transfer to others through traditional means such as writing or verbal communication (Tacit Knowledge). In many ways, it is a pragmatic approach, mimicking how humans would "naturally go about solutions" (The Interaction Design Foundation, 2023b).

Robertson and Simonsen (2013, p. 2) wrote that:
Participatory design can be defined as a process of investigating, understanding, reflecting upon, establishing, developing, and supporting mutual learning between multiple participants in collective 'reflection-in-action'. The participants typically undertake the two principal roles of users and designers, where the designers strive to learn the realities of the users' situation. In contrast, the users strive to articulate their desired aims and learn appropriate technological means to obtain them.

van der Velden and Mörtberg (2014, p. 1) note that participatory design is a "value-centred design approach" pledged to the mutual and democratic formation of a better future for all involved. Genuine participation should, however, include the user as a legitimate partner in the design process, rather than simply acknowledging their input as informants (Robertson and Simonsen, 2013). The participatory design approach actively engages all stakeholders, such as partners, customers, citizens, and end-users, in the design process to ensure that the final designs are practical, usable and tailored to the client's requirements. Instead of focusing solely on the final design outcome, this approach prioritises the design process. The goal is to create design solutions that are more responsive and appropriate to users' cultural, emotional, spiritual, and practical needs.

Spinuzzi (2005) discusses participatory design as a research method, explaining that it involves designing and researching. In this approach, designing is considered as research. Participatory design creates a platform for users and designers to collaborate and find solutions. Brandt *et al*. (2013) state that participatory design is not just one approach but a family of design practices with different toolboxes and design agendas. Methods such as workshops, drama, storytelling, and design

games facilitate dialogue, negotiation, and the emergence of new ideas among designers, developers, and users. The involvement of users in the design process should go beyond mere input as informants and include them as legitimate partners. This method offers flexibility and allows users and designers to work together to find solutions. According to the IDxF (2023), key aspects of participatory design include inclusion, collaboration, empowerment, iteration, contextual understanding, and user advocacy.

Tracing back to the same time as participation design, design thinking has been a popular concept since 1969. However, the most used methodology today is developed by the Hasso-Plattner Institute of Design at Stanford, commonly known as d.school (Dam and Teo, 2022). Essentially, design thinking is a human-centred approach to innovation that involves empathy for the user, creativity in generating insights and solutions, and rationality in analysing and implementing ideas (d.school, 2024).

Design thinking has clear links with the mutual and democratic creation of better futures that participation design approaches strive for. On Stanford's d.school[3] (2024) page, it states:

The nature of design affords people the opportunity and privilege to shape the world that they-and others-inhabit. This is power. In a just world, that power is shared, prioritising the voices and ideas of people most impacted by new designs' intended and unintended effects. We aim to actively confront and challenge the mindset that design can only be used by a privileged few.

Design thinking involves five iterative modes: empathy, define, ideate, prototype, and test. During the empathy mode, designers try to understand the needs and experiences of their users. In the define mode, designers frame problems and synthesise insights. The ideate mode is where creative solutions are brainstormed without judgment. During the prototype mode, ideas are translated into tangible representations for testing. Finally, in the test mode, prototypes are evaluated with users to gather feedback and refine solutions (Doorley *et al*., 2018). How these approached work together is shown in Figure 1.

The Hasso Plattner Institute of Design at Stanford University, commonly known as d.school, is a design thinking institute based at Stanford University (Hasso Plattner Institute of Design, 2023).

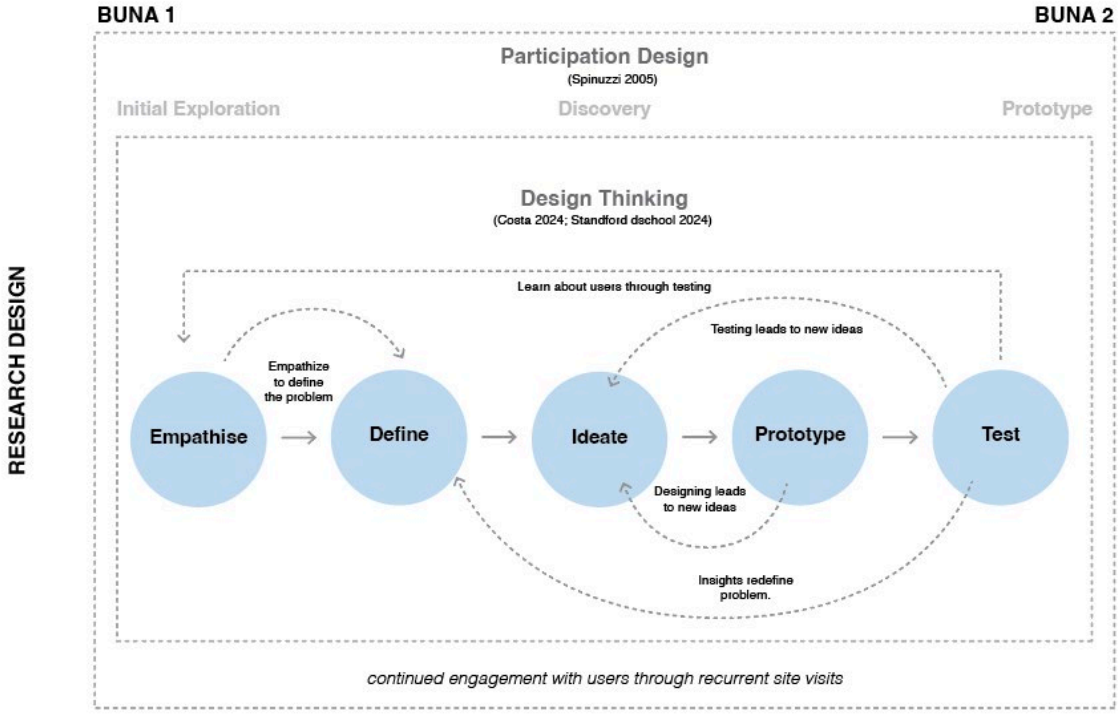

Figure 1: Research methodology for the project

Spinuzzi (2005) argues that the work done by users is not always visible, and their knowledge is often implicit. He (Spinuzzi, 2005, p. 166) writes, "One goal of participatory design is to preserve tacit knowledge so that technologies can fit into the existing web of tacit knowledge, workflow, and work tools, rather than doing away with them". Collaborative development in product design enables researcher-designers to avoid assuming they know everything. By inviting participants to be co-researchers and co-developers, researcher-designers can tap into the tacit knowledge and invisible practices that might otherwise have been overlooked. This approach also encourages the end user to participate in their empowerment.

3.2 Sampling

Fish farmers and one extension officer from the Thohoyandou region were purposively sampled for the project as they had been part of the initial development of the Buna platform (Rouhani *et al,* 2022). By working with the same group of farmers, a level of continuity in developing platform's development is provided. Their location in Thohoyandou also minimises travel for the research team and maximises the ability to conduct feedback sessions in future.

3.3 Project Phases and Data Collection

The stages of participatory design proposed by Spinuzzi (2005) were followed while simultaneously employing the iterative design thinking process. Various data collection methods were used; these are outlined below. For the purposes of this discussion, "Buna1" refers to the initial platform before any design changes were made, while "Buna2" represents the updated digital design prototype based on the participative process. Each engagement with fish farmers took place in Thohoyandou, Limpopo, at one of the farmers' homesteads.

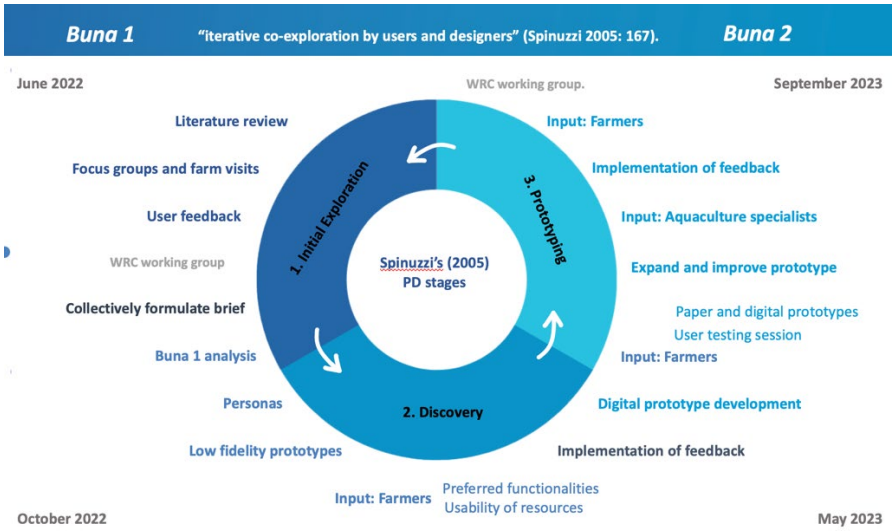

Figure 2: The development of Buna following participatory design stages

3.3.1 Stage 1: Initial exploration

In the initial phase, as outlined by Spinuzzi (2005), ethnographic methods were employed to create an understanding of the context in which fish farmers operate and use the Buna platform. This phase entailed investigating farmers' current perceptions of the platform. This was done through engagement with farmers on 21 July 2022. A focus group interview served to reacquaint farmers with the Buna platform and introduce new team members. It began with an overview of project roles, aims, and objectives, followed by a walkthrough of the existing platform to gather feedback on usability and relevance to daily business practices. Discussions centred on layout, content, and accessibility, with a focus on mobile-friendliness and literacy levels, but also asked farmers to share their experiences and daily challenges of fish farming. Site visits to five farms on 22 July 2022 provided insights into farmers' working conditions and internet access (Figure 3).

The goal, or design brief, that developed from our interaction with the farmers was to update the design of Buna to be mobile-friendly and accessible to users with varying levels of literacy, both in a traditional and digital sense, to improve their businesses and foster a sense of community.

Figure 3: Site visits to farms, Thohoyandou, Limpopo. 20-22 June 2022

This phase also involved a review of existing literature on best practices for designing with low-literate users. Insights from the literature were used as a starting point for the analysis of the Buna platform and compared with data collected from farmers.

3.3.2 Phase 2: Discovery

At this stage, the users and stakeholders involved in the project had agreed on the desired outcome (Spinuzzi, 2005). The design team used the insights gained from the initial workshop to generate preliminary, low fidelity design ideas for the website/online platform redesign. Before the next meeting with the farmers, the Buna team met with the extension officer from Vhembe, to discuss the preliminary changes to Buna and his ideas for suggested changes to the website. During the session (6 October 2022), the extension officer was also provided with basic training on the platform, including a demonstration of the farmer registration process and the production data entry process. Since extension officers work closely with farmers, it was important to gather input from them individually during the design process to better understand the government official's needs and link them to the farmer's needs.

A second focus group with farmers (25 October 2022) compared Buna 1 with printed versions of the low-fidelity designs for Buna 2. This comparative approach facilitated the collection of feedback regarding the suggested design changes, but also allowed for design and functionality suggestions from the farmers.

Active participation from farmers was encouraged, as they entered were invited to enter their information into the system, navigate the platform, and provide feedback through various methods such as pointing at screens, examining prototype printouts, or expressing thoughts in writing and

drawings on paper. Discussions revolved around incorporating farmers into decisions concerning information design on the website. This included considerations for icons, article formats, video links, and other aspects, all with the overarching goal of envisioning a solution tailored to meet their specific needs.

3.3.3 Phase 3: Prototyping

In this stage, following Spinuzzi's (2005) model, designers and users iteratively refined technological artefacts to align with the envisioned workplace from Stage 2. Using insights from previous stages, the design team developed mid to high-fidelity prototypes of Buna2, which were presented to users for feedback and further iteration. During this phase, emphasis was placed on the platform's visual appearance, colour schemes, iconography, information presentation, and responsiveness across different devices. These iterative stages were revisited as needed until a consensus design solution was reached among stakeholders.

Data was collected through two focus groups. The first, on 5 May 2023, made use of paper printouts, and two computers were available to demonstrate functionality, scrolling and audio and video solutions to the farmers. Participants were encouraged to comment on the design and functionality of the platform and were at certain stages of the discussion asked to identify how they would navigate to specific areas (for example, identify how you would problem solve not being able to find your farm on the map during registration, or indicate how you would edit your profile).

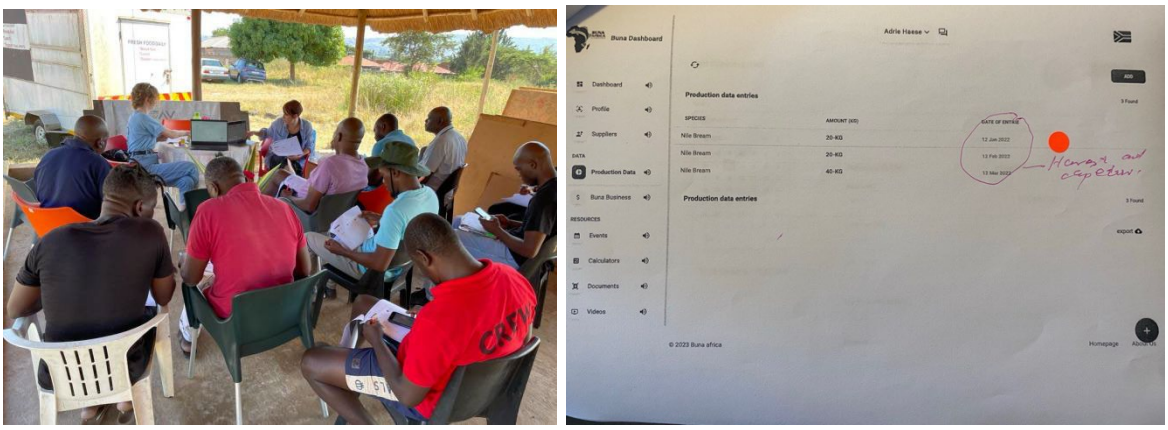

Figure 4: User testing and feedback session on 5 May 2023 using paper prototypes (right), laptops and mobile phones

Farmers made some comments on design, ease of use and functionality, but discussions also included suggestions or comments on content (Figure 4).

The final focus group was held with farmers on 18 September 2023 and served as the final user testing session for Buna 2, which at this stage was a high-fidelity prototype. Buna 2 had been loaded

onto a demo site, and farmers would be able to engage with it individually, using their own mobile devices. To gather feedback, farmers were provided with Wi-Fi access and directed to the Buna 2 demo site, with options to use researchers' devices if needed. The session emphasized the site's demonstration nature and ensured no data was permanently recorded. Farmers provided additional feedback using paper printouts. They were guided to register, input their farm's address, explore the dashboard, access farming information, search for suppliers/documents, record production data, utilize calculator functions, and edit their profile.

As noted earlier in the report, we identified the crucial competencies necessary for utilizing Buna while conducting the literature review. These competencies were then associated to the DigiComp competency areas, and A Likert scale questionnaire (Appendix 4) was developed to assess user experiences, focusing on registration, information accessibility, data management, and overall website functionality.

Farmers were encouraged to offer additional comments on design, functionality, and navigation. Thirteen participants provided feedback, with one form excluded due to multiple responses per question. Observations of farmers' reactions and behaviour while using Buna were also noted

3.4 Data Analysis

Focus group data was collected predominantly through researcher transcription and field notes, and where possible, recordings were made transcribed. Translators were available in cases where farmers did not understand English, or preferred to express themselves in another language. The outside venue made recordings difficult. Researchers used peer checking to make sure they were understanding a documenting and understanding participant verbal responses correctly.

Document analysis was used to study the sketches, annotations, or notes associated with the paper prototypes. The research team kept detailed notes during the platform walk-throughs.

Basic statistical analysis was used to analyse the final questionnaire, and a thematic analysis used to analyse any additional written notes or suggestions made by the farmers.

3.5 Ethical considerations and permissions

Ethical clearance was obtained from the University of Johannesburg[4] (Appendix 5). For each site visit, Mr Rouhani gained appropriate permission to engage with fish farmers and government extension officers from the Provincial and District officers of the Limpopo Department of Agriculture (Appendix 6) as the department has an established relationship with the fish farmers, and acts as gatekeepers (Singh and Wassenaar, 2016) for the study.

All participants were asked to sign informed consent forms before taking part in the project (Appendix 7). Participants who did not attend the first workshop were asked to sign informed consent forms at the start of any new sessions. Workshop data was transcribed and coded to protect the identities of participants.

[4] Ms van Zyl, who was party responsible for guiding the design work on this project, are based at the University of Johannesburg. The student who did preliminary research is also based at the university, and the student who will benefit from the bursary in 2023 will be registered at UJ. As such, ethical clearance was sought from this institution.

4. CHAPTER 4: RESULTS AND DISCUSSION

During the design process, continuous feedback was sought, and design improvements were carried out iteratively. The findings were condensed into key themes that emerged during the participatory design process rather than being presented chronologically. The term "Buna1" refers to the initial platform before any design changes were made, while "Buna2" represents the updated digital design prototype based on the participative process.

Engaging with the farmers proved to be very productive and yielded valuable results. We received contextually relevant feedback on the functionality of the Buna platform and, more importantly, gained insights into how farmers envision using the platform in their business practices.

In this chapter, we will begin by presenting the findings from the literature review, followed by how these findings were applied in the analysis of Buna 1. We will then discuss the themes that emerged from engaging with farmers. Next, we will report on the notable design changes, the motivation behind them, and the final design outcomes. After that, we will provide an outline of the software changes that were made to improve the accessibility and usability of the platform.

4.1 Findings from the Literature: Building a Framework for Buna2

While there are many resources available providing insights and recommendations for designing digital artefacts that cater to users with lower literacy levels, there are few examples of user participation in the development of such digital tools. Jones *et al.* (2017) argue that although research has mainly focused on improving the lives of emerging users, there is still a need for more emphasis on involving users in the development process.

To understand how Buna1 compared to literature and guidelines on designing for users with low literacy, a literature review was done. From the literature, key themes were distilled, which could be used to analyse the Buna platform and make suggestions for design changes that were informed by feedback from the users (farmers) and best practice guidelines.

