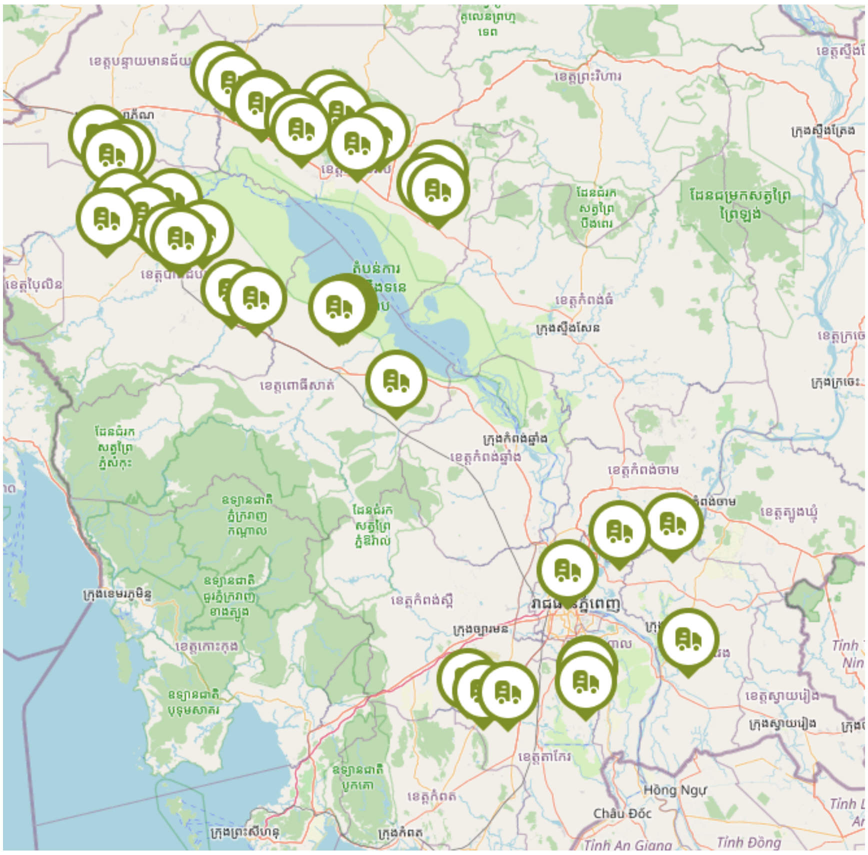
Exploring technology acceptance through human centered design in agricultural innovation

A case study of a digital marketplace for Cambodian Smallholder Rice Farmers and Seeder Service Providers



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Abstract

This thesis investigates the development and user perception of the Market Dashboard, an innovation part of the Excellence in Agronomy project of CGIAR, aimed at supporting Cambodian smallholder rice farmers and farm-machinery service providers in improving their mechanized Direct Seeded Rice (mDSR) practices.

The study aimed to enhance the dashboard's usability and potential adoption by employing the Technology Acceptance Model (TAM), Human-Centered Design (HCD), and Reflexive Monitoring in Action (RMA). This process involved two cycles of prototype testing with potential end users: Cambodian smallholder rice farmers and farm-machinery service providers, incorporating their feedback throughout the study.

First prototypes revealed issues with technological proficiency, language barriers, and insufficient feedback integration as key challenges. The improved second prototype showed limited improvement, as little feedback was integrated into the second prototype.

The feedback from Cambodian smallholder rice farmers and farm-machinery service providers indicated a positive perception of the utility of the Market Dashboard but highlights the need for training and incorporation of feedback from end users. The research underscored the importance of continuous feedback integration, addressing power dynamics in such participatory action research, and overcoming logistical challenges. Adjustments to the second prototype were almost invisible to the participant and showed that the implementation of feedback was a bottleneck.

The study reveals the potential of the Market Dashboard to meet the information needs of Cambodian smallholder rice farmers and farm-machinery service providers and demonstrates the added value of an open knowledge platform regarding rice production. Effective integration of user feedback enhances its impact and potential adoption.

Acknowledgements

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I am beyond grateful for all the Cambodian smallholder rice farmers and farm-machinery service providers who participated in the interviews. your willingness to share your time and provide feedback on the Market Dashboard was invaluable. And a special thanks to my translator. The understanding of the feedback of the participants would have been impossible without your help.

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1. Problem statement

This study explores the development of the Market Dashboard, a digital marketplace, for Cambodian smallholder rice farmers and farm-machinery service providers. It is focused on the involvement of end-users, the Cambodian smallholder rice farmers and farm-machinery service providers, in the design of the Market Dashboard.

The Market Dashboard is a digital marketplace for farmers and farm-machinery service providers. The creating of such a marketplace of farm-machinery service producers including a knowledge hub open to all smallholder rice farmers is a redesign of how knowledge is produced and eventually used (Abson et al., 2017). The goal of the application is to facilitate farmers in renting machine services for their farming operations. In addition, the dashboard features an information hub focused on agronomic practices related to mechanized direct seeding. The dashboard thus functions as a digital extension tool for smallholder rice farmers in Cambodia, developed by the International Rice Research Institute (IRRI) and the International Maize and Wheat Improvement Centre (CIMMYT). One particular farm operation that may benefit from mechanization is transplanting. Manual transplanting is either done by broadcasting or by transplanting seedlings from a seedbed. The first method typically is inefficient for seed, the latter inefficient for labour. Mechanical seeding can increase seed and labour efficiency. While only wealthier farmers can afford purchasing a seeder, service providers offering machine seeding are in principle available for all farmers. Giving smallholder rice farmers access to information on direct seeding and contact details of service providers may encourage them to apply mechanized direct seeding. EiA (2021) stated that, exactly the access to information, inputs, and the rice market is not open to most farmers.

The Market Dashboard is part of the project Excellence in Agronomy: Adapt, intensify, grow, Modernizing Agronomy Research. The project, initiated by OneCGIAR, aims to catalyze transformative change in agriculture. The Consultative Group for International Agricultural Research (CGIAR) refers to a partnership between international organizations that are focused on research in food security. CGIAR strives for better integration and greater impact in interdependent challenges that our world is currently facing, such as increasing food security, reducing poverty, improving overall human health and nutrition, and handling natural resources in sustainable ways (CGIAR, n.d.).

The project, Excellence in Agronomy, aims to "*deliver an increase in productivity and quality per unit of input (agronomic gain) for millions of smallholder farming households in prioritized farming systems by 2030, with an emphasis on women and young farmers, showing a measurable impact on food and nutrition security, income, resource use, soil health, climate resilience and climate change mitigation*." As CGIAR has stated (CGIAR, n.d.). One of the focal points of EiA in Cambodia is the introduction of mechanized direct seeded rice (mDSR). This shift reflects a recent trend away from manual rice transplanting towards mechanized direct seeding. The farmers currently use high seed rates in direct seeding, and experience problems with pests, lodging etc. This results in low yield and profit. Therefore, mDSR is introduced as a means for farmers to mechanize operations while simultaneously reducing seed rates. Additionally, a knowledge hub within the Market Dashboard provides users information on seed quality, pest damage, lodging, and more. Although mDSR technology exists is available in the country, its adoption among farmers remains low. To address this challenge, the Market Dashboard is developed to facilitate connections between farmers (clients) and farm-machinery service providers. It is also designed to serve as an information hub for agronomic recommendations about direct seeded rice.

Tailoring the Market Dashboard more towards the needs of the end user, the smallholder farming households, may enhance the acceptance of the Market Dashboard. This, in turn, could improve access to mDSR services and knowledge, thereby influencing farmers' their productivity and the quality of their produce.

Innovation and mechanization in rice production is of importance as rice is an important crop in Cambodia. Around 50% of the agricultural GDP comes from rice production and around 75% of cultivated land is dedicated to the production of rice (Dunn et al, 2023). The rice sector in Cambodia has shifted to manual or broadcast direct seeding, and out of transplanting, due to limitations in labor (Becker et al., 2024). However, direct seeding also introduces its own challenges. More grass weeds became present after the shift to direct seeding and farmers in Cambodia mostly depend on pre-emergence herbicides to combat those weeds, and more risks appear due to climate change (Bairagi et al., 2020; Martin et al., 2020). One option to improve the yields from direct seeded rice is mechanized row seeding. This involves not only the use of machines but is also associated with agronomic practices such as low seed rates, improved weed management, and suitable fertilizer and water management. Machines are however too expensive and inefficient for individual farmer investment. A farm-machinery service provider system that can implement row direct seeding for farmers can enable access and lower costs for farmers to implement mechanized direct seeded rice (mDSR; Touch et al., 2023).

Questions arise about smallholder rice farmers and farm-machinery service providers their willingness and the necessity, in terms of demand and usefulness, to use such a Market Dashboard in their daily agricultural practices and therefore the adoption of such a dashboard. Hence, it is essential to determine whether users recognize the potential value of the Market Dashboard and to explore whether it adequately addresses the needs of the end users. It needs to be explored how Cambodian rice farmers access new information and if the Market Dashboard can be a feasible tool for knowledge extension. Especially, as new knowledge is desired by the rice farmers as Dunn et al (2023) showed through interviews with 168 Cambodian rice farmers families. In this study, the farmers highlighted their desire for education and training on improving cropping practices, how to use pesticides, pest identification, and so on (Dunn et al., 2023). Providing smallholder rice farmers nationwide access to knowledge and services through a dashboard will be an accessible approach. However, testing is needed to ascertain whether the Market Dashboard is an appropriate technology for transferring this new knowledge and effectively serving its intended purpose.

However, farmers' desire for knowledge does not directly translate into farmers using the EiA Market Dashboard. Here adoption comes into play. The term adoption on itself can be troublesome, as it is still rather vague. What exactly is meant with adoption and when is a new technology adopted (Glover et al., 2016)? To further understand adoption the Technology Acceptance Model is used to investigate the end user's perspective on the new technology, thus the potential of the technology.

The aim of the research is to explore the human-centered design aspects of innovation during its developmental phase. This includes investigating the innovative practices farmers already have experimented with or implemented themselves. It seeks to assess the demand for a Market Dashboard among smallholder rice farmers and farm-machinery service providers. Furthermore, the study aims to optimize the dashboard by aligning it with the preferences of smallholder rice farmers and farm-machinery service providers, as it is intended to facilitate their access to knowledge in an open manner. . Involving the farmers and farm-machinery service providers could potentially influence their adoption of the digital dashboard. However, long-term adoption of using a dashboard is seen as one of the difficulties by agriculture cooperatives (Hendrawan et al., 2023). Questions arise about the openness of the innovation: Is the Market Dashboard as open as it claims to be? Do all smallholder rice farmers and farm-machinery service providers have the necessary resources and knowledge to use the dashboard as an R&D tool, considering ownership of mobile devices, internet connectivity, and proficiency with mobile technology? Are there opportunities for their involvement in the development of the Market Dashboard? Alongside the development of the Market Dashboard by IRRI and CIMMYT, this thesis will explore open innovation, through the human centered design that is incorporated in the experiment. Enabling farmers to test the dashboard and give feedback enables co-learning practices, and thereby shows the potential of those practices to strengthen the power and influence of the innovation and helps to tailor the innovation to the needs of the potential end users.

This thesis focuses on the interaction between the developers, the end users, and researchers involved in the development of the Market Dashboard, through two rounds where prototypes of the Market Dashboard will be tested. Through these two prototype test rounds following the model of Reflexive Monitoring in Action the following two research questions will be answered:

RQ1: *How does the involvement of Cambodian smallholder rice farmers/service providers influence the development of the Market Dashboard?*

The sub questions will focus on the aim of IRRI and the developers with the Market Dashboard, the feedback retrieved from the smallholder rice farmers and service providers after the first and second prototype testing rounds, and the extent to which feedback from the first round is implemented into the second prototype.

RQ2: *What is the perspective of the Cambodian smallholder rice farmer/service provider on the Market Dashboard?*

Here the sub questions divide the different categories of the extended Technology Acceptance Model: perceived usefulness, perceived ease of use, experimentation possibility, benefits of the innovation, and complexity of the innovation as perceived by the smallholder Cambodian rice farmers and farm-machinery service providers.

In this study, the concepts of Reflexive Monitoring in Action, Human Centered Design, and Technology Acceptance play a central role. These concepts will be further explained in section two: the conceptual framework. Section three elaborates upon the set-up of the study as well as the method for data collection. Subsequent to the method, sections will follow for the results, discussion, conclusion, and appendices.

2. Conceptual framework

2.1 Framework & concepts: Human Centered Design, Technology Acceptance Model and Reflexive Monitoring in Action

Theories on Human Centered Design, Technology Acceptance, and Reflexive Monitoring in Action are incorporated in this thesis to understand the perspectives from potential users on usefulness of the Market Dashboard. It checks if design components fit their needs, and then ultimately, brings out insights for the use of a digital tool to accelerate the access of machines (mDSR) throughout Cambodia.

The use of the theory of Human Centered Design makes it possible to involve the end users in the development. This will help to get clarity on questions such as: "How does the end user interact with the innovation, the Market Dashboard", "Does the end user understand how to use the innovation", and "what other requirements does the end user have for the innovation to be successful? Human Centered Design will help gathering answers on the acceptance towards the technology as the participants will be asked to give feedback on the innovation.

