

Transdisciplinary Responses to Climate Change: Institutionalizing Agrometeorological Learning Through Science Field Shops in Indonesia

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Science Field Shops (SFSs) are an example of a transdisciplinary educational commitment where farmers, scientists, and extension staff exchange knowledge on agrometeorology in dialogue form to better respond to climate change. How can scientists, farmers, and extension staff build up this transdisciplinary collaboration? How has the agrometeorological learning environment been institutionalized in several places in Indonesia? An interdisciplinary collaboration between agrometeorology and anthropology serves as basis for developing seven climate services that are provided in the SFSs. Through Knowledge Transfer and Communication Technologies, farmers have become active learners, researchers, and decision makers of their own responses to the consequences of climate change. Although such an approach proves efficient in improving the farmers' knowledge and anticipation capability, the transdisciplinary collaboration with state authority needs to be overhauled to improve the process.

Keywords: Agrometeorology; Climate Change; Indonesia; Science Field Shops; Transdisciplinary Educational Commitment

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Do not enforce farmers to only focus on achieving the target to increase productivity. Help us with a policy of water allocation from the irrigation canals, and facilitate us in improving our understanding about climate change.¹

INTRODUCTION

Mobilizing efforts such as technologies and capital to improve agricultural productivity and achieve self-sufficiency in rice constitute a significant part of the Indonesian state's objective to feed the population and to sustain economic growth. In the course of the Green Revolution since the early 1970s, high productivity has become the state's primary objective for agricultural development which was flanked by the introduction of new high-yielding varieties in association with chemical fertilizers and pesticides, large-scale irrigation, and new

1 This request was directed to the government by a group of rainfall observers in East Lombok led by Mastariadi in order to change the government's policies on agricultural development (Mastariadi, 4 November 2015).

technologies (Hansen, 1978; Hardjono, 1983). From the beginning, the Green Revolution has been contested and numerous problems have been reported (Conway & Pretty, 1990; Fox, 1991; Hardjono, 1983; Schiller, 1980; Winarto, 2004a, 2013). Summarizing the criticism, Conway (1985) argues that high productivity was achieved at the expense of agro-ecological sustainability, namely ecosystem stability and equity for local farmers. Farmers as the main producers of food became both the target and the victims of the Green Revolution. Even though they succeeded in increasing agricultural productivity, they have been culturally and ecologically marginalized on 'their own fields'. Many of them did not foresee the consequences of the top-down technology packages which increased productivity but drastically changed their habitat (Chambers, 2009; Fox, 1991; Scoones & Thompson, 2009; Winarto, 2004a, 2013). One devastating consequence was the severe outbreak of brown planthopper (BPH) in 1985,² just one year after Indonesia's declaration of rice self-sufficiency. In order to fight the negative consequences of ecosystem instability and empower farmers, a number of international and national multidisciplinary scientists collaborated with the Indonesian government to introduce programs of Integrated Pest Management (IPM) (Fox, 1991; Kenmore, 1992). Referring to Paulo Freire's liberal education philosophy (1972), andragogy (Knowles, 1973; Knowles & Associates, 1985), and the Farmer First paradigm (Chambers, Pacey, & Thrupp, 1989), adult education for farmers as well as people's empowerment and participation became the hallmark of these programs. One strategy was the introduction of Farmer Field Schools (FFSs) (Dilts & Hate, 1996; Fox, 1991; Kenmore, 1992; Pontius, Dilts, & Bartlett, 2002; Wardhana, 1992; Winarto, 2004a, 2004b). Despite the proliferation of IPM, Indonesia faces severe environmental problems as the Green Revolution paradigm is still underlining the country's agricultural policies (Winarto, 2009, 2011; Winarto et al., 2012a). As a result, a devastating outbreak of BPH all over Java from 2010 to 2012 reduced rice production significantly and 1.96 million tons of rice were lost (Bortrell & Schoenly, 2012; Departemen Proteksi Tanaman, 2014; Fox, 2014; Winarto et al., 2012a; Winarto et al., 2012b).

