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Buna Africa: The participatory design of an online aquaculture platform

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Abstract

Aquaculture has become the fastest-growing animal production sector globally, with production in Africa especially, steadily increasing. The move from subsistence to commercial fish farming requires emerging farmers to access technical information and support services. In order to address this need, the Rural Fisheries Programme, a developmental unit with the Department of Ichthyology and Fisheries Science at Rhodes University, South Africa, developed Buna Africa. Buna Africa is an online platform intended to support the development and management of the aquaculture sector by providing fish farmers with technical support and services to assist them in increasing production and becoming more efficient and secondly, providing governments with a means to track production data in their area, and to use this data to inform policy and management decisions. Buna is currently being piloted in Zambia and Malawi. During this process, it was recognised that the design of the platform needed to allow greater access to, and understanding of the content, to enable farmers with low literacy, or limited experience with digital platforms to make optimum use of the platform. For this reason, an interinstitutional and interdisciplinary project was embarked on to address both user interface design and scientific information of the platform, with members from Ichthyology and Fisheries Science at Rhodes University, Graphic Design at the University of Johannesburg and Information Design at the University of Pretoria. The research is framed using the following questions: What are the current user and stakeholder perceptions of the Buna platform in terms of ease of use, accessibility and understandability, what type of online formats are required to allow easy access to the Buna platform, and lastly, how can the design of the Buna platform allow for easier access, engagement and understanding 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 as such recommended as being an effective means of creating digital solutions. Fish farmers from the Vhembe district in Limpopo were purposively sampled for the project, as they had been part of the initial development of the Buna platform. Spinuzzi's (2005) participation design phases were used to collectively formulate the Design Brief for the Buna platform with the fish farmers, to analyse the website and create prototypes and to then collect feedback on the implemented changes. Engagement with the farmers was positive, and valuable, context relevant feedback was received on how the Buna platform functions, and more importantly, how farmers envisage themselves engaging with it. Findings emphasised that access to

information, and the ability to create a community of practice were the most valuable aspects of the platform. More broadly, the paper speaks to how participatory design can be viewed as a strengths-based and proactive way to engage with, and involve local communities in the development of systems that will allow them to actively participate in the Fourth Industrial Revolution.

Keywords: 4IR, aquaculture, design for social change, participation design.

Introduction and background

According to the Food and Agriculture Organization of the United Nations (FAO 2023), aquaculture is the fastest-growing animal production sector. This sector is expected to continue expanding as demand for fish increases. Aquaculture production is not distributed equally across the globe. The FAO (2022, p. 8) reported that in 2020, Asia accounted for 70% of all global fisheries and aquaculture production. Africa, on the other hand, only accounted for 7%, despite the continent's favourable conditions.

A significant factor in this disparity in production between Africa and Asia could be attributed to the technical capacity of fish farmers (Rouhani & Britz 2004). Aquaculture is a technical activity, and for farmers to be successful in it, they need to be sufficiently skilled and capacitated. The Agricultural Sector Education Training Authority (AgriSETA) 2021 report outlines a skills plan for the Aquaculture sub-sector in 2020-2021. It highlights significant challenges faced by the aquaculture sector, including unsupportive regulations, limited land access, skill shortages, financial barriers, fragmented marketing, and competition from cheap fish imports (AgriSETA 2021, p. iv). These obstacles hinder the subsector's growth. The report emphasises the importance of training to address these issues by identifying scarce skills, closing training gaps, and building the capacity of aquaculture workers. This capacity-building effort aims to unlock the sector's potential, create jobs, and enhance support services (AgriSETA 2021, p. vi).

In order to assist South African fish farmers (and government extension officers[1]) to develop their technical skills, in 2010 Rhodes University developed a technical manual for fish farmers (Rouhani & Vine 2010).[2]

In 2021, Rhodes University completed a three-year project[3] to convert the aforementioned manual into an online platform called Buna Africa. The objective was to design an online platform that attempts to solve two key challenges facing the aquaculture sector, namely:

- Fish farmers need access to technical information and support services to enable them to not only increase production but also become more efficient and financially secure.
- Government Departments mandated to oversee the aquaculture sector do not have systems in place that enables farm production data to reach them. Without this data, governments are unable to develop effective aquaculture policy or to manage and develop the sector.