The literature review began through consulting guidelines created by Srivastava *et al*. (2021) in their paper titled *Actionable UI Design Guidelines for Smartphone Applications Inclusive of Low-Literate Users*. In their paper, the authors proposed a framework called SARAL that can be used to develop and analyse applications for low-literate users. They conducted a systematic literature review of UI design studies for low-literate populations and used 53 relevant papers to derive 13 guidelines, their actionable definitions, and examples categorized within 5 themes. Although at the time, Buna was not available as a smartphone application, it still needed to be responsive to smartphone use. Therefore,

the guidelines provided are relevant to its redesign. UNESCO's report, *A Landscape Review: Digital Inclusion for Low-skilled and Low-literate People* by Zelezny-Gree *et al*. (2018) also provides actionable guidelines for designing technology to be more inclusive, accessible, and usable for people with low levels of skills.

The aforementioned documents served as the foundation for the remainder of our literature search, which involved including studies that contain practical guidance on design as the inclusion criteria. Studies that incorporate such design principles usually provide actionable recommendations on the use of language, images, icons, and colours in Human-Computer Interactions, as well as cultural considerations, with a focus on creating culturally relevant and responsive designs (see Chaudry *et al*., 2012; Cremers *et al*., 2008, 2017; Jones *et al*., 2017; Medhi *et al*., 2006; Medhi *et al*., 2011; Medhi, 2015; Rahman and Fukuda, 2015; Srivastava *et al*., 2021; Summers *et al*., 2007; Summers and Summers 2005; Walton *et al*., 2002; Zelezny-Gree *et al*., 2018, for further details).

Notable insights gathered from the literature include:
Jones *et al.* (2017) found that the use of mobile devices and software is increasingly focused on learning about others, rather than just the self. However, Robinson *et al.* (2014) express concerns that mobile app design encourages "heads-down thinking" and discourages engagement with the physical world. They argue that designers must consider the needs of users and enable them to engage with the external world. Andrew *et al.* (2018) research on participatory design in rural areas found that navigation UI icons, such as arrows, were confusing for users. They suggested using icons that were more relevant to their immediate surroundings. Walton *et al*. (2002) argue that designing for cross-cultural communication is a significant challenge, especially in South Africa and the African continent due to its cultural diversity. Despite guidelines, achieving true cross-cultural design or internationalization remains difficult. As such, they (Walton *et al*., 2002) emphasize the importance of discovering effective communication methods tailored to specific audiences.

The literature mentioned above was used to create a literature table that was used to compare the articles included in our review. Additionally, it can also be used as a checklist to analyse the Buna1. Along with the literature table, a Heuristic evaluation of the website was conducted using Nielsen Norman Group's (2023) Heuristic Evaluation Workbook. The workbook uses Jakob Nielson's (1994 in Nielsen Norman Group, 2023) 10 general principles for interaction design. These principles are called "heuristics" since they are broad rules of thumb and not specific usability guidelines. A heuristic evaluation is a method for identifying design problems in a user interface. Evaluators judge the design against a set of guidelines (heuristics) presented in Table 1 that make systems easy to use, according to Nielsen Norman Group (2023).

Table 1: Useability Heuristics from Nielsen Norman Group (2023)

Nielson's heuristics	Description
Visibility of system status	The design must consistently inform users of ongoing activities, providing feedback within reasonable time frames.
Match between system and the real world	It should communicate using language and concepts familiar to users, avoiding technical terms and following real-world conventions.
User control and freedom	Users should have a clearly marked "emergency exit" to reverse unintended actions swiftly and without complication.
Consistency and standards	Consistency in terminology and actions helps users understand without confusion, aligning with industry standards.
Error prevention	Effective designs anticipate and prevent errors or offer confirmation before irreversible actions, rather than relying solely on error messages.
Recognition rather than recall	Minimize users' cognitive load by keeping elements visible and reducing the need to recall information.
Flexibility and efficiency of use	Expert users may benefit from hidden shortcuts, while interfaces should avoid unnecessary information to maintain clarity.
Aesthetic and minimalist design.	Error messages should be clear, without cryptic codes, and provide helpful solutions.
Help users recognize, diagnose, and recover from errors.	Ideally, systems should be intuitive, but supplementary documentation may be necessary for complex tasks.
Help and documentation.	The design must consistently inform users of ongoing activities, providing feedback within reasonable time frames.

The Digital Competence Framework for Citizens (DigiComp) has emerged as a pivotal point of reference for shaping digital competence endeavours in Europe, despite not being originally tailored for the African context. DigiComp, however, offers a shared comprehension of digital competence, establishing a foundation for delineating the digital skills essential for effective engagement with the Buna platform, which can arguably be used in the South African context. Its primary objective was to furnish a tool for enhancing citizens' digital competences while aiding policymakers in devising strategies and educational schemes to bolster digital literacy. Furthermore, DigiComp introduced a standardized terminology for identifying and describing key domains of digital proficiency (Carretero *et al.*, 2017).

Within DigiComp, five distinct competency areas are delineated, each representing an individual's adeptness, capacity, or expertise in a specific realm of knowledge, skill, or activity.

Competence area 1: Information and data literacy
Competence area 2: Communication and collaboration
Competence area 3: Digital content creation
Competence area 4: Safety
Competence area 5: Problem solving

Within these competence areas, 8 proficiency levels signify citizens' evolving competence, shaped by cognitive demands, task complexity, and self-sufficiency (as shown in Table 1 below). The creators of this framework, Stephanie Carretero, Riina Vuorikari, and Yves Punie (2017), illustrate this idea with an example: A level 2 individual can recall and execute simple tasks, occasionally seeking digital expertise when needed. In contrast, a level 5 citizen possesses the capacity to not only apply their knowledge, handle diverse tasks, and solve problems but also assist others in doing so.

Levels in DigComp 1.0	Levels in DigComp 2.1	Complexity of tasks	Autonomy	Cognitive domain
Foundation	1	Simple tasks	With guidance	Remembering
	2	Simple tasks	Autonomy and with guidance where needed	Remembering
Intermediate	3	Well-defined and routine tasks, and straightforward problems	On my own	Understanding
	4	Tasks, and well-defined and non-routine problems	Independent and according to my needs	Understanding
Advanced	5	Different tasks and problems	Guiding others	Applying
	6	Most appropriate tasks	Able to adapt to others in a complex context	Evaluating
Highly specialised	7	Resolve complex problems with limited solutions	Integrate to contribute to the professional practice and to guide others	Creating
	8	Resolve complex problems with many interacting factors	Propose new ideas and processes to the field	Creating

Figure 5: Main keywords that feature the proficiency levels (Carretero et al., 2017)

We identified the crucial competencies necessary for utilizing Buna and associated these competencies with the DigiComp competency areas. In this way, we devised a Likert Scale questionnaire for users to fill out during the final site visit (Appendix 4).

4.2 Analysis of Buna Website

The literature mentioned above was used to analyse the Buna platform, as can be seen in Figure 6. The framework developed by Srivastava *et al*. (2021) was modified to include other consulted literature and discussed based on the following themes: Modes of interaction, Visual Design, Online Content, Navigation, Help, Forms and Consent, and Human Considerations.

Figure 6: Framework used when reviewing Buna1

4.2.1 Modes of interaction for users

Digital platforms should provide multiple modes of interaction to cater to different types of users. This includes textual, numerical, graphic, audio, and video formats, with a focus on low-literacy users (UNESCO, 2016, 2018; Srivastava *et al*., 2021). While Buna Africa uses images and text on its homepage, it lacks consistency in the use of mixed media on subsequent pages. Improving numeric input forms and offering appropriate formats for downloadable resources can enhance user engagement and comprehension. Nielson (2023) reminds us that users base their experience with a platform on their experiences with other technology. As such, using solutions that align with industry standards may help users understand a new platform without confusion.

4.2.2 Visual Design of digital platforms

According to Srivastava *et al*. (2021), it is recommended to have a clean and minimalist interface that includes visual cues like highlighted text. Cremers *et al*. (2008, 2017) and Summers and Summers (2005) as well as the Neilson's heuristics (2023) advise avoiding information overload and maintaining consistent screen layouts. Although Buna's design is minimalist, it lacks visual cues, and the text-heavy interface might overwhelm users.

4.2.3 Online content of digital platforms

Online content is made up of textual, audio, and visual elements that are essential for user engagement. To ensure user comprehension, it is recommended to use language that is free of jargon, simple sentences, and provide local language support (Summers *et al*., 2005; Summers and Summers, 2007; CDC, 2009; Cremers *et al*., 2008, 2017; Medhi *et al*., 2011; Srivastava, 2021). However, Buna's current use of English is complex, lacks local language support, and overwhelms users with written information. Nielson Norman's (2023) heuristic guidelines note that the digital there should be a match between system and the real world – in other words, that the user interface should communicate using language and concepts familiar to users, avoiding technical terms, and following real-world conventions.

Audio support, particularly voice-based interfaces, is effective for users with low literacy levels, but Buna currently lacks this feature (Medhi *et al*., 2006; Sherwani, 2009; Rahman and Fakuda, 2016). Visuals play a crucial role in usability, and graphics can improve accessibility for low-literate users (UNESCO, 2018). Although Buna incorporates photographs effectively, it underutilizes other graphics, missing opportunities to enhance user experience.

Recommendations include using participative design to create culturally relevant icons, instructional graphics for tool usage guidance, and consistent use of photographs to improve visual consistency (Cremers *et al*., 2008, 2017; CDC, 2009; Rahman and Fakuda, 2015).

4.2.4 Navigation of digital platforms

Navigation should be simplified, avoiding hierarchical structures, and incorporating review mechanisms to aid users (Chaudry *et al*., 2012). Buna's navigation, while generally straightforward, could be enhanced by streamlining content areas to minimize cognitive load. Pages like "meet the team" may not be essential for farmers and could be nested under relevant sections to reduce menu items. Linear registration pages with progress indicators are recommended.

4.2.5 Finding and using help features on digital platforms

Help features should be easily accessible and include elements like FAQs and tutorials to support users (Medhi *et al*., 2006; Srivastava *et al*., 2021). Buna should consider adding a help button on each page and simplifying the help menu/interface to reduce textual input. Proactive briefing through FAQs and tutorials can aid users in understanding processes. Successful UI systems should pre-empt and prevent errors before, for example by offering confirmation before irreversible actions (Nielson Normal, 2023). For example, farmers could be prompted to double check that they have entered their production data correctly.

4.2.6 Using fillable forms and seeking consent from users of online platforms

Forms should be designed with lower literacy users in mind, ensuring clarity and simplicity (Summers *et al*., 2007). Buna's disclaimer page should be simplified and integrated into the registration process, with visual aids like infographics to clarify data usage.

4.2.7 Human considerations in the development of online platforms

Cultural relevance is crucial in design, with attention to diverse user backgrounds (UNESCO, 2018). Buna should explore co-development of icons to ensure cultural understanding. Target audience diversity should be addressed, recognizing varying literacy levels and tech savviness among farmers. Co-design methodologies and ongoing facilitation are vital for local adoption and user support (Medhi *et al*., 2011; UNESCO, 2018; Srivastava *et al*., 2021). The Buna team should continue engaging with government and extension officers to provide training and support for users.

4.3 Feedback From Farmers and Site Visits

Even though our field trips were successful, the research team did have some challenges – which is expected when conducting field trips. These challenges included:

1. Logistical arrangements to meet with the farmers. To organise a date to meet with the fish farmers in the field, the research team had to coordinate with the Provincial Department of Agriculture. In some cases this took some time and therefore in some cases it delayed when field visit could be organised.
2. Inconsistency in which farmers come to the workshops. During the various field visits we conducted, some farmers were not able to attend the workshops or new farmers would appear. While this is understandable as farmers are busy and they must prioritise their livelihoods first, it nevertheless presented the research team with a challenge by having new farmers join the process as it went along.
3. Not all farmers had cell phone. Some farmers did not have cell phone data to enable them log in into Buna during the workshop. This was however a small challenge as the research team were able to "hot spot" the farmers to their devices. The down side was that this decreased the internet speed.

The first objective that we set for the project was understanding user and stakeholder perceptions of the currents Buna platform. We looked specifically at the usability and relevance of the platform. Based on feedback from the first focus group, and farm visits, The following themes emerged on the participant's initial perceptions of Buna and challenges, or barriers, they experienced in accessing and using Buna.

4.3.1 User and stakeholder perceptions and required format of Buna1

When assessing the current perceptions of the Buna platform in terms of its ease of use, accessibility, and understandability, the main finding was that all stakeholders preferred mobile use. The Buna platform needed to be optimized for mobile phone usage, as this was the preferred method of access.

Upon first impression, farmers found the platform to be beneficial in providing access to technical information, educating new farmers, and supporting business development. They could see themselves using it for their daily business needs. However, some of the features, such as the calculator tools, need to be simplified for easier use.

The participants were particularly enthusiastic about the potential of the platform to build a community. They expressed the view that it could help foster the growth of a fish farming community in Thohoyandou, as well as nationally and internationally. They also believed that the platform could improve communication with extension Officers. However, they did not see it as a substitute for face-

to-face contact with government officials, as they considered it an important part of their relationship with the Department.

4.3.2 Barriers to engagement with the platform

A barrier to engagement with a product or service, in this case, Buna, is any obstacle or hindrance that prevents or discourages users from actively interacting or participating in the use of the product or service.

Although a few barriers to engagement were identified in our initial engagement with farmers, they became evident primarily during stages two and three, when farmers interacted with prototypes. Feedback revolved around challenges arising from the rural context, technical engagement, and language usage. Primary barriers identified can be classified as contextual, technical and linguistic.

4.3.3 Contextual barriers

We use the term contextual barrier to refer to external factors, circumstances, or environmental conditions that hinder or limit engagement with Buna. Most participants indicated that they used mobile phones for internet access since they didn't have laptops. They also mentioned that limited Wi-Fi availability at their homes forced them to purchase data, which raised concerns about financial implications. There were no municipal Wi-Fi hot spots in Thohoyandou, and participants could not think of any local media centres or libraries that they could use for internet access.

These statements can be backed up by Stats SA's 2020 General Household Survey report, which notes the proportion of South Africa's households with internet access only via mobile phones as 89.4% (Omar, 2022). For households with no access to a mobile phone or a landline, Limpopo ranked the highest at 3.2% (Omar, 2022). The Thulamela Municipality IDP Review 2023/24-2025/26 (2023) notes that most people in the Thulamela local municipality (under which Thoyondou falls) that do have access to internet have this via mobile phones (27 546), as opposed to from home (3316) or work (2257).

Although the Buna1 platform worked well on laptops, it was not mobile responsive, meaning engaging with it on a smartphone could be frustrating. As a mobile-friendly solution, Buna would need to take into consideration data costs for users, as most farmers relied on data bundles. Positioning this feedback in the context of South Africa's reputation of having high-cost data – which many people cannot afford meant looking for lightweight and cost-effective, potentially able to run without data or work as a mobile site.

During the discussion of the registration process and examination of low-fidelity paper prototypes, it became evident that complex input requirements, such as address fields, posed challenges. Entering an address seemed like a straightforward task, but within our participant groups, some farmers stated that they were unsure of their stand number, that they did not have a street name, that their address was not registered with the municipality, or that they could not find it on Google Maps (or did not know how to use Google Maps). Farmers who had complete addresses were not sure how to format them so that it would be found by the map widget on Buna1. It became clear that address input would differ for different regions, and the platform would need to be able to address this. As a solution, it was agreed that an option should be included for indicating that the address is unknown. This would allow extension officers to contact the farmer, arrange a meeting, and assist in establishing the correct address.

4.3.4 Technical barriers

A technical barrier represents challenges with or from technological limitations, issues, or complexities that hinder engagement with Buna.

Buna offers information resources in the form of documents and videos, guiding fish farming. While the content was considered useful, some farmers felt it involved excessive reading or contained information not relevant to their specific circumstances (such as content about fish farming in other countries). They also expressed concerns about the complexity and heavy use of technical language in the content, making it difficult to interpret or apply certain documents (such as the water quality table available as an Excel file). Video was the preferred format of information dissemination, both in terms of technical information and providing clarity on how the Buna platform worked. A few of the farmers asked if videos could be downloaded and stored on their devices so that they would not incur the costs of streaming the video if they wanted to recap on its content.

The farmers thought that the use of mathematical terms in the calculator tools may pose a challenge. Some farmers expressed doubts about assuming terms like "subsample" would be understood.

Farmers observed that the calculator tools being used by Buna1 were dependent on specialized equipment such as weighing scales. It was acknowledged that not all farmers had access to equipment like nets or weighing scales, relying instead on readily available items such as buckets. Farmers pointed out that they typically measured fish food with a scoop, rather than weighing it. One suggestion was to use an easily accessible, standardized measurement, such as a 300 ml cold drink tin, to determine how much food should be given. Farmers also recommended the inclusion of an instructional video combining visuals and audio to explain the required information and inputs for using the calculator functions effectively.

4.3.5 Linguistic barriers

Linguistic barriers are viewed as obstacles related to language differences or communication challenges that impede effective engagement with a product or service.

Farmers found the content of Buna to be text-heavy, and while they recognized English as the language of business and access, they believed that certain content required multilingual support and could benefit from voiceovers. Consequently, Venda audio feedback, reflecting the primary language spoken by the participating farmers, was incorporated into Buna2 for selected menu items and functions. Farmers found the Venda voiceovers useful and clarifying during their interaction with Buna2. However, further discussion raised concerns that location-specific voiceovers might exclude farmers who relocate to the Limpopo area for business. Inclusion was a vital aspect for the farmers, leading to a suggestion to include English voiceovers alongside multilingual support options. As Buna will be available in South Africa, which has 11 official languages, as well as Malawi and Zambia, implementing multilingual support will require careful planning.

The use of aquaculture business jargon posed a barrier for farmers, as they were unfamiliar with terms such as 'commercial' and 'extensive' operation types. They also questioned why 'subsistence' or 'small-scale' options were not included. Two fish farmers expressed the perception that the classification of operations was a way to encourage farmers to expand their businesses to the "next level." An explanation is necessary to guide farmers in selecting the appropriate operation type, which may also need to be tailored to specific countries, as what is considered commercial in South Africa might be considered small-scale in Zambia or Malawi.