The Technology Acceptance Model (TAM) is an analytical model within human centered design for measuring people's acceptance towards an innovation on specific aspects. The TAM will help getting clarity on which aspects of the Market Dashboard are good in the eyes of the potential end-users and what aspects need alternation to make it more interesting for them to use the Dashboard in the future. The aspects that will be focused on are the complexity of using the Market Dashboard for the end user, the usefulness, what the advantages are of using it, and the influence of being able to experiment with it.

Human Centered Design and the TAM are applied in a structural way through using the model of reflexive Monitory in Action through which questions on implementation of feedback can be answered. Here the central question is: Is feedback as provided by the Cambodian smallholder rice farmers and farm-machinery service providers used and implemented? Additionally, the observations of the researcher can help answer questions on how the end user uses the Market Dashboard. For example, are they struggling with certain actions whilst using the Market Dashboard? Are they exploring all parts of the Market Dashboard? Are they able to use the Market Dashboard on themselves or do they need guidance?

2.1.1 Human centered design

Human centered design is the design of a specific innovation through information obtained from the end users. The potential end users get actively involved into the development of the innovation. Their point of view and feedback plays a central role in the development of the innovation (Dopp et al, 2019).

In order to actively involve end users into the development a usability test can be carried out, here will be looked at the potential of the innovation and the interaction with the end user. In this case the interaction of the Cambodian smallholder rice farmers and farm-machinery service providers with the Market Dashboard. This will be done through looking at how they use the Market Dashboard and asking questions. So, observation is used as a tool to understand and see how the end users use the Market Dashboard (Dopp et al., 2019). Here the observations can be compared with the aim of the developers. Do the end users use the Dashboard the way the developers had imagined? The additional questions asked to the users, the farmers and service providers, will help to gain deeper understanding of their user behavior. Through this perspective the end user is seen as someone who makes plans, has goals, and makes actions informed by feedback. This feedback can then be used further in the development, making a more valuable Market Dashboard for the farmers (Wright & McCarthy, 2022).

The human centered design cycle contains of four different stages: the understanding and specification of the context of use, requirements obtained from the end user, a design of an innovation that meet the end user's requirements, and an evaluation of how the design meets the requirements. Here the end evaluation can be done through user-based testing. This model is visualized in figure 1 (Seufert et al., 2021). Here at the stage of evaluation it is evaluated what needs to be changed and to which stage more attention should be paid to before the design meets all the end users' requirements.

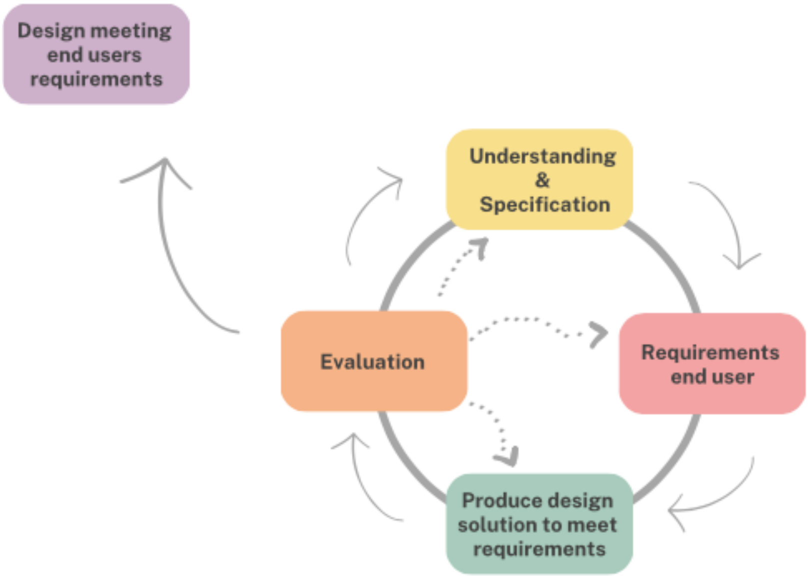


Figure 1. Human Centered Design Cycle

Through involvement of rice farmers, service providers, and researchers in the design, as Dopp et al (2019) state, the acceptability, appropriateness, and feasibility of the Market Dashboard can be influenced. It incorporates centricity of the end user, the farmer and the farm-machinery service provider, which can be beneficial in the development of software systems and applications (Seufert et al., 2021).

2.1.2 Technology Acceptance Model

The Technology Acceptance Model (TAM) is a model for understanding the determinants influencing people in their individual use and adoption of information technology. It proposes that factors such as perceived usefulness and complexity influence the adoption of applications (Venkatesh & Bala, 2008).

The model can be applied for education IT, looking into the e-learning acceptance (Granic & Marangunic, 2019). Which is relevant as the online dashboard has as end goal to inform, educate, and help smallholder rice farmers in Cambodia. Additionally, "Smartphones have the potential to be utilized as a communication and distribution medium for internet-based information" and "By being accessible online, it is claimed that information is also more diversified, giving farmers access to a number of information sources that can assist them in making more educated decisions” (Hendrawan et al., 2023).

The TAM corresponds partly to the five factors mentioned by Long, Blok, and Coninx (2016) that affect the way an innovation will be used and spread. These five factors are the advantage of the innovation, the ease of adoption, how complex or simple it is, if there are ways to try out the innovation and experiment with it, and how easy it is to observe the benefits of the innovation in terms of use and effects (Long et al., 2016).Usage of this model will give insight, and maybe a pattern, in the reasons why the dashboard, developed by IRRI, has potential or not. These results then can be transformed into a model, predicting Cambodian rice farmers decision influences on how and when they will use the Market Dashboard of IRRI.

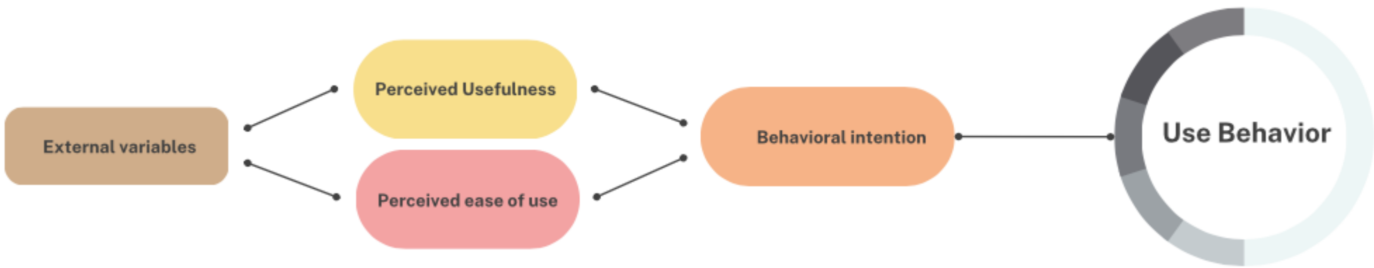


Figure 2. The Technology Acceptance Model (Davis, 1986; Venkatesh & Davis, 1996)

In figure 2 the Technology Acceptance Model is visualized. This model entails that an individual’s intention to use certain IT’s is determined by two things: the person’s perceived usefulness of the IT and the perceived ease of use of the IT (Venkatesh & Bala, 2008). However, this initial model is not a perfect fit of the case study on the Market Dashboard of IRRI. This model is rather consumeristic and mainly focuses on the individual. The project also focuses on the collective of farmers and service providers throughout the country and there is a possibility for the end users to get involved in the development of the dashboard through trying out the dashboard in interview rounds. Therefore, an extended version as explained in figure 3 will be used.

Perceived usefulness

Perceived usefulness consists of whether the person believes that the usage of the IT, the dashboard, will have added value to their job performance or makes their job easier. Furthermore, Venkatesh and Bala (2008) state that there are general determinants of perceived usefulness. Those are the subjective norm, image, job relevance, output quality, result demonstrability, and perceived ease of use. These determinants will be viewed the perspective of the Cambodian smallholder rice farmer and service provider. Here there will be looked at what the farmer does, what the service provider does, which role the information provision plays, and how this changes their practices in daily work life.

Perceived ease of use

The perceived ease of use consists of whether the person sees using the IT, the Market Dashboard, as easy and effortless. Here, Venkatesh and Bala (2008) state that the main moderators of perceived ease of use are experience and voluntariness. It depends on past experiences they had with innovations. But it also is of importance to look how this is influenced by others, other farmers, other service providers, family members, friends, etc. This will have an influence on how individual the perceived ease of use is.

Behavioral intention and use behavior

Someone's behavioral intention is the probability that that person will perform a certain behavior (Davis, 1986). Behavioral intention is influenced by two things: a person's their perceived usefulness and perceived ease of use (Venkatesh & Bala, 2008). If the perceived usefulness from the end users of the Market Dashboard is high and the Market Dashboard is perceived as easy to use, the probability will become higher that he or she will use the Market Dashboard themselves. This eventually thus influences the behavioral intention and the intention to use the Market Dashboard (Venkatesh & Bala, 2008).

Broadening the TAM with the remaining factors mentioned by Long et al. (2016) gives a new visualization which can be seen in figure 3.

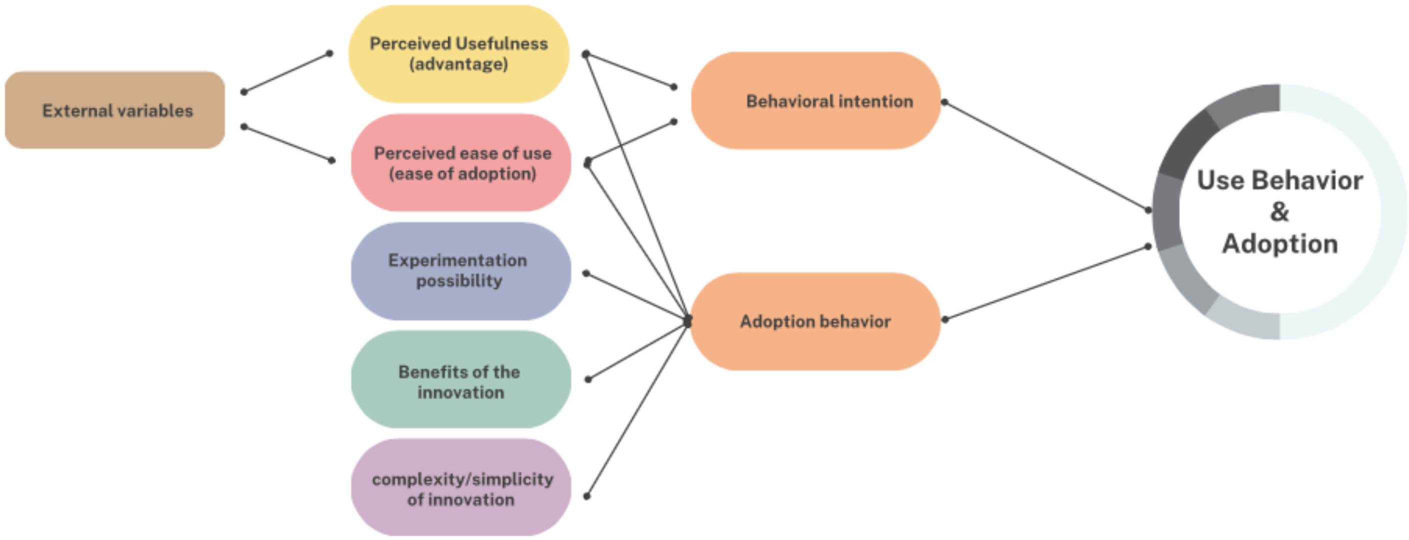


Figure 3. combination of the TAM and five factors that influence the way an innovation will be used and spread (Davis, 1986; Long et al., 2016; Venkatesh & Davis, 1996).

Here the perceived usefulness is complemented by the perceived advantage of the innovation. Which entails a comparison with previous generations of similar products and services and benefits of the innovation compared to similar existing products. This can be looked at from multiple perspectives. What advantages do the smallholder farmers/service providers see in the Market Dashboard themselves? What advantages do they get told by others, and who are those others?

The figure is also broadened with the experimentation possibility (absence or presence of this) and the complexity or simplicity of the innovation. Adoption behavior is here seen as the intent to use a new technology, which is influenced by the five factors shown in figure 3 (Long et al., 2016). Here the focus will be more on letting the technology integrate with the way they perform their work. Not only for once, but for a longer period, actively using the dashboard for multiple seasons.

The broadened technology acceptance model, as in figure 3, will be used within this thesis as a starting point for indicating farmers and service providers their point of view towards the new technology, the

Market Dashboard, and factors influencing their adoption to using the dashboard. So, not only will be looked at the intention of the farmers and service providers, which is mainly captured in the TAM, but the factors influencing adoption of technology are added as well (Long et al., 2016). That way it can become clear what the exact advantage of this innovation is and where there are points for improvement (Long et al., 2016).

The extended Technology Acceptance Model can be used for looking into the behavioral intentions of Cambodian smallholder rice farmers. Here the focus will be on the end user's perception, intention, and factors influencing adoption, in this case about the Market Dashboard (Hendrawan et al., 2023).

Adding to the adopting potential of the dashboard is the implementation of Reflexive Monitoring in Action (RMA) within the development phase of the dashboard. The implementation of RMA can have positive influence on people adopting and using the information technology, in this case the Market Dashboard (Phan et al., 2018). Also, using a combination of the TAM together with the RMA experiment creates a research environment where both the perception on, and adoption of the new technology are considered. Hereby, covering all five factors influencing the spread and usability of the Market Dashboard (Long et al., 2016).