Despite criticism and failures of the Green Revolution condensed in 20 years of the Farmer First movement (Chambers, 2009; Scoones & Thompson, 2009), the research paradigm and the transfer of top-down technology packages are still highly prevalent in the development agenda of many developing countries (Jakku & Thorburn, 2010; Luyet, Schlaepfer, Parlange, & Buttler, 2010; Sumberg, Thompson, & Woodhouse, 2013). Farmers are still kept marginalized without sufficient knowledge to understand and foresee the risk of their agricultural practices. This gains even more importance in the course of recent environmental and climate change (Winarto, 2013). Farmers have always responded to climatic variability, particularly to changes in rainfall distributions and patterns, by adapting their practices throughout the season. In the midst of ongoing climate change, however, farmers in Indonesia do not yet know that climate change is their 'new enemy'. High day-time temperatures

2 The brown planthopper (BPH, *Nilaparvata lugens*) is a miniscule fast breeding insect that lodges in the stalks of rice plants. It feeds directly on the rice plant and in large numbers is capable of sucking the life out of extended fields of rice, causing so-called 'hopperburn'. The BPH is also a carrier of two destructive rice viruses: ragged stunt virus and grassy stunt virus, either of which can be as devastating to a rice crop as the direct feeding by the BPH (Fox, 2014; see also Bortrell & Schoenly, 2012).

in some tropical and subtropical rice growing regions are already close to the maximum levels. The increase in intensity and frequency of heat waves coinciding with sensitive reproductive stages can result in serious damage of rice production (Stigter & Winarto, 2013; Thornton & Cramer, 2012). Stigter, Winarto, and Wicaksono (2016) highlight the increased average annual temperature in Indonesia, the changes in the seasonality of precipitation (wet and dry seasons), the increased wet season rainfall in southern regions of Indonesia, and the decline of southern Indonesia rainfall up to 15% (Aldrian & Djamil, 2008; Case, Ardiansyah, & Spector, 2007). Based on these data, farmers in Indonesia do suffer and will continue to suffer from increasing temperatures as well as from decreasing rainfall (for the strong relationship between the El-Niño Southern Oscillation [ENSO] and rainfall variability in most of Indonesia, see Boer & Suharnoto, 2012; for the changing starts of the rainy season, see Marjuki et al., 2014). For many farmers in Indonesia, these phenomena related to climate change are relatively new (Winarto & Stigter, 2011). Unfortunately, extension facilitation by intermediaries fails to provide farmers with knowledge and strategies (Lubis, 2013) or is not working as effectively as it should (Cahyono, 2014). In this article, we propose the concept of Science Field Shops (SFSs) to address this missing link. SFSs provide dialogic exchange of knowledge amongst farmers, scientists, extension staff, and policy makers, through which farmers learn agrometeorology, in order to better respond to climate change and challenge the agricultural paradigm associated with the Green Revolution. Thereby, we propose a new approach to learning and practicing agriculture in a more sustainable way. One important basis for developing the transdisciplinary project of SFSs is interdisciplinary collaboration across two disciplines, namely agrometeorology and anthropology. This article aims to examine how the transdisciplinary project of SFSs has been introduced and developed in several places in Indonesia and to elaborate on the results on farmers' capability in responding to the consequences of climate change in agriculture. The structure of the article is organized as follows: We first discuss the transdisciplinary educational commitment which includes policy and social learning. We then describe the establishment of SFSs through the provision of climate services and the institutionalization of agrometeorological learning in two locations in Java and Lombok (Indramayu, West Java; East Lombok, West Nusa Tenggara), following the first initiative in Gunungkidul, Yogyakarta. Finally, we elaborate on the challenges of interdisciplinary and transdisciplinary work not only within the farming communities but also regarding the effort to involve other academic institutions and government agencies. We conclude with success factors and future challenges.

A TRANSDISCIPLINARY APPROACH FOR POLICY AND SOCIAL LEARNING

Since the late 1980s, andragogy and experiential discovery learning, which was developed in the Integrated Pest Management Farmer Field Schools (IPM FFSs), has slowly spread throughout Indonesia and became a model for the initiation of various kinds of 'schools', including the Climate Field Schools (CFSs). Since 2003, government officials have carried out CFSs to provide farmers with new knowledge on weather and climate in various regions in Indonesia. Based on our observation of the implementation of a CFS in Gunungkidul, Yogyakarta province, however, we criti-

cized the prevailing paradigm of simply teaching over a limited period of time instead of providing a mutual and enduring learning situation (Anantasari, Winarto, & Stigter, 2011). Based on their observation in Indramayu, West Java province, Siregar and Crane (2011) also argue that activities in the frame of CFSs lack to identify, enhance, and build on farmers' knowledge, capacities, and institutional processes.