The farmers emphasized the need for the platform's resources to be easy to understand and context-relevant, specifically pointing out that some of the document and video content on the platform was not from South Africa. They suggested location-specific libraries, or the option to filter searchers by location.
The second and third project objectives were to identify the necessary formats to enable easy access to the Buna platform and to make design improvement, to facilitate easier access, engagement, and understanding of its content. Incorporating farmer’s feedback, or user voices, into this process was an important aspect of the participation design approach to the project.

4.4 Incorporating User Voices

The participatory design process with farmers emphasized the importance of technical information access and community building within the Buna platform. It also revealed the potential for improved

communication between farmers and government officials, the value of user-generated content, and the need for customization options that cater to users' diverse needs and preferences.

During the feedback process on Buna, farmers were asked to suggest how they would like to use the platform and what could be added to make it more beneficial for them. From these interactions, two key aspects emerged as highly valuable to the farmers: access to technical information on fish farming and the potential for community building. While community building may not have been the initial goal of the platform, the farmers expressed a strong interest in using it to connect with and educate other farmers, which fosters a sense of community and support. This aligns with criticisms of current mobile design trends that discourage real-world interaction and highlights the importance of accommodating users' needs and aspirations (Robinson *et al*., 2014).
During the discussions, farmers expressed their frustrations with the limitations of government support and extension officers. These officers are responsible for reaching out to various types of farmers, including those in aquaculture, crop farming, and beekeeping, which often leads to travel and time limitations. However, farmers also saw an opportunity for a platform that could enable positive communication and collaboration between them and the officials. They suggested that the platform could have features like forums and chat functions to help them stay connected. This need for human mediators was also highlighted in a study by Medhi *et al*. (2011). The platform would not replace human interactions but would complement and enhance them, providing continuous training and assistance for farmers while enabling monitoring and evaluation.

Farmers' interest in personalizing their profiles and generating content is a promising indicator towards co-design solutions that encourage local adoption. User-generated content, particularly in local languages, plays a significant role in facilitating technology acceptance and usage among individuals with limited digital proficiency or literacy (Zelezny−Gree *et al.,* 2018). Nevertheless, ensuring the accuracy of user-generated content presents some challenges. However, it is essential to consider allowing users to customize the content, interface layout, and functionalities of the platform according to their needs and preferences, as emphasized by Srivastava *et al*. (2021).

Final feedback on the Buna2 showed that most farmers expressed satisfaction with the design changes and found visual cues and voiceovers to be valuable additions. Encouragingly, most farmers expressed their willingness to use the platform, which bodes well for local technology adoption. Farmers were able to identify Buna’s utility in their daily life, giving the example of instances where local farmers had overfed their fish, resulting in the fish dying. They believed that having access to information and tools, such as the feeding calculator could prevent these mistakes.

For the most part, farmers felt that their voices had been heard and that their suggestions had been applied to Buna 2. Only one farmer reported feeling that their suggestions were not incorporated into

the current platform. It's worth noting that some suggestions, like the addition of invoicing capabilities, are still under development and require further research for implementation beyond the timeframe of out project. What is however promising is the forward-thinking nature of the suggestions.

Written feedback acknowledged that farmers felt the platform could assist them. Quotes supporting this include:

“The other information that can help us is to know how many fish can fit into a certain space. The platform is helpful, it can teach us to harvest good and health(y) fish.”

“Buna platform is very helpful. I can teach us managing and lead us to better.”

“The lecture [testing session] was very much good because we can calculate the ration [of food]”.

“Thank you for your support / teaching us.”

“I find it helpful. The website is straightforward.”

Feedback also noted that farmers felt that they could learn how to use the platform, the need for training and human intervention. This indicates that Buna as a platform may not work for digital novices without initial support. Quotes that support this notion include:

“I think the demo Buna is very much understandable and easy to learn, it’s very clear and its navigation is simple, only data is needed.”

“Technology is very much important nowadays. We need more time for training as old people.”

“It will be easy by the time one is getting used to the system.”

The extension officer provided the following written feedback after the session:

“As an extension officer, I see Buna as an important tool for farmers to communicate, getting information about fish farming and I commend the app to be accepted by government of South Africa for all the farmers to use. It is also a platform where fish farmers can share the experiences of each other. I approve [of] Buna to be used by farmers.”

4.5 Design Changes and Improvements

Spinnuzi (2005) emphasizes that in Participation Design, "Design is Research." The process of interpreting feedback and implementing these into design changes for further user testing was iterative. As a chronological exploration of each design change is beyond the scope of this report, we report on the main design changes implemented in the development of Buna 2.

Figure 7: User personas developed for Buna

The United Nations Educational, Scientific and Cultural Organization observes that beyond its conventional concept of the ability to read, write and demonstrate basic numerical skills, “literacy is now understood as a means of identification, understanding, interpretation, creation, and communication in an increasingly digital, text-mediated, information-rich and fast-changing world” (Khuluvhe, 2021, p. 3). Based on insights from literature and our interactions with farmers during farm visits, three user personas were created as representations of potential Buna users (Figure 7). The fictional users helped the design understand what the farmers’ core needs are, what motivates them, what their behaviours (in terms of navigating the South African inland fish farming sector) are, what type of technology they have access to, and what their pain points are. Pain points are “a persistent or recurring problem (as with a product or service) that frequently inconveniences or annoys customers” (Merriam-Webster, 2024). The first persona was a subsistence farmer, the second was a small-scale farmer, and the third was a young entrepreneur looking to grow their business. These three users had different motivations for farming and varied in their knowledge, confidence, and ease of use with technology and social media.

The website was analysed accordingly, and design suggestions were made for rough prototyping. A preliminary style guide was developed to establish a consistent brand identity that can be recognized and trusted across all platforms.

Throughout engagement with farmers, the feedback we received on the visual design of Buna was less feedback than expected. It was however clear that the farmers prioritized content and functionality over complex design. When comparing the low-fidelity prototype versions, the farmers preferred a clean, one-column design.

Key design changes that have been made to Buna2 are summarised below:

4.5.1 Updated brand identity, style guides and icons

One of the objectives we in the early phases of the project was to develop an updated style guide for Buna. Creating a coherent brand identity is a means of creating trust between user and brand. Under the guidance of her supervisors, UJ Honours student, Bethanie Trollope, updated the colour palette to be more vibrant, incorporating colours of water, alongside warmer, earthy tones to communicate the agricultural focus of the platform. The logo has been updated to reflect the colour change and also make the text more visible.

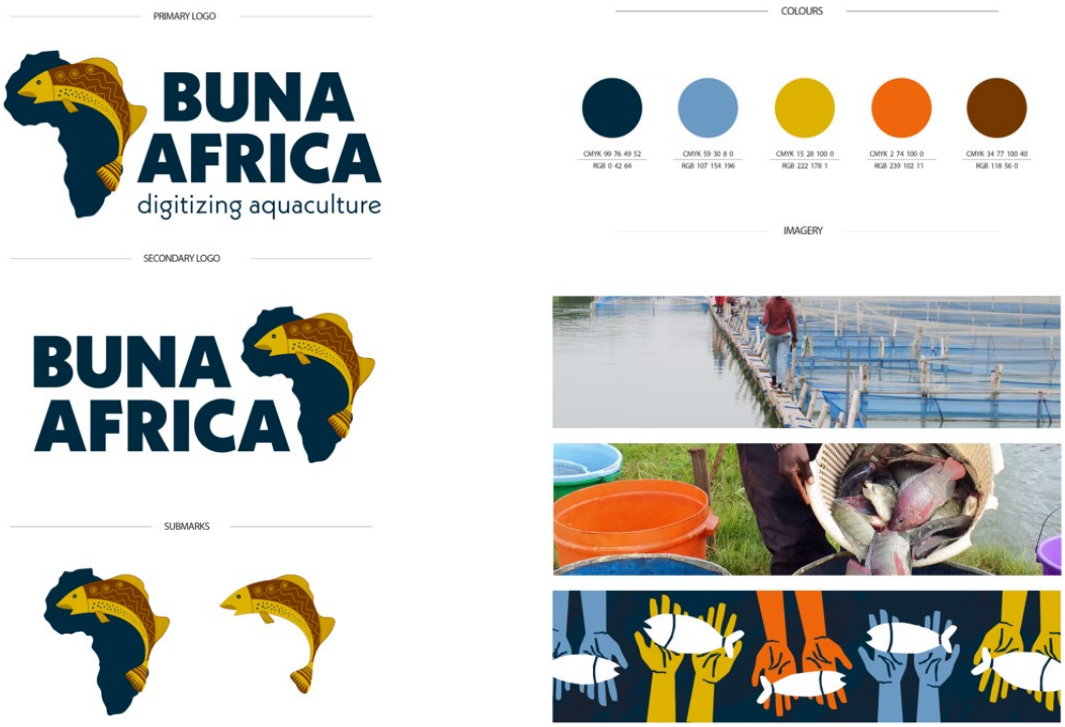

Figure 8: Updated Buna Brand Identity Guide

Images used across the website have been updated to reflect feedback from the farmers. Images include people working and farming using accessible materials. Alongside this, Ms Trollope has also

developed an illustrative style for Buna – as seen in the final image in Figure 8 (hands holding fish). This style can be applied to the design of future infographics and video animations.

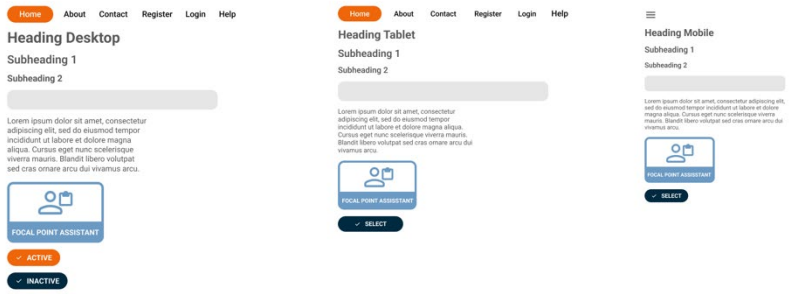

Figure 9: Updated Buna Style Guide – responsive application

The style guide has been updated to make allowance for responsiveness, as seen in Figure 9. Ms Trollope has applied the updated identity every page of Buna.

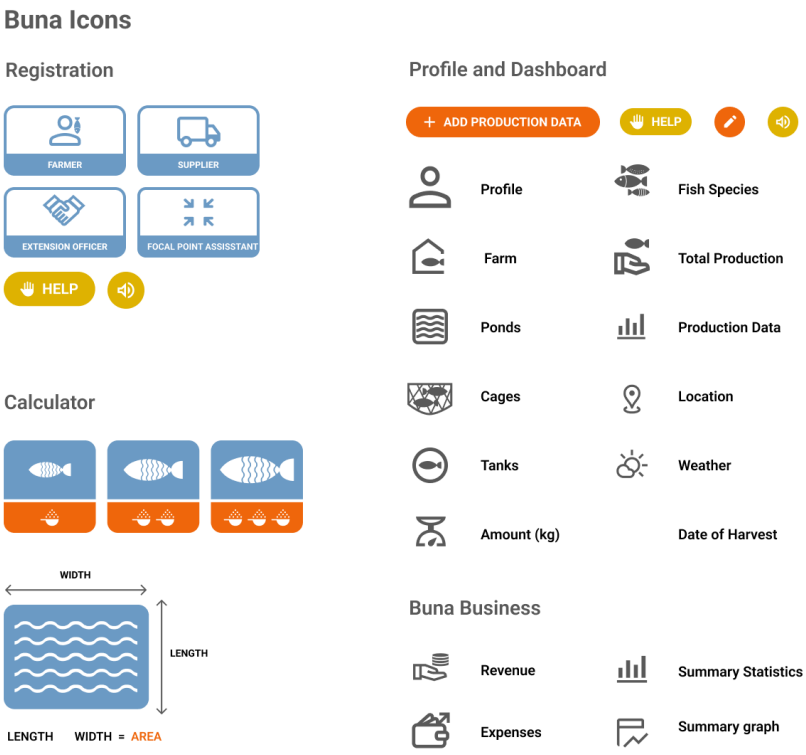

Figure 10:Icon development

Icons and an illustration style guide have been developed using Google Fonts' Material Symbols font. Material Symbols "offers 3,031 glyphs in a single font file with a wide range of design variants" (Google Fonts, 2023). Icons have been adapted to reflect the nature of the platform and the reality of the farmers (Figure 10), for example:

The 'waves' icon has been contained in a border to provide a representation of 'ponds' (Figure 11):

Figure 11: Ponds icon development

The outside camera icon has been adapted, taking the fish from another icon to represent the fish farm (Figure 12):

Figure 12: Fish farm icon development

Where icons could not be sourced and adapted, they were created, such as the 'cages' and 'fish species' icon (Figure 13), where the specific shape was discussed with fish farming experts.

Figure 13: Cages and fish species icon development

Using the Material Symbol allows for future designers on the project to have a ready-made starting point for future icon development.

4.5.2 Registration

The registration pages have been redesigned using visual cues for each role (Figure 14). Once selected, a description of the role appears below (text is still being finalised).

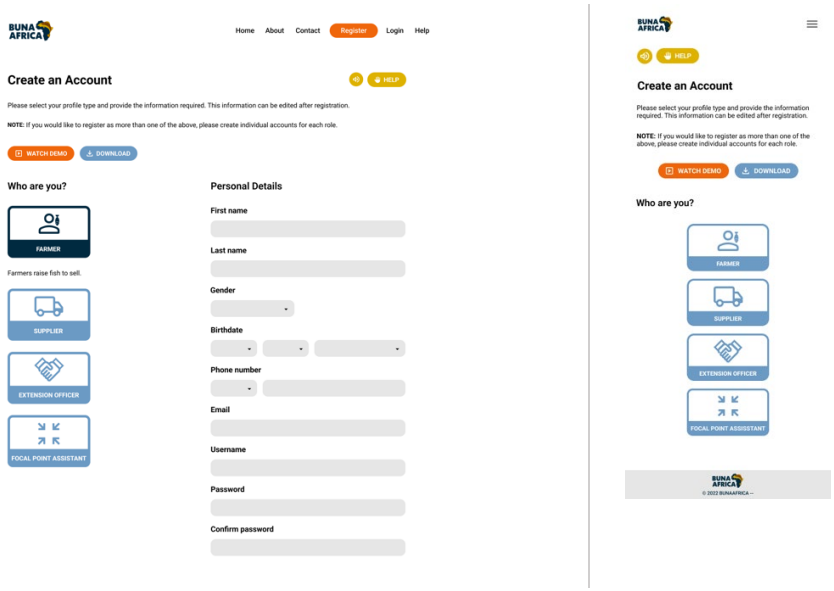

Figure 14: Desktop (left) and mobile (right) registration page

Because most users will be registering using their mobile device, the decision was made to use one page for the registration and rely on scrolling, rather than several pages. Although this includes more scrolling, it is arguably easier for users to complete the form this way, rather than navigating between separate registration pages using “back” and “next” buttons. They also have an immediate overview of what kind of information will be required for registration. However, in the final testing, some farmers struggled with scrolling, and rather than scroll down, waited for a new page to load after their selection had been made. As such this is being rethought in the final design solution. We are in the process of updating this, so that the registration process on the phone becomes more intuitive.

In our previous session, farmers noted that providing an address for, or locating their farm was difficult due to contextual factors (for example, they don’t have a stand number). We have as such provided different options that farmers can use to capture their address or ask for assistance to do so. Figure 15 gives an overview of the options available to farmers and accompanying instructions. A demo video available on the registration page provides additional help for users (see section below).

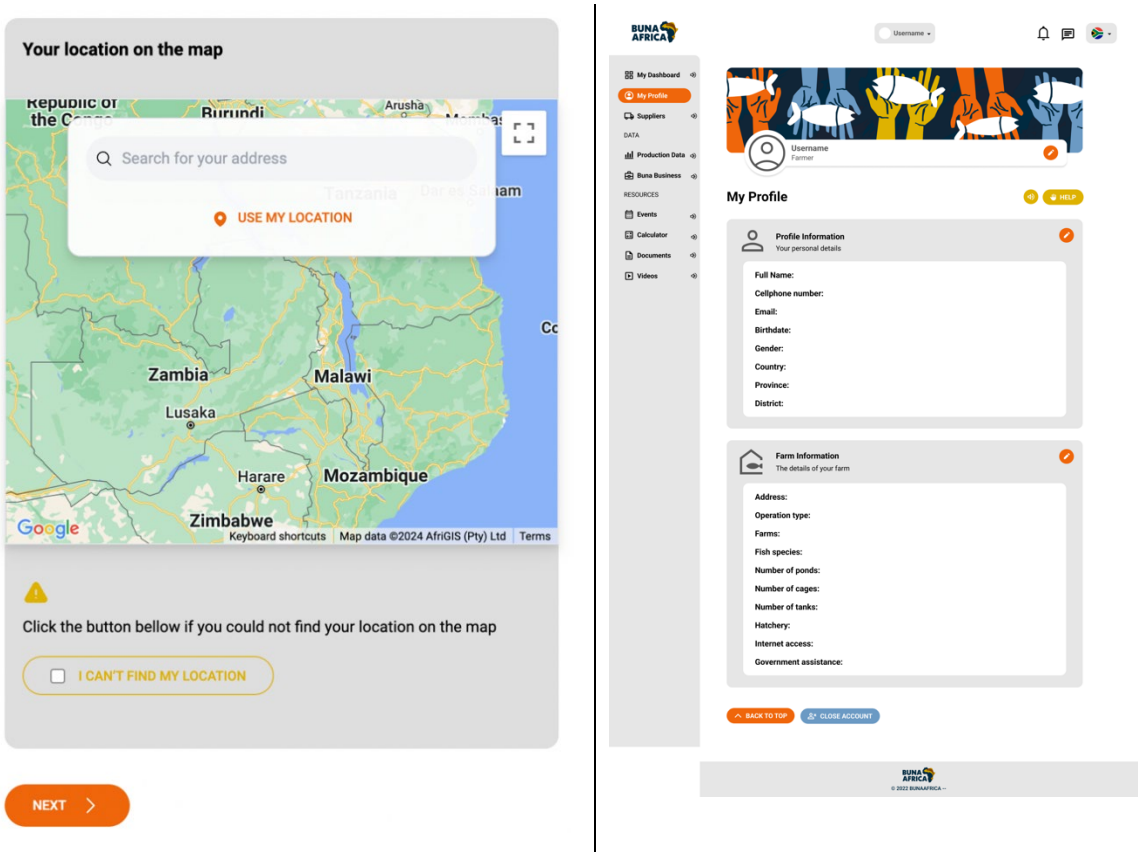

Figure 15: Three methods of locating farm during registration and updates to the profile page

4.5.3 Profile page

The profile page (Figure 15) is now customisable, and users can add a profile picture. A background banner has also been provided that indicates the user's role (farmer). The same style can be used to create backgrounds for suppliers, extension officers and other roles.