In developing Buna, fish farmers in the Vhembe district of Limpopo Province were engaged through the Provincial Department of Agriculture. Their feedback, along with insights from government

[1] An extension officer is a government official who provides technical support and services to fish farmers. These services are generally related to animal husbandry and production.

[2] Funded by the Water Research Commission (WRC).

[3] Funded by the WRC.

aquaculture extension officers, influenced the initial design and functionality of the platform. By March 2021, Buna was fully functional, and was being piloted in Malawi and Zambia.

However, Buna Africa expanded beyond being a mere online manual for fish farmers. Various additional features were incorporated to enhance its benefits. The manual was condensed and included hyperlinks for easier information retrieval. Each chapter was accompanied by relevant YouTube video links, allowing farmers to access technical information from different regions, such as a tilapia spawning video from Ghana. A directory of suppliers, including feed manufacturers and fingerling producers, was included. Additionally, a real-time messaging system similar to WhatsApp was integrated, enabling farmers to connect and communicate with each other, as well as extension officers, through the platform. The addition of a "calculator" function allowed farmers to calculate pond area, the size of their fish without weighing all the fish in a pond, compare fish age and weight to ideal conditions, and determine appropriate feeding amounts. These features and more empowered fish farmers to make informed decisions.

Furthermore, farmers can submit their production data through Buna Africa, which is then shared with government officials. This feature fulfils the crucial requirement of providing data to government officials[4] responsible for policy and decision-making in the sector.

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 such apps already available (Dhenuvakonda & 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 AgriSETA (2019, p. 17), emphasises the importance of providing training to existing small-scale farmers to enhance their understanding of fish biology. This training aims to improve the productivity and profitability of their businesses. In order 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 who have limited resources (AgriSETA 2019, p. 17). Many fish farmers reside in under-resourced rural areas. Access to knowledge and information is crucial for empowering such communities (Rahman & Fukuda 2015, p. 126). AgriSETA (2019, p. 17) emphasises the significance of getting the basics right in pond farming to avoid being stuck in a cycle of low productivity.

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, p. 3). In South Africa, computer literacy has been recognised and promoted as a form of literacy since at least 2014 (Walton 2014, p. 108). Additionally, the use of multimodal ensembles, such as smartphones, is becoming more prevalent in everyday digital communication (Taylor 2023).

Recognising the need for improved access and comprehension of Buna's content among farmers with low literacy and limited digital platform experience, an interdisciplinary project was initiated. This project involved collaboration between Ichthyology and Fisheries Science at Rhodes University,

[4] Buna Africa complies with POPIA requirements by explaining to users how their information is used and who has access to it. Additionally, some information is anonymised before it is made available to government officials. The use of the platform is voluntary, and farmers can unsubscribe at any stage.

Graphic Design at University of Johannesburg, and Information Design at University of Pretoria. The primary objective was to enhance both the user interface design and scientific information of the platform.

User Interface (UI) design involves creating visual and interactive elements in software or digital platforms to enhance user experience and usability. It aims to develop an interface that is visually appealing, intuitive, and promotes efficient user interaction. Key considerations in UI design include user-friendliness, clear information presentation, consistency in design elements, and responsiveness to user actions (Interaction Design Foundation 2023).

The case study research as such aimed to explore the following aspects of the Buna platform:

1. *User and stakeholder perceptions*: Assessing the current perceptions of Buna in terms of its ease of use, accessibility, and understandability.
2. *Required formats*: Identifying the necessary formats that would enable easy access to the Buna platform.
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 as such recommended as being an effective means of designing digital solutions.

More broadly, we were interested in how participatory design can be viewed as a strengths-based and proactive way to engage with and involve local communities in the development of systems that will allow them to actively participate in 4IR using this case study.