2.1.3 Reflexive monitoring in action

Reflexive monitoring in action will be used as a methodological model for gathering the data within two cycles of prototype testing and interviewing. The concepts of Human Centered Design and the Technology Acceptance Model fit well within reflexive monitoring as it creates a structure for continuous improvement and actively engages stakeholders. Using all three together creates a holistic approach focusing on the practical needs and the theoretical understanding of the end user's acceptance of the Market Dashboard.

Through Reflexive Monitoring in Action the smallholder farmers and service providers will be involved into the process of developing a dashboard where they themselves are the main target group of.

Hereby, it will be identified if their needs and wishes are being met in the current prototype of the dashboard and what can still be altered or improved. Creating an environment where open innovation and a more bottom-up management approach can unfold (Liberloo et al., 2022).

Reflexive monitoring in action functions as a starting point for stimulating learning processes within projects. Reflexive monitoring in action interventions aim to support systems innovation. It can be used at a specific moment within a project to monitor the activities at that specific moment. Through this intervention it can be analyzed if directions or actions need to be changed, as at regular intervals the participants of the reflexive monitoring in action reflect on the four key aspects: observation, analysis, reflection, and action (Van Mierlo et al., 2010).

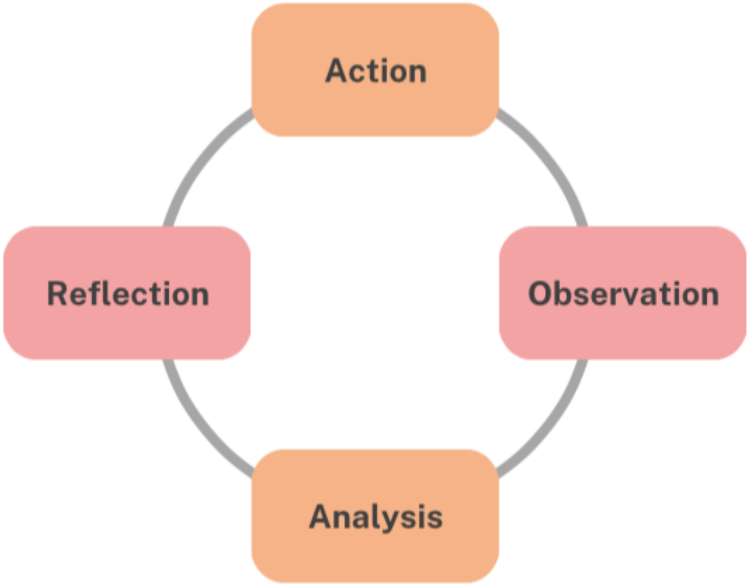


Figure 4. The Reflexive Monitoring in Action cycle (Van Mierlo et al., 2010)

Reflexive monitoring in action is a type of monitoring that lays emphasis on reflexivity of the project itself and learning from each other. When system innovation is wanted there is a need for in-depth reflection and learning alongside. RMA enables these reflection and collective learning processes as a continuous process alongside the development of an innovation that aims at system change

(Arkesteijn et al., 2015; Liberloo et al., 2022). This way in the process there is ongoing reflection on the ambitions, the practices, and already made developments.

RMA is relevant as the role of farm advisors is becoming more divers. The focus of farm advisors is shifting as well. Instead of only enabling a knowledge transfer, their roles become more diverse and interactive now. New activities include the facilitation of knowledge exchange with each other and learning from each other (Liberloo et al., 2022). RMA is a way of enabling such interactive knowledge transfer and structural systems change.

Using only an expert approach can be problematic, so it can be beneficial to keep participants close and learn together with them, which is possible through RMA. Additionally, to only learning, RMA enables the creation of solutions at the same time thereby enabling structural change. Structural change within the system but also organizationally, as the people involved in the RMA were not involved before (Klerkx et al., 2012; Mierlo et al., 2010).

Therefore, RMA enables a process of value co-creation, as the smallholder farmers and service providers get involved in the development of the Market Dashboard. This involvement can be seen as a value co-creation process. Farmers and service providers involved get a better understanding of the dashboard and can give their own input within the development. This active participation in development of the dashboard can have positive effect on the adoption/usage of the dashboard (Phan et al., 2018).

Both terms (TAM, the expanded version, and RMA) enable open innovation and a deeper collaboration of the developers with two big stakeholders, the smallholder farmers and service providers. Both terms fit in under the umbrella of responsible research and innovation (Klaassen et al., 2020).

The Technology Acceptance Model will help in identifying the factors characterizing the motives of individuals to use the dashboard and what they have already tried in the past (in terms of trying out/applying new innovations/technology). Which can show why the dashboard has or has not the potential to become a success, plus can give insight in what should be changed.

Plus, instead of letting the farmers and service providers “wait and see” until the final version of the dashboard is developed, through these methods you let them be actively involved into the design of the end product as well. The development process no longer is in a rising line but becomes a circular process. This will be done through two cycles of prototype testing by the smallholder farmers/service providers and providing the developers with the feedback obtained from this. Additionally, the developers will also be interviewed.

It becomes more active, enabling open innovation and creating more equal power structures, not so much of a top-down approach, through the active involvement of the farmers and service providers in the different phases of the Reflexive Monitoring in Action cycle. The stakeholders therefore are more entangled in the process, as they get observed whilst trying out the dashboard, their feedback is being analyzed and reflected on, and in the end translated into action. Resulting in an end product that eventually also becomes theirs through their active involvement.

3 Method

On base of the concepts explained, the research questions can be further specified in the following:

RQ1: How does the involvement of Cambodian smallholder rice farmers / service providers influence the development of the Market Dashboard?

Sub:

- What is the aim with the IRRI Market Dashboard from the perspective of the developers?
- What are the comments based on the observations on the smallholder rice farmers and service providers on the first cycle of trying out the prototype?
  And what is the feedback of farmers/service providers in the first cycle of trying out the prototype?
- What do the developers think of the feedback provided by the farmers after the first trial?
- What is the feedback of farmers/service providers after the second try out of the prototype?
- To what extent did the developers implement the feedback of the farmers/service providers and what was their motive for this?

RQ2: What is the perspective of the Cambodian smallholder rice farmer/service providers on the Market Dashboard?

- What is their perceived usefulness?
- What is their perceived ease of use?
- What is the experimentation possibility?
- What are the benefits of the innovation in the eyes of the farmer/service provider?
- How complex is the innovation for the farmers/service provider?

3.1 Implementation of the methods

3.1.1 RQ1: Human Centered Design

For answering RQ1, "How does the involvement of Cambodian smallholder rice farmers influence the development of the Market Dashboard?" a two-cycle experiment following the Human Centered Design model was carried out.

Here the Cambodian smallholder rice farmers and service providers tried out the prototype of the Market Dashboard twice. Before the interviews with the farmers and service providers an interview with the developer was carried out. This interview functioned as getting an understanding of the perspective of the developer and what the aim was with the Market Dashboard. The first prototype is the initial prototype from the developers, which was tested out in the first feedback cycle (RMA). Here the farmers and service providers were observed when they tried out the dashboard for the first time. It was observed how they navigate through the dashboard, what pages they visit, what they open, what actions they take. Additionally, there was looked at facial expressions and comments made by the farmer and service provider alongside trying out the Market Dashboard. Then farmers and service providers were questioned about the dashboard. What did they like about the dashboard what did they not like? The more in-depth interview guide for this can be found in Appendix A. This information was used to answer the sub question “What is the feedback of farmers/service providers in the first cycle of trying out the prototype?” and thereby gaining and understanding and specification of the context of use of the end user of the innovation and requirements from them for using the innovation (first and second stage of Human Centered Design).

After this first interview round the feedback of the farmers and service providers was passed on to the developer. The developer was asked about their opinion on the feedback provided by them, which helped answering sub question “What does the developer think of the feedback provided by the farmers/service providers after the first trial?”. They got the chance to change the prototype and implement the feedback provided by the farmers/service providers. Important note is that they did not have to implement the feedback if they do not want to. This was also part of the research (looking at what they eventually implement and what not and why) and answered the sub question “To what extent did the developer implement the feedback of the farmers/service providers and what was their motive for this?”. This reflects the third stage of Human Centered Design, in what sense does the design meet the end user’s requirements, together with an evaluation (fourth stage of Human Centered Design) that helped to alter the innovation more to the preferences of the end user.

Then the new prototype was brought back to the same farmers and service providers who tested the first prototype. They again were observed and asked questions. This feedback then was used to answer the sub question “What is the feedback of farmers/service providers after the second try out of the prototype?”. This was a new cycle as described in Human Centered Design.

3.1.2 RQ2 Technology Acceptance Model

For answering RQ2: "What is the perspective of the Cambodian smallholder rice farmer/service providers on the Market Dashboard?" the extended Technology Acceptance Model will be used.

Within the technology acceptance model an overview will be made of the way farmers/service providers operate right now, including what types of new technologies are being used, and what viewpoints they held on to those new technologies. Through this starting point it will become clear what way the farmers and service providers operate right now and what kind of innovative sources are already being used or tried out. What kinds of technologies do the farmers and service providers use within their work. Besides that, questions will be asked on the new technology from IRRI, the Market Dashboard. Here it will become clear what the added value of the new dashboard is for the farmers and service providers individually. Thus, also gives insight in understanding and specification of the context of use of the innovation and what the needs are from the end user (first and second stage of Human Centered Design).

Through interviews with the Cambodian smallholder rice farmers and service providers based on the five factors of the TAM the question: What is the perspective of the Cambodian smallholder rice farmer/service provider on the EiA Market? Will be answered (Marangunic & Granic, 2014).

The answer on RQ2 will consist of the answers to the different sub questions taken all together. The interviews done for answering RQ2 will be retrieved after letting the Cambodian smallholder rice farmers/service providers try out the first prototype of the Market Dashboard. The interview will be subdivided into five parts, all focusing on one of the factors of the extended Technology Acceptance Model. These factors are the perceived usefulness, the perceived ease of use, the experimentation possibility, the benefits of the innovation, and the complexity of the innovation (Knott et al., 2022).

3.2 Data collection method

The study design uses a Human Centered Design approach where in a two-cycle prototype testing experiment was carried out. In these, there were three groups studied: the researchers and developers of the Market Dashboard, the Cambodian smallholder rice farmers, and the seeder service providers. The main method used to collect data was semi-structured interviews.

A. Interview with developers

Before carrying out the two-cycle prototype testing, interviews were done with the developers of the Market Dashboard (Developers from IRRI, CIMMYT, EiA). This served as an ultimate starting point, indicating the aim of the developers with the new tool: the EiA Market Dashboard. Besides their aim with the innovation questions were asked about the purpose of it and how this fits the wishes of the end users, the smallholder Cambodian rice farmers and service providers. This helped to understand and specify the context of use, the first stage of human centered design.

B. Two round interviews with farmers and service providers

The two-cycle (two cycles of RMA: observation, analysis, reflection, and action) experiment was done with the Market Dashboard prototype, where the Cambodian smallholder farmers and service providers got to test a prototype of the Market Dashboard twice. This was both done through observations (part of RMA) and interviews (for gathering an in-depth analysis (RMA) from the farmer and service provider on the Market Dashboard). The interviews were done in collaboration with a translator, as the researcher did not speak Khmer. The translator was informed about the purpose and subject of the experiment. The feedback that was obtained through this first round of prototype testing gave insight in the requirements for the Market Dashboard from the end users, the smallholder Cambodian rice farmers and service providers. This was part of the second stage of Human Centered Design, requirements from the end user.

C. Feedback to developers

The feedback retrieved from the first prototype test out was then passed on to the developers who then get the chance to reflect (RMA) on and implement (action part of the RMA) the feedback. Here more clarity was given on the design of the innovation meeting the end user’s requirements (fourth stage of Human Centered Design). As feedback was retrieved through the interviews that followed the Technology Acceptance Model. The implemented feedback resulted in a new prototype of the Market Dashboard, which was used for the second round of prototype testing.

D. second round interviews with farmers and service providers

In the second round the farmers and service providers got to test the improved prototype and gave feedback (RMA round 2) again. Here again there was reflected on the second and third stage of the Human Centered design Model (requirements from end user and the design of the innovation meeting those requirements). Plus, a second evaluation was carried out on how the design of the Market Dashboard design met the requirements of the end user, the smallholder rice farmers and service providers, and of the developers and researchers.

Here, overall, the focus was on the postmodern research paradigm. Where innovation should come from dialogue, mutual understanding, and trust between stakeholders. Communication is about the interpretation of each other making meaning together. Which was done through the exchange of feedback between farmer, service provider, and developer (Leeuwis & Aarts, 2011).

The specific group of farmers and service providers that was selected for the rounds of interviews were from two provinces, Takeo and Battambang. The EiA has been testing mechanized DSR in several provinces in Cambodia. In a survey completed by EiA in 2021-22, the greatest number of users and service providers were in Battambang and Takeo. Furthermore, the districts and villages were purposively selected to be able to get farmers who had been using mDSR. In this study, the focus is the potential adoption of the dashboard, and so it was important that the study respondents were already aware of or are using mDSR.

3.3 Data characteristics

The farmers selected for the Market Dashboard try out cycles were selected from the following provinces in Cambodia: Takeo and Battambang. In total 44 farmers were interviewed, 20 from Takeo and 24 from Battambang. The experiment was carried out at the farmer's property. From these farmers 14 were female and 30 men. The size of the farm differed amongst the farmers.

The service providers selected for the Market Dashboard try out cycles were selected from the following provinces in Cambodia: Takeo and Battambang. In total 15 service providers were selected to participate in the two-cycle experiment, 6 from Takeo and 9 from Battambang. The experiment was carried out at the service provider's property. From these service providers all 15 were men.