A transdisciplinary educational commitment would be a necessary means to meet the needs of local farmers in the current dynamic situation of high complexity and uncertainty resulting from climate change. Scholars increasingly ascertain the importance of transdisciplinary research in development cooperation for addressing social-environmental problems (Brutschin & Wiesmann, 2002; Christinck & Padmanabhan, 2013; Cronin, 2008; Lang et al., 2012; Pohl & Hadorn, 2008). Cronin (2008) defines transdisciplinary research (TDR) as

a practice that transcends the narrow scope of disciplinary views. It challenges existing boundaries and 'redraws the map'. . . . It is an approach in which researchers from a wide range of disciplines work together with stakeholders. TDR aims to overcome the gap between knowledge production on the one hand and the demand for knowledge to contribute to the solution of social problems, on the other. (pp. 2-3)

As socio-ecological research focuses on the solution of real-world problems, the involvement of actors from outside academia in the research process is of utmost importance (Cronin, 2008; Lang et al., 2012). Thus, "transdisciplinarity combines interdisciplinarity with a participatory approach" (Cronin, 2008, p. 4). Transdisciplinary educational commitment then moves beyond transdisciplinary research by producing knowledge together to contribute to the solution of problems people face in their immediate environment. The above-mentioned criticism of CFSs makes it clear that a transdisciplinary educational commitment was absent in the state's CFSs. The state's CFSs 'curricula' were designed by agrometeorologists and delivered by agricultural officials. Therefore, no direct relationship between scientists and farmers, which would have enabled a process of intersubjectivity, was established. As there were no social scientists involved in CFSs, the examination of socio-cultural factors regarding the above-described contested agricultural development was also not tackled. However, both the challenge of climate change and the need for farmers to respond to the dynamics of this change require the collaboration of scientists from different fields (in this case agrometeorology and anthropology) and the active participation of farmers on the ground. In anthropology, such an approach is called collaborative ethnography. Lassiter (2005) defines it as "an approach to ethnography that *deliberately* and *explicitly* emphasizes collaboration at every point in the ethnographic process, without veiling it – from project conceptualization, to fieldwork, and especially through the writing process" (p. 16). In a later article, he advises anthropologists to use that approach in developing "community-based collaborative action" (Lassiter, 2008, p. 74-75). In collaborative research, ethnographers move away from the investigators' realm of definition, purpose, and authority. In contrast, collaboration entails joint production by scientists and the community. In SFSs, the anthropologist initiates transdisciplinary collaboration and acts as a mediator and cultural

translator between two domains of knowledge: the scientific and the local (Winarto, Stigter, Dwisatrio, Nurhaga, & Bowolaksono, 2013; Winarto & Stigter, 2013). However, the anthropologists have to move beyond just being cultural translators as one important task is to introduce new habits to the farmers. Thereby, interacting directly with farmers inter-subjectively becomes the main role of the anthropologists. The establishment of SFSs was the first step to move into ‘public-anthropology’ by directly addressing issues beyond conventional anthropological concerns (Lassitter, 2005, 2008). In this unique process, we exercise and experience immersion into the farmers’ lives in order to enable us to build up a close relationship with them. At the same time, we detach ourselves from the intimate relationship to provide room for continuously reflecting on the transdisciplinary collaboration. Detailed documentation of both visual and inscription data as well as analyzing and processing farmers’ rainfall data and agroecosystem observation become integral parts of our work.