Literature

Designing for users with low literacy

Though extensive insights and recommendations on designing digital artefacts for users with low literacy exist, there are fewer resources that offer examples of user participation in the development of such digital artefacts. Jones et al. (2017, p. 169) argue that although research has predominantly focused on how to improve emerging users' lives,

> It is now time to engage with such users so that they can help sketch out a longer-term technology road-map that will lead to devices and services which will be of value 5 to 10 years from now.

In *Actionable UI Design Guidelines for Smartphone Applications Inclusive of Low-Literate Users*, Srivastava et al. (2021, p. 136, 3) propose the use of their Smartphone Applications embracing Low-literate users (SARAL) framework as not only a means to develop, but to analyse applications for low-literate users. The authors conducted a "systematic literature review (SLR) of user interface (UI) design studies with and for the low-literate population" (Srivastava et al. 2021, pp. 136-134), from which 53 relevant papers were used to derive a framework containing 13 guidelines, their actionable definitions, and examples, categorised within five themes. While Buna is not currently available as a smartphone application,[5] it still needs to be responsive to smartphone use, making the guidelines provided relevant to its redesign. UNESCO's report, *A Landscape Review: Digital Inclusion for Low-*

[5] A mobile website ensures compatibility with any smartphone and eliminates the need for frequent updates, regardless of the operating system.

skilled and Low-literate People (Zelezny-Gree et al. 2018, p. 8) addresses how technology can be "designed to be more inclusive, accessible and usable for people with low levels of skills", and similarly provides actionable guidelines that can be considered by UI designers.

Design guidelines generally include actionable advice on language, images, icons, and colour use in human-computer interactions, as well as cultural considerations – focusing on the creation of culturally relevant and responsive design (c.f. Chaudry et al. 2012; Cremers et al. 2008, 2017; Jones et al. 2017; Medhi et al. 2006; Medhi et al. 2011; Medhi Thies 2015; Rahman & Fukuda 2015; Srivastava et al. 2021; Summers et al. 2007; Summers & Summers 2005; Walton et al. 2002; Zelezny-Gree et al. 2018).

Raza et al. (in Zelezny-Gree et al. 2018, p. 40) specifically note that "integrating social elements to the user experience for technologies used by low literate and low-skilled people bolsters the spread and adoption of these technologies". Jones et al.'s (2017) research indicated a shift in focus from the individual mobile user, noting that participating "emergent" users were instead interested in using devices and software to learn about other people, rather than focusing on the self. Robinson et al. (2014) express concerns about the prevailing trend in mobile design that promotes what they refer to as "heads-down thinking", wherein mobile apps discourage engagement with the physical world. They assert that mobile app designers have room for improvement in terms of considering the needs and experiences of actual users in their designs, as well as enabling them to engage with the external world. Both cultural relevance and the participative design processes are evident in *The talking book: participatory design of an icon-based user interface for rural people with low literacy* by Andrew et al. (2018). The authors explained how certain "navigation" UI icons, such as arrows, were confusing for users, who suggested icons that were relevant to their immediate surroundings.

Walton et al. (2002, p. 530) emphasise that despite the existence of guidelines, addressing the challenges of communicating across cultural and literacy boundaries requires more than superficial visual changes. This challenge is further magnified by the cultural diversity in South Africa and the African continent. They argue that achieving true cross-cultural design or internationalisation is highly challenging, and even designing inclusively for a South African audience is a formidable task. Nevertheless, they emphasise the importance of continuing to explore effective communication methods tailored to specific audiences (Walton et al. 2002, p. 531).

Participation design

Spinuzzi (2005, p. 164) writes on PD as a research method, stating that "[a]s the name implies, the approach is just as much about design – producing artefacts, systems, work organisations, and practical or tacit knowledge – as it is about research. In this methodology, design is research". Van der Velden and Mörtberg (2014, p. 1) note that PD is a "value-centred design approach" pledged to the mutual and democratic formation of a better future for all involved. PD methodologies are as such recommended as being an effective means of creating digital solutions. Brandt et al. (2013, p. 146) note that PD is not "one approach but a proliferating family of design practices that hosts many design agendas and comes with a varied set of toolboxes". Sabiescu and Memarovic (2013, p. 615) state that,

> Design aims to produce useful artefacts for a certain class or community of users, usefulness that can be determined only in direct relation to the user activities that the artefact will support. Effective design needs to build on a thorough understanding of the user activities that its outcome will serve. In PD, this understanding is advanced by enabling users' direct participation in design activities.

