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TECHNOLOGY TRANSFER PATHWAYS OF INFORMATION AND COMMUNICATION TECHNOLOGIES FOR DEVELOPMENT (ICT4D): THE CASE OF THE WEATHER-RICE-NUTRIENT INTEGRATED DECISION SUPPORT SYSTEM (WeRise) IN INDONESIA

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ABSTRACT

Sustaining ICT4D project outputs after a project's implementation period is among the challenges of technology transfer. This study aimed to develop Technology Transfer Pathways (TTPs) for the Weather-rice-nutrient integrated decision support system (WeRise), a seasonal climate predictions-based ICT4D tool developed by the IRRI-Japan Collaborative Research Project (IJCRP) for Indonesia. It utilized the stakeholder approach, and employed focus group discussions, key informant (KI) interviews, individual surveys, and literature review for data collection. Data were analyzed through content analysis, stakeholder analysis, process mapping, and descriptive statistics. The Contingent Effectiveness Model of Technology Transfer was used as a framework for the analysis. Research findings showed two possible TTPs. The first pathway is via the traditional public domain: from research institutions to extension agencies, then to farmers. It involves a set of government agencies who could undertake localization, further development, operation and maintenance, technology assessment and information dissemination, and institutionalization. An alternative pathway would also involve an existing multi-stakeholder platform that could facilitate coordination, feedback, and monitoring. Both pathways have interconnected sub-pathways, coinciding with Douthwaite et al.'s (2017) Theory of Change which shows that agricultural research for development achieves impact through technology development and adoption, capacity development, and policy influence.

Keywords: modern extension advisory services, digital tools, climate-smart agriculture

INTRODUCTION

Information and Communication Technologies for Development (ICT4D) projects aim to bridge the digital divide by providing equitable access to up-to-date communication devices which include various associated services and applications (Rouse 2011). The ICT4D value chain covers key areas including readiness, availability, uptake, and impact. Readiness includes systemic prerequisites including infrastructure. Availability refers to the implementation of the ICT4D initiative. Uptake pertains to access translating to actual usage. Impact includes outputs, outcomes, and contributions of the ICT to broader development goals (Heeks 2010). Among the UN sustainable development goals is zero hunger which targets doubling agricultural productivity and incomes of small-scale food producers (UN 2015).

Rainfed rice farmers usually have small landholdings, and production is characterized by low yield and high poverty incidence due to uncertainties as it relies on rainwater availability. The onset, duration, and amount of rainfall have become difficult to predict amidst climate change, which has caused more weather variabilities (IRRI 2015). Timely access to the right information could enable smallholder farmers to make informed decisions which could affect their livelihoods and impact food security.

Funded by the Ministry of Agriculture, Forestry and Fisheries of Japan, the IRRI-Japan Collaborative Research Project (IJCRP) developed the Weather-rice-nutrient integrated decision support system (WeRise), an ICT4D tool aimed at improving the livelihoods of small-scale rainfed rice farmers in the context of climate change. It is an online application that applies seasonal climate predictions in a crop growth model. Based on the upcoming cropping season's weather characteristics, crop growth development, soil characteristics, and farm management practices, WeRise provides advisories on the optimum sowing timings, fertilizer application schedule, and the suitable variety for planting. Advisories could be generated three months before the cropping season; thus it could give farmers enough time to plan their resource utilization and crop production schedule more efficiently. With proper resource utilization through the strengthened capacity for climate change adaptation, WeRise could help transform rainfed rice production into a more productive and sustainable production system ultimately contributing to food security (Johnson 2016). WeRise was developed using the Scale Interaction Experiment–Frontier Research Center for Global Change (SINTEX-F), a seasonal climate predictions model, and ORYZA, a crop growth model. Indonesia was selected for WeRise development because of its significant rice demand and larger rainfed rice areas compared to other countries in the region. Moreover, Indonesia experiences substantial damage from El Niño Southern Oscillation. SINTEX-F has a high skill in predicting this phenomenon (Hayashi et al. 2018).

IJCRP intends to handover WeRise to Indonesia by the end of its implementation on September 2020. In Indonesia, agricultural technologies for the public domain (e.g., WeRise) generally follow the traditional Technology Transfer Pathway (TTP): from research institutions to extension agencies in-charge of dissemination to farmers (Jamal et al. 2016). Research institutions and funding agencies often lack the incentive, capacity, legal mandate, and operational flexibility to monitor the research investments (Zuniga and Correa, 2013). Hence, sustaining ICT4D project outputs is challenging. Developing possible TTPs may be considered part of the project's exit strategy. The exit strategy would facilitate systematic transitions; help gain credible commitment of stakeholders to project sustainability thereby increasing the likelihood of achieving the sustainable development outcomes that the project initially sought out (Gardner et al. 2005).