Policy Learning and Social Learning

Two challenges need to be addressed for the institutionalization of SFSs among farmers and policy makers, namely policy learning and social learning. According to Albright and Crow (2015), policy learning is about “changes of beliefs, attitudes, goals, or behaviors – in response to new information” (p. 80). Agrometeorological learning is then about such changes due to new meteorological and climatological knowledge acquired by farmers (Stigter & Winarto, 2016). Therefore, the establishment and institutionalization of new mutual participative educational commitments, for example observation and analysis of rainfall, enable policy learning in the field of agrometeorology among farmers. As a result, farmers are able to make decisions that enhance their capability to adapt to climate change. In a further step, a social learning process among the rest of the community members is expected to occur. Luks and Siebenhüner (2006, p. 419) assert that the process of social learning is highly inter-related with the generation, construction, and representation of scientific knowledge as well as with the openness and flexibility of the governance system. One challenge is to ensure the maintenance of the social learning process. Generally, farmers are used to and willing to share what they learn and know to their fellow farmers (Winarto, 2004a, 2004b). For farmers who have not personally experienced the observation and analysis of rainfall patterns, it is, however, difficult to follow the outcomes and advice of the rainfall observers in the community. For the rainfall observer, agrometeorological learning is a direct way of observing and analyzing emerging problems and opportunities related to meteorological and ecological phenomena. Even so, for a social learning process to take place among the rest of the community members, a larger movement of scaling-up the SFSs is necessary, and this also requires support from state authorities. One rainfall observer in Indramayu complained that “my neighbors would not listen to me (to change their farming strategies) since nobody from the government backed me up” (Condra, 5 August 2015). Without the state’s support, the extent to which social learning could take place within and beyond the community is still a prevailing problem.

SCIENCE FIELD SHOPS IN PRACTICE: KNOWLEDGE TRANSFER AND COMMUNICATION TECHNOLOGIES

In general, farmers are aware of changes to their environment due to climate change and they have strategies and knowledge as the basis for their work to enhance resilience. Improving farmers' knowledge and decision making to cope with climate change are the main objectives of our transdisciplinary collaboration. This process takes place via Knowledge Transfer and Communication Technologies (KTCT) in the frame of SFSs (Winarto, Stigter, Ariefiansyah, & Prihandiani, 2016; Stigter, 2016a). Knowledge transfer refers to the practical problem of transferring knowledge from one part of an organization to another. Knowledge transfer seeks to organize, create, capture, or distribute knowledge and ensure its availability for future users. Farmers have their own ways and habits of transferring knowledge among themselves using their own communication technologies (Winarto, 2004a, 2004b). How could this knowledge be used and improved in SFSs? We examine this process in the following sub-section.

Introducing and Establishing Science Field Shops

SFSs are a new extension approach in which knowledge is exchanged or transferred for operational use by farmers. The scientists (agrometeorologists and anthropologists) have been working collaboratively on an interdisciplinary basis to introduce seven climate services (see list below) to farmers who have become active learners and researchers throughout the establishment of the SFSs on a transdisciplinary basis. After establishing the first SFS in a hamlet in Gunungkidul, Yogyakarta, from 2008 to 2009, we introduced agrometeorological learning processes among farmers in other regencies, namely Indramayu in West Java in 2009 and East Lombok in West Nusa Tenggara in late 2014. Various donor agencies funded the SFSs and academic institutions and (inter)national agencies supported the operational costs of both scientists and farmers. In the early stage of its establishment, the collaborative work focused on policy learning among the rainfall observers who joined the SFSs by providing the seven climate services for farmers. Gradually, we introduced the SFSs to local and national government agencies as an alternative extension approach to assist farmers in the midst of ongoing climate change. At a later stage, the scientists gradually addressed social learning through the informal scaling-up of SFSs among farmers and by formally establishing new satellite groups as well as inviting agricultural officials to participate. In this transdisciplinary process of knowledge transfer and communication between farmers, scientists, and at a later stage also extension intermediaries (Winarto et al., 2016), the farmers are active learners. They carry out their daily observations of rainfall and agroecosystems, document their findings, and analyze and discuss them together in monthly meetings. They play an active role in analyzing the impacts of particular rainfall patterns to the ecosystem and reporting on the most vulnerable situations. Scientists and extension workers have the role of establishing climate services which provide (new) operational knowledge in agrometeorology. The aim is the establishment of KTCTs in Science Field Shops in order to improve farmers' anticipation capability in decision making that enables them to

better cope with the consequences of climate change. We have learned that what is missing in almost all extension attempts in developing countries is a mutual dialogue for knowledge transfer. For that reason, SFSs are organized as a flexible mutual commitment between farmers, scientists, and any extension intermediary who wants to join to hold dialogues on climate problems. Agrometeorological learning should lead to policy learning such as changes of beliefs, attitudes, behaviors, and goals due to the transfer of new knowledge (see Albright & Crow, 2015). The new knowledge is obtained through KTCTs on the basis of seven climate services (Stigter, 2016b; Winarto et al., 2016):

1. Daily measurement of rainfall by all rainfall observers in their plots by using rain gauges

The first thing all participating farmers have to learn is measuring the rainfall on their plots on a daily basis. This quantitative data is exchanged and discussed on a monthly basis in the SFSs meeting. Thereby, farmers understand how the rainfall varies through time and space. Rain gauges serve as KTCTs as they are used to exchange and discuss the data gathered (see Figure 1).