Workshops, drama, storytelling, and design games serve as methods that foster dialogue, negotiation, and the emergence of novel ideas, challenging assumptions among both users, designers and developers (Sabiescu & Memarovic 2013, p. 613). Genuine participation should, however, include the user as a legitimate partner in the design process, rather than simply acknowledging their input as informants (Robertson & Simonsen 2013). This method provides opportunities for users and designers to workshop solutions together. As such, PD tends to be quite flexible.

The Interaction Design Foundation (2023) describes the key aspects of participatory design as inclusion, collaboration, empowerment, iteration, contextual understanding, and user advocacy.

Methodology

This qualitative research took the form of a case study, working with purposively sampled group of farmers that represent the population of the study – fish farmers in Africa. Fish farmers from the Thohoyandou region were purposively sampled for the project as they had been part of the initial development of the Buna platform (WRC research project 2018 to 2021). By working with the same group of farmers, a level of continuity in the development of the platform is provided. Ethical clearance for the project was granted by the [Institution name].[6] All participants were asked to sign informed consent forms before taking part in the project. Workshop data was transcribed and coded to protect the identities of participants.

Spinuzzi's (2005, p. 167) participation design stages, namely, the initial exploration of work, the discovery process and prototyping, were used to collectively formulate the design brief for the Buna platform with the fish farmers, to analyse the website and create prototypes and to then collect feedback on the implemented changes. Used iteratively, these provided us with what Spinuzzi (2005, p. 167) describes as "iterative co-exploration by users and designers". Each stage is briefly discussed below.

Initial exploration of work

Spinuzzi (2005, p. 167) describes the first stage of the Participatory Design (PD) process as involving ethnographic methods like observations, interviews, walkthroughs, and artefact examinations. In June 2022, the Department of Agriculture organised a meeting at a participating farmer's homestead, which served as a reintroduction to the Buna platform for farmers and extension officers, as well as an introduction to new members of the research team. The session began with an explanation of project roles and research objectives.

During the meeting, which took the form of a focus group, farmers were asked about their access to online resources, internet availability, data accessibility, and device preferences. Using laptops, the research team demonstrated each page of the Buna platform, explaining its purpose and demonstrating how it can be used. A focus group discussion followed, where farmers shared their initial perceptions of the platform's usability and understandability. They provided feedback on page contents, layout, use of text and images, colour, and how they perceived its relevance to their daily farming practices. Farmers were also asked to identify aspects they liked, disliked, found distracting, or felt could be improved.

In addition, the research team conducted visits to five farms to observe the farmers' work, assess the size of their ponds, and evaluate the existing internet infrastructure on the farms.

[6] Ethics clearance number [Insert after review].

Discovery

During the discovery phase of the project, the desired outcome was established through agreement with users and stakeholders (Spinuzzi 2005, p. 167). The goal was to update the design of Buna to be mobile-friendly and accessible to users with varying levels of literacy, both in traditional and digital sense, to improve their businesses and foster a sense of community. Building upon the outcomes of the initial workshop, the design team made progress in rethinking the platform's design.

Based on insights from literature and our interactions with farmers during farm visits, three user personas were created as representations of potential Buna users. The website was analysed accordingly, and suggestions were made for rough prototyping. A preliminary style guide was developed to establish a consistent brand identity that can be recognised and trusted across all platforms. For initial, low-fidelity prototypes, we focused on the general layout, home page, and registration process.

Through coordination with extension officers, we arranged a second meeting with the farmers, with 12 attendees present. Farmers split into two groups, considering the group size and time constraints. During this focus group, a walkthrough Buna was done, and farmers were presented with the original digital platform, as well as printed versions of the low-fidelity prototype. The comparison enabled feedback to be gathered on their perception of the design team's suggestions and using the two versions of the platform to complete tasks, aiming to understand their preferred functionalities and assess the usability of the tools. Farmers were invited to actively participate by entering their own information into the system, navigating the platform, and providing feedback through various means such as pointing at screens, prototype printouts, or writing and drawing on paper. Discussions centred around involving farmers in decisions related to information design on the website, including icons, article formats, video links, and other aspects, with the aim of envisioning a solution that meets their specific needs.