This study adapted the Contingent Effectiveness Model of Technology Transfer (CEMTT), a qualitative model developed by Bozeman (2000) as a framework to develop the TTPs. It was ideal as it enabled identification of various actors for the uptake and dissemination of WeRise, in terms of their linkages/relationships and associated characteristics, entry points for project implementation, and barriers and prerequisites to a successful technology transfer (Matsaert 2002).

MATERIALS AND METHODS

Elements of the Contingent Effectiveness Model of Technology Transfer (CEMTT). Technology transfer has been defined in various ways and contexts. This study uses the following definition:

> *Technology transfer is the process of movement of technology from one entity to another. The movement may involve physical assets, know-how, and technical knowledge (Souder et al., 1990 and Ramanathan, 1994 cited in Ramanathan, 2008; Bozeman, 2000).*

Unlike technology diffusion which often refers to passive spreading of a specific technological knowledge related to a specific innovation of interest within a specific population, technology transfer is a proactive process, intentional and involves agreement (Rogers, 2003; Hameri, 1996; Autio and Laamanen, 1995; Ramanathan 1991; Hameri, 1996 cited in Ramanathan, 2008).

The study adapted the CEMTT which looks into various determinants of effectiveness, including the technology itself, the demand environment, and the associated characteristics of the transfer agent and the potential transfer recipients (Fig. 1). The CEMTT suggests that a critical mass of demand determines the technology transfer's success and the success rate is higher if technology recipients were sets of government agencies. Since the demand environment is dynamic, new technologies should have flexible infrastructure rather than a set of fixed institutionalized resources. Co-funding among agencies is also helpful in inducing demand. Moreover, CEMTT assumes that the parties involved in the technology transfer may have several goals and effectiveness criteria. For instance, the effectiveness of technology transfer may be evaluated not only based on the number of adopters, but also on the scientific and technical human resource development that may result from the capacity building that needs to be implemented during the process, and political rewards such as increased funding that may arise as a result of the technology transfer process (Bozeman 2000). These are in addition to contributions to economic development and market impact, which the project initially sought, that could translate into achieving Indonesia's sustainable development goals of food security and poverty reduction through increased profits for farmers.

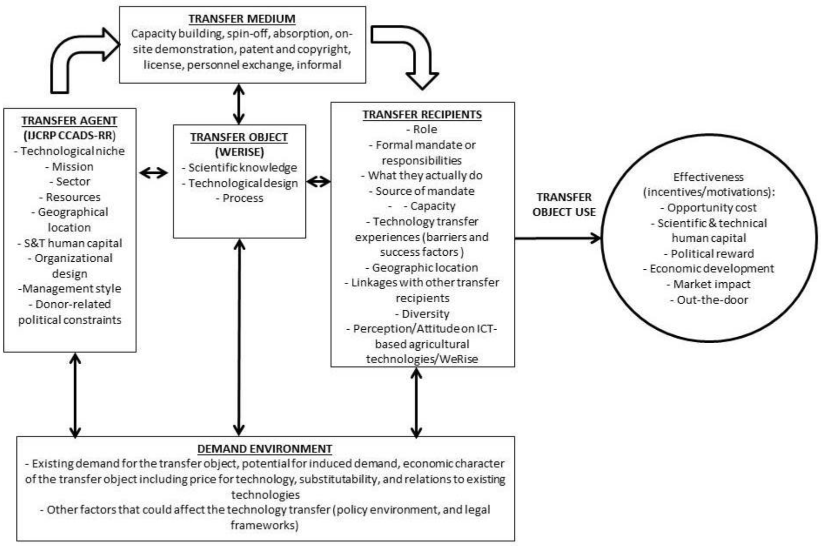

Fig. 1. Conceptual framework of the study
Source: modified from Bozeman, 2000.

Research sites. For its primary data requirements, the study focused on the cases of Segala Anyar Village located in Pujut district in Central Lombok, West Nusa Tenggara (WNT, S8˚ 46' 19", E116˚ 46' 17"), and Serdang Village located in Serdang District in Deli Serdang, North Sumatera (NS, N3˚ 38' 19", E98˚ 49' 27"). Indonesia has 12 rainfed rice producing provinces. WNT and NS are among the six rainfed rice producing provinces where the IJCRP sites are located. The basis for study site selection was described by Hayashi et al. 2018.