Figure 1. A farmer is measuring rainfall. (photo by Aria S. Handoko).



Figure 2. A farmer is observing the agroecosystem condition of his field.
(photo by Muki T. Wicaksono).

2. Daily or weekly observation of agroecological aspects (soil, plants, water, biomass, pests, climate extremes)

On pre-printed data sheets, on a daily or weekly basis, farmers fill in observations on crop stages and how their plants look, including colors due to fertilizer treatments and drought. From the nursery stage onwards, they also record detailed observations on pests and diseases (if any) and any consequences found or suspected. Farmers may also list soil treatments prior to sowing and include the sowing and planting methods they have used. They list the varieties they have sown and keep records of fertilizers (organic and/or inorganic) used at specific crop phases. Treatments involve irrigations and withholding irrigations at specific crop phases as well as the spraying of pesticides, organic and/or inorganic, at specific conditions of pest/disease infestation. The data sheets serve as KTCTs and are the basis for exchange, discussions, and the development of strategies during SFSs (see Figure 2 and 3).

3. Measuring of yields and analysis of the correlation to rainfall and inputs (amount & timing)

Farmers focus on expected and measured yields. Moreover, they explain differences in yields in relation to rainfall and other agroecological inputs (amounts and timing) available, affordable and used (varieties, water, fertilizers, pesticides, labor, machin-



Figure 3. Group of rainfall observers discussing their agrometeorological observations. (photo by Yunita T. Winarto).

ery, and knowledge). Farmers communicate and discuss the procurement of yields among themselves. Moreover, they compare yield, rainfall, and other data with those from previous seasons. The analysis, understanding, and comparison of yields are part of KTCTs.

4. Organization of the SFSs themselves

The continuation of the SFSs among farmers needs to be entirely in the hands of the farmers. In both Indramayu and East Lombok, we helped farmers to form a core group of rainfall observers consisting of the first batch and a number of satellite groups with new rainfall observers. The leaders of the groups organize farmers' meetings to exchange and discuss knowledge amongst each other or with extension intermediaries.

5. Development and exchange of monthly updated seasonal climate predictions in the form of seasonal rainfall scenarios

We send farmers monthly climate scenarios in order to provide them with new knowledge that can be combined and discussed with their gathered data. We explained and discussed the terminology of the climate scenarios in advance so that farmers know how to interpret the data.

6. Delivering new knowledge related to the above listed points

Scientists deliver new knowledge, including the provision and discussion of answers to all agricultural/climatological questions raised by participants throughout the year.

7. Guidance on the establishment of farmer field experiments to get on-farm answers on urgent local questions

Farmers are encouraged to carry out experiments on their own plots. For example, scientists guided farmers to find out the most effective strategies for mitigating methane emissions – released from the plowing of wet biomass in an aerobic condition – while also sustaining and/or increasing yields and reducing costs. Such reports on experiments aiming to prevent climate change and sustain or increase yields while reducing costs are an important part of KTCTs and constitute ‘win-win solutions’ for both the environment and the farmers.

Another aspect of KTCTs is the training of farmer facilitators which the farmers choose themselves. The scientists trained these facilitators in train-the-trainer workshops to improve their climate literacy and agrometeorological learning skills and knowledge to enable them to facilitate other farmers and new members. Other forms of KTCTs used by farmers to exchange knowledge are daily or regular informal discussions, mobile telephones, rural radio, and television. Information is also spread through existing state agricultural extension services where farmers keep track on how the ongoing season is progressing. The up-scaling of all these KTCTs and the reporting on the up-scaling process are also exchanged and discussed in the SFSs and therefore are part of KTCTs themselves.

In transdisciplinary research, the role of farming communities is significant. Based on our experience, we learned that the implementation of SFSs in different places and farming cultures/systems has to address the peculiarities of each community. Agrometeorological learning in the framework of climate change needs to include and address local socio-cultural aspects and the specific ecological landscapes. We reflect on the gradual learning processes in the transdisciplinary setting of SFSs in the following section.