Prototyping

Spinuzzi (2005, p. 167) describes stage three, prototyping, as the iterative process of shaping technological artefacts to align with the envisioned workplace from stage two.

Building upon the outcomes of stages one and two, a rough redesign of the website, referred to as Buna 2, was created. During the prototyping stage, farmers had the opportunity to witness the implementation of suggestions from the previous phase in the updated design of the platform, including its mobile responsiveness.

To facilitate feedback, two computers were available for demonstration purposes, while paper printouts allowed farmers to provide input through writing, drawing, or using Post-it notes. The session encouraged farmers to comment on the design, functionality, and navigation of the website. Farmers were asked to identify how they would navigate to specific areas and provide insights on visual design, ease of use, functionality, and content suggestions for Buna.

Iteration is an essential aspect emphasised by Spinuzzi (2005, p. 167), and the three stages should be repeated multiple times. Currently, the design team is incorporating the feedback received and will meet with the farmers again later in 2023 to discuss the implemented changes and progress towards a final design solution.

Results

The design process is iterative, involving continuous feedback and refinement. Instead of presenting the findings chronologically, we condensed them into key themes that emerged during the PD process. "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.

Engagement with the farmers yielded positive and valuable results. We received contextually relevant feedback on the functionality of the Buna platform and, more importantly, gained insights into how farmers envision their engagement with it.

Initial perceptions of the Buna platform

Farmers highlighted the need for guidance on accessing Buna from their mobile devices, as the platform was not mobile-responsive. Since all participants used their mobile phones to access the internet and preferred this method, prioritising mobile design was crucial. None of the farmers owned a laptop or had access to facilities like libraries or community centres for internet access. Limited farmers had Wi-Fi at home, relying instead on purchasing data for their mobile devices. Government-provided Wi-Fi hotspots were not available in the area, leading to concerns among farmers regarding data usage and the associated financial implications. While cell phone signal was generally good on the farms, feedback emphasised the importance of considering the costs of mobile data.

Farmers' feedback on Buna's features, including document and video resources, calculator tools, and supplier information, provided valuable insights. They found the platform beneficial for accessing technical information, educating new farmers, and supporting business development. The calculator tools, enabling calculations for fishpond size, average fish weight, and feeding quantities, were particularly well received. However, discussions indicated a need for simplifying the tool based on farmers' feedback. Building a fish farming community through the platform was consistently emphasised throughout the project. Feedback regarding Buna's features, including video resources, calculator tools, supplier information, and chat functions, emphasised the farmers' appreciation for the sense of connection and community that these tools provided.

Barriers to engagement

Barriers to engagement became evident primarily during stages two and three, when farmers interacted with prototypes. Discussions revolved around challenges arising from the rural context, technical engagement, and language usage.

Contextual

During the discussion of the registration process and examination of low-fidelity paper prototypes, it became apparent that providing an address posed challenges. Some farms lacked a street name, while others were uncertain about their stand number or how to format their address. In order to address this, 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.

Technical

Buna offers information resources in the form of documents and videos, providing guidance on 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 pertaining to 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).

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. 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, standardised measurement, such as a 300ml 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.

The feedback emphasised the need for the resources on the platform to be easy to understand and context relevant. Video was the preferred format of information dissemination, both in terms of technical information and providing clarity on how the Buna platform worked.

Language

Farmers found the content of Buna to be text-heavy, and while they recognised 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.

Visual design

We received less feedback on design elements than we had hoped – with farmers focusing extensively on the content and functionality of the platform. Farmers preferred the clean, one-column design of Buna2, which had minimal text compared to the text-heavy two-column design of Buna1. The mobile version of the platform was also well received. Feedback on the updated images used on the platform generated varied opinions. While some participants felt that a visually appealing image created interest in the platform itself, with one farmer remarking on the hard work that farmers do, others suggested replacing the image with a picture of two men working to better demonstrate this, as the prototype showed people walking on a fish farm.