Regency profile. With a population of approximately 900,000, Central Lombok is among the eight regencies of the WNT province of Indonesia. It has a total land area of 1,208.39 km^2 and has the largest rainfed rice area (i.e., 13,642 ha. out of its 87,064 ha. total rice area) among the regencies/cities in Lombok Island. Central Lombok is subdivided into 12 districts and 139 villages. Forty-three percent of Central Lombok's labor force is engaged in agriculture (BPS, 2015). It has long dry seasons. Approximately half of Central Lombok was affected by severe drought in 2014 (Sudaryonto 2017). Deli Serdang has a population of 2 million and is among the 25 regencies of NS. With a total land area of 2,241 km^2, the Deli Serdang Regency is comprised of 22 districts and 380 villages in the rural areas and 14 villages in the suburban areas. During the period 2014-2016, a total of 278 natural disasters occurred in Deli Serdang. Topping the list are typhoons (22%), floods (14%), volcanic eruptions (5%), and landslides (4%). Deli Serdang is the third top wetland rice producer of the province of North Sumatra in 2015. Fifteen percent of its labor force is employed in agriculture (BPS, 2016).

Data collection methods and research instruments. Desk review of secondary sources including IJCRP's Annual Review and Planning Meeting (ARPM) documentations, project reports, principles and implementation plan, and other secondary literature was done before and after primary data collection.

Face-to-face individual interviews of 60 rainfed rice farmers (i.e., 30 farmers per study site) were conducted in May 2016 in NS and WNT. Due to limited time and budget, the sample size (n) of 30 farmers per study site was based on the rule-of-thumb for in-depth surveys. It was assumed to be sufficient to generate information from a relatively homogenous population. Data collected were on socio-economic and demographic characteristics, general farm characteristics and production practices and constraints, cropping calendar, historical production utilization, weather extreme experiences, cost of production, and knowledge, attitude, and skills related to ICT4D. A total of 10 Focus Group Discussions (FGDs) (i.e., five per site) with key informants (KIs) from the Assessment Institute for Agricultural Technology (AIAT), farmers' associations, and extension agencies at the provincial, district and sub-district levels of WNT and NS were also held. There were 49 participants from NS and 43 from WNT in the FGDs. Questions asked included their roles, mandates, capacities, perceptions and previous technology transfer experiences including other stakeholders they have worked with. FGDs with heads and directors of key institutions were also held in Bogor, Indonesia in August 2016 and August 2018 to solicit feedback on the latest version of WeRise and its potential for rainfed rice production in Indonesia and identify a dissemination pathway.

Consultations with other KIs including those from some institutions who joined the FGDs in Bogor were also held during the initial stages of project implementation. The consultations and ARPMs of the IJCRP were useful in understanding the dynamics of technology transfer at the national and local levels. The instruments for the individual interviews and FGD guides were developed in the English language, pilot-tested, revised, and translated to Bahasa with the help of project partners. Prior to the interviews and FGDs, the survey respondents and FGD participants were oriented about WeRise. Researchers from AIAT WNT and NS and Indonesian Center for Rice Research (ICRR) who served as facilitators, enumerators, and translators were also given an orientation on WeRise, survey objectives and data to be collected.

Sample and Sampling Design. Farmer-respondents for the individual interviews were purposively selected with the help of the extension workers and farmer leaders in the study sites. Selection was based on the farmer's availability and willingness to participate in the study.

For the FGDs conducted in May 2016, participants were also selected purposively with the help of AIAT partners, extension workers, and farmer leaders. FGD participants were selected based on their previous experiences in technology transfer and/or if they are working in agencies with extension as part of their mandate or major role. In general, the participant's perceived roles on technology transfer include technology information dissemination, capacity building, technology assessment through research (i.e., demonstration plots and conduct of comparative studies), changing the mindsets of farmers, coordination and policy formulation. Each group comprised of 8-13 participants. The composition of the participants for the FGD in Bogor was recommended by the IRRI Representative and Liaison Scientist. FGD participants in Bogor together with KIs consulted during the initial stages of project implementation are key officials of selected Indonesian National Agricultural Research and Extension System mostly from the Indonesian Agency for Agricultural Research and Development (IAARD) of the Ministry of Agriculture (MoA) with influence at the policy level.