Institutionalizing Agrometeorological Learning: A Gradual Learning Process

For both farmers and scientists, the most important experiences throughout their collaborative work, are the farmers’ significant changes in attitude and strategies and the scientists’ improvement in the SFSs materials and approaches. When looking back at the starting point of the SFSs, the farmers describe significant changes they have been experiencing gradually over time. Through ongoing intersubjectivity with the farmers in the past years and daily reflection on what was missing in farmers’ learning, the scientists improved the farmers’ new habits of measuring daily rainfall and taking notes of their agroecosystem observation over time (Prahara, Winarto, & Kristiyanto, 2011; Winarto & Stigter, 2011). Based on farmers’ reports and evaluations, the scientists gradually improved the template for documenting these data (Winarto & Stigter, 2016). For the farmers, quantifying rainfall and writing down the

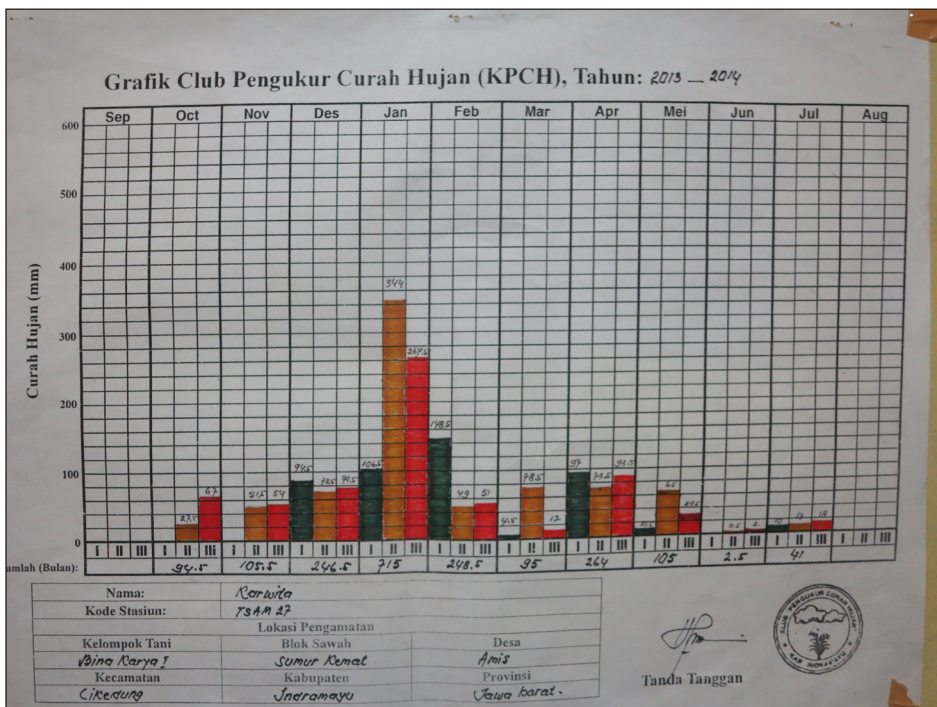


Figure 4. Annual rainfall graph. (photo by Muki T. Wicaksono).

results were new skills. In the beginning, they produced incomplete data. Writing down knowledge based on their observations meant simplifying very complex phenomena into a few words or short sentences (Prahara et al., 2011; Winarto & Stigter, 2016). Thus, scientists had to repeat explanations, revise the template, and correct farmers' mistakes from time to time. Eventually, once the farmers understood the benefits of their data, they could do the documentation on their own initiative. Carrying out the data collection on a daily basis, the farmers realized how significant and valuable it was. They were able to compare rainfall patterns between years and to produce hypothetical assumptions on particular agrometeorological phenomena such as the relation between certain rainfall patterns and the infestation of particular pests/diseases. Based on our dialogues, we collaboratively produced monthly and annual rainfall graphs (Winarto & Stigter, 2016). These graphs (see Figure 4) can be considered a new form of KTCTs. With the graphs, farmers can visually depict their analyses on rainfall, pest/disease populations/infestations, and the plants' age in one graph. The graph can be used by the farmers themselves and distributed to others in their community.