Following feedback from the initial workshop, graphic cues, such as country flags next to country dialling codes, were incorporated into the registration process. This change was well-received and sparked discussions on additional opportunities for integrating graphics into the platform. Suggestions

included the use of infographics or instructional illustrations to enhance user experience and understanding. Farmers discussed a few options for more relevant icons. Suggesting a cup with pellets for the feeding calculator spoke directly to the methods farmers used to feed their fish, whereas farmers emphasised the need for the pond calculator to indicate that a pond is rectangular – something that is standard practice among this group of farmers. Finally, farmers emphasised the need for visual feedback when they completed tasks, such as successfully capturing production data.

Customisation

Farmers were interested in customising their Buna profile by adding profile photos and creating and uploading their own video content and tutorials to share with other farmers. This was linked to conversations about the platform to include location-specific content. The video library is currently predominantly populated with existing video content from other regions of Africa, such as Ghana. Farmers felt they would connect better to the farming practice in videos created specifically for their location.

Discussion

Significant changes have already been made to Buna based on the interactions with the farmers. However, this development is ongoing, and this paper can only report on a small part of the process. Our next engagement session and further user testing will steer us to a final design solution. Concluding discussions following the prototype stage of Buna2 reiterated the usefulness of the platform for farmer's daily business. Features and functions were reviewed multiple times, with participants providing inventive ideas concerning these.

Strengths of the participative process were evident in how tacit knowledge from the farmers could be used to inform the design and development of the platform. Understanding how farmers work, and how they imagine incorporating the platform into their daily lives has provided insight into how tools need to be presented for maximum accessibility. This was particularly evident when looking at the calculator tool, where feedback indicated the need to consider alternatives to the traditional science of measuring and weighing by imaging innovative, affordable, easy-to-access materials in combination with multimodal methods to allow farmers to track the weight and feeding requirements of their fish. The prototype 'walkthrough' video demonstrating how to use the calculator tool that developed in response to farmer's feedback was positively received and led to a broader suggestion of an FAQ video library for the platform. In this way, the participative process forced the design team to take a step back and look at the broader picture, recognising that an instructional video can embed support into the digital solution design.

Through our interactions, two key aspects of the Buna platform 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 engaging with the platform to connect with and educate other farmers, fostering 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, p. 17).

The discussions also touched on the frustrations farmers faced in their interactions with extension officers and government support. Farmers recognised the limitations of these services (i.e., that officers have travel and time limitations, and in addition to aquaculture farmers, are also tasked with crop farmers and beekeepers) but suggested that the platform could facilitate positive communication

and collaboration between farmers and officials through features like forums and chat functions. This echoes the need for human mediators in the overall system, as emphasised by Medhi et al. (2011, pp. 2, 10). The platform can complement and enhance human interactions rather than replace them entirely, ensuring continuous training and assistance for farmers while enabling monitoring and evaluation.

The farmers' interest in customising their profiles and creating their own content is promising, as it aligns with the idea of co-designed solutions that promote local adoption. User-generated content, particularly in local languages, holds significance in facilitating the acceptance and utilisation of technology among users with limited literacy or digital proficiency (Zelezny-Gree et al. 2018). However, challenges arise in ensuring the accuracy of user-generated content. Nonetheless, allowing users to customise the content, interface layout, and functionalities of the platform according to their needs and preferences is crucial, as emphasised by the assertion of incorporating users' cultural identities, literacy levels, and technological exposure (Srivastava et al. 2021, pp. 15, 136).

In summary, 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 customisation options that cater to users' diverse needs and preferences. 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.

Conclusion

The participation of farmers in the redesign process offered insightful 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, p. 169).

Beyond the scope of this project, but specifically in the African context, we suggest participation design methods can be used as a strength-based way of engaging communities in digital design collations, allowing them to actively participate in 4IR. In this way, 4IR is something that is developed with, rather than for communities – and communities are empowered to decide how they want to engage with such systems. In doing so, sustainable, and inclusive development of design solutions can be encouraged in a manner that is community driven and culturally relevant, rather than externally imposed.

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