Data Analysis. Descriptive statistics including means, percentages, and frequencies using the Excel software data analysis tool were used to analyze the data. Tables were used to present and summarize the data. The classical content analysis, a qualitative analytical technique, was used to analyze the focus group data of this study. Content analysis is the "study of recorded human communications" involving coding, a "process of transforming raw data into a standardized form." The classical content analysis is essentially a quantitative method with its system of categories at its core (Babbie 2001 cited in Kohlbacher 2006). In this analytical technique, the codes are categorized and counted (Onwuegbuzie et al. 2009). Process mapping and stakeholder mapping were also done to analyze the key institutions in terms of their capacities and linkages, identify potential entry points, and develop the TTPs.

RESULTS AND DISCUSSION

Demand environment. Rice provides more than half of the calorie and protein intake requirements of Indonesians. Approximately 19 million people rely on rice production as their source of income and employment. Irrigated areas supply approximately 80% of Indonesia's domestic rice production, hence; contribute significantly to Indonesia's food security. However, irrigated rice production is threatened with land conversion problems, deteriorating irrigation facilities, and high cost of development and rehabilitation of irrigation facilities. Areas for potential expansion are now limited due to increasing water scarcity aggravated by competing water uses of various sectors (agriculture, household, industrial) and climate change (Sumaryanto 2014). Enhancing rice production in rainfed rice areas is among the potential solutions to address some of these challenges (Sulaiman et al. 2019).

Two project study sites were examined to gain an understanding of the rainfed rice ecosystems and develop WeRise according to the local context. Majority of the respondents in the study sites are male with an average age of 43 and 45 years old for WNT and NS, respectively. Farming is the major source of income of most respondents, while other sources included employment, pension, and business. Most of the respondents fall below the poverty line or may be considered poverty-prone. On average, the respondents have been engaged in rice farming for approximately half of their lifetime. Majority of the respondents in WNT own their lands while in NS, most respondents are renting. Most of the respondents from both sites (46%) have finished senior high school. All respondents in NS had formal schooling with three out of the 30 having acquired Bachelor's degrees while six out of the 30 from WNT have no formal schooling at all.

Although the farm characteristics and crop production practices of the respondents at the two sites generally differ, they face similar constraints including weather and information-related constraints particularly difficulty in determining the onset and distribution of rainfall for the upcoming cropping season. Farmers mostly rely on local wisdom and/or their own experiences for information on crop production and weather according to the face-to-face survey. Only a few receive weather forecast once a year from a government agency. Participants of the farmer group FGDs mentioned rainfall prediction, nutrient management, and description of varieties as among the information they need. The Cropping Calendar Information System Technology, locally known as Kalender Tanam or Katam, an ICT4D tool developed by the IAARD provides these information particularly the average rainfall conditions for a planting season; a forecast on the start of planting time; potential threats of climate-related hazards such as flooding, drought, and pest and disease attacks; recommended variety; type and amount of fertilizer to respond to climate-related hazards; and available farming machinery. Since its launch in 2011, the upgraded versions of Katam have been released but usage remains low. Some studies show that, in certain villages, farmers seem to have never heard of it (Anggarendra et al. 2016). Moreover, feedback of its dissemination indicates that its recommendations are not implemented because they are not suitable to the local conditions/local practices (52.75%) and the recommended variety and water are not available (43.25%) (Yulianti et al. 2016). The latter indicates that Katam might be more suitable for irrigated conditions.

WeRise could be integrated with Katam as a special module targeting the rainfed rice conditions. This was suggested during the presentation on National Strategy and on-going researches to map CCADS-RR in Indonesia (Zaini and Jamil 2015). CCADS-RR succeeded the IJCRP on Climate Change Adaptation in Rainfed Rice Areas (CCARA) which started the development of WeRise.

> *"Every six months, new data of the integrated cropping calendar (ICC a.k.a. Katam) are released and distributed to extension workers and to the local government. In the past, IAARD makes a copy of the cropping calendar and give it to lower level of extension workers (BPP) and sub-district level. WeRise could be combined with ICC (an existing tool) to prevent confusion among farmers. WeRise and ICC could be made into one model."- Director, ICRR*

> *"WeRise could be integrated into ICC or just simply be a stand-alone tool that specializes in rainfed rice areas only. It could also be included as a package with ICC depending on how farmers will take it. Advantages and disadvantages should be examined." - Deputy Director for Research and Collaboration, Indonesian Center for Agricultural Land Resources Research and Development (ICALRRD)*

The following proposed TTPs, which show technology transfer recipients and their potential roles in the uptake and dissemination of WeRise, could facilitate this.