Another significant achievement by the farmers was monthly-organized evaluation meetings. In Indramayu, these meetings have been held since 2009 by rotation principle. Visiting places far away from their villages and discussing data became a strong communicative event, strengthening the network, and establishing friendships (Giller, 2013). Such meetings are significant KTCTs to support the learning process. Farmers share and exchange their data, discoveries, ideas, problems, and solu-

tions. Learning from one another and from the scientists is the most valuable thing that they missed in formal extension meetings. Farmers are used to observing and interpreting phenomena in their fields, but not as detailed as in SFSs. However, their observations also depend on what is considered significant in local settings. In Indramayu, pest/disease infestations have always been a threat. Thus, in the early years of the learning process, they particularly used to share and discuss ideas of how to treat a particular pest or disease. By using various components of agrometeorology, the farmers were gradually motivated to analyze yields and the differences found between farmers, different planting seasons, and the same planting season in different years. From 2013 onwards, farmers were stimulated to carry out simple standardized 'win-win solution experiments'. They had to discover the most effective strategies for mitigating methane emission that would not reduce yields but only costs. Farmers learned that for farmer-led field experiments, they had to prepare and compare one 'field as usual' and one experimental field with only one variable differing from the usual field. This is an example of how farmers gradually learn to incorporate scientific premises in their own trial-and-error activities (Winarto & Stigter, 2016). Throughout the intersubjective relationship, it is crucial that farmers themselves sustain the objective of institutionalizing agrometeorological learning. Yet, without a common goal to achieve, it would be difficult to reach a consensus or compromise on the diverse values, norms, and rules between the different parties (Brutschin & Wiesmann, 2002). Therefore, it was a pleasant surprise for us and other parties that up to 2016, the SFSs in Indramayu could be carried out under the leadership of farmers, thereby highlighting the benefits of SFSs. The rainfall observers in that region have become the source of climate scenarios for other farmers and regency authorities. For the farmers in East Lombok, the SFSs were the first opportunity to come into contact with agrometeorological knowledge and learning that could help them to understand puzzling phenomena. Over a relatively short time, the East Lombok farmers, just as the Indramayu farmers from 2010 onwards, gained confidence in the new learning process and started to 'trust' the monthly rainfall scenarios provided by the scientists. In comparison to their own traditional cosmology (*warigé*), which became out of line with the recent weather and climate conditions, "the seasonal scenarios contained truth", as the rainfall observers argued (Zulkarnaen and Mastariadi, 4 November 2015). Gradually, other farmers in East Lombok perceived the rainfall observers as *mangku hujan*.³

Gaining trust, enriching knowledge, proving the advantages, having freedom to speak, and obtaining a feeling of ownership for the learning activities and outcomes are important elements for a sustainable transdisciplinary collaboration. Yet, only through strong dedication, mutual trust, and ongoing intersubjectivity between all parties over time, can the institutionalization of SFSs as an educational commitment take place.

3 *Mangku hujan* was a traditional informal leader in the old social structure of the *Sasak* ethnic group in Lombok having the capability to define and determine local regulations and provide guidance about farming.

MOVING FORWARD: INTER- AND TRANSDISCIPLINARY CHALLENGES

Institutionalizing agrometeorological learning in a transdisciplinary collaboration is not possible without establishing an interdisciplinary foundation among scientists on different scales. Without the involvement, organization, and education of scientists from local universities and/or other institutions, the materialization of such an educational commitment to assist farmers is doomed to fail. However, breaking the 'walls' between different faculties, disciplines, and scales in establishing the research team is not an easy task. The most important thing to begin with is to seek scientists from different disciplines: natural sciences (e.g., agrometeorology, agronomy) and social sciences (e.g., anthropology, sociology) who agree to cross the boundaries of their own disciplines. In Indonesia, as elsewhere, this is not an easy task due to the traditional boundaries of faculties and the virtual absence of scientists who are interested to initiate and pursue an inter- and transdisciplinary research project. Building a 'common language' between different disciplines needs the high motivation, stamina, patience, and passion of the scientists to learn from one another. All parties have to set up common goals and institutionalize values, norms, and rules for establishing new habits in a collaborative process. Without the willingness for continuous reflection and learning at every stage of the collaboration, the necessary intersubjective relationship is not possible. Only on such an interdisciplinary basis, KTCTs can be developed in a learning arena such as the SFSs. However, one remaining constraint is how to sustain the work, especially with regard to local universities where agrometeorologists and social scientists have not been ready to work collaboratively in providing climate services to farmers.