The two-cycle experiment was carried out in the period starting from December 2023 until January 2024. Here observations together with semi-structured interviews were selected to be able to answer RQ1 and RQ2. As this gave structure for answering the research question, but also provided the space to dive deeper into the answers provided by the farmers/service providers on the spot.

Contact with farmers and service providers was made through the help off IRRI Cambodia. They contacted cooperatives within their network who helped with getting farmers and service providers to participate in the interviews.

The following cooperatives were involved in the interviews:

Within Takeo:

- Baksei Rekreay agricultural cooperative in Angbaksei Village, Cheang Tong Commune, Tram Kak district, Takeo province.

- Tuol Prahvihear agricultural cooperative, in Pontong village, Ban Kam commune, Prey Kabbas district, Takeo province.

Within Battambang:

- Tek Chet Kasekor agricultural cooperative in Tanak village, Kea commune, Mong Rosei district.

- Reang Kesei agricultural cooperative in Svay Cheat village Rang Kesei commune Sangkae district.

- Kamping Puoy agricultural cooperative in Oupong Morn village, Ta Kream commune Banan district.

- Sangha Phal agricultural cooperative in Sangha Phal village, Khmach Romeas commune, Bovel district.

- Morak Dok Basai Treng agricultural cooperative, Tuol Tasok village, Bansai Trey commune, Thmarkol district.

Characteristics of the population:

The interviews were carried out in two different provinces of Cambodia, namely Takeo and Battambang. In the first round, 26 participants were from Takeo and 33 from Battambang. In the second round, there were 24 participants from Takeo and 23 from Battambang. In total, 44 farmers (14 female and 30 male) and 15 service providers (all male) participated in the first interview. Ten farmers (3 female and 7 male, 2 from Takeo and 8 from Battambang) did not participate in the second round due to various reasons, such as lack of time or being away from the area. Therefore, the results of these ten farmers were separated from the others in the basic descriptives of round one of the interviews. Similarly, two service providers (both male, both from Battambang) did not participate in the second round, and this division between participants who participated twice and those who participated once was made for service providers as well. A clear overview of the population can also be seen in figure 5.

	Farmers who did one interview		Farmers who did both interviews		Service providers who did one interview		Service providers who did both interviews		Total
	Male	Female	Male	Female	Male	Female	Male	Female	
Takeo	1	1	11	7	0	0	6	0	26
Battambang	6	2	12	4	2	0	7	0	33

Figure 5. *Overview population two interview rounds*

All farmers and service providers had internet connection and a mobile phone (or at least a family member with a mobile phone). Out of 59 total participants who participated at least once, 50 used the internet for getting new information about rice farming. The most mentioned websites or apps for getting new information were Facebook, YouTube, Telegram, Chamka app, TikTok, Google, and Tonle sap app. Participants mentioned that they learned various things through using these online sources, such as vegetable farming, animal farming, fertilizer usage, how to plant rice, fish farming, how to make a pond next to rice farming, harvesting machines and machine operation, land preparation, transplanting, seed production, and more. All participants were familiar with direct seeded rice in some way, either by trying it before, being involved in a demo, or planning to apply Mechanized Direct Seeded Rice (MDSR) in the future. Most of them had access to a machine for MDSR through their cooperative, and most were interested in applying MDSR in the future as well.

3.4 Tools for analyzing the data

The data retrieved through the interviews and observations was transcribed. Notes were made about the observations and interviews and recordings are made of all the spoken content in the two-cycle experiment. Notes were made in English through the help of a translator who translated all the interviews on the spot for the researcher.

The transcript was analyzed through methods of qualitative content analysis in AtlasTi. The coding scheme was based on the concepts used (Human Centered Design and Technology Acceptance Model). Here the data that was collected through the two interview rounds with the farmers and service providers was coded. With the created codes, code networks of reoccurring comments per theme were made. These networks gave an overview of what reoccurring feedback was given. Here coding clusters amongst certain themes were made. For the TAM model the clusters were perceived ease of use, perceived usefulness, benefits, the experimentation possibility, and complexity of the innovation. For human centered design focus is on recommendation given by the participants. What is currently good and what aspects of the Market Dashboard need to be changed after round one. In the second-round subdivision can be made about what is good about the Market Dashboard, what is changed, and what still needs to be changed. To indicate if participants observe change in the Market Dashboard and how this change is perceived.

Observations were subdivided in different topics. Focus was on what exactly participants were struggling with, how this shows, what components of the Market Dashboard are easy to use and what components are difficult, and how do they use the Market Dashboard.

Next to AtlasTi, SPSS will be used for obtaining basic descriptives and analysis of the answers given on the likert scale questions. This will help to see if the end users experience a change between the two prototypes. Here ordinal data is collected, making it possible to calculate the median and the mode.

3.5 Validity and trustworthiness

Validity and trustworthiness are achieved by using TAM, RMA, and Human Centered design principles. The prototype testing cycles are designed to align with the four cycles of RMA, ensuring a structured and iterative process of collecting and handling feedback. The questions in the interviews with Cambodian smallholder rice farmers and service providers are structured along the five factors of the extended TAM, providing a thorough view of the participant's perspective on the Market Dashboard. Validity is ensured by the sample size and the diversity of participants. A total of 44 farmers and 15 service providers are interviewed, in the two provinces (Takeo and Battambang) from seven cooperatives, this diverse sample allows for a representative understanding of the perspective of the potential end users on the Market Dashboard. Consistency, and trustworthiness of results, is achieved through a standardized structure and setting for all the interviews, discussing the same concepts across all sessions (detailed version of interview guides can be found in appendix A). This way the research design ensures that the outcomes are reproducible.

3.6 Ethical considerations

Respect for the autonomy, privacy and dignity of participants

For obtaining interviews, consent from participants was needed (Kelman, 1982). The subjects in the research, the participants, knew their participation is voluntary. This was discussed with the participants before starting the interview. Participants were informed about participation and that they could quite at any time and that withdrawal has no consequences for them, after this the participant orally agreed to understand this and to participate.

Additionally, participants stayed anonymous. This way harming participants is limited, and privacy is ensured as their identity is protected within the study. In the final report no participant can be identified through the responses he or she has given (Knott et al., 2022). All names were removed in the final version However, the study will include face-to-face interviews. Therefore, participants were informed about possible consequences of participating in the research.

Additionally, disclosure is needed about the study. Participants in this study were informed beforehand on the purpose of the research. After this disclosure of information, they decided whether they want to participate in the research. It was also made clear what the exact purpose is of the study, how the findings will be used, and who will have access to the findings (Dingwall et al., 2017).

Scientific integrity

The way the research was carried out ensures quality, integrity and contributes to creating understanding of matters. This study follows scientific standards and ethical guidelines, ensuring honesty in the data reporting and ethical conduct (Oates et al., 2021). Additionally, the code of conduct of IRRI and WUR will be followed, this is further discussed down below.

Reflexivity and positionality

Being aware of the position of the researcher vs the participant, the smallholder rice farmer and service provider. Here power relations needed to be considered. Such as, what are these during for example interviews and how is the researcher perceived by the interviewees (Knott et al., 2022). It is possible that the participants, the Cambodian smallholder rice farmers and service providers looked up to the researcher. Therefore, a careful and accessible approach was needed, ensuring participants that they can be open and give their honest opinion without any consequences.

Ethical obligations that need to be followed within the research also have to do with the analysis and reporting. Unexpected results, whether negative or not, need to be disclosed even when affecting the results or findings. Therefore, the bottlenecks that were found are discussed thoroughly in the findings and discussion. Additionally, the ethical guidelines of WUR (code of conduct) and IRRI were followed. These consist of five principles (Algra et al., 2018).

Honesty which means being accurate in your work, reporting the right way, being open to other points of view and seriously considering those as well, being open about points that are uncertain within the research. Meaning that also opinions that differed from what is desirable were discussed and mentioned in the findings and discussion, as those showed best what still needs to be changed in the eyes of potential end users of the Market Dashboard.

Scrupulousness Using methods that are scientific. This was done in this thesis through using the theories on the Technology Acceptance Model, Human Centered Design, and Reflexive Monitoring in Action. Furthermore, the best care is put in in carrying out the research and reporting findings.

Transparency is ensured through being clear on what sources have been used to gain knowledge and how data is retrieved. This is done through the detailed method section within this thesis, explaining what methods have been used for the data collection and analysis. Such as the two cycle interviews and the use of AtlasTI for the qualitative data.

Independence is maintained as this thesis is not guided by any non-scientific or non-scholarly considerations. There was no bias or external pressure from commercial, personal, or political interests. The findings stand on their own merit.

Responsibility is acknowledged by the researcher, who is committed that the interest and well-being of other humans is taken into consideration. Meaning respecting the rights and dignity of participants (Algra et al., 2018).

4. Findings

Context: description of the site as a rice-based agriculture area

The location where interviews were held consisted mainly of the meeting points of cooperatives. Those were the places where people, rice farmers, came together. Here trainings were held on rice production, meetings with local farmers on the farmers their progress (growth of their rice), meetings with companies such as chemical producers etc. The cooperatives visited were located in two provinces, Takeo and Battambang. The location of the interviews was known by the participants as most were also active in the cooperative. The setting was informal, often consisting of a table and some chairs, where researcher, translator and participant (the Cambodian smallholder rice farmer or service provider) were sitting around the table.

Current mDSR uptake and information context

All farmers, except one, and all service providers participating in the study owned a mobile phone with internet connection. They use their phones mostly during lunch breaks and in the evening. Social media is the main source of information, also related to rice production. The main platforms that are used are Facebook, YouTube, and Telegram. However, most participants only browse through and hardly use search functions to find specific information.

For specific questions relating to agricultural practices, most farmers mentioned they ask the cooperative leader, the Cambodian department of agriculture and forestry (PDAF), or specific companies that sell for instance fertilizers or chemicals.

Developer's perspective on tool design

The very first interview held was with the developer of the Market Dashboard. This interview functioned as the starting point of the reflexive monitoring in action experiment, wherein human centered design and technology acceptance played a crucial role. Here the view of the developer on the project of the Market Dashboard became clear and the developer's end goal with the Market Dashboard. The developer who had a background in engineering technology started working on the project and the Market Dashboard for almost a year at this point (November 2023). It started off as a not so big project in the eyes of the developer, however it grew into a more ambitious and bigger project over time.

It is mentioned in this interview that the status of the Market Dashboard development was over 60%, as the interface was developed where a map was included, a page with the different services available, and a knowledge hub with different articles on rice farming. The developer mentioned that the largest changes in the Market Dashboard for upcoming months will consist of internationalization, enabling multiple languages, and that certain functionalities are still missing, such as a search tool and filter tool. The surface however will not change that much.

The developer's personal goal within the project was to work with this specific tool that works with the front and back end of the Market Dashboard, as the developer has not used this specific tool before. Making it possible for the user to use the Market Dashboard, meaning that a click on a certain part of the Dashboard will lead to a reaction from the Dashboard. For example, when a farmer clicks on the dot of a service provider's profile on the map that the profile will load and gives more information on that specific service provider.

Additionally, the service provider mentioned that the main problem that was found so far was that there are not enough service providers to make the Market Dashboard work. Ideally the Market Dashboard is seen as the new Uber where rice farmers can find a service provider for the right type of mDSR on their field.

To make the Market Dashboard a success the developer mentions that it is needed to let the end users try out the prototype, a quote from the developer is: "I think this is necessary, this will be helpful. Good to talk to them face to face and get feedback". This openness towards receiving feedback from the end users with the development of the Market Dashboard showed openness towards using the model of Reflexive Monitoring in Action. Making it possible to learn together with the farmers and service providers to reflect on feedback and improve the innovation.

Preliminary feedback on the design

Before the first round of interviews with farmers and service providers with the first prototype, last feedback from the IRRI Cambodia office was passed on to the developer. Main points for improvement that needed to be done before the first round were the enablement of creating new profiles on the Market Dashboard to make it possible to let new users have their own account, with a difference between farmer accounts and accounts for service providers and being able to choose the language: division between English and Khmer.

My personal comments here were similar, but also consisted of questions on user ability and if users get instructions on how to use the Market Dashboard. If not, it could be useful to add a main page where user instructions are given. Additionally, there are reservations about the jargon used, as it might have been too difficult to understand by the farmers and service providers and this is one of the main barriers of pro-environmental technologies to become a success (Long et al., 2016).

The first design of the Market Dashboard that was used in the first round of interviews is visualized in figure 6, representing all components and functionalities of the Market Dashboard.

The different pages of the Market Dashboard	**Functionalities per page**	**Functionalities further explained**
Log-in	Button to choose language Create account Log in Button to sign in	English/Khmer Choice between farmer/service provider account Phone number and password field

Map with service providers	Map of the world, focus on Cambodia Dots with the profiles of all service providers	Contact details and button to make a call
Services page	Filter Button per machine Filter button per area	
Profile page	Personal account details	Name, area, farmer/service provider, contact info
Knowledge hub	Articles	Pdf's

Figure 6. The design components of the first prototype of the Market Dashboard as used in the first round of interviews

Testing the first prototype

Scale questions

Within the first round of interviews, the most frequently provided answer by both groups on all scale questions was score 4 (indicating ease or usefulness). This pattern remained consistent when examining the responses farmers and service providers individually. Only questions where the mode was not 4 were “The information in the knowledge hub was useful” and “How did you experience navigating through the different parts of the market dashboard?” when asked to farmers who only did the first interview. All other groups had a mode as 4. Here in the group with farmers who only did the first interview, for both questions, the mode was 3.5. For the question on navigating ease for service providers, only of the group who participated only in the first interview, the mode was 3. For all other scale questions, for both the service providers and farmers, both the first interview and second interview, the mode was 4. Overall, the different aspects of the market dashboard were interpreted as being easy to use and useful to use in their lives, which indicates a positive stance on the Technology Acceptance Model. However, these scale questions lacked further explanation and certain nuance, as the answers to the qualitative questions will show that, although most aspects of the dashboard were seen as useful and easy to use, there were still points for improvement and points of attention.