WeRise technology transfer pathways. The Indonesian Agroclimate and Hydrology Research Institute (IAHRI), ICRR, Indonesian Agency for Meteorology, Climatology, and Geophysics (BMKG), and Indonesian Central Bureau of Statistics (BPS) could undertake localization/further development, and operation and maintenance of WeRise (Fig. 2). The AIATs in the respective rainfed rice producing provinces could be in-charge of technology assessment, information dissemination and feedback to the developers in coordination with the local governments and extension offices at the provincial and district levels and farmer groups.

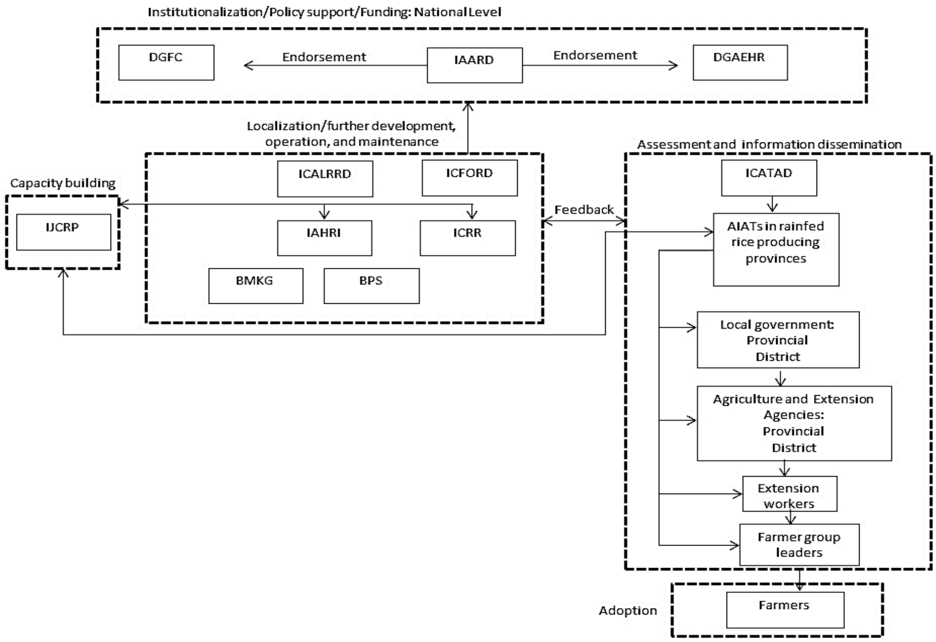

Fig. 2. WeRise technology transfer pathway in Indonesia (Option 1).

IAHRI, ICRR and AIAT; and their coordinating institutions ICALRRD, Indonesian Center for Food Crops Research and Development (ICFORD), and Indonesian Center for Agricultural Technology Assessment and Development (ICATAD); respectively are under the IAARD of MoA. Except for ICFORD, these potential technology transfer recipients are part of the National and Provincial Taskforces of Katam. The National Taskforce led by IAHRI is in-charge of developing and maintaining Katam and producing the recommendations while the Provincial Taskforce led by AIAT is responsible for technology information dissemination, collecting feedback at the provincial and district levels, and validation through interviews and FGDs with farmers (Yulianti et al. 2016). ICALRRD, ICFORD, and ICATAD could provide links to the IAARD director. IAARD provides support to other technical agencies of the MoA including the Directorate General of Food Crops (DGFC) and the Directorate General of Agricultural Extension and Human Resource (DGAEHR) through technology and institution innovation, policy synthesis, and agricultural development analysis (Rafani 2014). The DGFC is tasked to formulate and implement policies related to increasing the production (seed supply, cultivation practices, marketing, post-harvest, processing) of major commodities including rice (Rumanti et. al. 2016). The DGAEHR is tasked to strengthen the agricultural extension system, revitalize agricultural training and establish credible education programs. Under the DGAEHR are the Agricultural Extension Center and the Agricultural Training Center. Its major programs encourage the youth to engage in farming and promote cyber extensions for technology information dissemination to address the shortage of extension workers. Still within its scope is the College of Agricultural Extension (STPP) where junior extension workers are trained (Andoko et al. 2018). IAARD, DGFC, and BPPSDMP could, therefore, play major roles in the institutionalization, policy support, and funding at the national level to sustain WeRise.