4.5.4 Production calculators

The calculator pages have been simplified, with all three calculator tools (Figure 16 and 17) now available on a single page. Images have been added to support the written description of each calculator tool. The demo video will be updated to reflect the current design of the pages once completed.

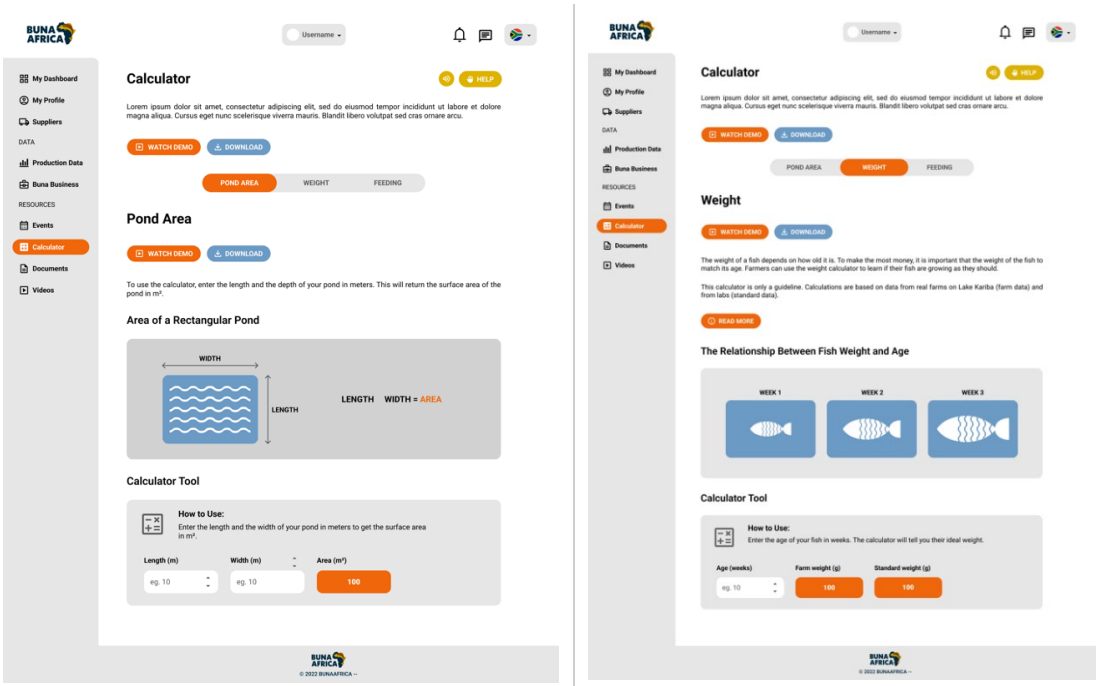

Figure 16: Area of pond calculator and fish weight calculator

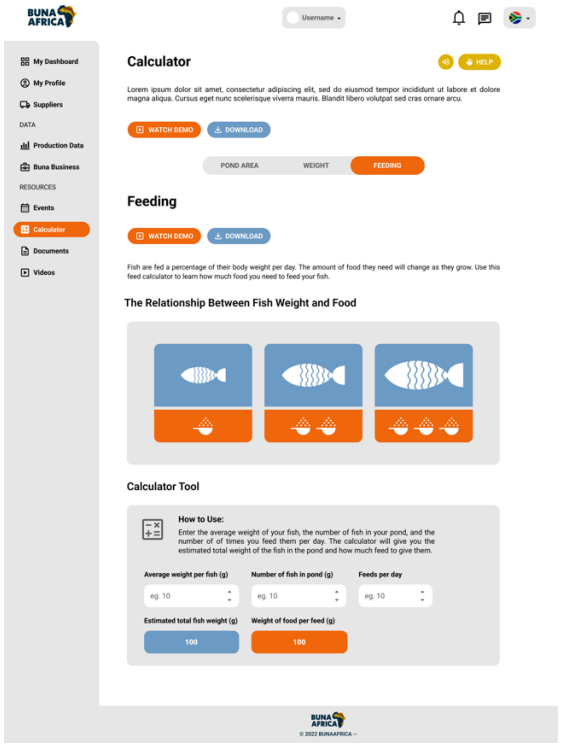

Figure 17: Feeding calculator

4.5.5 Visual feedback

Users receive feedback in the form of a confirmation page.

4.5.6 Demo videos

Demo videos (Figure 18) have been added to important pages such as the Registration and Farmer's Dashboard, and also to resources offered by Buna, namely the production data pages, calculator tools, documents and video libraries and events, suppliers' pages. These videos provide a visual explanation of how Buna works, which is often clearer and more engaging than written instructions. Users can quickly understand the app's features and functionalities through these videos, and developers can highlight the app's key features and demonstrate how they solve problems. Demo videos could help reduce the amount of support requests that extension officers receive.

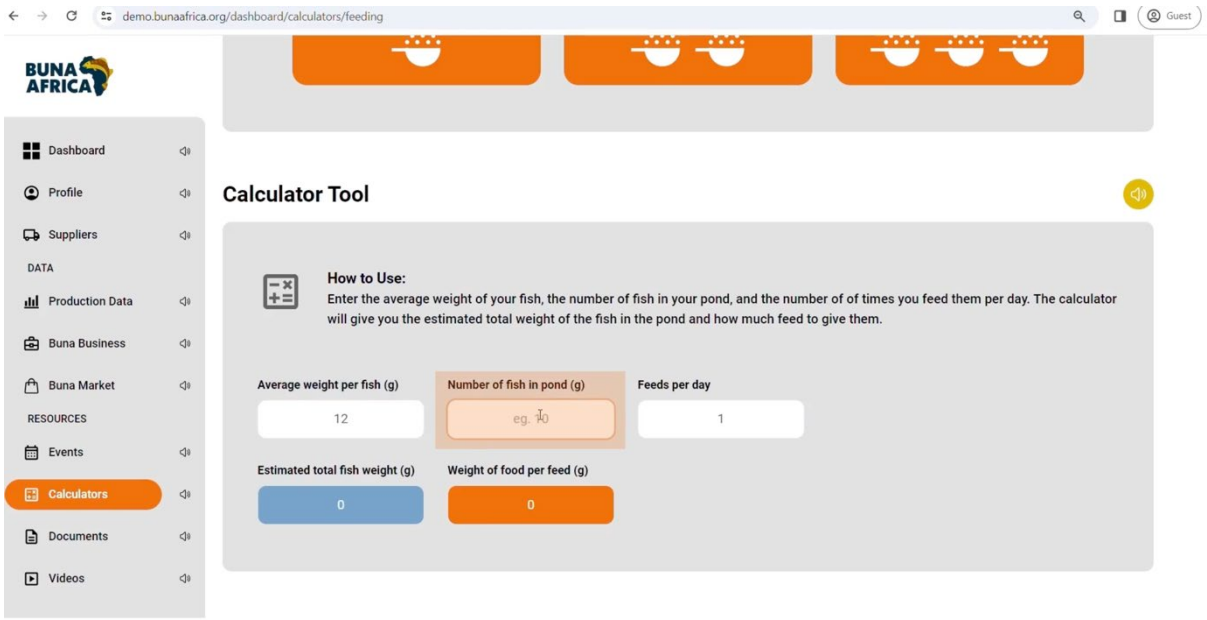

Figure 18: Still from a demo video explaining how to use the fish feeding calculator

4.5.7 Voiceovers

Location-specific voiceovers are available for all menu items, and based on farmer feedback, English voiceovers have been incorporated onto all pages. These voiceovers name the page (e.g. 'Your Dashboard"), and also give a short explanation of the purpose of the page. This can be seen in Figure 19.

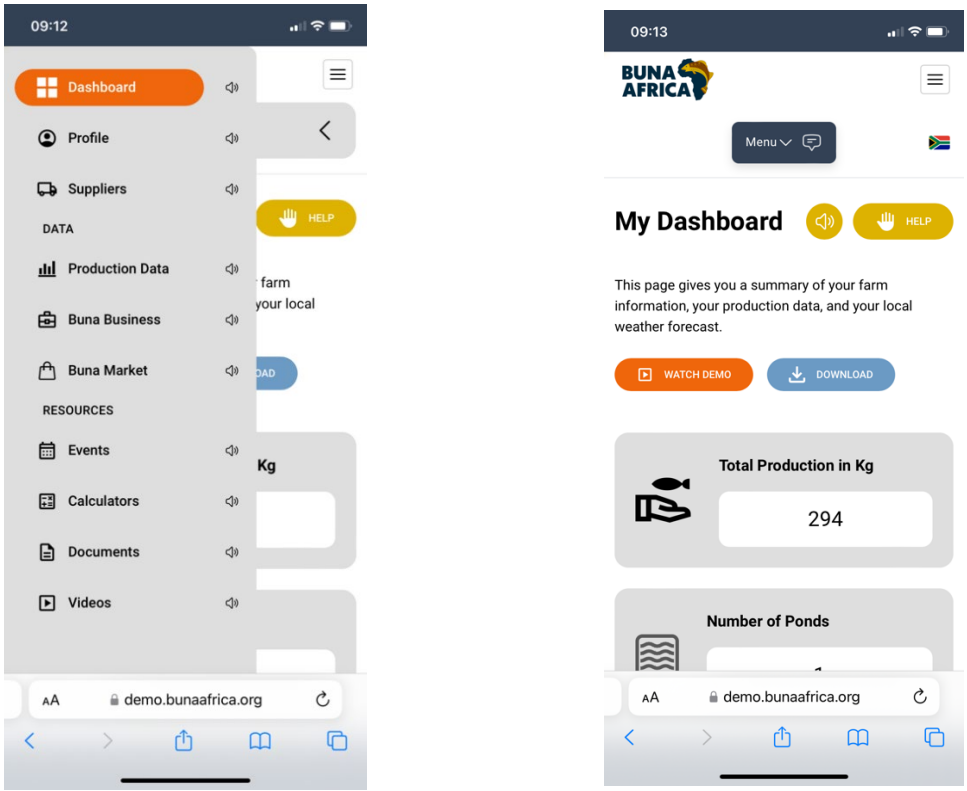

Figure 19: Location specific voiceovers available on the dropdown menu, and English voiceovers are on each platform page

4.6 Exploring AI in Design Solutions

During the development of Buna2, Ms Trollope investigated using ChatGPT to simplify the complex language that was used on Buna1. The tool proved to help reduce the amount of text on the platform and making use of "plain English" to simplify complex instructions. It's worth noting that AI was used to edit existing writing rather than generate instructions. Therefore, the writing and instructions on the website are still those produced by human aquaculture experts and not information that was initially generated by AI.

Whereas the Venda voiceovers were authentically performed by a human voice actor, English voiceovers for the platform pages and the demo videos were created using an AI generator, *Narakeet*[5]. The English (South African) voice was selected, and the *Aletta* voice was selected to narrate. Ms Trollope reported that the narrator struggled with African words like Buna, so she spelled them phonetically to get the correct pronunciation, i.e.: 'Boonah'. Ms Trollope wrote the scripts herself and used the Windows Snipping Tool and ClipChamp to edit the audio and footage. After Effects was used to add the highlights.

[5] The tool is available at https://www.narakeet.com/

Ms Trollope experimented with AI-generated images for the website, but ultimately decided to use photographs taken by professional photographers as the generated images were not well-received. Although text-to-image models like Midjourney have made it easier to create unique visual content (Everypixel journal, 2023), Ms Trollope found that AI-generated images using prompts such as "African" or "South African Fish Farming" were inaccurate and failed to capture the context of the farmers, as well as the specific fish species she wanted to include. AI-generated images have been criticized for perpetuating stereotypes about African people, which stem from the data used to train the technology (Tiku *et al*., 2023). While there are many arguments surrounding the use of AI-generated images and the potential harm they may cause, the design team simply found that they could not accurately capture the complexity and true nature of the audience they were designing for, and for now, the team does not feel confident in creating AI-generated images that would respectfully portray the fish farming community, its heritage, and its history. As part of the redesign, the team chose to use actual photographs of fish farmers, fish farms, and their surroundings to create a more empowering and accurate depiction of the industry.

While offering the potential to streamline certain elements in the design process, in this way saving time and resources – specifically in rewriting text and assisting with voiceovers, AI was not a replacement for the humans driving the process. The ethical concerns regarding data ownership, authorship, and intellectual property rights still require resolution (Marr, 2023) mentioned in the introduction were also becoming more complex during 2023.

In summary, the emphasis on context relevance in our engagement sessions led to an increased use of context-specific Icons, photographs, and content. Icons and graphics tailored to the context, for example, using a cup in the fish feeding calculator (instead of a scale), and changing the shape of the fishpond from circular to rectangular to better represent on-the-ground practice. Whereas this solution was positively received in final feedback, it does raise concerns about the rollout to different countries, where farming practices may differ, and icons may need to be rethought. Finding a balance between universal representation and relevance to users is such an ongoing challenge.

4.7 Software Development Updates

Buna 1 was developed using a WordPress platform. This system was initially suitable as platform to test the concept of Buna. However, as we moved into the piloting phase, it was important that Buna was based in code, so that it could sustain the various functions in Buna and for it to be scalable.

Buna 2 was updated using JavaScript as the primary language. This project was implemented using several frameworks built with JavaScript, third-party frameworks, and third-party Application Interfaces (API). Buna 2 also uses different cloud computing providers including Amazon Web Services (AWS),

Google and MongoDB Atlas. Buna is highly flexible, scalable, and secure thanks to the combination of the different technologies during the development.

4.7.1 JavaScript

JavaScript is a popular programming language used for creating interactive web pages and web applications. It is a cross-platform, object-oriented scripting language used to make webpages interactive (e.g. having complex animations, clickable buttons, popup menus, etc.). There are also more advanced server-side versions of JavaScript such as Node.js, which allow you to add more functionality to a website than downloading files (such as real time collaboration between multiple computers). Inside a host environment (for example, a web browser), JavaScript can be connected to the objects of its environment to provide programmatic control over them.

4.7.2 JavaScript frameworks used in Buna

A framework is a platform for developing software applications. It provides a foundation on which software developers can build programs for a specific platform. A framework is a structure that you can build software on. It serves as a foundation, so you’re not starting entirely from scratch. Frameworks are typically associated with a specific programming language and are suited to different types of tasks. A list of JavaScript frameworks used to develop Buna included:

4.7.3 Typescript

TypeScript is a high-level programming language developed by Microsoft that adds static typing with optional type annotations to JavaScript. It is designed for the development of large applications and transpired to JavaScript. TypeScript is a syntactic superset of JavaScript, which means that it shares the same base syntax as JavaScript but adds something to it. TypeScript will report an error during development that JavaScript could loosely ignore until runtime. TypeScript has more advantages than the error case cited above.

4.7.4 React

This is the heart of the project. React is a JavaScript library for building user interfaces. It was developed by Facebook. React is a frontend framework and allows developers to build reusable UI components and manage the state of those components. It is used to create complex, interactive web applications that can be updated in real-time without requiring a page refresh.

4.7.5 Node.js

Node.js is a cross-platform, JavaScript runtime environment that executes JavaScript code outside of a web browser. It is built on the Google Chrome V8 JavaScript engine, which is the same engine used in the Chrome browser. Node.js is used for building scalable network applications. It is commonly used for building server-side applications, command-line tools, and desktop applications. Node.js is used in Buna to build the server-side code.

4.7.6 Remix

Remix is a full-stack (frontend and backend) web framework that allows developers to build modern, fast, and resilient user experiences with web fundamentals. It is built on top of React and is used for server-side rendering. This means that both the backend and the frontend can be made using a single Remix app. Data is rendered on the server and served to the client side with minimum JavaScript. Remix is designed to encourage progressive enhancement in the React space and focuses on accessibility. It unifies the client and server with web standards so you can think less about code and more about your product.

4.7.7 Socket.IO

Socket.IO is a JavaScript library that enables real-time, bidirectional, and event-based communication between the browser and the server. Socket.IO is built on top of Node.js and is designed to handle asynchronous I/O operations. It is commonly used for building server-side applications, command-line tools, and desktop applications. In Buna this Socket.IO is used to build Buna Chat (The chat functionality).

4.8 Third-party Frameworks Used in Buna

4.8.1 TailwindCSS

Tailwind cascading style sheets (CSS) is a utility-first CSS framework that allows developers to build modern, fast, and responsive user interfaces without leaving their hyper text markup language (HTML). It provides a set of pre-defined CSS classes that can be used to style HTML elements. Tailwind CSS is designed to be highly customizable, so developers can easily create their own custom styles by extending the predefined classes. Tailwind CSS is designed to be highly modular, so developers can easily add or remove features as needed. Tailwind CSS is also highly scalable, which means that it can be used to build applications of any size.

4.8.2 Docker

Docker is a platform for developing, shipping, and running applications using containers. Docker provides the ability to package and run an application in a loosely isolated environment called a container. Containers contain everything needed to run the application, therefore the need to rely on what is installed on the host is negated. This allows the software developer to host the application on a wide range of cloud providers, provided the host supports the Docker Environment.

4.9 Third-party APIs Used in Buna

An application Programming Interface (API) is a software interface that allows two different software applications to communicate and exchange data with each other. It provides a way for different applications and systems to communicate with each other, exchanging data and enabling functionalities. APIs used in Buna include:

4.9.1 Twilio SMS API

Twilio SMS API is an API that enables you to add messaging capabilities to your applications. With the API, you can send and receive SMS, MMS, and WhatsApp messages. Buna uses this API to Send SMS to users after registration and any other time the user interacts with a functionality that requires notifying the user provided that they didn't provide an email address during registration.