Although it is not easy to change farmers' habits and culture, they are seen to internalize new habits easily through direct experiences of what is happening in the fields and gaining confidence in the advantages of their agrometeorological learning. This stands in contrast to changing bureaucrats' culture and perspectives. Our experience in establishing transdisciplinary work with both farmers and local/regional authorities in the two regencies shows that it is much easier to gain the farmers' trust and willingness to collaborate than that of government officials. Facilitating policy learning among the farmers has been the major accomplishment of our transdisciplinary work. The strategies developed by rainfall observers in collaboration with local village officials to avoid harvest failures due to the strong El-Niño in 2015 (which lasted up to April 2016) exemplify this accomplishment. In a village meeting in Indramayu, the rainfall observers developed the strategy to adopt the schedule for preparing lands and nurseries by anticipating the expected short rainy season, the lack of rainfalls throughout the rainy season, the availability of irrigation water, and the population and life-cycle of white rice stemborer. They calculated the time of making the nursery bed, the type of nursery, and the maturing age of rice variety to be cultivated. Although they experienced severe water scarcity in the middle of the rainy season planting, the farmers could still gain their harvests by relying on the groundwater resources at the time when the paddy did not need much water. Another benefit was their successful strategy in avoiding pest infestation. In this case, the policy learning and the social learning took place once the local officials understood the need to appropriately define the preparatory stage of the forthcoming

planting season to avoid harvest failures. In contrast, farmers experienced hardships and harvest failures without any timely guidance and assistance by the agricultural officials even though some rainfall observers were able to anticipate the long drought of the 2015/2016 rainy season. Instead of working on a flexible planting scheme, the government expected farmers to keep planting rice to reach the state's annual target of boosting up rice production (Winarto, Stigter, & Ariefiansyah, 2015). Without any governmental support, the rest of the community members that have not experienced any agrometeorological learning would follow their previous strategies. The long drought trapped them in a harsh situation without any water supply during the growth of rice. This is illustrated by the complaint of a rainfall observer in Indramayu who experienced harvest failure in 2015 when planting rice in the dry season with normally sufficient irrigation water.

We are having a long drought this season [dry season of 2015], but why did the government force us to plant rice without taking into account that there would be a strong El-Niño this season? Now we have lost our harvest. If the government had advised us and helped us planting another commodity, we would not have experienced this harvest failure. (Condra, 5 August 2015)

These cases highlight that the main aim is to implement a sustainable long-term educational commitment and not only a short-period training such as in the state introduced Climate Field Schools. In this process, the biggest challenge is to stimulate a policy learning process among government officials. Differences between the two research sites are prevalent here as the East Lombok regency authorities supported the up-scaling of the SFSs in a relatively shorter period than the Indramayu regency authorities. Recently, the local and regency governments in Indramayu and East Lombok agreed to facilitate the establishment of the SFSs at the village and/or district levels. However, the top-down approach which focuses only on achieving the national rice production target has continued without any focus on educating farmers to be responsive to the uncertain consequences of climate change. Finding an appropriate approach to invite, motivate, and involve local and regional state authorities in developing SFSs in their regions is now becoming a significant part of scientists' responsibility.

CONCLUSION

This article has shown that the collaborative work between scientists from different disciplinary backgrounds such as agrometeorology and anthropology proves to be useful in initiating, introducing, and institutionalizing a transdisciplinary collaboration with farmers. Only by positioning farmers as main partners and active learner-researchers and not merely as receivers of technology, Science Field Shops could be established on the basis of Knowledge Transfer and Communication Technologies. However, changing farmers' habits, knowledge, and practices to be rainfall observers, researchers, and responsive decision makers of their own fields takes time. Gaining confidence, belief, and trust that the new learning and habits are beneficial for improving their anticipation capability and decision making over time constitutes a sig-

nificant part of the entire process of institutionalizing agrometeorological learning. Incrementally, farmers realized that only the combined process of gathering rainfall data, understanding their field agroecosystem conditions, and receiving monthly seasonal scenarios enabled them to better anticipate future requirements. The major challenge, however, is to initiate and establish transdisciplinary collaboration with state authorities. Agricultural development programs in Indonesia still refer to the Green Revolution paradigm. Therefore, high productivity is still the main objective of the state's agricultural policy, whereas adaptation to the increasing uncertainty and consequences of climate change on agriculture has not been seriously addressed. We propose that state representatives should be collaborative in developing new agendas and strategies in agricultural production that consider climate change and sustain the livelihood of farmers.



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