An alternative of the TTP (Fig. 3) will include the Provincial Technology Commission (PTC), a multi-stakeholder platform that could serve as a coordination and feedback platform, facilitate integration of WeRise in the policy, research and technology development programs of the province; and play a major role in the institutionalization, policy support and funding at the local level. PTC was established under a gubernatorial decree with members from the Provincial Research and Development Agency (PRDA), Chamber of Trade and Commerce, agriculture agencies, province-based academic institutions, legislative members, and farmer groups. The proposed TTPs have three interconnected sub-pathways, coinciding with the Theory of Change by Douthwaite and co-workers (2017) which shows that agricultural research for development achieves impact through technology development and adoption, capacity development, and policy influence.

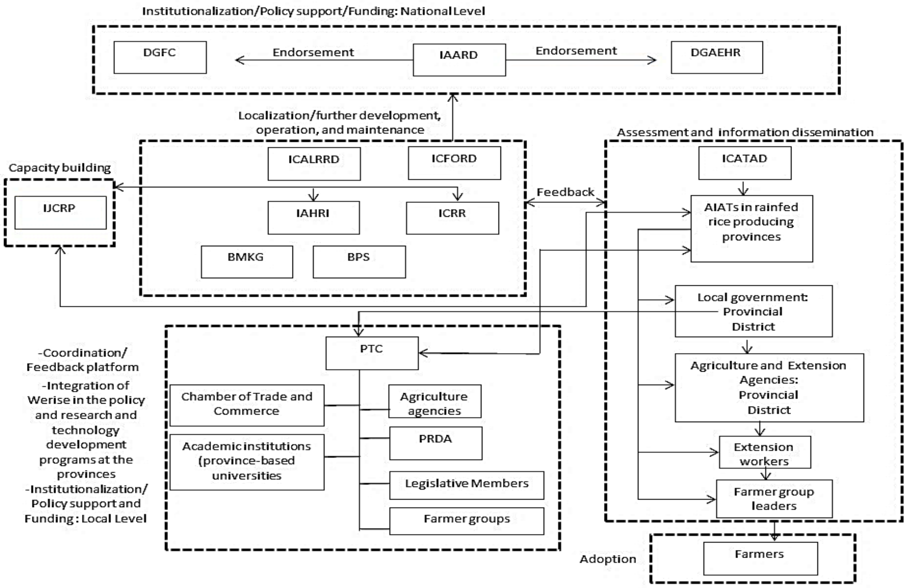

Fig 3. WeRise technology transfer pathway in Indonesia (Option 2).

Constraints to technology transfer. These include resource limitations, inherent characteristics of end-users, and the absence of enabling mechanisms (Table 1). The FGD participants counter these constraints by printing results and bringing it to the end users since internet access was a problem.

Table 1. Constraints encountered during technology transfer among FGD groups. (n=8)

Problems encountered	AIAT	Provincial	District	Sub- district	Total*
Lack of access to/insufficient facilities	2	1	2	1	6
Insufficient technology information facilitators	2	1	1		4
Budget constraints for a wider scale technology validation	1		2	1	4
Internet access	1		1		2
Insufficient technology training	1		1		2
Lack of trust on facilitators/local knowledge prevails	1		1		2
Low awareness level/education of farmers		1	1	1	3
Absence of a reward and punishment system for extension workers				1	1
Government program on increasing cropping index and accelerating planting time is contrary to the ICT tool recommendation on optimum cropping calendar	1				

Source: FGDs, 2016.

* Frequency counts are number of FGD groups where the item/theme has emerged/was mentioned.

Prerequisites of effective technology transfer. The FGD participants also identified factors to ensure their active participation in technology transfer activities (Table 2). From these factors, it could be gleaned that the prerequisites of an effective technology transfer identified by the FGD participants include the dimensions of the CEMTT. These are the associated characteristics of the transfer object, transfer recipients, transfer object use, and context-enabling mechanisms (Table 3).

Table 2. Factors to ensure active participation in technology transfer.

Factors to ensure active participation in technology dissemination (n=FGD groups)	FGD group				
	AIAT	Provincial	District	Sub district	Total
Dissemination is part of the main tasks/functions	1	1	2		4
Appropriate facilities are available (e.g., laptop, internet, handphone, camera, motorcycle, etc.)		2	1	1	4
Reward and punishment mechanisms are in place		1			1
The technology is ready for dissemination.		1			1
The technology has good accuracy.		1		1	2
The technology could increase rainfed rice productivity.			1		1
The technology is easy to use.			1		1
The technology could help farmers in deciding when to plant.			1		1
Knowledge and experience on rice production	1				1
They should understand the technology.		1			1
The area planted to rainfed will be increased			1		1
The technology could minimize disadvantages (risks) of farmers in rainfed rice areas.				1	1
Posters and other dissemination materials are available.				1	1
Good coordination among institutions		1			1

Source: FGDs, 2016.