4.9.2 OpenWeather API

OpenWeather API is an API that provides weather data for any location on the globe. With the API, you can access current weather data, hourly, 5- and 16-day forecasts, and historical weather data for any coordinate. The API also provides weather maps, UV Index, air pollution, and government weather alerts. Buna uses this API to provide weather forecasts to farmers.

4.9.3 Google Maps Platforms APIs

The Google Maps Platform APIs provide a set of APIs that allow developers to add maps, routes, and places to their applications.

4.10 Cloud Service Providers Used in Buna

Cloud computing is the on-demand delivery of IT resources over the Internet with pay-as-you-go pricing. Instead of buying, owning, and maintaining physical data centres and servers, you can access

technology services, such as computing power, storage, and databases, on an as-needed basis from a cloud provider.

The Cloud Service Providers used in Buna include:

4.10.1 MongoDB Atlas

MongoDB Atlas is a cloud-based database service that allows developers to deploy, manage, and scale their MongoDB databases with ease. It provides a suite of cloud database and data services to help you build with data using the MongoDB document model. One can create, query, analyse, and manage data in any form, across any cloud, with a flexible and intuitive query API, security, and scalability. MongoDB Atlas is designed to be highly available, secure, and scalable, with built-in automation and monitoring. Buna uses MongoDB to maintain the database.

4.10.2 Amazon Web Services

Amazon Web Services is a cloud-based platform that provides a wide range of on-demand computing resources and services, including computing power, storage, and databases, to help businesses scale and grow. Buna uses AWS as a hosting platform among other services.

Some of the advantages of AWS are:

- Scalability**:** AWS allows you to scale your infrastructure up or down based on your business needs. You can add or remove resources as needed, without having to worry about the underlying hardware.
- Cost-effective**:** AWS offers a pay-as-you-go pricing model, which means that you only pay for what you use. This can help you save money on infrastructure costs.
- Reliability**:** AWS is designed to be highly available and reliable. It offers multiple availability zones and regions, which means that your applications can continue to run even if one zone or region goes down.
- Security**:** AWS provides a wide range of security features to help protect data and applications. It offers encryption, identity and access management, and network security features, among others.
- Flexibility**:** AWS offers a wide range of services and tools, which means that you can choose the ones that best fit your business needs.

4.11 Database

Buna uses MongoDB maintained on MongoDB Atlas as a database model. However, all database logic is built with PRISMA which is a Node.js and TypeScript ORM (Object-Relational Mapping) that

allows developers that supports both relational and non-relational database models this means Buna can easily switch to use any database of choice including PostgreSQL, MySQL, SQL Server, SQLite, MongoDB, and CockroachDB. Hence making Buna very flexible enough to work with any database.

4.12 Data Privacy and Security

Buna uses one centralised database to keep all the data together. However, Buna is built to encapsulate data, e.g. a country cannot have access to another country's data. Some users are only allowed to have access to certain data depending on their roles and level of permissions they are granted.

4.13 Challenges with Software Development

The development of Buna has been a journey and some things had to be modified/changed along the way. Thanks to the flexibility that coding comes with, anything is possible.

Some challenges worth mentioning:
Next.js was used in place of Remix and is used for the same purpose as Remix.
Although Next.js is robust and can handle everything Remix can do, the current Version (Version 12) just was not as flexible enough as Remix is when taking Scalability of Buna into consideration.

When Buna was first deployed Docker was not used, this meant a couple of things that docker is designed to facilitate. One, the developer had to rent a virtual computer on AWS (EC2) and set up every application that is required to run Buna. This takes time. With Docker this process becomes considerably easy and Short. All the developer needs to do is set up the Docker environment on the virtual machine or even better use a service on AWS (ECS) that already has the Docker environment set up automatically. Secondly, without Docker every time there is an update in code, the running version of Buna had to be shut down before patching the updates. However, with Docker, the current running of Buna will be shut down only when a new container with updated data is started.

4.14 Discussion of the project

Globally, the aquaculture sector is experiencing continuous growth, driven by increasing world population, pressure on wild fish stocks, and rising consumer demand. South Africa's Department of Forestry, Fisheries & Environment (DFFE) is dedicated to supporting the expansion and improvement of this sector, recognizing its potential to enhance food security and economic growth. With the expected enactment of the Aquaculture Development Bill, likely in 2024, DFFE aims to assume a leadership role in this endeavour (Government Gazette, 2023). Aligned with global trends, South

Africa's aquaculture sector will prioritize technological advancements and innovation under DFFE's guidance. Given the technical nature of aquaculture, innovation and research play crucial roles in driving progress. Notably, innovations in the sector, such as the GIFT tilapia strain have led to breakthroughs such as more efficient fish farming methods and improved fish feed formulations (Bhendarkar and Kalbande, 2022).

The challenge within the South African aquaculture sector (and across the developing world) is not so much as the limitations of the development of digital platforms that fish farmers can use, but rather with limitations on the part of farmers. As noted in the introduction, fish farmers, based in rural areas, may lack access to internet infrastructure and also have low literacy and/or digital literacy skills. As such, the development of digital technologies, should not only look to innovate, but also consider how to do so in a way that is inclusive of populations with diverse literacy levels and digital skills. This project sought to explore how that could be done through the process of participation design.

After various engagements and consultations with farmers, the front end of Buna was completely re-designed. It is important to note that this redesign was not superficial or cosmetic. In many cases it involved structural changes to Buna, meaning that “back end” (new coding) had to be developed to accommodate these new changes. In many cases, the flow of information and services in Buna also had to be re-written to reflect the front-end changes being made.

The project's participatory approach enabled the design team to take into account the broader context and identify the need for instructional support in the Buna2 platform. The calculator tool received positive feedback, but feedback from farmers' interactions with it led to the development of an FAQ video library and demo videos on each page. Two critical aspects of the Buna platform emerged as highly beneficial to farmers during interactions: access to technical information on fish farming and the potential for community building. Although community building was not initially a primary focus, farmers expressed a strong interest in using the platform to connect with and educate other farmers, fostering a sense of community and support.

Farmers have found access to technical information and community building to be valuable features of the platform. They have also suggested that the platform could facilitate positive communication with officials, which could decrease frustrations experienced in their interactions with extension officers and government support. The use of local languages is a crucial factor in helping people who have limited literacy or digital skills to accept and use technology. However, there are challenges involved in ensuring that the language used is not so specific to a particular location that it excludes potential users of the platform. Language decisions will need to be made in conversation with government partners. It was also noted that the need to customize their profiles and farmers' interest in content creation is promising, but presents challenges in ensuring accuracy. Nonetheless, allowing

users to customize content, interface layout, and functionalities according to their needs and preferences is crucial for accommodating diverse user groups.

By considering and integrating these insights, the platform can better serve users from under-resourced communities and contribute to their empowerment in the context of the Fourth Industrial Revolution.

Advances in AI has in the last few years opened many exciting new possibilities in not only in developing new services for farmers but also in assisting in how we can make these online platforms more accessible to the farmers. Although used minimally in the development of Buna2, AI has the potential to provide ways in which we can create content specifically tailored for users with low literacy. This includes using AI to create content (text and audio-visual materials), specifically tailored for fish farmers. We are now even approaching the threshold, that farmers themselves will be able to generate their own content using AI.

5. CHAPTER 5: CONCLUSION, RECOMMENDATIONS AND FUTURE PLANNED WORK

Considering that the first email in South Africa was sent only as recently 1989 (from Rhodes University to the USA), it understandable that how these three disciplines of science, social, digital and biological sciences interact with each other is a relatively new area of study.

As new as the digital sciences are, in today's world, there does not seem to be any facet of human life that is not connected, dependent or even reliant on the digital revolution. From communication, trade, health education and even social needs. A stark reminder of how important the digital revolution came to light during the early days of the coronavirus pandemic in early 2020. When government ordered a hard shutdown, those who had internet connection or had businesses with digital capabilities were able to trade and earn an income. Those without internet connection or digital presence found themselves outside the main economy.

Listed below are the main recommendations for this study, which explored how to address the needs of rural fish farmers with low digital literacy to use a technical online aquaculture platform.

5.1 Recommendations

5.1.1 Continued Development

Without a doubt, the outcomes of this research study have enabled Buna to be more accessible to users with low literacy and digital literacy skills. Bearing in mind that aquaculture itself is a technical activity, conveying information to farmers can be challenging. Therefore, the process and methodology of presenting information to fish farmers needs to take into consideration these two parameters.

While there are many areas of research in this field that can be undertaken, it is suggested that research into voice over prompts is prioritised. This research would go beyond simply to provide an audio of the text, but rather to present the user a synthesis of the text and to contextualize it within the needs of the user. The inclusion of Artificial Intelligence would need to be included in this research.

In developing the capabilities of Buna to provide a much larger range of voice over prompts, one in which the factors such as language, dialect and accents is taken into consideration it would also be important to explore how the changing demographics of the aquaculture sector is a factor in this.

Presently in South Africa, many small-scale fish farmers in are middle aged or older. This is an observation based on many years of field work (DFFE does not keep a comprehensive statical database of fish farmers, that is continually updated and include monthly farm production data). However, DFFE through their Aquaculture Bill are seeking to bring in youth into the sector. Shifting the demographic will

likely influence how Buna is presented to the younger generation, therefore further research into UI & UX will need to consider this factor.

5.1.2 The use of AI

Within the digital sphere, AI is possibly the single most important field of innovation that is currently taking place. AI is growing not only in its technical capabilities, but also in the scope that it can be used. We are yet to fully understand where this relatively new innovation will lead society to.

Within the scope of Buna there are many research opportunities around the use and incorporation of AI. Within just a few years there has been significant progress in the field of AI, it would however still be prudent to acknowledging that AI is still very much in its “teething” phase and still prone to miscalculations. An example of the power of AI is the popular platform ChatGPT4. This platform is now being used across society in a wide range of applications. From students using it to assist with their assignments to the legal fraternity in writing legal briefs. It is in fact presently possible to incorporate ChatGPT4 within Buna. ChatGPT4 comes with an API which is essentially an “adaptor” that allows it to be integrated into other online platforms (such as Buna). There is significant evidence, that even though ChatGPT4 is exceptionally powerful and useful, it is still prone to mistakes. Therefore, its inclusion in and useful, as important as it may be, still needs to be done in a way that is careful and thoughtful.

One area of research in integrating AI into Buna would be to use ChatGPT4 as a support tool to extension officers. Extension officers interact with farmers and are often asked to provide with technical support. Therefore, it is envisaged a tool like ChatGPT4 could become a useful support for farmers when they are in the field. The research would then look at how an AI tool such as ChatGHT4, is practically used in the field, what are the typical questions being asked, the integrity and reliability of the answers CHAT GPT4 provides.

Once this research is conducted and the capabilities of AI services such as ChatGPT4 is fully understood and its efficacy within the sphere of aquaculture is tested, only then would the scope of the research be widened to make ChatGPT4 available to farmers. The rational for this two-step process is that it would be unwise to offer this service to farmers when it has not yet fully tested. Poor advice to farmers by ChatGPT4 could have financial consequences and as such it is important that only reliable and tested information systems are offered to farmers. It is also important to recognise that AI platforms such as ChatGPT4 have machine learning capabilities, this means that as it is used, it also learns. Therefore, overtime, the quality of the responses of ChatGPT4 should be improving.

5.1.3 Implementing Buna in South Africa

Though Buna is being adopted and used in other part of Africa, it is still not being adopted at either a provincial or national level, even though Buna was developed within South Africa using government funding. Furthermore, Buna was developed primarily taking into considerations the needs of South African farmers and the needs of government in managing and developing the sector.

There have been engagements with provincial as well as the Department of Forestry, Fisheries and the Environment (DFFE) on adopting Buna, however these initiatives have not been successful. It is recommended that the Water Research Commission (WRC) continue to engage with DFFE to explore possible avenues to implement Buna in South Africa.

It is also important to bear in mind, that South Africa's strength in contributing to the development of aquaculture in Africa is through innovation. South Africa has a strong science and technology foundation and therefore, developing and using Buna within South Africa would be an important way to demonstrate its technological abilities.

5.2. Future planned work

Globally, the world is becoming digital. This is the future. Aquaculture is also embracing digital solutions. Digitisation in aquaculture will become an area of research and development like nutrition, genetics and animal husbandry. Therefore, based on the experience of this research study the following areas of research are proposed.

5.2.1 Market Function Development

Fish farmers have primarily two main objectives, the first is to ensure that they can grow the fish to market size in a way that is profitable. The second is to ensure that once the first objective is met, that they are then able to sell the fish. Marketing fish is therefore a top priority for farmers.

The reality that many farmers face is that they are generally located in rural areas, where land and water is available and relatively not expensive. Markets on the other hand are generally located in the urban areas – where there is congregation of people and greater buying power. This geographical gap between where the farmer is located and where the main markets are located presents a challenge to the farmer.

Therefore, it is proposed that a key research area in Buna would be to develop a function that connects farmers with fish traders. The concept would be that traders would be enables to register on Buna as a

user. Then when traders are looking for fish to buy, they would indicate what species of fish they are looking for, the quantity and the price they are willing to pay per kilo. Fish farmers would then be able to view which trader is searching for fish and determine if the parameters they have set are agreeable to the farmer.

Likewise, this market function would enable farmers to indicate when they plan to harvest fish, what species, amount, and the price they are looking for. Fish traders would then be able to view which farmer is selling and then contact them to finalise the deal.

This function would enable farmers and fish traders, to connect through Buna in real time. This connection, of farmers to fish traders, would provide both parties a very efficient and effective way to find each other, taking geographical separation out of the equation. There is however a more significant outcome to this proposed function. This service could be coded in a way that it would leverage significant economic data, that would be of great use to the farmer, trader and more importantly governments. Economic data on parameters as how much fish is being sold at what price and where it is sold to is of great importance for policy makers.

The important of fish sale (economic) data cannot be underestimated. In Ghana, the Ghanian Aquaculture Chambre of Commerce, on a weekly basis publishes the volume of fish that was traded in the country and at what prices. This type of data has helped both farmers and traders to succeed in their business development. The Ghanian government also used this data manage and develop the sector. However, this data is collected manually (and not through an online platform).

Therefore, research to develop a market function in Buna, would not only be of significant use to both the farmers and traders, but it would also greatly assist DFFE to better understand the economic value of the sector and to make informed decisions on what interventions are needed.

It is entirely possible that within a few the use of AI could be extended to offer farmers a much broader support service, such as calculating fish production, and possibly even predicting water quality issues before they occur (based on historical and present water quality data). AI could even be used in the future to predict market demands. The research into incorporating AI into Buna and the aquaculture sector could possibly become the one of the most important research areas in the sector.

5.2.2 Connecting researchers and farmers

Enhancing the relationship between fish farmers and researchers is an important component of developing a vibrant and successful aquaculture sector. Innovation and research are what has made the aquaculture sector so successful in such a short span of years. Recently aquaculture production

surpassed beef production (globally) www.fao.org and this was largely possible due to research and innovation, such as improving the performance of feeds and developing the protocols for farming new species of fish.

However, there still seems to be a gap between farmers and researchers. Many farmers (especially small-scale farmers) feel that researchers are not addressing their immediate needs and that the knowledge that is produced by these researchers is not accessible to them. This gap between these two important actors in the aquaculture sector is not desirable, especially when considering that the majority of global aquaculture production is undertaken by small-scale farmers.

Platforms such as Buna could play an important role in bridging the gap between researchers and farmers. The same way Buna currently connects service providers (such as feed manufactures) to farmers, it is envisaged that Buna could also be used to connect farmers to researchers. This could become an important function of Buna. It is therefore proposed that research is conducted to determine how such a function could be developed and implemented within Buna.

The research targets could include to develop a mechanism in which farmers are able to voice their research needs. The research could also include to develop a mechanism in which research results, such as scientific papers, is presented to farmers in a manner that is accessible to them. AI could play an important role here. Platforms such as CHAT GPT4 could be used to scan a scientific paper and “re-write” it in a way that small-scale farmers can engage with. AI could also be used to translate these “re-written” papers in a language of preference to the farmers, and even to produce animated videos on that paper. All of this could be done automatically by AI.

Using Buna to connect farmers and researchers could become a relevant solution to a problem that has been around for years. The mistrust between farmers and researchers is not healthy and there are now digital solutions that can be deployed. To build this trust between farmers and researchers, it is proposed that this feature could include a section where the profile of researchers is open to farmers. The feature would also include a way for farmers and researchers could exchange ideas. The research would examine these conversations to how it is being used and measure outcomes.

5.2.3 Production Calculators

Currently in Buna there is a function that is available to farmers to assist them to calculate production. In this function, the age / weight relationship of Nile tilapia (grown in cages in Lake Kariba) is used to assist farmers to determine what weight their fish should be in at a given age. This is an important parameter to measure production.

Most small-scale farmers know the age of their fish, but they are unsure what the weight of the fish should be at a particular age. The issue is that if farmers under-feed their fish, then it's a loss of income of income and if they over-feed their fish, it is also a loss of income. Therefore, knowing how big their fish should be (weight) at a particular age and how much to feed them is central to farming fish successfully and profitably.

Presently in Buna, the fish calculator is only available for farmers growing Nile tilapia in cages in Lake Kariba. It is important for Buna, that this service is extended to other species of fish used in the aquaculture sector, such as trout, catfish and other species of tilapia. Also, within the same species, that production calculators are developed for different methods of growing fish, such as in ponds, cages and recirculating systems. There can be difference in these different methods of growing fish.

It is therefore proposed that there should be a dedicated research thrust to bolster the fish production calculator in Buna to include as many relevant species as possible of fish within the aquaculture sector. The research could also include to develop new methods in which age / length / weight growth relationship data is captured and incorporated in Buna. The research could also include the use of AI to develop these models and to also calculate the feeding regimes of these fish, based on their size.

It is important to note that commercial large scale fish farms have this data (for the species of fish they are working on), but in many cases they are unwilling to share it as they regard this data as proprietary information as it is central to their operation and business viability. Therefore, it is important for many small-scale farmers that research in developing a production calculator is undertaken and made accessible to them. This type of technical data could assist many small-scale farmers to become more efficient and increase profitability.