Open questions

The answers to the open questions however showed more nuance and explanation of participants experience with the first interview round of the Market Dashboard. These answers can be subdivided into five themes: benefits, willingness to use, ease of use, recommendations, and end user involvement. Networks with most occurring themes and quotes of participants were made and these resulted into the themes perceived ease of use, benefits, complexity (recommendations), perceived usefulness, and end user involvement through experimentation possibility.

Perceived usefulness & Benefits

Under two themes, being usefulness and benefits, several recurring themes emerged among farmers and service providers. When asked in an informal manner, some farmers and service providers identified specific benefits. However, others struggled to articulate what the benefit of the Market Dashboard was for them. Commonly cited benefits included the access to new information, contact details of service providers, and potential gain in customers.

The feedback revealed overarching themes in benefits of the Market Dashboard such as time, videos and pictures, reading and writing, language accessibility, ease of contact with service provider and getting their details, financial gains, knowledge gain, and willingness to use the platform.

Farmers highlighted that the Market Dashboard makes it easy to find a service provider near them and get the contact details, resulting in saving them time for other tasks. Responses included statements like "*Easy to find and contact service provider*", "*It saves time for her in contacting the service provider*" and "*It saves time for him*".

Another benefit, mostly mentioned by service providers, was money. They mentioned that the Market Dashboard will make them more visible to potential customers, which would lead to a higher income. They said "*Yes, customers will more easily come to him*" and "*yes more clients, more money*". Most farmers mentioned that the agreed-upon price with the service provider through the dashboard is reasonable, however a minority deemed them a little bit high.

The service providers showed enthusiasm towards the Market Dashboard. They were expressing excitement about the potential gain in customers they could get from the Market Dashboard. Smiles on their faces were visible.

(Observation from the researcher of service providers trying out the Market Dashboard for the first time, December 2023)

Furthermore, participants mentioned the benefit “Knowledge gain” with enthusiasm. They said the Market Dashboard can provide them good access to agricultural knowledge and that when they want to know something they can look it up in the knowledge hub.

Regarding willingness to use the platform a division is made between participants who thought the Market Dashboard was difficult to use and did not see the benefit of it and participants who mentioned that all farmers should use the Market Dashboard. Most participants showed a willingness to use the Dashboard, however part of this group was having difficulties understanding how the Market Dashboard functions.

Ease of use & complexity of the innovation

As already came forward during the observation of the first interview round, almost all participants required guidance in their first try-out. Some expressed discomfort with the platform, mentioning difficulties in usage. Comments underscoring this are: “*little bit difficult for him*”, “*uncomfortable, how to use*”, “*feels strange. Feels uncomfortable to use, log in, scroll*.”.

While I observed the farmer look at the log in page of the Market Dashboard for a couple of minutes, I saw he did not really know what to do. He asked for help as he was not able to read himself. He needed guidance in creating a new account and even expressed later that it would be beneficial for him to have a training on how the Dashboard works. Other participants mentioned the same desire for a training whilst I observed them struggling to use the Market Dashboard. They could not independently use the website and needed instructions from us.

(Observations from the researcher of a farmer testing the Market Dashboard on December 7, 2023)

However, there were also many positive reactions such as "*it is good, easy to choose", "impressed when she opened it. She feels it is easy to use and important for her to have the access", "it is good and easy to use. Will be popular to use in the future".*

Although participants struggled with using the Market Dashboard, participants maintained optimistic regarding the potential benefits of the platform. This was also evident in comments of participants expressing their desire for training to enhance their proficiency with the Market Dashboard. In their perception, the Market Dashboard is beneficial because of the contact details of service providers and the information in the Knowledge Hub.

Factors influencing the ease of using the Market Dashboard identified by participants included the language used, literacy levels, and the design elements including usage of videos and pictures.

Benefits

To maximize the benefits of the Market Dashboard, the end-users suggested several enhancements to increase its value, and consequently, their willingness to use it. One key recommendation is to incorporate more visual aids such as videos and pictures (step-by-step) throughout the Market Dashboard, catering to users with varying literacy levels. Multiple participants raised the concern of their illiteracy. This was the main reason why participants mentioned that they want more videos and pictures in the Market Dashboard. As when more pictures and videos are included, they could still make sense of the information on the dashboard. Quotes were "*Video and more step-by-step pictures as I cannot read but then I can look at the photos".* Others also mentioned that they do not like to read long texts and therefore prefer videos and pictures.

Additionally, multiple participants raised their concerns about the language in the dashboard. In the first prototype multiple pages of the dashboard were in English. Participants mentioned they cannot read and understand this. "*Only concern is about the language, has to be all Khmer", "He is concerned about that he cannot read the information".*

Experimentation possibility

Overall, most participants expressed enthusiasm for trying out the Dashboard, despite their difficulties in understanding how the Dashboard functions. They mentioned their interest in such a Dashboard, as it provides them access to relevant knowledge on agricultural practices. Quotes were "*Happy to see the platform and would appreciate to use it"* and "*he thinks this is the better way, he can get more knowledge from the program, easier".*

> *She was very excited about trying out the Market Dashboard. At the end she shared how grateful she was to be involved in the research and get the chance to try out the Market Dashboard. Her excitement showed also in the comments she made such as "ohs" and "ahs"*
>
> *(Observations from the researcher of a farmer testing the Market Dashboard on December 12, 2023)*

Besides their positivity on their experience several participants expressed positivity about being involved in the development as well. Quotes were as follows "*should be tried out and taught and shared with everyone", "is good, good to try out with the farmers*", and "*yes useful*". Others were more neutral about being involved in the development. Participants expressed they had no particular feelings during the interview round of the Market Dashboard, which was also related to them not knowing about the concept of the Market Dashboard. However, they still appeared open to the idea but reserved judgment until they would have more experience with the Market Dashboard.

Conversely, a minority had more of a negative experience with the experimentation with the Market Dashboard. Emotions such as being afraid, uncomfortable, scared, and confusion are mentioned and hindered their engagement with the prototype. Their apprehension toward potential adoption of new technology was reflected in their response.

In summary, most participants were positive about being involved in the development of the Market Dashboard and thought it was useful to experiment with it. However, technological proficiency and the language used emerged as a barrier to some, leading to reliance on guidance and hesitancy in independent usage. The feedback per theme as mentioned by the Cambodian smallholder rice farmers and farm-machinery service providers is summarized below in figure 7. Addressing these concerns through trainings and user-friendly design enhancements could foster greater acceptance amongst potential users.

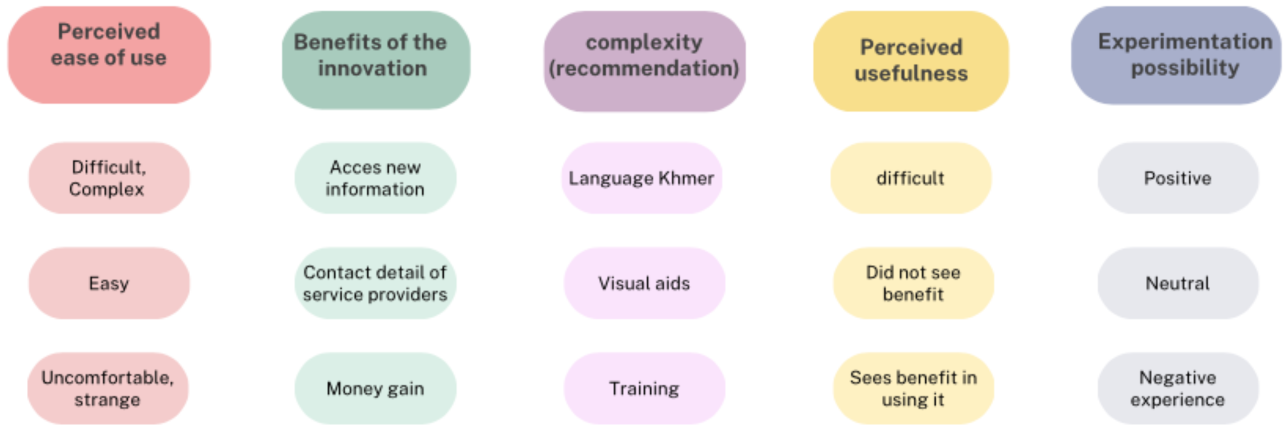


Figure 7. Extended TAM with most mentioned feedback per theme as mentioned by Cambodian smallholder rice farmers and service providers after round 1

Handover of feedback to the developer

Main feedback provided by the Cambodian smallholder rice farmers and service providers as mentioned under Appendix C was passed on to the developer. Key aspects emphasized included the language of the Market Dashboard, the presentation of information in the knowledge hub including the preference for visuals, and the need for improved functionality to indicate the user's own location on the map. The complete list as presented under Appendix C was provided to the developer.

The developer had a period of over a month to assess the feedback and implement improvements into the next prototype of the Market Dashboard. In the developer highlighted that especially a dot indicating the user's location could improve the ease in using the Market Dashboard, together with fully translating the Market Dashboard to Khmer.

However, the weekend before the second round of the interviews, and thus the testing of the second prototype, no changes had been implemented in the Market Dashboard yet. Meaning that there were only done a couple of changes in the Market Dashboard whilst traveling to the first location, Takeo, before trying out the second prototype.

Changes that had been implemented (some before starting the second interview round and some whilst already carrying out interviews) where the videos added to the knowledge hub, added pictures to the files as preview of the documents in the knowledge hub, added blue spot to the map indicating the user’s exact location, a filter in Khmer to filter on service providers, and almost all text translated in Khmer. The choice to implement only this feedback was influenced by multiple factors. One was that the developer had limited time and said that implementing more feedback was not feasible. This also resulted in that the developer still had to implement some of the changes whilst second interviews were already being conducted. The developer focused on the most frequently mentioned feedback, since there was limited time to make adjustments to the Dashboard, and this way, the developer could make the most visible change within the second prototype of the Market Dashboard.

The second prototype of the Market Dashboard and its components can be visualized as in figure 8. Main differences are the blue dot for indicating the user’s own location and the videos that were added to the knowledge hub. The implemented changes are limited. Only a couple point of feedback from the Cambodian smallholder rice farmers and service providers has been implemented in this new prototype. Feedback such as on the use of step-by-step pictures, a connection with Facebook to log in, search bar in the knowledge hub, and more were not implemented. Argument from the developer for not implementing more feedback was due to a lack of time. The changes that were made, such as the dot on the map and the filters, were also not functioning well, which was also because of the lack of time.

The different pages of the Market Dashboard	**Functionalities per page**	**Functionalities further explained**
Log-in	Button to choose language Create account Log in Button to sign in	English/Khmer Choice between farmer/service provider account Phone number and password field
Map with service providers	Map of the world, focus on Cambodia Dots with the profiles of all service providers	 Contact details and button to make a call

	Blue dot indicating location of the user	
Services page	Filter Button per machine	Both in English and Khmer
	Filter button per area	Both in English and Khmer
Profile page	Personal account details	Name, area, farmer/service provider, contact info
Knowledge hub	Articles Videos	Pdfs with picture as preview

Figure 8. *The design components of the second prototype of the Market Dashboard as used in the second round of interviews*

Testing the second prototype

Scale questions

Similar to the first prototype, the mode for almost all the scale questions was 4, which may indicate that there was minimal difference in the perceived ease of use of the market dashboard and the perceived usefulness. However, again the scale questions lacked further explanation and nuance. As when looking at the mode for the farmers and service providers who participated in both interviews, the mode did not change for any scale question (all were 4). Additionally, in the second interview, specific questions were asked about the improvement of the Dashboard. Participants were asked about certain aspects and if they perceived them as easier than the first time testing out the Market Dashboard. Amongst farmers, 25 out of 34 answered that the revised Dashboard was easier to use. Within the group of nine farmers that responded differently, answers included: "*it is the same", "map more difficult", "more difficult", "neutral", and "does not really know"*. Nine out of 13 service providers answered that the newer version was easier to use than the first version of the Market Dashboard. This exemplifies improvement in the acceptance of the technology (TAM), the Market Dashboard.

Open questions

Comments were made that the second version was easier to use because they already gained experience using the Market Dashboard during the first prototype. This implies that the perception that the second prototype was easier to use is not solely connected to the implementation of provided feedback from the first interview and testing round of the dashboard. In the following paragraphs, insights from the participants per theme of the TAM are described.

Perceived usefulness

The perceived usefulness was similar to the perceived usefulness during the first round of testing. Overall, the Market Dashboard was seen as a useful tool, particularly for accessing service provider contact details, despite many already being familiar with local providers. Farmers expressed that as the number of service providers grows in the future, the Dashboard could become an essential tool for locating them. However, participants predominantly favored the knowledge hub, considering this feature to be very useful.

Perceived ease of use & complexity of the innovation

To determine the specific impact of new implementations in the second testing round on the dashboard's usability, participants were questioned about the new features introduced in the second prototype.