Table 3. Prerequisites for an effective technology transfer.

Prerequisites for an effective technology transfer	Count
Transfer object associated characteristics (i.e., readiness, accuracy, and ease of use)	4
Transfer recipient associated characteristics (i.e., mandate, capacity -knowledge, skills and resources at disposal)	11
Transfer object use-effectiveness criteria (i.e., market impact - technology could help farmers in deciding when to plant and increase productivity)	4
Context-enabling mechanisms (incentives/reward and punishment, good coordination among institutions)	2

Source: FGDs, 2016.

Operationalizing the TTPs. Given the constraints encountered in previous technology transfer activities and the factors identified as prerequisites to technology transfer, the following should be considered in operationalizing the TTPs for WeRise in Indonesia:

Capacity building. WeRise will be transferred in forms applicable to the roles/level of use of the transfer recipients. For the Katam National Taskforce led by IAHRI who could operate, maintain, and further develop/localize WeRise in the context of the Katam platform, capacity building would include the transfer of scientific knowledge, technological design, and the development process. As the demand environment is dynamic, the capacity building should aim to equip the transfer recipients with knowledge, skills, and resources (database, development manual/codes) needed to operate the system freely. The freedom to operate is among the concerns laid out by stakeholders for project sustainability.

Farmers trust experts such as extension workers for more complex technical information (Feder and Slade 1984; Howell 1984, pp. 174, 179 cited in Feder et. al., 2004). Extension workers are among the major source of information of farmers, as primary WeRise infomediaries. Capacity building of extension workers from AIATs and local extension agencies on technology information dissemination should be undertaken. The foundations of WeRise development, navigation, generating and understanding the advisories and disseminating the information to end users/farmers using field language (simple and easy to understand at the farmers' level) should be included in the capacity building. By the end of the capacity building, certified WeRise facilitators should be equipped to communicate the WeRise advisories to the end-users (farmer groups/farmers) ahead of the cropping season.

The farmer respondents were not asked how they prefer to receive information such as the WeRise advisories. Face-to-face meetings (i.e., group/coordination meetings, training of extension workers) and printed materials which were utilized the most with Katam, coincides with the most preferred mode of information delivery (transfer medium) by farmers in the Philippines. Farmers preferred lectures because they could instantly ask questions (Manalo and van de Fliert 2011). Following lectures are print publications because farmers consider them as useful reference materials they go back to in case concepts have been unclear to them initially. Online information lagged behind the other mediums. Through capacity building, the constraints encountered in previous technology transfer activities particularly the insufficient number of technology information facilitators, insufficient training on the technology, low awareness level of farmers, lack of trust on the extension workers will be addressed.

Trust building. To establish proof that indeed WeRise works, on-farm validation activities/on-site demonstration plots are necessary and identified during the FGDs with extension agencies and farmer groups as among the most effective dissemination strategy in addition to capacity building (i.e., training/seminar and LAKUSISI or train-visit-supervise approach). Demonstration plots were the least utilized transfer medium (6%) for Katam (Yulianti et al. 2016). This could be attributed to its cost. IJCRP has ongoing validation activities in selected project sites but these are limited due to budget constraints. FGD participants also mentioned budget constraints to conduct a wider scale technology validation as among the technology transfer constraints. Given the resource limitations, creativity is needed in resource generation whether in monetary or in-kind. Sub-districts have lands that could be used as demonstration plots. The provincial governments through the PRDA have a budget to conduct their own R&D but lack the capable researchers. Collaborative arrangements may be explored. Existing farmer field schools could serve as venues for introducing WeRise. To create sustained adoption, farmer cooperators who have good farming practices and capable of taking risks (with capital) are important stakeholders. They are usually innovators or leaders in their communities.

Coordination platform. Good coordination among the technology transfer recipients is among the prerequisites identified for an effective technology transfer in this study. Coordination with provincial extension agencies is a concern in disseminating another ICT4D tool developed by IRRI (Santoso et al. 2010). The decentralization of Indonesia's extension system resulted in weak coordination as district levels are given more freedom in planning development programs independently. This could result in disintegrated programs at the provincial level (Margono and Sugimoto 2011).

The alternative TTP proposed (Option 2) includes an existing multi-stakeholder platform, the PTC which could be maximized to facilitate coordination and feedback. There might be no need to establish a new platform as what was done during the Site-specific nutrient management (SSNM) rollout in Indonesia. To facilitate dissemination, a Fertilizer Working Group (FWG) was established to formulate fertilizer recommendation across national institutions. But activities of the FWG have been limited because members have regular jobs and no specific budget was allocated for the activities (Santoso et al. 2010). Informal WeRise groups/small clusters consisting of WeRise champions) may also be established to serve as a platform for feedback, monitoring, and evaluation.