5.2.4 Water quality monitoring

For many small-scale farmers dealing effectively with water quality is often out of reach to them. The challenges around water quality are made up of two different issues, the first is being able to records or measure the various water quality parameters needed to manage a fish farm, such as dissolved oxygen (DO), pH, and ammonia. The next is to then once that information is obtained, to determine what it means and how to use to solve a problem they may be facing.

The first part deals with farmers having access to instruments that can measure the required water quality parameters. Over the years, as technology has progressed, these instruments have become more affordable and as such more accessible. There are now instruments available (often called data loggers) that can be left in a pond and it will automatically record and transmit water quality information.

This innovation makes it now possible to provide farmers with water quality information in real time at regular intervals.

It is therefore proposed, that research is conducted to develop a pathway, that water quality from a farmers data logger is submitted automatically to Buna, and then using machine learning and AI, that this information is then presented to the farmer (on their dashboard) and it then informs the farmer as to what the data means and if there are problems to advises the farmer on what should be done. For example, if the information coming in from the data logger is indicating that the DO levels in the pond are dropping, then Buna could then advice the farmer that they should either increase aeration in the pond or and reduce the stocking densities in the pond in question.

Water quality has significant bearings not only on production, but also fish health. It is known that when water quality declines, fish become stressed and therefore much more susceptible to fish diseased. Therefore, research into using Buna as a platform to integrate farm water quality data and making it accessible to farmers using AI and machine learning would be of significance importance to the farmer.

It is also possible that farm water quality data is pooled centrally and then used by government to manage and develop the sector nationally. For example, if water quality data indicates that water quality in a region of the country is declining, it would require national interventions.

5.2.5 Farmer content development capabilities

Most fish farmers worldwide are small-scale. They are indeed the mainstay of the aquaculture sector. However, for the most part, their voices / needs are not proportionately represented. There are several reasons for this. Most fish farmers are based in rural areas, and operate small farms, their focus is generally on production and feel they are too small to contribute towards “big picture” issues. Language could be another barrier for small-scale farmers to feel they are not part of the bigger debates in the country. They may not be well conversant in English and as such may feel inadequate to contribute to national debates.

However, as most fish farmers are small-scale farmers, it stands to reason that collectively, they have a lot of knowledge to share. The difficulty is that there are few platforms for farmers to share the knowledge that they have, and even if they are to share it, it would most probably be broadcasted in their own local language, which may mean that it is then restricted to whoever can speak that language.

This problem creates an opportunity for Buna. Buna could be used as a platform for small-scale farmers to create content and share it with other farmers. Creating this farmer-to-farmer link, could become an important function in Buna.

The research here would be to develop a methodology for farmers to create content for Buna. The problem to solve is that many farmers may have limited use of English, and probably only fluent in a local language. It is also possible that farmers may also not be comfortable to write an article that would convey the message that they want to share with other farmers.

With regards to developing short videos, another avenue of sharing content, it is also possible that farmers may not also have all the necessary skills to create a short video of the content that they would like to develop.

The research here would be to collaborate with a school of journalism and explore how AI tools could be used to assist farmers to create content for Buna (such as short articles and videos). Presently there are several AI platforms that can create videos and assist with content development (such as Fliki and Synthesia). However, within the context of assisting fish farmers to produce content the ability of these platforms is largely unknown. Therefore, it would be important to conduct research to develop appropriate methodologies on how to use existing AI platforms as tools to assist fish farmers to develop their own content. These AI could also be used to translate the language that the farmers are using into English (or even other international languages used across the globe).

It would be important to do this research project in collaboration with a school of journalism as the skills set, they have would be relevant to this research. If this research is successful, it could have significant impact on the sector, as small-scale farmers would now be able share their experience and project their voice beyond their immediate surroundings but now reach national and even international audiences.

5.3 Conclusion

Aquaculture in Africa is shifting away from subsistence type farming to one that is profit and production orientated. Fish farmers are no longer interested in farming fish that is modelled on “hand to mouth” farming, they are instead looking to develop farms that can be financially successful. With this shift, farmers are looking for information and services in real time. They want to be connected to markets and the value chain. They want to be connected to other farmers, share experiences. They also want to be connected to the services and functions that government provides, such as extension services and fish health.

To achieve all of this, farmers are increasingly using the IoT’s to connect to the bigger world. It is therefore important that government takes notice of this shift. Government needs to recognise that the needs of farmers have changed, and it therefore needs to adapt to this. Government needs to facilitate the process in which fish farmers increasingly use digital platforms and services to manage and operate their farms.

The challenge is that while many farmers are increasingly using digital platforms and services, the reality is that many farmers have low digital literacy. Therefore, when developing and designing bespoke digital platforms such as Buna, there needs to be consideration not only with regards to the contents of the platform intended for farmers, but also how it is delivered, also known as the UI and UX.

Buna has evolved into a strong and relevant aquaculture platform that addresses the needs of the sector. It provides farmers and government officials with many functions and services that is relevant to their needs. However, the initial development team at Rhodes identified the need to re-design Buna so that the UI took cogenesis of the fact that many farmers have may have low literacy levels and/or low digital literacy skills.

Literature surrounding designing for users with low literacy promote “co-designed solutions” as a means to promote local adoption (UNESCO, 2018). The United Nations Educational, Scientific and Cultural Organization’s (2018) report note that participatory design methodologies as the most the effective when creating digital solutions for low literate and low-skilled populations. As such, participatory design methods were used in redesign of Buna.

We found that the participation of farmers in the redesign process was valuable and insightful. Farmers offered suggestions on designs, functions, and content – demonstrating how their tacit knowledge could be leveraged in the design of digital solutions. Some of these suggestions raised new challenges or "wicked problems" that will drive further development of the platform and potentially challenge the original intentions of Buna. The significance of engaging with users lies in the opportunity to leverage their insights for the long-term development and design of a platform that caters to user needs (Jones *et al*. 2017). Our findings confirmed most of the guidelines that are currently suggested by Srivastava *et al*. (2021), UNESCO (2018) and others, and emphasised the importance of visual design in the communication of technical information.

Throughout this process, farmers continually indicated that they saw the benefits that Buna offered as being valuable for accessing technical info, educating new farmers, and supporting business development. Beyond this, the opportunity to build a community of practice through the platform was highlighted. Farmers viewed this as a valuable way to increase awareness of fish farming, share their knowledge and grow aquaculture nationally. In this way, the development of Buna to develop an entire community, rather than individual farmers was brought to the fore. Another important takeaway from the research is that farmers viewed Buna as a way to improve communication with extension officers. As such, we believe that the platform is effectively communicating what sets it apart, and we can continue working to build it as a tool to foster positive farmer – government relationships. The participatory design process with farmers highlighted the importance of technical information access and community building within the Buna platform. It also sheds light on the potential for improved communication

between farmers and government officials, the value of user-generated content, and the need for customization options that cater to users' diverse needs and preferences.

An aspect that fell beyond the scope of the project, but needs to be considered for the future, is the redesign and adaptation of the “resources” library available on Buna. Although the information is now better organised and searchable, the design team still feels that the formats are too complex and should be simplified for Buna. This is no small task, as the translation of scientific concepts and jargon associated with the aquaculture industry will be time consuming and difficult. However – we feel that to grow the industry, such an endeavour is warranted. The findings from such an experience can also be used to investigate which methods can be used to simply other complex information – for example government policies – that may enable South Africans to be more involved, active citizens, regardless of their literacy levels or digital skills.

We have learned a lot from the participative process, not only in terms of redesigning Buna, but in the way we think participatory design can be used in the African context. We emphasise that participation design methods can be a powerful way of engaging African communities in digital design collaborations, allowing them to actively participate in the 4IR. This approach empowers communities to decide how they want to engage with such systems, promoting sustainable and inclusive development of design solutions that are community-driven and culturally relevant. By embracing this approach, 4IR becomes something that is developed with communities, rather than for them. The participative process can thus be seen as a strengths-based method that could avoid the perception of new technology as an external imposition on communities.

Buna now has a completely different “front end” (UI), based on the outcomes of the research conducted, and these changes were positively received by the farmers. However, to remain relevant, the Buna platform needs to be adaptive and dynamic, like the Aquaculture sector. As the needs of farmers evolve, demographics, literacy and technical skills change and new digital innovations become available, Buna will also need to be updated. This type of interdisciplinary research – where aquaculture, design, social science, and software development meet – will increasingly become an important research area as this field grows.

The role of AI in the future of this type of research cannot be understated. As noted earlier, AI development in aquaculture presents exciting potential for the future of Buna. It’s capabilities to identify and prevent the spread of disease, to monitor fish health and food wastage, presents ways of improving inland fish farming on the continent. In terms of design, AI’s use in evaluating and designing user interfaces (Grigera *et al*., 2023) could present ways to streamline the continued development of Buna. AI could even assist farmers in their own content creation, as such leading to the sharing of knowledge from South African fish farmers. AI is, however, still a debated area – with ownership and copyright

issues that need to be resolved. Further, despite the possibilities it offered, we found it difficult to create content at accurately captured the complexity of the South African aquaculture.

AI is still in its infancy, yet it is having significant impact in the digital world. How it is used responsibly and effectively to promote the development of the aquaculture sector locally remains to be explored. As AI technology improves and becomes more reliable, it will have a huge impact in society. Currently Buna is using AI, but in a small and measured way, through text simplification, and voiceover creation. It is expected, that as AI technology improves and becomes more reliable, it would be further used in Buna to enhance the experience of farmer.

It is also proposed that further research be undertaken to develop other functions in Buna, this includes the capabilities for Buna to connect farmers to researchers, for farmers to connect their own content, to strengthen the ability for Buna to assist farmers to calculate farm production and to assist farmers to grapple with water quality issues. It is also proposed that that further effort is made to engage with the relevant provincial and national government departments to implement Buna in South Africa, as it is now being adopted in other countries on the continent.

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APPENDIX 1: CAPACITY BUILDING

Degree Purposes

Student Involvement

As part of the project, a student bursary has been made available for one full-time honours student to be involved in the research project. The contract for the project was finalised on 21 April 2022. By this stage, the University of Johannesburg's honours students were already well into their research methodology module and had decided on a direction for their theoretical and practical projects for the year. As such, it was decided that the bursary would be reserved for 2023. This would have allowed for adequate time to advertise the bursary, accept and review applications and to then award the bursary in early 2023. It also allowed the selected student to select the Buna project for both their theory and practical modules. This extended engagement also allowed the student to have a more meaningful experience with a research team, the project and the design solutions that result from it.

Participation Design unit 2022

Despite not having a full-time student on the project, the Buna project was selected as a "client" for the 2022 Graphic Design Participation Design Learning Unit. As part of their first semester work, the Communication Design Honours students complete the Participation Design Learning Unit. The learning unit provides students with the opportunity to work with real-world clients, and the potential for their design solutions to be implemented after the completion of the project.

The student was expected to:

- Conduct adequate research to identify, and analyse key stakeholders, complex client problems, targets, and objectives to construct a conceptual strategy for the chosen client, to be included in a research report and video summary, documenting the process, and other documents.
- Apply research and client feedback to conceptualise, visualise and expand original design ideas according to the requirements of the client and project brief.
- Produce reactive, appropriate design solutions that are impactful, practical, and potentially unique, demonstrate innovative thought and communicate to the client's specific target group persuasively and professionally.

For the Participation Design Learning Unit, the student was given the brief to:

- Conduct Initial research into Buna platform: The student needed to look at the current Buna Platform in terms of design, navigation, and presentation of information, and then make recommendations on how this could be improved drawing on principles of UI design.
- Develop a Corporate Identity: Buna did not yet have an established visual identity. The student was asked to propose one based on the aims of the platform, combining the concepts of fish farming, Africa, and technology. The visual identity needed to be applied to social media platforms.
- Suggest a campaign to encourage fish farmers to make use of the platform. The student was required to do research to make suggestions about what format this should be (print, social media, etc.).

Based on the above, the student was required to engage with the “client” (the Buna team) and use professional skills to develop an understanding of the platform, its target audience and aims. Several meetings were had between the student and the client, where the client provided background information and insight on Buna Africa. The student then used this, alongside desktop research and an analysis of the website to propose her design solution. Her design solution included a logo, colour palette and style guide that she suggests would build confidence in the brand, and for the organization to easily recognizable and distinguish it from competitors.

WRC bursary 2023

The WRC bursary was announced for the BA Honours Graphic Design program at the University of Johannesburg. After registration, interested students were invited to apply. Two applications were received, and a merit selection was made based on the third-year practical and theory marks. Ms Bethanie Trollope joined the Buna research team in February 2023.

During the year, Ms. Trollope played an active role in two site visits to Thohoyandou. Using previous WRC reports and her experiences in Thohoyandou, she designed the final corporate identity and style guide for Buna2. Ms. Trollope was also essential in the implementation of crucial design enhancements to the final prototype of Buna2. She engaged proficiently across various design platforms, including Figma, and worked with the software developer and research team throughout the project.

The bursary was designed in a way that allowed Ms. Trollope to focus on Buna for the practical aspect of her degree (Communication Design A (CDH8XA4) and Design Project B (DPH8XB4)), while also pursuing her interest in AI for the research component of her honours degree (Design Theory A (DTH8XA4), Research Methodology (RMH8XA4) and Research Essay B (REH8XB4)). This approach

enabled her to make significant contributions to the development of Buna, while also fulfilling all the academic requirements of her degree.

Ms Trollope will graduate with a cum laude in March 2024.

Ms Trollope's report is available in Appendix 2.

Non-degree Purposes

Fish farmers from the Thohoyandou region

The project teams interactions with the fish farmers build capacity. The farmers were exposed to new innovations and thy learnt to use Buna Africa. For the farmers, being able to navigate Buna and learning how the various functions worked build their capacity. For example, withing Buna, there are a number of YouTube videos on various aspects of fish farming within the African context. The farmers expressed that they enjoyed watching these videos and they learnt from it.

Also, when the project team was meeting the farmers, there were lengthy discussions not only around the development of Buna, but on aquaculture itself. Farmers wanted to know what our rationale was for the various functions. Therefore, in those deliberations, there was an exchange of ideas and as such capacity building of the farmers.

During one of the field visits to Thohoyandou, the research team visited the fish farms of the farmers we were working with. During this farm visit, there was many discussions on how the farmers could improve their facilities. This engagement was a form of capacity building.

Limpopo Department of Agriculture officials (Aquaculture Directorate)

The aquaculture extension officer based in the Thohoyandou District, and an official from the Head office in Polokwane, were integrally involved in all of the activities of the research team during the various field trips. These officials were trained how to use Buna and they were present during the various workshops with the fish farmers. These officials were very much involved in the workshops with the fish farmers. Therefore, the learning experience of the fish farmers during these meetings would be similar to that of the Limpopo Department of Agriculture officials.

The research team

It is important to acknowledge that during this research project, within the team itself there was significant learning and as such capacity building. This research was in intersection of various disciplines of science. Therefore, research team members had to learn new knowledge from other disciplines to create a space for the research team to work together effectively. This shared knowledge building exercise is reflected in the way the UI of Buna was designed and developed. User interface is not only an expression of design, but it also needs to be rooted in the principles of aquaculture.

APPENDIX 2: STUDENT REPORT

Buna Africa's UI/UX Redesign

Bethanie Trollope
Department of Communication Design
University of Johannesburg

In 2023, I was awarded a scholarship for my Honours in Design degree by Rhodes University's Department of Ichthyology and Fisheries Science and the Water Research Commission (WRC). As the recipient of this scholarship, I spent the year working alongside Buna Africa's researchers and contributors to redesign the user interface and user experience (UI/UX) of the organisation's online platform. During this process, I drew from my existing knowledge of UI/UX best practices, as well as appropriate literature, to achieve a final product that would engage, and be accessible to, Buna Africa's target audience. Additionally, I experimented with emerging generative artificial intelligence technology to identify its possible applications within the context of the organisation. The following report documents the key changes made to Buna Africa's UI in service of improving the overall user experience, as well as the knowledge and experience I gained in completing this project.

The first step of any UI/UX project is to identify the target users of the platform and establish their needs. In earlier reports by Buna Africa (Haese *et al*., 2022), the platform's primary users are described as small-scale African aquaculture farmers living in rural areas. Many of these farmers have limited access to digital infrastructure and experience low levels of literacy (Haese *et al*., 2022). Other key users of Buna Africa, specifically government officials and suppliers of market-related goods and services, do not necessarily face the same challenges. As such, any UI/UX design solution created for Buna Africa needed to cater for those with low levels of literacy, both in the traditional and digital sense, without isolating its more advanced users. An appropriate framework to guide the creation of such a solution was found in *designing SARAL* (Smartphone Applications embRAcing Low-literate users), introduced by Ayushi Srivastava, Shivani Kapania, Anupriya Tuli, and Pushpendra Singh in *Actionable UI Design Guidelines for Smartphone Applications Inclusive of Low-Literate Users* (2021). This framework provided a set of actionable and adaptable guidelines around which I was able to develop UI/UX designs that were not only appropriate for users of varying literacy levels, but also culturally relevant. Also of great importance to the redesign of Buna's UI/UX was feedback received from farmers on the existing website, as set out in earlier reports provided to me by the Buna Africa team (Haese *et al*., 2022), and by the farmers themselves during a research trip to the Vhembe district of Limpopo, South Africa in May of 2023 (Haese *et al*., 2023). What follows is an outline and rationale for the changes made to Buna Africa's website in line with the information gathered.

General redesign

To avoid user confusion, Srivastava *et al*. (2021) recommend that UI intended for users with low levels of literacy should be simple and minimalist in appearance. Good use of colour and typography should be used to emphasize important information and create visual cues that guide users across the platform. While the use of colour in Buna Africa's existing UI did successfully emphasize important features like buttons, the overall appearance of the design felt dated and slightly austere due to its cool colour palette and large, unbroken areas of white (figure 1). To make the platform feel more inviting, a new, warmer colour palette was adopted, and areas of white were broken up by introducing grey/coloured panels (figure 2). These panels also work to provide structure to the platform as they break up large amounts of information into smaller, easier-to-manage sections that are clearly demarcated.