The preview of the documents in the knowledge hub had been changed through adding pictures as the preview of the pdfs in the hub. Participants overall commented that this made it easier to use the knowledge hub as the pictures gave an indication on what the article was about. On the question: the use of pictures for the documents in the knowledge hub makes the market dashboard … to use, 29 out of 34 farmers mentioned this had a positive influence on using the Market Dashboard. For 12 out of 13 service providers, this made it easier to use the Market Dashboard; only one service provider answered that he did not remember the look of the knowledge hub in the first version so could not answer this question. They liked that they could see a preview this way. Some also commented that this made it easier for people who cannot read to make use of the knowledge hub "*better, than previous one. Farmer cannot always read, so is handy*". However, for some also with pictures it was still difficult to use the knowledge hub.

On the question ”How is it to use the map now that there is a dot indicating your own location?”, seven out of 34 farmers said that this made it easier to use the Market Dashboard. The others mentioned that they did not see this new implemented blue dot or that the previous version was easier. Two out of 13 service providers mentioned that this made it easier to use the Market Dashboard; the others did not see a blue dot. So, the lower score on this question mainly had to do with most people not seeing the blue dot. People had to zoom in on the map on their own location to see the blue dot indicating their own location, whereas the aim of the dot was to not have to zoom in to find your own location. This caused that a lot of participants mentioned that the dot did not make it easier to use the map. One of the comments was “*why is there no blue dot*?”. However, people did mention that such a dot would make it easier to use the map.

> *After asking the farmer if he saw any changes in the new prototype the farmer started to look for them in the Market Dashboard. He did see the new pictures in the knowledge hub and the videos. However, besides those he said that not a lot has been changed and asked it is still the same right?*
>
> *(Observations from the researcher of a farmer testing the Market Dashboard on January 18, 2024)*

In the second prototype a feature was added for filtering per service, so farmers could collect a specific machine in a specific area. Most participants did not find this feature themselves during the tryout of the new prototype. After showing them, some did mention that this made it easier to use the Market Dashboard, as it makes it less messy. However, others commented that a search tool would be easier. Therefore, only four out of 13 service providers and 10 out of 34 farmers mentioned that this made it easier to use the Market Dashboard. Others mentioned they did not notice this function or that it is easier to have a search function instead.

The new prototype consisted of almost only Khmer language, whereas the first prototype consisted of more English language than Khmer. Almost all participants mentioned that this change made it easier to use the Dashboard. 26 out of 34 farmers highlighted that the usage of only Khmer language in the Market Dashboard made it easier to use the dashboard. For the service providers, this was 12 out of 13. People made comments such as “*way easier, English is not understandable*” and “*easier than previous time*”. However, this was not applicable for all participants as some are unable to read and therefore did not notice this change.

The changes in the knowledge hub and the language used in the Market Dashboard had the most influence on the ease of use of the Market Dashboard. Whereas most participants did not notice the blue dot indicating the user's own location and the filter function for different services. Reason for this could be that the blue dot only appeared when you zoomed in closely on your own location, which was hard as most participants did not know their location on the map, which negated its purpose.

Overall ease compared with previous prototype

Most participants answered that this version was easier to use than the first prototype. Comments were made that this had to do with that this version is almost all in Khmer and that they already had some experience with using the Market Dashboard because of the first try out in the first interview round. Some mentioned that they still had difficulty with using the Market Dashboard and had difficulty with finding the website. Farmers and service providers mentioned that it was easier to use the Market Dashboard in the second interview round as they already had some experience from the first round. However, comments were still made about the preference for a training on how to use the Market Dashboard.

Benefits of the innovation

Most participants answered that the Market Dashboard is beneficial for them to use as it provides access to new knowledge and makes it easy to find a service provider in the area. Multiple participants answered that the Market Dashboard would mainly be beneficial for them because of the new knowledge they can access through the knowledge hub, and not so much because of the information of service providers, "*mostly for new info, already knows how to contact the service provider*". Most farmers who were interviewed were part of a cooperative and get into contact with a service provider through the cooperative and the cooperative leader.

Experimentation possibility

Stayed the same as during the first round of interviews. Most of the participants were enthusiastic about being involved in the development of the Market Dashboard. Some mentioned in the second round that testing the Market Dashboard twice with help present if needed was very helpful for them to learn how to use the innovation. This way the experiment already became a bit of a training on how to use the Market Dashboard as well.

Main feedback after second round of testing from farmers and service providers consisted of comments on how the language, in the second prototype almost all Khmer, made it easier to use the Market Dashboard. The increased use of visuals in the knowledge hub also made the dashboard easier to use. However, comments were also made on why certain aspects were not improved. Such as the map. For most farmers the blue dot indicating their own location was not visible. The feedback per theme as mentioned by the Cambodian smallholder rice farmers and farm-machinery service providers is again summarized in figure 9. Changes when comparing the figure to figure 7 are minimal as the participants saw minimal change between the two prototypes. Therefore, the most mentioned feedback after round two categorized as within the TAM model looks very similar. Differences are that it was overall less uncomfortable to use the Market dashboard as participants already had experience with using it and that it was easier through the language of Khmer and more visual aids.

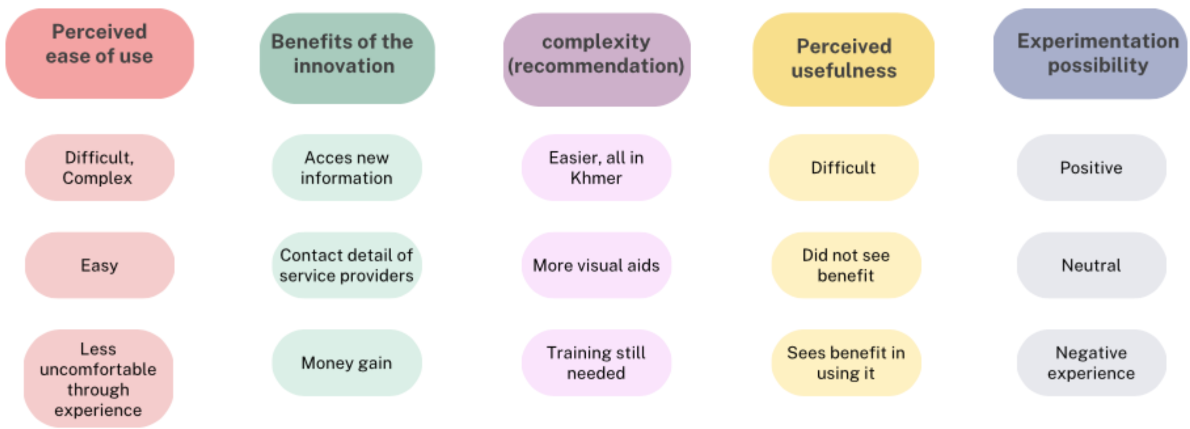


Figure 9. Extended TAM with most mentioned feedback per theme as mentioned by Cambodian smallholder rice farmers and service providers after round 2

5. Discussion

The results of this study reveal several interesting findings that provide insight into the development and usability of the Market Dashboard for Cambodian smallholder rice farmers and farm-machinery service providers. While the Market Dashboard is generally positively perceived by Cambodian smallholder rice farmers and service providers, its usability remains a challenge due to technological proficiency issues, language barriers, and insufficient feedback integration. Despite the improvements made in the second prototype, participant feedback indicates remaining issues that underscore the necessity for more effectively incorporating user input to enhance adoption and effectiveness. Additionally, educational levels and labor availability significantly impact the adoption and effectiveness of the Market Dashboard. These findings align with expectations and overlap literature on mDSR, RMA, HCD, and TAM, highlighting expected outcomes and areas that need further improvement.

Comparative studies, such as those by Liberloo et al. (2021), have demonstrated the value of a reflexive approach together with user feedback integration. For this research, the monitoring and evaluation of the feedback retrieved by the interviews with participants encouraged the project to be reflexive. Participant feedback and observations on their use of the Market Dashboard have provided new insights and prompted a reconsideration of the current design of the innovation. This supports the notion that a "*reflexive evaluation approach provides promising principles and concrete tools that may well complement current system approaches in development evaluation*" as mentioned by Arkesteijn et al (2015).

Another factor influencing the system's transition is related to labor availability (Becker et al. 2024), particularly in the context of transitioning towards mDSR and intensifying farming practices. Given the limited number of service providers equipped with machines for mDSR, farmers may face constrained choices. However, all interviewed farmers did acknowledge the presence of a nearby service provider. However, most did not have the option to choose between different service providers. To establish the Market Dashboard as the primary method for farmers to access mDSR on their land, increasing the number of service providers with the machine on the platform is likely to enhance its appeal. This change would thereby transform the system through which farmers engage with service providers.

Educational levels also play a significant role. The study of Hendrawan et al. (2023) demonstrated that smallholder farmers with higher levels of education tend to hold a more positive view on the usefulness and ease of use of ICT in their daily activities. However, upon reviewing the Market Dashboard, the majority of Cambodian smallholder farmers and service providers held a positive view on the usefulness of the Market Dashboard. It is evident that farmers with lower levels of education tend to have more difficulty using ICT, in this case the Market Dashboard. The study also emphasized the importance of agricultural cooperatives offering training sessions to acquire technological skills and knowledge. Such initiatives would greatly benefit Cambodian smallholder rice farmers and service providers by enabling them to effectively utilize the Market Dashboard.

Findings were mostly consistent with expectations derived from the literature on TAM, HCD, and RMA in relation to rice farming in Cambodia. However, alternative methods for creating cocreation practices during the development of an innovation exist. For instance, employing design thinking may foster co-creation processes (Dos Santos et al., 2018). Reflexivity, which is integral to both design thinking and RMA, appears crucial for developing a useful innovation. The additional benefit of RMA is its focus on transformation of the system, thereby having the potential to create significant changes. Participants expressed disappointment over the lack of substantial improvement between the two prototype versions. For further development of the Market Dashboard, it is important that developers incorporate user feedback into the design of the dashboard. This fosters the collaborative approach between the developers and the end-users, which impacts the Market Dashboard in being a valuable source for Cambodian smallholder rice farmers and service providers.

A significant bottleneck identified during the RMA cycles of this research is the actual implementation of participant feedback into the Market Dashboard. The second prototype, as used in the second round of interviews, did not incorporate the majority of feedback provided by Cambodian smallholder rice farmers and service providers. Only minor alternations were implemented, which resulted in participants perceiving minimal changes in the new prototype.

The second prototype used in the second round of interviews did not incorporate the majority of the feedback provided by Cambodian smallholder rice farmers and service providers. Only minor alterations were made, which resulted in participants perceiving minimal changes in the new prototype.

Next to lack of implementation of feedback, it is questionable whether the Cambodian smallholder rice farmers and service providers are using the Market Dashboard as intended. The primary function of the innovation is to provide rice farmers an overview of service providers offering mDSR and facilitate contact with them. However, many rice farmers now already know who to contact for the service or are aware that their cooperative leader can arrange contact with a service provider. This brings into question whether they will adopt the Market Dashboard to connect with the service providers, as the technological skills of most participants were not sufficient to be able to use the Market Dashboard independently. Participatory action research can offer great benefits, but power inequalities need to be considered. Smallholder rice farmers might feel uncomfortable expressing themselves in front of the dashboard developers and higher management of IRRI. This complicates the trust-building process, emphasizing the necessity for an effective approach to maintain trust despite disparities in power. There is a risk that participants may only provide positive responses out of fear of reprisal, leading to lack of honesty. However, when done correctly, participatory action research has the potential to be empowering, transformative, and collaborative (Hawkins, 2015).

The timing of the interview rounds of this research also posed a challenge, as the second round coincided with the harvesting season of the wet season which is between October and December (Bunna et al., 2019). Affecting the availability of participants during the second round of interviews, resulting in a lower number of participants compared to the first round. Moreover, participants' unfamiliarity with using tablets posed a challenge; many were uncomfortable using a device that was not their own. Time constraints further complicated the development of the Market Dashboard's initial prototype, delaying its readiness for testing. These factors also influenced the feedback received, which might have been different if the Market Dashboard had been more developed at the time of testing.

Language barriers presented further limitations, as Cambodian smallholder rice farmers and service providers spoke little to no English, a translator had to translate all interview questions. This posed a risk of losing nuances in translation.

Improving the integration of feedback retrieved through the cycles of reflexive monitoring in action could significantly enhance the usability of the Market Dashboard. In summary, while this research yielded valuable insights into developing a digital marketplace for Cambodian Smallholder Rice Farmers and Seeder Service Providers, several challenges need to be addressed. To ensure the validity and comprehensiveness of future research on this topic, it is essential to improve feedback integration, address power imbalances, optimize interview timing, enhance participants' technological literacy, and overcome language barriers.

6. Conclusion

The perspectives of the Cambodian smallholder rice farmers and farm-machinery service providers on the Market Dashboard, analyzed through the TAM, revealed generally positive perceptions towards the innovation. Utilizing the TAM framework allowed for the collection of recommendations from end users, providing deeper insight into specific features influencing the acceptance of the Market Dashboard.