Policy advocacy. PTCs have inherent problems including the frequent change in leadership of its member institutions as incumbent heads are the PTC representatives by default, low participation rate, and some district offices may not be represented (Saediman 2015). Policy advocacies by IJCRP to create an enabling environment for the TTPs to materialize could help address these problems.

Legal framework. Technology transfer is deliberate and involves an agreement. The IJCRP has been implementing WeRise development and validation activities with partners through PLAs (Partner Letter Agreements), a legal framework executed by the representative heads of IRRI and partner agencies. The success of technology transfer is often affected by the absence of a clear legal framework for the exploitation of the IPR resulting from the research (Zuniga and Correa 2013).

WeRise is considered an international public good. IRRI and MAFF expressly decide that global accessibility and impact, as well as any commercial licensing and use of all intellectual assets/properties developed under the IJCRP, will be subject to the Consultative Group on International Agricultural Research (CGIAR) Principles and Guidelines on the Management of Intellectual Assets (IRRI, 2015). By the end of the project, a cooperative R&D agreement (i.e., MOA) with IRRI or MAFF/JIRCAS and the lead transfer recipient who will be in-charge of operating and maintaining the system will have to be executed. A legal instrument could articulate the technology transfer recipients, agent and their roles and responsibilities (resource contributions) in the technology transfer. A detailed work plan could also help in implementation.

Institutionalizing WeRise may be done at the national level and provincial level where it could be part of the implementation of a bigger development program. For instance, in the implementation of UPSUS (Upaya Khsusus), a national self-sufficiency program involving rice; Pemupukan Hara Spesifik Lokasi (PHSL) (Nutrient Manager for Rice), soil test kits, and a planting system, were recommended to be used as part of a technology package. This strategy would enable bundling or integrating WeRise into the provincial R&D programs (i.e., agricultural crop insurance, best crop management practices) and the chance of adoption could increase.

Maintainance of WeRise. The cost to operate and maintain WeRise will in effect be shouldered by the technology transfer recipients. The success rate is higher if sets of government agencies are involved as it allows co-funding. The cost and available resources to operate, maintain, and localize WeRise should be considered in transferring WeRise to Indonesia in particular to IAHRI to increase the chance of sustaining it. A possible advantage would be on the more efficient use of data. WeRise cost on data acquisition may be decreased as a local Indonesian agency (BMKG) could provide the data requirements to operate and maintain WeRise as with Katam.

Generating fees (e.g., tapping telecom providers for counterparts, asking farmer groups to pay a meager amount for every advisory, bundling of WeRise advisories with other information that farmers will be willing to pay for such as input prices, etc.) from WeRise is possible. In these cases, the applicable law and IP policies of the technology transfer agent and recipients should be applied. Other ways to facilitate the operation and maintenance by the technology transfer recipients can be through reducing costs by scouting a web server for bulk data storage and national agencies as providers of seasonal climate predictions.

Post-technology transfer support. To facilitate a smooth transition towards project sustainability, IJCRP should provide post-technology transfer support, details of which should be discussed and agreed with the institutions who will be in-charge of WeRise uptake and dissemination. Monitoring and evaluation should also be done after the transfer to evaluate how the transfer progresses and if a redesign of the pathways is necessary.

CONCLUSIONS AND RECOMMENDATIONS

The proposed TTPs include a set of government agencies currently involved in the development, validation, and dissemination of Katam, an ICT4D tool, as technology transfer recipients. Absorption or integration of WeRise with Katam to cater to rainfed rice conditions, capacity building of technology transfer recipients, and on-site demonstrations to establish proof of accuracy are major transfer media to sustain WeRise after the end of IJCRP implementation in September 2020. The proposed TTPs would allow co-funding among the government agencies, maximization of resources including data utilization, and do not necessitate the need to establish new entities. IJCRP as the transfer agent plays a critical role in laying the groundwork to ensure a smooth transition by getting the commitment of the transfer recipients to project sustainability via a legal framework so the latter may be able to maximize WeRise and its associated research outputs, policy advocacy to ensure a post-technology transfer support during the transition. Further examination of the PTCs in the rainfed rice areas which were found to be a potential coordination/feedback platform, to explore specific collaboration; and executing a technology transfer work plan among the technology transfer recipients are recommended.

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