By using a single font size and weight to present text, the original UI of Buna lacked structure and hierarchy of information (figure 1). This made the platform's information appear dense and difficult to navigate. To combat this, a variety of font sizes and weights were introduced throughout the platform to provide visual structure, and information was broken up into short sentences under clear headings (figure 2). The overall size of Buna Africa's text was also increased in line with best practices for designing with users with low literacy (Summers and Summers in Haese *et al*., 2022).

Responsiveness

As previously stated, many of Buna's target users live in rural areas with limited access to digital infrastructure. Not all users are able to access a desktop and will rely upon their smartphones or tablets. As such, the new UI was designed to be responsive and work intuitively across a variety of devices (Figure 3), while remaining visually and structurally consistent – if users are to move from one device to another, the platform must navigate the same to prevent confusion.

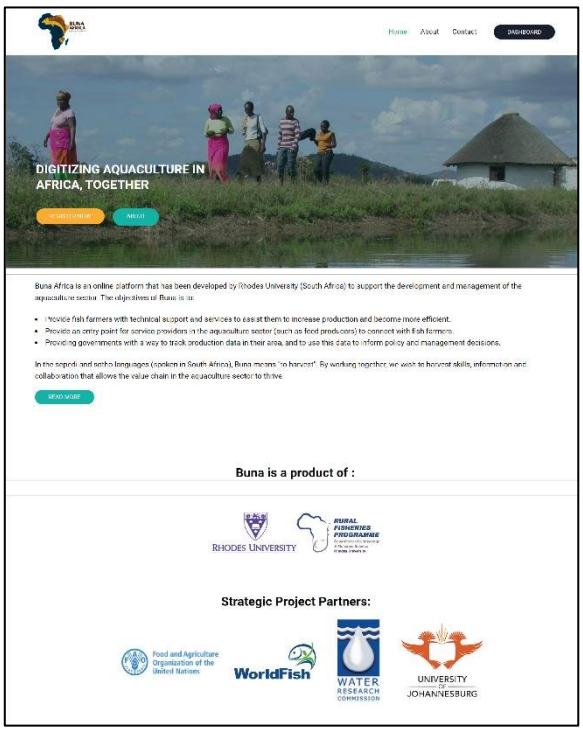

Figure 1:
Existing homepage with old colour palette

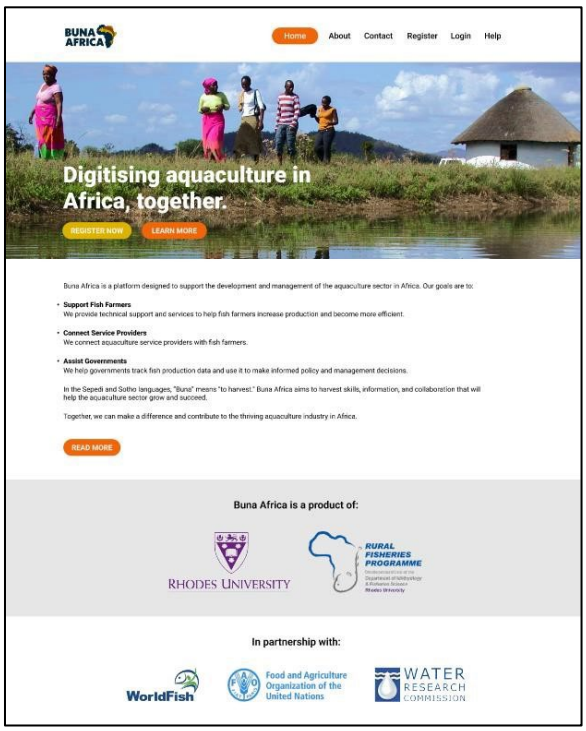

Figure 2:
Updated homepage and colour palette

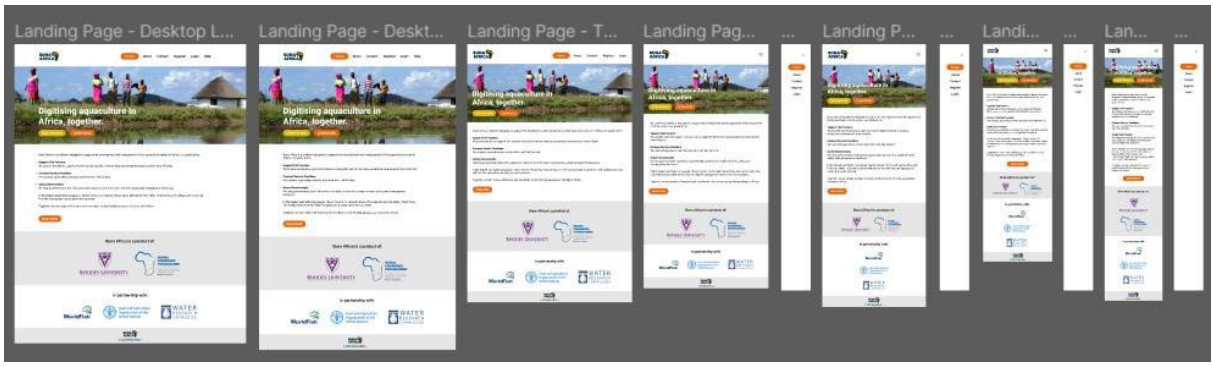

Figure 3: Buna Africa's updated UI is responsive and works consistently across a variety of devices

Presentation of information

When presenting text to users with low literacy, it is advised that a single, left-aligned column be used (Summers and Summers in Haese *et al.*, 2022). Where possible, information should be broken down into clear sub-sections (Kodagoda *et al.,* in Srivastava *et al.*, 2021). In response to this advice, the redesign has forgone double-column layouts where possible and has made the demarcations between individual elements clearer by using grey blocks to group information.

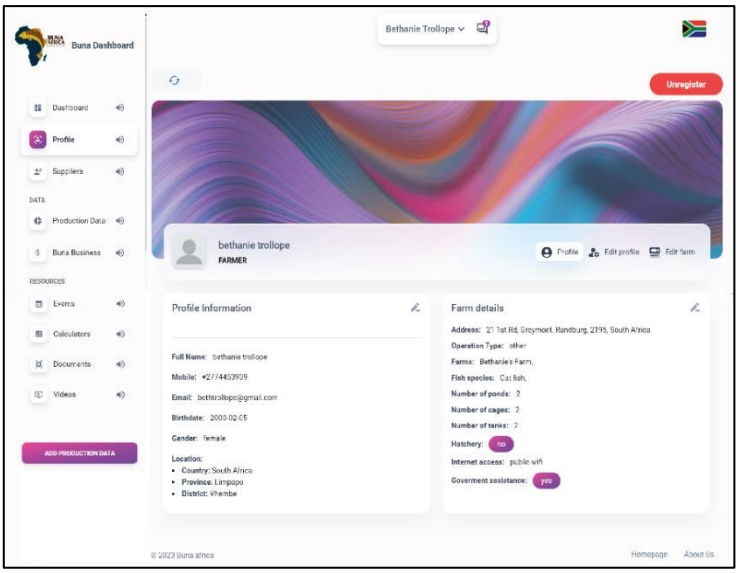

Figure 4: The original profile page design has a double-column layout and individual elements are not clearly demarcated

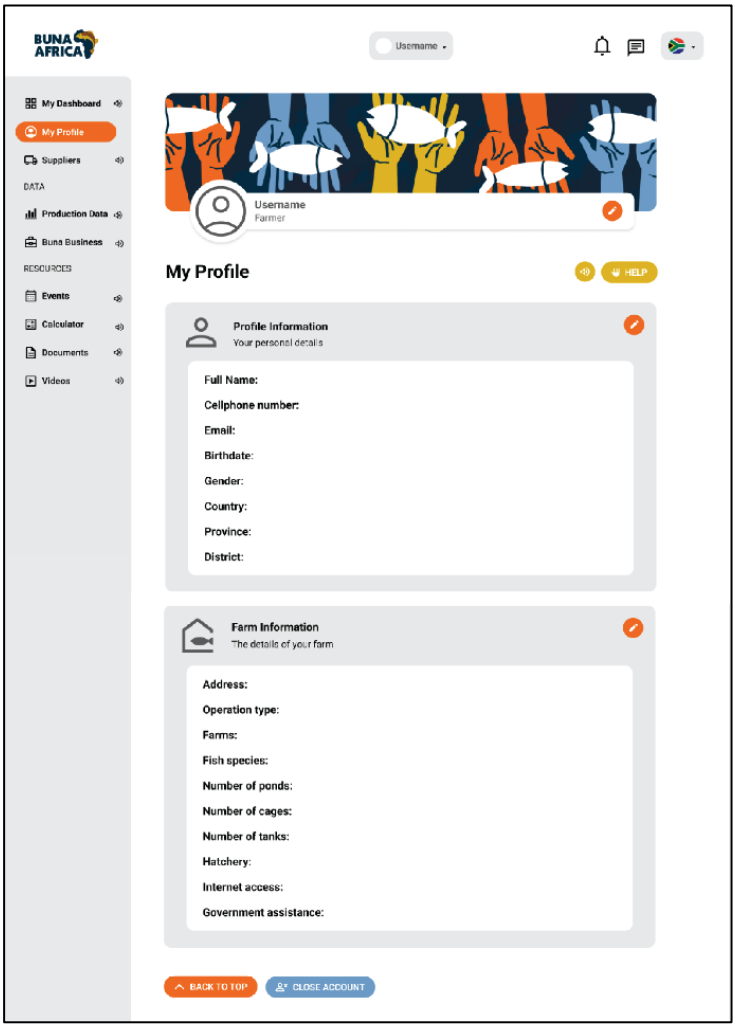

Figure 5: The updated design features a single-column layout and clearly defined sections

When designing for users with low literacy, it is recommended that information be presented using a variety of media (Srivastava *et al.,* 2021). By combing simple, jargon-free text with imagery (photos, illustrations, icons, etc.), videos, and audio, a designer increases the number of opportunities a user has to gain understanding. Buna Africa's original UI did provide limited audio and video resources, but the consistency with which they were used needed improving. Opportunities to include imagery were also underutilized. Much of the original UI's information was presented in the form of dense, jargon heavy text only (Figure 6). The updated design includes the following changes to address these issues and improve overall comprehension:

- Text has been reduced and simplified to a sixth-grade level, in line with best practices for designing for users with low literacy (Haese *et al*., 2022). Where possible, jargon has been removed (Figure 7).
- Simple diagrams have been included to demonstrate more complex concepts, particularly those involving mathematics (Figure 7).
- Demo videos are available on each page so that users can watch how to effectively navigate the website and make use of its features (Figure 7).
- Buttons now feature icons to illustrate their purpose (Figure 8).
- A read-aloud feature is available at the top of every page so that users can listen to, rather than read, text-based information (Figure 8).

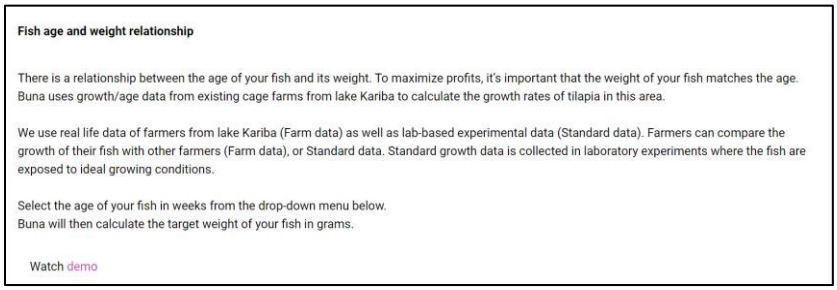

Figure 6:
The original design featured large areas of dense text without visuals or audio and the link to access the demo video was not immediately obvious.

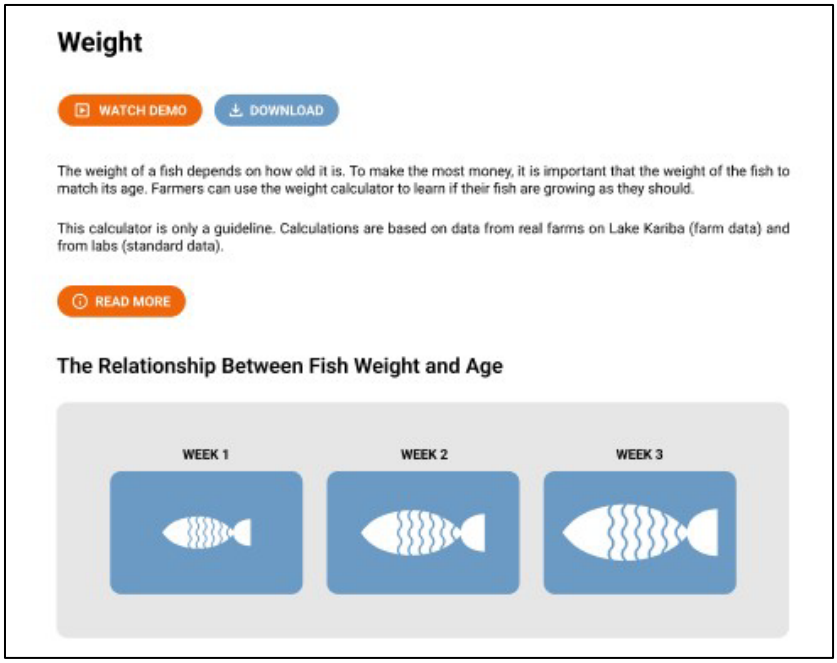

Figure 7:
Buna Africa's updated design includes simplified text and simple diagrams. Buttons, including those for demos, are easy to locate.

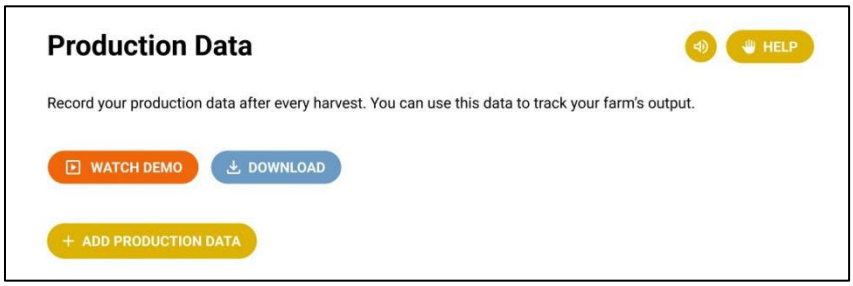

Figure 8:
Buttons now feature icons to illustrate their purpose. Read-aloud and help buttons are available on each page (top right corner)

Help menu

Srivastava *et al*. (2021) emphasise the importance of a consistent and easily accessible help menu. This suggestion was incorporated into the redesign in the form of a help button that appears at the top each page (Figure 8). When clicked, the button navigates to a new page where the user can specify the kind of help he/she needs (Figure 9).

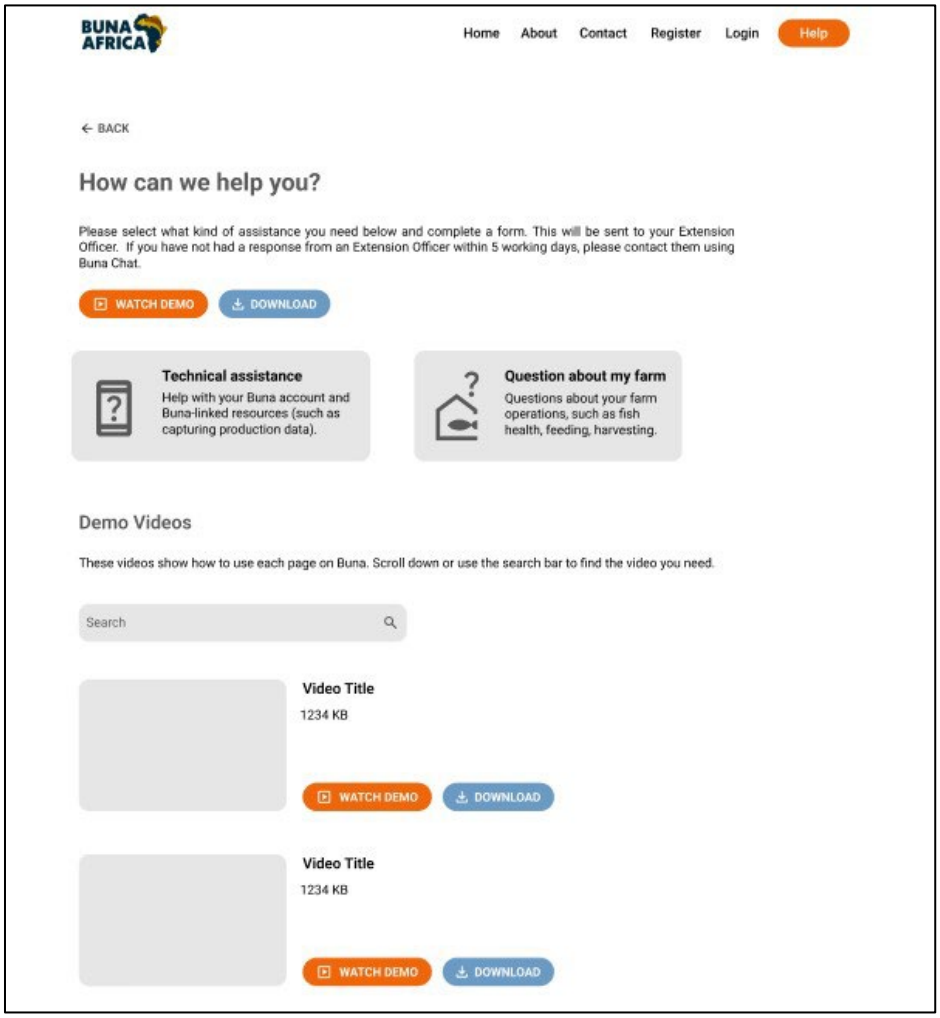

Figure 9:
Buna Africa's newly introduced help page

Artificial intelligence

In addition to a UI/UX redesign, I was asked to explore the ways in which artificial intelligence (AI) could be used by Buna Africa to improve their operation. I chose to incorporate this request into my honours research, investigating the ways in which Text-to-X AI could be used by UI/UX designers to generate content and assets capable of improving the accessibility of South African, government-aligned online platforms for users with low literacy. Text-to-X AI is defined by Feuerriegel *et al*. (2023) as a type of AI that can generate a range of output types from a simple text-based input. In carrying out my research, I identified and made use of the following types of Text-to-X AI as having potential to improve Buna Africa's online accessibility:

- **Text-to-text AI** – Text-to-text AI is often used to simplify dense text (How to use AI to summarize text [sa]), generate copy (Hetler, 2023), and translate text from one language to another (Hetler, 2023). This type of AI was used to simplify much of the text from Buna Africa's original UI to a sixth-grade level. Other possible applications worth investigating as

Buna Africa expands include translating information into multiple languages and simplifying the dense academic articles and papers available on the platform's *Documents* page.