The perceived usefulness of the Market Dashboard remained constant across the two prototype testing cycles. However, the first round of prototype testing indicated that the participants experienced difficulties using the Market Dashboard independently, due to limited technological skills. While some of their recommendations were incorporated into the second prototype, the results were mixed. The introduction of new features such as the blue dot on the Service Providers map and service filters did not enhance useability for the majority of participants using the Market Dashboard. This was primarily because most participants were unaware of these new features. Conversely, the addition of pictures to the knowledge hub files and full translation of the Market Dashboard to Khmer did have a positive impact on perceived ease of use. The Market Dashboard was perceived as beneficial, primarily because it can provide them access to valuable information about rice farming and service provider contact details. However, many Cambodian smallholder rice farmers already had existing methods to contact local service providers, typically through cooperative leaders. Participants appreciated being involved in the development of the Market Dashboard and being able to experiment with it. Their enthusiasm and positive attitude towards their involvement remained consistent throughout the study.

The user-centered approach, HCD, significantly influenced the development process of the Market Dashboard. Incorporating user feedback, addressing barriers, such as literacy levels and technological skills, lead to a more user-friendly second prototype. This approach is likely to positively influence the adoption of the technology. Following the model of Reflexive Monitoring in Action supported in facilitating continuous improvement cycles, ensuring that user feedback played a central role.

Despite active involvement of the potential end users through TAM and HCD, not all feedback was effectively integrated. The minimal changes observed in the second prototype highlighted a bottleneck in the development process.

In summary, the EiA Market Dashboard shows potential in addressing the information needs of Cambodian smallholder rice farmers and farm-machinery service providers. Addressing user feedback proves to be an essential step in maximizing its potential impact and adoption. Incorporating these insights in the Market Dashboard will help create a tool that better serves the intended needs of the intended end users and contributes to mDSR practices in Cambodia.

Appendix A – the in-depth interview guide

The process

All interviews will start by a short introduction of the researcher, the translator, and an explanation of the research and IRRI. An indication about the length of the interview will be given. Then it will be stated that the interviews will by anonymous, on a voluntary basis, and the person being interviewed will be asked for consent and asked if it is okay if the interview is recorded.

I am a Masters student from Wageningen University, studying Communication and Innovation, and doing research in collaboration with IRRI. This interview will take up between 45 and 60 minutes. Would it be okay for you if I record the interview? Next to that, the given answers will not be shared with third parties.

Participant will be informed of the possible consequences of participating in this research. Additionally, participants will be informed that they can quit at any point and that it is completely fine to do so.

The aim of the research is to tailor the Market Dashboard of IRRI more towards the wishes of Cambodian smallholder rice farmers and service providers through actively involving them into the development (Human Centered Design).

This will be done through finding out what types of innovations Cambodian smallholder rice farmers and service providers already have tried out themselves. Plus gaining understanding of how this was experienced by them. Additionally, the experiment is carried out to gain understanding on how the Market Dashboard is used by the end user, the Cambodian smallholder rice farmers and service providers, and what their feedback is on the Market Dashboard so far.

Interview guide Smallholder Rice farmers interview round 1

for RQ1 and RQ2 for the Cambodian smallholder rice farmers and service providers

Questions asked in the interview are split up in different subtopics covering the five different factors influencing user behavior & adoption. However, the experiment will start off with some introductory questions. To investigate if they own the digital appliances needed for using the Market Dashboard and have access to internet. Additionally, questions will be asked on what sources they already use to obtain new information and what kind of innovations they have already tried out themselves.

Then Cambodian smallholder rice farmers and service providers will be observed while they try out the Market Dashboard for the first time. After this we will start asking the questions on the five different factors influencing user behavior & adoption.

Introductory questions

1. Name
2. Location
3. Phone
4. What gender?
- 1. Male
- 2. Female
- 3. Other
5. How old are you?
6. Do you have a mobile phone, a computer, a laptop, or a tablet?
7. Do you have an internet connection?
8. Do you use the internet for getting new information about rice farming?
9. If so, what kind of websites do you use for getting agriculture information?
10. What have you learned from this agriculture information?
11. What sources do they use, in what way do they use mobile phones in their work?
12. What recommended practices have they already tried? What did work and what did not and why?
13. Have you tried mechanized direct seeded rice before (use machine seeders)?
- 1. Yes
- 2. No
14. How did you access the machine?

15. Would you be interested to do this again in the future?
- 1. Yes
- 2. No

Observation

Spiel:

Farmers often cannot find a seeder service provider when they need it. We are testing a tool which is like a Grab/TADA that can help farmers find the seeder service providers that can come to their area. We would like you to test this tool. Your observations can help so the developers can improve it and in the future farmers

As a researcher observing how the smallholder rice farmers make use of the prototype. Before asking specific interview questions related to the Market Dashboard.

The process:

a farmer accessing the app should follow a specific process as defined by Mutasim/developer. Then trace that process how the farmer is doing it. Do they know how (this is perfect it means it is intuitive and can be used by someone at the level of farmers..,or do they get guidance on how to use (if you have to do it for them)

the idea of how the Market Dashboard should be used.

- *Log into the market dashboard: with existing account/creating an account.*
- *Editing the profile: choosing whether you want an account as service provider/farmer/other. Adding personal details such as name, phone number, address.*
- *Moving to the page with services. Selecting the service needed.*
- *Looking at the map where the service providers are located for the required service.*
- *Choosing a service provider and getting in contact with the service provider. Calling them, making an appointment and agreeing upon a price with the service provider.*
- *Additional: go to knowledge hub and choose articles on subject you want to learn more about.*

16. What parts of the dashboard are they exploring? What did they not explore?
17. What difficulties do they have when using the dashboard?
18. How do they navigate through the dashboard?
19. What comments were made?
20. What facial/bodily expressions were noticeable?

Perceived usefulness:

Clarity of information

21. How was your experience using the dashboard?
22. What information was provided through it?

Was the information useful:

23. The information about seeder service providers was useful

1	2	3	4	5
Very useless	useless	neutral	useful	very useful

24. The map of service providers was useful

1	2	3	4	5
Very useless	useless	neutral	useful	very useful

25. The information in the knowledge hub was useful

1 2 3 4 5

Very useless useless neutral useful very useful

26. The information on different services available was useful

1 2 3 4 5

Very useless useless neutral useful very useful

Impact on farming practices

27. is it something new, what way do they get their information on machine access right now.
1. Cooperative
2. Friends/neighbors/relatives
3. Printed advertising by service providers
4. Social media (FB, Tiktok, etc.)
5. Extension staff (government)
6. Extension staff (NGO, other)

28. Were you able to access the seeder service provider you chose?
29. Was the price ok? How did you negotiate on the price of the service?
30. What do you think the Market Dashboard can add to your life? What benefits would it give you, if any?
31. What would you change to make the dashboard fit more in your daily working life?
32. What can make it easier for you to use this?

Perceived ease of use:

33. What are first thoughts when opening the dashboard?
34. What do you think of the layout and the design of the dashboard?
35. What pages did you see in the Market Dashboard?
36. How was it to find a useful seeder service provider?

37. Did you get into contact with the service provider? How did you experience the making of contact with the service provider?
38. Would you like to use the Market Dashboard in your daily working life? Why?
39. What would you change to make the Market Dashboard easier to use?

40. How did you experience logging into (or registering for) the Market dashboard?

1	2	3	4	5
Very difficult	difficult	neutral	easy	very easy

41. How was it to find a suitable service provider on the map? On the list?

1	2	3	4	5
Very difficult	difficult	neutral	easy	very easy

42. How was it to find the right machine for what you needed?

1	2	3	4	5
Very difficult	difficult	neutral	easy	very easy

43. How did you experience navigating through the different parts of the Market Dashboard?

1	2	3	4	5
Very difficult	difficult	neutral	easy	very easy

44. How did you experience finding the information in the knowledge hub?

1	2	3	4	5
Very difficult	difficult	neutral	easy	very easy

Experimentation possibility:

45. What do you think of this try out? Is testing the app twice enough? Would you like to be more involved in the development then twice in testing out the prototype?

46. What do you think of being involved in the development of the Market Dashboard?

1	2	3	4	5
Very useless	useless	neutral	useful	very useful

47. Do you have any specific expectations or concerns for the testing process of the Market Dashboard?

Benefits of the innovation:

48. Do you think it would be beneficial to use this Market Dashboard in your daily working life? Why?

Complexity/simplicity of the innovation:

49. Is the concept of the dashboard clear to you?

Yes/no

50. Do the functions in the Market Dashboard make sense to you?

Yes/no

51. How is the ease of using the dashboard perceived by smallholder farmers once applied to their everyday practices?

1 2 3 4 5

Very difficult difficult neutral easy very easy

Feedback/suggestions for improving the app

52. Did you experience any technical difficulties?

Wrap-up

Thank you for participating in the interview. Are there any last remarks or do you have any questions for me about the interview or about the research?

I am going to stop the recording now.

Interview guide Smallholder Rice farmers interview round 2

1. In the first interview you mentioned you use … for getting new information
   - When do you use this source?
   - What time of the year, specific days, specific hours of the day.
   - For what information?
   - How do you get information about direct seeding?
   - How do you get information about pesticides and pest control?
   - How do you get information about weed management?
   - How do you get information about what machines are appropriate for you to apply mechanized direct seeded rice?
   - How do you get information about where service providers are located?

2. Do you still remember testing the first version of the market dashboard?
3. Still able to log into the market dashboard? (observe how much time it takes)
4. Do you see any changes? If so, what has changed?
5. What still needs to be changed?
6. How is it to use the market dashboard? Easy/neutral/difficult
7. Is it easier to use this prototype than the previous version? More difficult/neutral/easier
8. Who in your household is most likely to use the Market Dashboard?
9. Would you talk about the Market Dashboard to others and what would you tell them?
10. If so, who would you tell about the market Dashboard and why would you tell them?
11. When/at what time would you use the Market Dashboard?
12. Where/at what location would you use the Market Dashboard?
13. What is the service that you would need and what would be the maximum willingness to pay for this service?

14. Would you be willing to pay a fee to get the service of a service provider through the market dashboard?
15. How did you experience logging into the Market dashboard?
16. The information about seeder service providers was:
17. The map of service providers was:
18. How was it to find a suitable service provider on the map? On the list?
19. The information in the knowledge hub was:
20. How did you experience finding the information in the knowledge hub?
21. The information on different services available was:
22. How was it to find the right machine for what you needed?
23. How did you experience navigating through the different parts of the Market Dashboard?

Impact on ease of use of the changes in the Market Dashboard:

24. The use of pictures for the documents in the knowledge hub makes the market dashboard:
25. How is it to use the map now that there is a dot indicating your own location?
26. Being able to filter per service makes the dashboard:
27. The usage of only khmer language in the market dashboard makes the dashboard more difficult/ not more or less/ less difficult or easier to use.

28. How likely is it that you will use the market dashboard in your daily life?

29. How beneficial do you think it is to use the Market Dashboard in your daily working life?

30. How is the ease of using the dashboard perceived by smallholder farmers once applied to their everyday practices?

31. Do you have any questions or feedback for further development of the market dashboard?

Interviewguide Service Providers interview round 1

Introductory questions

1. Name
2. Location

3. Phone
4. What gender?

- 1. Male
- 2. Female
- 3. Other

5. How old are you?
6. Do you have a mobile phone, a computer, a laptop, or a tablet?
7. Do you have an internet connection?
8. Do you use the internet for getting new information about rice farming?
9. If so, what kind of websites do you use for getting agriculture information?
10. What have you learned from this agriculture information?
11. Do you offer your services as service provider commercially? If so, via which channels?
12. What kind of services do you offer as a service provider?

Observation

Spiel:

Farmers often cannot find a seeder service provider when they need it. We are testing a tool which is like a Grab/TADA that can help farmers find the seeder service providers that can come to their area. We would like you to test this tool. Your observations can help so the developers can improve it and in the future farmers

As a researcher observing how the smallholder rice farmers make use of the prototype. Before asking specific interview questions related to the Market Dashboard.

The process:

a service provider accessing the app should follow a specific process as defined by Mutasim/developer. Then trace that process how the service provider is doing it. Do they know how (this is perfect it means it is intuitive and can be used by someone at the level of service provider..,or do they get guidance on how to use (if you have to do it for them) *the idea of how the Market Dashboard should be used*

- *Log into the market dashboard: with existing account/creating an account*
- *Editing the profile: choosing whether you want an account as service provider/farmer/other. Adding personal details such as name, phone number, address.*
- *Getting called by farmers requesting their service. Calling them, making an appointment and agreeing upon a price with the farmer.*
- *Additional: go to knowledge hub and choose articles on subject you want to learn more about.*

13. What parts of the dashboard are they exploring? What did they not explore?
14. What difficulties do they have when using the dashboard?
15. How do they navigate through the dashboard?
16. What comments were made?
17. What facial/bodily expressions were noticeable?

Perceived usefulness:

Clarity of information

18. How was your experience using the dashboard?
19. What information was provided through it?

Was the information useful:

20. The information about seeder service providers was useful

1	2	3	4	5
Very useless	useless	neutral	useful	very useful

21. The map of service providers was useful

1	2	3	4	5
Very useless	useless	neutral	useful	very useful

22. The information in the knowledge hub was useful

1	2	3	4	5
Very useless	useless	neutral	useful	very useful

23. The information on different services available was useful

1	2	3	4	5
Very useless	useless	neutral	useful	very useful

Impact on practices as service provider

24. is it something new, what way do they get their clients right (for renting out direct seeding machines)?

- Cooperative
- Friends/neighbors/relatives
- Printed advertising by service providers
- Social media (FB, Tiktok, etc.)
- Extension staff (government)
- Extension staff (NGO, other)

25. Were rice farmers able to contact you for your services?

26. Was the price you agreed upon with the farmer ok? How did you negotiate on the price of the service?
27. What do you think the Market Dashboard can add to your life? What benefits would it give you, if any?
28. What would you change in order to make the dashboard fit more in your daily working life?
29. How would you use this dashboard whilst doing rice farming related practices?
30. Did you ever offer services/machines from others (like service providers)? If so, how did you get in contact with them?

Perceived ease of use:

31. What are first thoughts when opening the dashboard?
32. What do you think of the layout and the design of the dashboard?
33. What pages did you see in the Market Dashboard?
34. How was it to navigate through the Market Dashboard?
35. How was it to create your account as a seeder service provider?
36. Did you get into contact with the farmer? How did you experience the making of contact with the service provider?
37. Would you like to use the Market Dashboard in your daily working life? Why?

38. How did you experience logging into (or registering for) the Market dashboard?

1	2	3	4	5
Very difficult	difficult	neutral	easy	very easy

39. How did you experience navigating through the different parts of the Market Dashboard?

1	2	3	4	5
Very difficult	difficult	neutral	easy	very easy

40. How did you experience finding the information in the knowledge hub?

1	2	3	4	5
Very difficult	difficult	neutral	easy	very easy

Experimentation possibility:

41. Do you think that other direct rice seeding service providers would be interested in testing out a prototype of the dashboard? Y/N why or why not?
42. What do you think of this try out? Is testing the app twice enough? Would you like to be more involved in the development then twice in testing out the prototype?

43. Do you have any specific expectations or concerns for the testing process of the Market Dashboard?

Benefits of the innovation:

44. What are the perceived benefits of the dashboard for service providers?

45. What are perceived drawbacks of the dashboard in the eyes of the service provider?

Complexity/simplicity of the innovation:

46. Is the concept of the dashboard clear to you?

Yes/no

47. Do the functions in the Market Dashboard make sense to you?

Yes/no

48. How is the ease of using the dashboard perceived by service providers once applied to their everyday practices?

1	2	3	4	5
Very difficult	difficult	neutral	easy	very easy

49. What are you struggling with, when using the Market Dashboard?

Feedback/suggestions for improving the app

50. Did you experience any technical difficulties?

Wrap-up

Thank you for participating in the interview. Are there any last remarks or do you have any questions for me about the interview or about the research?

I am going to stop the recording now.

Interviewguide Service Providers interview round 2

1. In the first interview you mentioned you use … for getting new information
   - When do you use this source?
   - What time of the year, specific days, specific hours of the day.
   - For what information?
   - How do you get information about direct seeding?
   - How do you get information about pesticides and pest control?
   - How do you get information about weed management?
   - How do you get information about what machines are appropriate for you to apply mechanized direct seeded rice?
   - How do you get information about where service providers are located?

2. Do you still remember testing the first version of the market dashboard?
3. Still able to log into the market dashboard? (observe how much time it takes)
4. Do you see any changes? If so, what has changed?
5. What still needs to be changed?
6. How is it to use the market dashboard? Easy/neutral/difficult
7. Is it easier to use this prototype than the previous version? More difficult/neutral/easier
8. Who in your household is most likely to use the Market Dashboard?
9. Would you talk about the Market Dashboard to others and what would you tell them?
10. If so, who would you tell about the market Dashboard and why would you tell them?
11. When/at what time would you use the Market Dashboard?
12. Where/at what location would you use the Market Dashboard?
13. What is the service that you would need and what would be the maximum willingness to pay for this service?
14. Would you be willing to pay a fee to provide the service of a service provider through the market dashboard?
15. How did you experience logging into the Market dashboard?
16. The information about seeder service providers was:
17. The map of service providers was:
18. The information in the knowledge hub was:
19. How did you experience finding the information in the knowledge hub?
20. How did you experience navigating through the different parts of the Market Dashboard?

Impact on ease of use of the changes in the Market Dashboard:

21. The use of pictures for the documents in the knowledge hub makes the market dashboard:
22. How is it to use the map now that there is a dot indicating your own location?
23. Being able to filter per service makes the dashboard:
24. The usage of only Khmer language in the market dashboard makes the dashboard more difficult/ not more or less/ less difficult or easier to use.

25. How likely is it that you will use the market dashboard in your daily life?

26. How beneficial do you think it is to use the Market Dashboard in your daily working life?

27. How is the ease of using the dashboard perceived by smallholder farmers once applied to their everyday practices?

28. Do you have any questions or feedback for further development of the market dashboard?

Interviewguide developers

Interview guide for sub-question "What is the aim with the IRRI Market Dashboard from the perspective of the developers?"

First of all, the interview will again start off with an introduction on the research and the researcher. The developer will be informed on the length of the interview, will be asked for consent, and asked if it okay to record the interview.

Age?

Gender?

For how long have you been a developer?

How exactly are you involved in the development of the Market Dashboard?

For how long have you now been working on the Market Dashboard?

What is the current status of the Market Dashboard?

What do you want to achieve with the Market Dashboard?

What are the key components of the Market Dashboard? (interface, extension materials, ow they are structured, dry direct seeding and wet direct seeding)

How far is the development of the Market Dashboard right now?

How should the Market Dashboard be used? For what purposes?

What do you think of the idea of carrying out two prototype testing rounds by involving the Cambodian smallholder rice farmers and service providers?

Would you want to participate in the two-round experiment? Which means there will be one moment where you get provided with the feedback from the Cambodian smallholder rice farmers and service providers. Here you get the chance to implement their feedback. Then after the second round you will get their feedback again.

Then the following two sub-question can be asked after carrying out the first prototype testing round.

What do the developers think of the feedback provided by the farmers after the first trial?

What do you overall think of the feedback provided to you by the Cambodian smallholder rice farmers and service providers?

What surprised you?

Do you think that the feedback provided is useful, and in what sense? What points are useful?

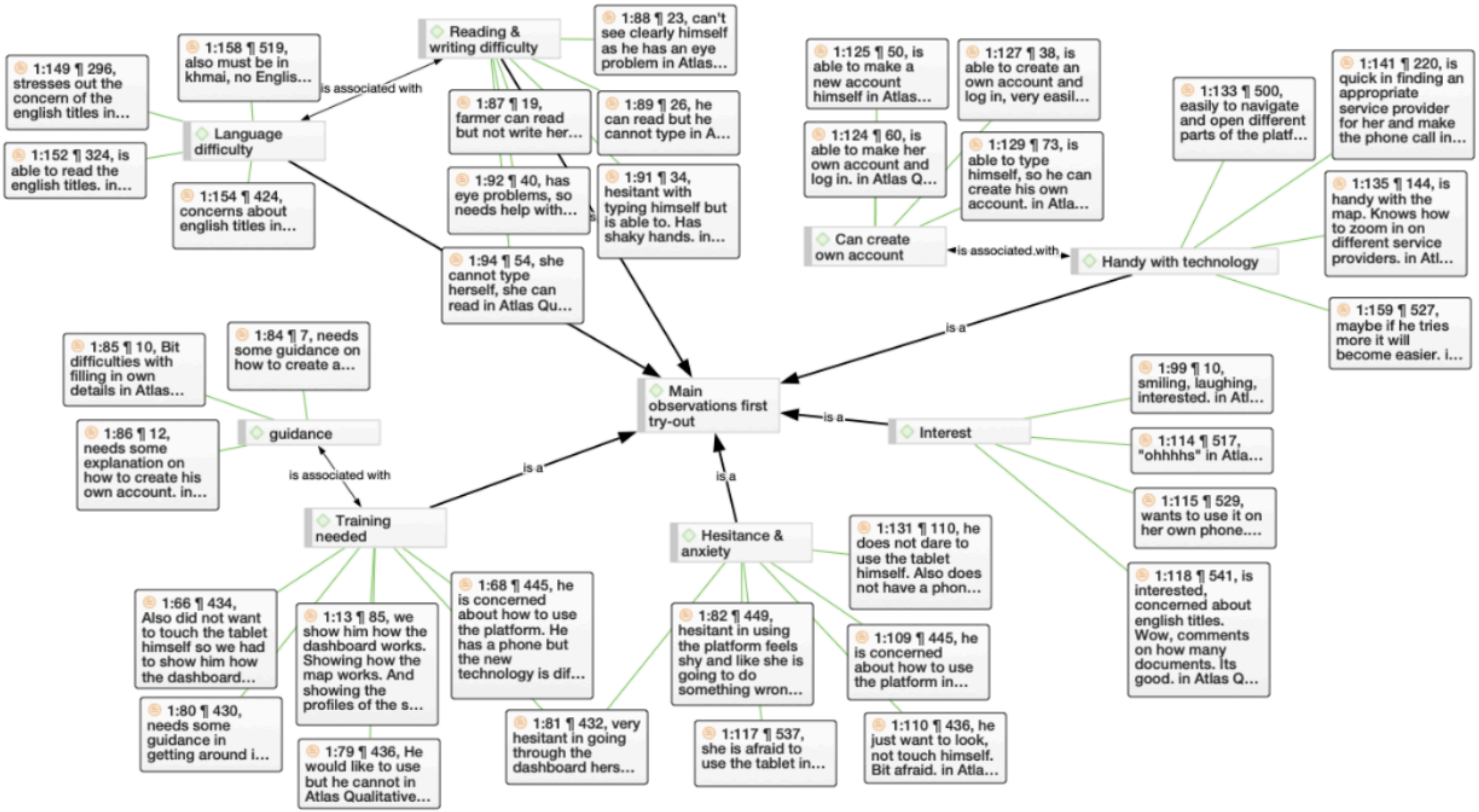
To what extent did the developers implement the feedback of the farmers/service providers and what was their motive for this?

What parts of the feedback did you integrate in the prototype? Why so?

What parts of the feedback did you not integrate in the prototype? Why so?

What do you think of the involvement of the end users in the development of the Market Dashboard?

Appendix B - Network observations first interview round Market Dashboard



Appendix C

Main feedback after first interview round from farmers and service providers

Above mentioned results consist of feedback from participants on the first prototype of the Market Dashboard. Underneath is the list of feedback mentioned per location. This list was passed on to the developer, so that feedback could be implemented before the second interviews and second prototype test.

Takeo

- Feedback that came back a lot is that everything must be in Khmer.
- More videos and pictures (step-by-step) instead of articles or complementary to the articles.
- Making the dashboard easy to use for people not being able to read/write.
- Not all farmers can indicate their own location on the map. A dot indicating their location on the map would be appreciated.
- People should be able to change password when they forget theirs.
- People want to upload their own profile picture.
- Farmers and service providers being able to adjust their profile information.
- Possibility to make words on the map bigger, as not everybody can read them. Plus being able to make the letters on the profiles of service providers bigger. General button to adjust the size of all text.
- Ability to make the call through clicking on the phone number at the profile in the service provider map.
- Possibility to make the call through internet. Maybe through a connection with Facebook messenger, as this is the most often mentioned platform.
- Prefer to see pictures in the dots of the map with service providers.
- Being able to filter on machine type, filter on different services.
- Filter on location.
- Information hub tailored to needs of service providers. More on topics such as machine maintenance for instance.
- Farmers would like the knowledge hub to not only focus on rice farming but make it broader, include fishing, vegetable farming, animal farming etc.
- Possibility to include weather conditions of the location of the user.

Battambang

- Concerns about the English language still present in the dashboard, all should be in Khmer.
- People want to see their password when creating a new account, to make sure they did not make mistakes. Is it possible to add a function so that they can see the password they typed.
- Concerns about the dashboard being a website. Multiple times we got the feedback that they would prefer an app. Personally, I would also say it is better to make it an app. As a lot of the users already have quite some difficulties with using the dashboard it would make it

easier to have an app. Then they do not have to find the website themselves every time they want to use the dashboard (as a lot of the target group is already a bit older, they also mentioned they have difficulty with remembering things. Also, saw that they struggled with finding the dashboard again after opening documents from the knowledge hub). They really like the dashboard but would prefer an app.
Next to this there maybe are more possibilities for using the dashboard offline when making it an app. In quite some areas the internet connection is not the best, which made it harder to use the dashboard.

- Users want more videos. Instead of articles with text in the knowledge hub.
- Preference for a dot on the map showing the current location of the user. That will make it easier for them to find their own location on the map and then find a suitable service provider.
- People would like more explanation on how to use the dashboard. In the observations it was also visible that people struggled the first time using the dashboard and a lot of the users also mentioned that they thought it was difficult to figure out how the dashboard works. My personal idea would be an introduction page where you would be redirected to immediately after logging in. This page could exist of text, pictures, or maybe even a video explaining how to use the dashboard. This way the users have more support in how to use the tool. Even though we tested the tool out together with the end users, there is a chance they will share the dashboard to others who then still do not know how to use the dashboard. Other way to get people to know how the dashboard works is by providing a workshop on this.
- If possible, end users would like to see more information (the names) on smaller villages on the map. Others mentioned they would also like the possibility of rotating the map.
- Farmers would like more information on the different machines. So, they can learn which machine is they appropriate one for them to choose.
- Overall, in Battambang there were not many users who were not able to read or write, whereas this was the case in Takeo.
- Also comments on the preference of pictures instead of the pdf pictograms in the knowledge hub. This is more appealing to the end users.

Other:

- Straight redirection to logged in version of the dashboard after pressing logging in button. In the first week this did not always work, however did not have any problems with this in the second week.
- If service providers register on the same location, it should not appear as only one dot on the map with service providers -> should still show up as two separate dots.
- Showing the different services available in the services page. -> enabling filtering per service.
- Can we change the looks of the pdf files? More appealing with pictures? Users in Battambang also mentioned this.

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