- **Text-to-audio AI** – Text-to-audio AI can be used to convert any text into an audio format. This was especially useful when creating high-quality voiceovers for the read-aloud feature and demo videos. At present, Buna Africa's audio is only available in English, but as AI technology advances and becomes more accessible, can grow to include a variety of African languages.

Text-to-image AI, which generates images from text prompts, was also investigated in the form of *Microsoft's Bing Image Creator*. While it was able to generate some imagery that was appropriate to Buna Africa, visual inaccuracies were a common occurrence (see the man wearing a fish on his belt in figure 10 for an example). As such, relying on Buna Africa's existing photo resources proved safer for the time being. As AI technology improves, however, text-to-image AI should be revisited – a resource that enables the organisation to create engaging and culturally relevant imagery without cost or travel may prove incredibly useful.

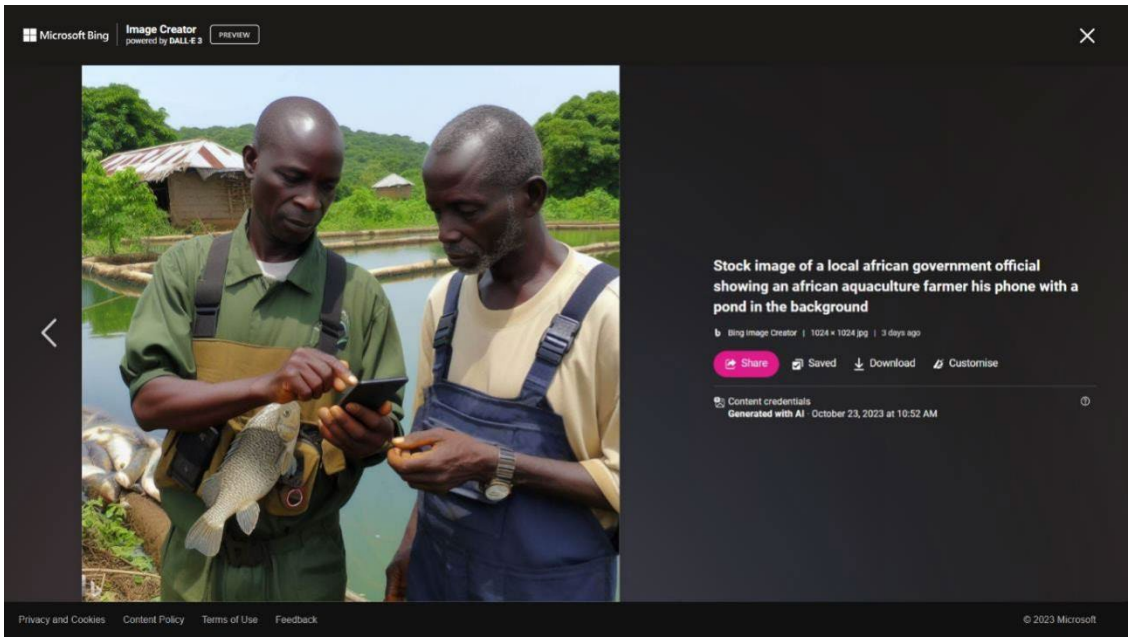

Figure 10: An example of the visual inaccuracies often present in AI-generated imagery

Personal experience

In completing this project for Buna Africa, I have gained invaluable knowledge and experience that will help me with future academic endeavours and in the world of work and I am incredibly grateful to all involved. Being able to work alongside Paul Chisenga, Buna Africa's web developer, was particularly exciting. I was able to gain insight into the relationship that exists between a project's UI/UX designer

and web developer – frequent communication and feedback is essential from both parties if a platform is to adhere to an established design while remaining functional. I was also able to participate in field research in Limpopo, during which I spent time with rural aquaculture farmers and learnt the value of user-centred design and research ethics. My biggest takeaway from this project, however, is that I have a deep interest in empowering others by making information and education accessible to all, regardless of their personal circumstances. As such, I will be studying to obtain a postgraduate certificate in education in 2024. I hope that, in time, this degree will enable me to work within the public education sector and allow me to contribute to the development of communities through knowledge.

References for Appendix 2 / student report

FEUERRIEGEL S, HARTMANN J, JANIESCH C and ZSCHECH P (2023) *Generative AI*. [O]. https://www.researchgate.net/publication/370653602_Generative_AI. (Accessed 19th October 2023).

HAESE A, VAN ZYL C, MABASA N and ROUHANI Q (2023) Deliverable 2: A report on making the necessary changes to Buna so that it is more accessible to fish farmers.

HAESE A, VAN ZYL C, MABASA N and ROUHANI Q (2023) Deliverable 3: A report on presenting the revised version of Buna to the fish farmers and their feedback.

HETLER A (2023) *What is generative AI? Everything you need to know.* [O]. https://www.techtarget.com/whatis/feature/Pros-and-cons-of-AI-generated-content. (Accessed 19th October 2023).

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IxDF (2023) *What is Participatory Design?*Interaction Design Foundation IxDF. https://www.interaction design.org/literature/topics/participatory-design. (Accessed 20th January 2024).

SRIVASTAVA A, KAPANIA S, TULI A and SINGH P (2021) Actionable UI design guidelines for smartphone applications inclusive of low-literate users.

APPENDIX 3: KNOWLEDGE DISSEMINATION AND TECHNOLOGY TRANSFER

Presentation at a Scientific Conference

The research team presented a conference paper, titled ‘Buna Africa: The participatory design of an online aquaculture platform’ at the Design Education Forum of South Africa 2023 conference on the 21 September 2023.

The conference theme, "Vulindlela: forging new pathways – advancing design education community's social and environmental impact, exploring novel routes within a southern African context," was explored over two days with lively discussions on presented papers. Our presentation was part of the 'Connecting: Co-design, co-research, and engaging with communities' session. Design, design education, and research operate within a networked environment involving various stakeholders like industry, communities, and end-users. Papers presented in this session explored ways in which design educators, students and designers can facilitate pathways for collaborative research and international cooperation to advance African design scholarship and practice.

All abstracts and full papers underwent a double-blind peer-review process to maintain anonymity for both authors and reviewers and complied with the Department of Higher Education and Training requirements to qualify as accredited conference proceedings. Academic peers from nine institutions, covering disciplines from architecture to visual studies, conducted the review before the conference, ensuring rigorous evaluation of the submissions.

Technology Transfer Within Buna

This research project had a theory component as well as a practical component. The theory was the research itself. This was successfully completed. The practical component is that Buna is a functioning online platform, and the outcomes of the research was implemented into Buna.

Therefore, the new knowledge and technology developed during this research project was implemented into Buna, making this new knowledge accessible to all of the uses of Buna. This is a very practical way for new knowledge to be shared (transferred) and used by a wider community, such as the fish farmers and the extension officers.

APPENDIX 4: DATA STORAGE

All the data of this research project will be retained by the project team members. Field notes and other “hard copies” of information will be filed and safe and kept in the offices of the researchers at their universities.

All soft copies of the research, including images taken during the field trip, will be stored electronically, on the devices of the researchers as well as on the servers of the university (Google Drive).

Regarding Buna itself, this digital platform is stored and functioned by AWS. Rhodes University pays a monthly fee to AWS for this service. Amazon web services provides industry level security.

APPENDIX 5: ETHICAL CLEARANCE

NHREC Registration Number REC-110613-036

ETHICS CLEARANCE

Dear Adrie Haese, Christa van Zyl and Qurban Rouhani (Rhodes University),

Ethical Clearance Number: Sem 1-2022-057

Topic: (Re)designing Buna Africa, an online platform for small-scale fish farmers, to increase accessibility for users with low literacy: A participatory design project

Ethical clearance for this study is granted subject to the following conditions:

- If there are major revisions to the research proposal based on recommendations from the Faculty Higher Degrees Committee, a new application for ethical clearance must be submitted.
- If the research question changes significantly so as to alter the nature of the study, it remains the duty of the student/researcher to submit a new application.
- It remains the student's/researcher's responsibility to ensure that all ethical forms and documents related to the research are kept in a safe and secure facility and are available on demand.
- Please quote the reference number above in all future communications and documents.

The Faculty of Education Research Ethics Committee has decided to Approved with minor changes

☒ Grant ethical clearance for the proposed research.
☐ Provisionally grant ethical clearance for the proposed research
☐ Recommend revision and resubmission of the ethical clearance documents

Sincerely,

Prof Mdu Ndlovu
Chair: FACULTY OF EDUCATION RESEARCH ETHICS COMMITTEE
14 of April 2022

APPENDIX 6: LETTER FROM VHEMBE DISTRICT FROM THE LIMPOPO DEPARTMENT OF AGRICULTURE

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
AGRICULTURE AND RURAL DEVELOPMENT

Ref: 12R
Enquiries: Dr T. Raphulu

24 March 2022

Qurban Rouhani
Rhodes University

RE: APPLICATION TO CARRY OUT RESEARCH UNDER THE DEPARTMENT OF AGRICULTURE & RURAL DEVELOPMENT

1. Kindly take note that your request to conduct research titled "*Using Buna Africa, an existing web-based app designed to assist small-scale fish farmers increase production, as a springboard to create new knowledge on designing online platforms that are more accessible to users with low literacy*", Proposal number 2022/2023-00795 has been granted. The permission to conduct research in the Province is valid from 01st April 2022 to 31st March 2024.
2. Please liaise with the office of the Scientific Manager: Aquaculture and Game, Mr Phosa Jacky @ 0609782231 to brief them on the study, to request fish farmer's database and the assistance.
3. The Research team is required to conform to lockdown regulations in order to mitigate the spread of COVID 19.
4. Kindly take note that you will be expected to hand over a copy of your report per deliverable on the targeted date as outlined in your research proposal (page attached) to the Department for record purposes. You may also be invited to share your findings in the Departmental Research Forum.
5. Hoping that you will find this in order.

Kind regards

Dr. T. Raphulu
Chairperson: Research Committee

24/03/2022
Date

67/69 Biccard Street, POLOKWANE, 0700, Private Bag X9487, Polokwane, 0700
Tel: (015) 294 3135 Fax: (015) 294 4512 Website: http://www.lda.gov.za

The heartland of Southern Africa - development is about people!

page 1 of 2

APPENDIX 7: INFORMED CONSENT FORM

SECTION B: Brief Summary for Reviewers (your research at a glance)
Faculty of Education Research Ethics Committee
NHREC Reference Number REC-110613-036

Title: (Re)designing Buna Africa, an online platform for small-scale fish farmers, to increase accessibility for users with low literacy: A participatory design project.

Background to the study including the nature of the research

We, Adrie Haese, Christa van Zyl and Qurban Rouhani are doing research on how participatory design can be used to redesign the Buna Africa platform to better address the needs of and increase accessibility for fish farmers with low literacy levels. As the Fourth Industrial Revolution (4IR) expands to rural communities, where fish farmers often reside, this knowledge and innovation will become increasingly important and relevant.

Buna Africa is a web-based platform that 1) assists African fish farmers with relevant information and services and 2) provides a conduit for government officials to obtain production data from the farmers. The primary purpose of Buna is to link fish farmers to the 4IR. When looking at the South African context, it should be recognizes that many rural fish farmers may have low literacy skills. These skills are not only seen in terms of traditional definitions of literacy (i.e. the ability to read and write) and language barriers, but also in terms of information literacies – a skill identified as essential, but under-represented, in the development of 4IR.

You are invited to take part in this research as you are a fish farmer that works with the Buna platform.

Intention of the project

The aim of this study is to work with fish farmers that use the Buna Platform to understand what the current user and stakeholder perceptions of the Buna platform in terms of ease of use, accessibility and understandability, to look into what type of online formats are required to allow easy access to the Buna platform and to use this information to investigate how the design of the Buna platform can be updated to allow for easier access, engagement and understanding its content.

It is a participatory design project and as such, input from the users of the platform, especially fish farmers, is essential to its success.

Procedures involved in the research

If you agree to participate in the research, we will ask the following of you:

To participate in 3 workshops, described as follows:

Workshop 1: We will ask you for feedback on the existing Buna website/online platform. You will be asked to give feedback on the accessibility, useability, and understandability of the website/online platform. You will also be asked to show us how you use Buna and explain what you like and/or dislike about it. We will use the information you provide to see how we can use design to improve the platform.

Workshop 2: You will be invited to be involved in the decisions around the design of information on the website/online platform, including aspects like icons, the format of articles, video links etc. to envision a solution

that meets your needs. We will present some design ideas for feedback.

Workshop 3: We will use the information from the first two workshops to a create a rough redesign of the website/online platform. This will be presented to the you to work through, to give feedback on and to make further suggestions for. We will look specifically at things the appearance of the website/online platform, the use of colour, the designs of icons, the presentation of information and the responsiveness of the website to different devices.

We will ask your permission to video record all three sessions so that we can see how you use the Buna platform. These recordings will not be shared with anyone outside the research team. If you prefer, we will hide your face during all the recordings.

Potential Risks

Select from ☒ Low ☐ Medium ☐ High risk, and elaborate here. Select from the following examples and give additional information where required.

The researcher does not expect any risk posed to the participants of this study.

Potential Benefits

Your contribution to the study will help us to improve the current design of the BUNA platform to make it easier for you, and other fish farmers to use. In this way, we hope to assist you in getting the maximum benefit from this online resource.

The study will also benefit Buna Africa in understanding how they can use design to communicate more effective to fish farmers and other stakeholders.

The results of this research may be shared through academic journals, so that others can learn from the work we are doing.

that meets your needs. We will present some design ideas for feedback.

Workshop 3: We will use the information from the first two workshops to a create a rough redesign of the website/online platform. This will be presented to the you to work through, to give feedback on and to make further suggestions for. We will look specifically at things the appearance of the website/online platform, the use of colour, the designs of icons, the presentation of information and the responsiveness of the website to different devices.

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Select from ☒ Low ☐ Medium ☐ High risk, and elaborate here. Select from the following examples and give additional information where required.

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The study will also benefit Buna Africa in understanding how they can use design to communicate more effective to fish farmers and other stakeholders.

The results of this research may be shared through academic journals, so that others can learn from the work we are doing.

SECTION D: Signatures required to indicate consent/assent.
(For all participants, parents, guardians and other stakeholders)

Faculty of Education Research Ethics Committee
NHREC Reference Number REC-110613-036

INFORMED CONSENT/ASSENT FORM

Project Title

(Re)designing Buna Africa, an online platform for small-scale fish farmers, to increase accessibility for users with low literacy: A participatory design project.

Adrie Haese and Christa van Zyl

2022/03/01

Please mark the appropriate checkboxes. I hereby:

☐ Agree to be involved in the above research project as a **participant**.
☐ Agree to be involved in the above research project as an **observer** to protect the rights of:
  ☐ Children younger than 18 years of age;
  ☐ Children younger than 18 years of age that might be vulnerable*; and/or
  ☐ Children younger than 18 years of age who are part of a child-headed family.
☐ Agree that **my child**, *Click or tap here to enter name* may participate in the above research project.
☐ Agree that **my staff** may be involved in the above research project as participants.

☐ **I have read the research information sheet pertaining to this research project (or had it explained to me) and I understand the nature of the research and my role in it.**

- **I have had the opportunity to ask questions about my involvement in this study.**
- **I understand that my personal details (and any identifying data) will be kept strictly confidential.**
- **I understand that I may withdraw my consent and participation in this study at any time with no penalty.**

Signature

Please provide contact details below <u>ONLY</u> if you choose one of the following options:

☐ Please allow me to review the report prior to publication. I supply my details below for this purpose.
☐ Please allow me to review the report after publication. I supply my details below for this purpose.
☐ I would like to retain a copy of this signed document as proof of the contractual agreement between myself and the researcher.

Click or tap here to enter name

Click or tap here to enter contact number

Click or tap here to enter email

* Vulnerable participants refer to individuals susceptible to exploitation or at risk of being exposed to harm (physical, mental, psychological, emotional and/or spiritual).

VIDEO, AUDIO OR PHOTOGRAPHIC RECORDING

By law, separate consent or assent must be provided to indicate willingness to be video / audio recorded or photographed. Please provide your consent / assent on this form:

Where applicable:

- ☐ I willingly provide my consent/assent for using **audio** recording of my/the participant's contributions.
- ☐ I willingly provide my consent/assent for using **video** recording of my/the participant's contributions.
- ☐ I willingly provide my consent/assent for the use of **photographs** in this study.

Click or tap to select a date

Signature of person taking the consent

Click or tap to select a date.

APPENDIX 8: A LIKERT SCALE QUESTIONNAIRE FROM FINAL DATA COLLECTION

HOW DID YOU EXPERIENCE:	Very Difficult This was really hard, and even after someone explained it, I still couldn't understand or do it.	Difficult - Neutral It was somewhat difficult, but I could manage with some help.	Somewhat Easy It wasn't too hard; I could do most of it by myself and ask for help if I got stuck.	Easy It was quite easy; I could do it all by myself.	Very Easy I could do it on my own and even help someone else.
Registering for an account					
Finding Your Farm (During Registration					
Interpreting / understanding the information on the dashboard					
Locating the information you needed					
Searching for information					
Capturing your production data					
Finding and viewing your production data					
Using the calculator functions					
Editing your profile					
Using the platform in general					

Question	Agree	Neutral	Disagree
The updated Buna is a better experience than the previous versions.			
The pictures help to understand the platform and its tools (e.g. the calculator)			
The voiceovers are useful			
I can see my suggestions reflected in the platform.			
I can see myself using this platform			

Please let us know about any other comments or feedback that you have: