Kasetsart Journal of Social Sciences 41 (2020) 60–67

Kasetsart Journal of Social Sciences

journal homepage: http://kjss.kasetsart.org

Practical agricultural communication: Incorporating scientific and indigenous knowledge for climate mitigation

Sukanya Sereenonchai*, Noppol Arunrat

Faculty of Environment and Resource Studies, Mahidol University, Nakhon Pathom 73170, Thailand

Article Info

Article history:
Received 2 November 2017
Revised 30 January 2018
Accepted 9 May 2018
Available online 26 May 2018

Keywords:
agricultural communication,
climate mitigation,
indigenous knowledge (IDK),
participatory communication,
scientific knowledge (SCK)

Abstract

Agricultural communication to mitigate climate change enables information dissemination of both scientific knowledge (SCK) and indigenous knowledge (IDK) for practical farming. This research analyzed knowledge utilization and conducted community-based participatory communication to propose a practical agricultural communication framework for climate mitigation. Based on a qualitative method of data collection in Phichit province, the key findings showed that SCK and IDK can be mutually utilized to enhance the good relationship among the people and for the people with nature. The participatory communication processes consisted of planning, interventions, and monitoring and empowerment. The successful farmers employing the farming practices of not burning rice straw, rice straw composting, and alternative wetting and drying technique were the main senders. The messages were related to their farming practices focusing on a practical and understandable message and graphic explanations. Vinyl was selected as a communication material for signage in the most noticeable areas in their communities. This research highlights that participatory communication with group dynamics and communication promotion mechanisms at both local and national levels should be enhanced.

Introduction

The agricultural sector plays an important role regarding global warming both in terms of greenhouse gases (GHGs) emission and carbon dioxide (CO_2) absorption into trees, soil, and humus (Arunrat & Pumijumnong, 2017). According to previous studies relating to agricultural communication (Cannon, Specht, & Buck, 2016), there is a lack of a communication model or guidelines regarding agricultural communication, scientific and indigenous knowledge, and climate change issues, while the more serious impacts of climate change are closer to the local farmers. The term 'scientific knowledge for climate mitigation' or 'scientific knowledge' means agricultural knowledge to reduce GHGs emission, which is accumulated by systematic study and organized by general principles. According to the definitions by Schoenhoff (1993) and Gadgil, Berkes, and Folke (1993) and the context of this study, the term 'indigenous knowledge for climate mitigation' or 'indigenous knowledge' means agricultural knowledge to reduce GHGs emission, which is discovered and developed through trial and error, and shared and practiced among a local community over time based on the social capitals. This knowledge is the basis for local-level decision-making to fit with the socio-economic and environmental conditions of that community.

Although SCK for climate mitigation has been globally disseminated, tailoring the knowledge, including coordinating with indigenous knowledge IDK for practical

* Corresponding author.
E-mail addresses: ssereenonchai@gmail.com, sukanya.ser@mahidol.ac.th (S. Sereenonchai).
Peer review under responsibility of Kasetsart University.

https://doi.org/10.1016/j.kjss.2018.05.014
2452-3151/

application at a local level, is scarce. To fill this gap, the goal of this paper was to explore a practical agricultural communication framework for climate mitigation, compiling both SCK and IDK, and the communicative intervention in local contexts. This study integrated the frameworks of science communication and integrated knowledge translation based on a participatory communication approach to frame and propose an agricultural communication model for practical climate mitigation. Through both primary and secondary data, the analysis and synthesis of this study can also disseminate both SCK and IDK to promote better understanding and raise awareness of the climate change impacts of farmers.

Literature Review

Climate change has already caused significant impacts on the agricultural sector in terms of water resources (Wilby et al., 2006), the production of crops such as maize, wheat, and rice (Challinor & Wheeler, 2008; Howden & O'Leary, 1997), and food security (Magadza, 2000). Shrestha, Chapagain, and Babel (2017) reported the potential impact of climate change on the water footprint of rice production using the DSSAT (CERES—Rice) crop growth model for the Nam Oon Irrigation Project located in northeast Thailand. Under Representative Concentration Pathways (RCP) 4.5 and RCP 8.5 scenarios, the simulation results showed a considerably high increase in the water footprint of KDML-105 and RD-6 rice varieties. In contrast, the ChaiNat-1 variety showed a decrease in projected water footprint. The results also indicated a huge increase in the blue water footprint in the future. Prabnakorn, Maskey, Suryadi, and Fraiture (2018) investigated climate data over a 30-year period (1984—2013) and evaluated the impacts of the recent climate trends on rice yields in the Mun River Basin in northeast Thailand. Their results reflected total yield losses due to past climate trends were rather low at below kg/ha per decade and they suggested that increasing temperature trends during the growing season will be highly likely to cause yield losses. GHG emission from rice production can be mitigated by decreasing nitrogen fertilizer use (Maelinda & Noorlidah, 2008) and the implementation of crop rotations (such mung bean, soybean) after rice harvesting (Arunrat, Wang, & Pumijumnong, 2016). Moreover, farmer management practices that enhance the soil organic carbon content may be important for the sustainable management of crop yields (Arunrat, Pumijumnong, & Hatano, 2017; Pan et al., 2009; Wassmann & Dobermann, 2007) and the mitigation of GHGs that contribute to global warming and climate change (West & Post, 2002). For this research, 'climate mitigation agriculture' was the main focus, which covered the farming patterns in rice fields to reduce GHGs emission covering the reduction of three main components: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

Three main concepts (science communication, integrated knowledge translation, and participatory communication) were integrated and utilized in this study to design the participatory agricultural communication approach for climate mitigation. *Science communication* consists of three main models: deficit, dialogic, and participation. The participation model is the co-production of knowledge where the public participate in the science or are actively involved with scientists in creating knowledge for themselves (Rowe & Frewer, 2005). Science communication must perform four interrelated tasks (Fischhoff, 2013): 1) identify the science most relevant to the decisions that people face; 2) determine what people already know; 3) design communication to fill the critical gaps (between what people know and need to know); and 4) evaluate the adequacy of those communications. *Integrated knowledge translation (IKT)* is the model of collaborative knowledge generation which involves ongoing, dynamic interactions among researchers and decision-makers and is mainly employed in health care. The benefits of IKT, derived from the collaboratory approach in terms of the co-production of knowledge, generate better science with more relevant and actionable research findings and increase the use of the findings in policy and practice including mutual learning among researchers, policy makers, and knowledge users (Gagliardi, Berta, Kothari, Boyko, & Urquhart, 2016). *Participatory communication* is the process by which individuals and communities are empowered to take control of their own lives through planned communication efforts (Felt, Dura, & Singhal, 2014). The participatory approach draws insight and ideas from the target audiences and the issues are relevant to their lives and lived experiences, so these approaches are more effective than a top-down communication approach (Singhal & Rattine-Flaherty, 2006).

Methods

Analytical Framework

Four main steps were conducted to achieve practical agricultural communication: 1) analyze and synthesize SCK and IDK regarding climate mitigation agriculture; 2) undertake a community contexts survey including background data, agricultural activities, and communication characteristics; 3) preparation of communication including a leading farmer group and agricultural knowledge for communication; and 4) participatory communication interventions. During the interventions, the agricultural practices, community communication, social capital, and social support of each area were considered for communication design and practice. The analysis of this study summarized the overall practical agricultural communication framework from both subdistricts. Consequently, the conceptual framework for this study is presented in Figure 1.

Study Area

Phichit province was selected as the study area because: 1) it is one of the top-three provinces for rice cultivation; and 2) from a communication perspective, there is active participation by local leaders and groups and they pay attention to healthy and environmentally-friendly agricultural practices. Then, this was narrowed down to the subdistrict level covering both irrigation and rainfed areas (Rang Nok and Nong Phra subdistricts), where there were also active local leaders and groups of local farmers (Self-Sufficiency farmer group and Rice Community farmer

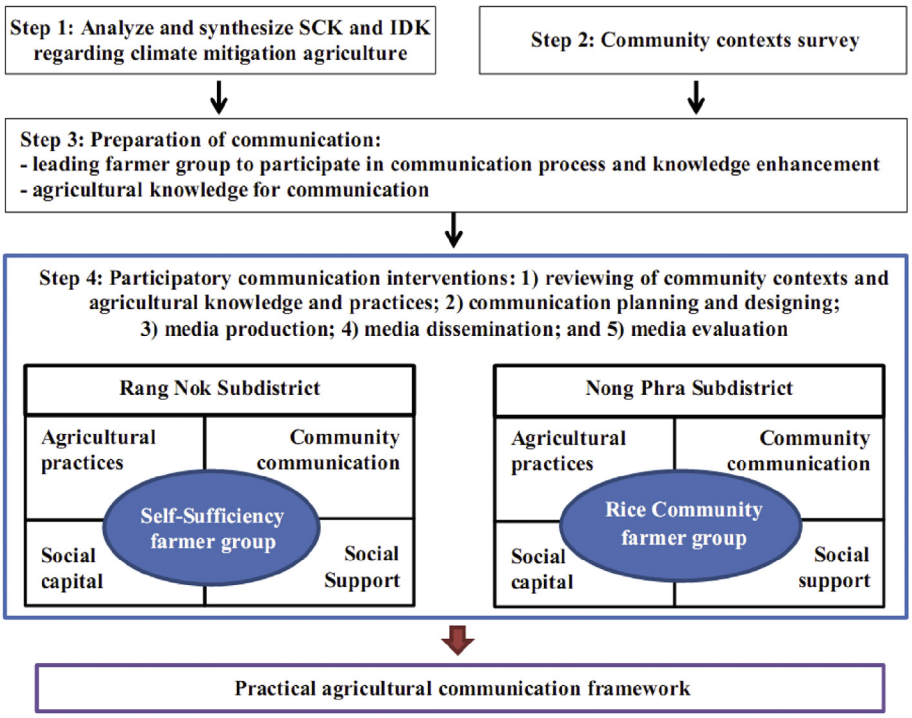

Figure 1 Analytical framework

group). Irrigation and rainfed areas can reflect different contexts of water resources for agricultural practices, for which the communication may be different. Therefore, this study can be an example for practical application in both types of areas in other places. Therefore, these areas were appropriate for analyzing the agricultural communication perspective.

Data Collection and Analysis

Documentary research was completed by analyzing the various types of media used to disseminate knowledge about climate mitigation agriculture. Purposive sampling was used in this study by considering the participants who were experienced or interested in climate mitigation agriculture and who played a key role in communication in a local community as elaborated in the following details. In-depth interviews were held with one representative from the Rice Department of Thailand, due to her direct experience, information, and ideas regarding practical methods for climate mitigation agriculture and to obtain a related governmental sector viewpoint on the issues. Six local government agencies were key informants in terms of leading agricultural knowledge and information, monitoring and empowering local farmers, and launching the strategies. Of these six, two informants were from the provincial level being one senior staff member of the Phichit Provincial Public Relation Center and the director of the Phichit Land Development Station, and four informants from local administration and local agriculture from both subdistricts: 1) Chief Executive of Rang Nok subdistrict, 2) Chief Executive of Nong Phra subdistrict, 3) Chief of Sam Ngam District Agricultural Extension Office, and 4) Chief of Nong Phra District Agricultural Extension Office. For the focus group discussion, the participants were invited via local leaders and a local broadcasting tower relying on voluntary based attendance. Therefore, 44 and 20 farmer representatives from Rang Nok and Nong Phra Subdistricts, respectively, participated in the focus groups. The discussion issues covered local agricultural and communication contexts, opinions and suggestions for participatory media planning process, and interest and willingness to attend the local participatory communication process. These discussions resulted in a team of selected members established for the participatory communication mission. Additionally, study sites surveys with non-participatory observation to understand the local agricultural and communication contexts were held. All data obtained were compiled, transcribed, and categorized into different themes based on the study goal. Content analysis and synthesis were completed to develop the practical agricultural communication framework for climate mitigation.

Results and Discussion

Communication Patterns of Climate Mitigation Agriculture

Based on the literature review and participatory action research process, the communication patterns can be divided into three main phases (Figure 2). This communication tool is different from others such as the process for communication for technology transfer in agriculture suggested by Ray, Axtell, and Porter (n.d.) and the process for communication in agricultural development in Pakistan

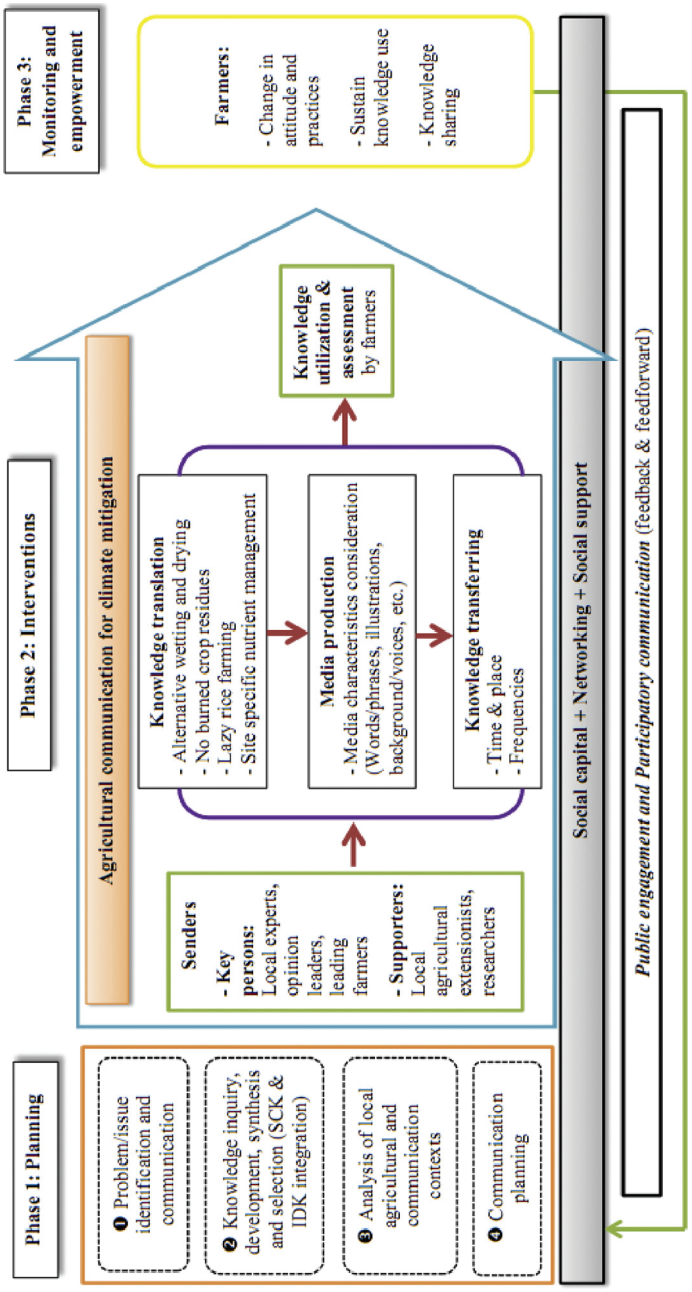

Figure 2 Practical agricultural communication framework for climate mitigation
Source: Adopted from Ray et al. (n.d.)

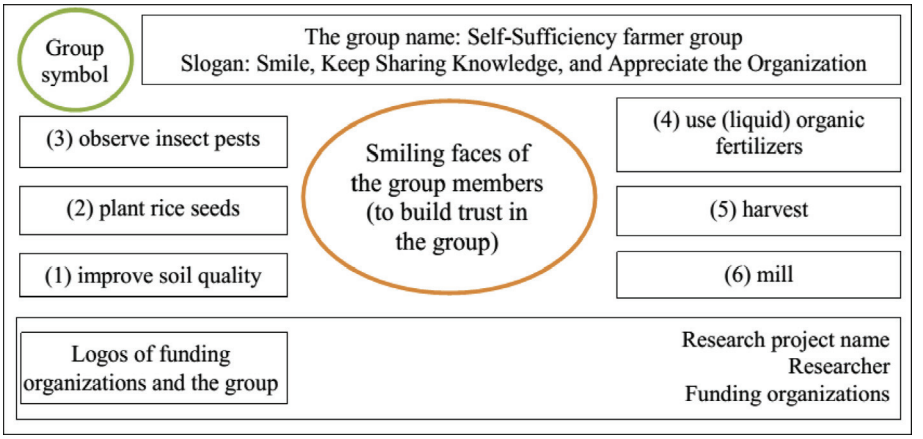

Figure 3 Communication material designed by the local people in Rang Nok

by Uddin (2016), and is essential for communicating climate mitigation. The components cover the communication elements of sender, message, channel and receiver. There are three phases of practical agricultural communication for climate mitigation: planning, intervention, and monitoring and empowerment. The measures of success for this kind of communication can be reflected by changes in attitude and practice, sustained knowledge use, and knowledge sharing among the target local farmers. This communication tool is outstanding compared to the previous tools used in agricultural practices because it is derived from the local participatory process. The local farmers who participated in the communication process shared a feeling of ownership of the communication contents due to closely involving their livelihood. The farmers also benefited from the healthy life and environment from the impacts of communication, because their agricultural practice changed to be more environmentally friendly.

The layout of the vinyl banners from Rang Nok subdistrict and Nong Phra subdistrict are presented in Figures 3 and 4, respectively.

Communication Guidelines for the SCK Regarding Rice Farming to Mitigate Climate Change

Use the Participatory Communication Strategy Developed and Implemented by Local Farmers to Mitigate Climate Change

The collaboration of farmers from both subdistricts in the communication mission—starting from determining the key communication message, and creating the content and graphics on the vinyl banner, to distributing and displaying the banner and measuring effectiveness of the project—is part of the participatory communication strategy that was developed and implemented by farmers in the community for themselves and their fellow farmers. In addition, the participatory communication model and the ritualistic model (Pengprang & Kaewthep, 2006) were used as foundations to the research by the researcher, in cooperation with representatives from the Rang Nok Subdistrict Administrative Organization (Rang Nok subdistrict) and those from the Rice Community farmer group (Nong Phra subdistrict). In this study, the researcher played a facilitating role in planning and implementing the participatory communication strategy, as well as building and promoting a democratic relationship while encouraging knowledge sharing activities to take place. This allowed the farmers to realize the importance of communication as a tool to promote understanding and awareness and to make behavioral changes in the community. In addition, the fact that local farmers took part in this communication project to tell the story of their own community has made them feel even more engaged as the message being sent was directly related to their way of life—especially when the senders are farmers within their community who are known for their success in implementing a farming method that is more friendly to the environment and farmers at lower costs. In the future, if the farmers would like to undertake communications for agricultural development, they could follow the guidelines suggested in this research. More importantly, the knowledge they have learned from this project will serve as a valuable social asset that will allow them to sustain their community development in the long run. The components of participatory communication include sender, message, channel and receiver, each of which should have the following characteristics.

Farmer Leaders: Message Senders Who Are Eager To Learn About the Farming Method That Is Environmentally Friendly and Good for Farmers with Lower Costs. Farmers who will serve as senders of the message to persuade other farmers to change their farming method and turn away from using chemicals (for greater yield) and burning straw (for earlier start of the next season) should be successful farmers or "models" that are trusted by other farmers (Kaewthep, 2006). In this study, farmer leaders who served as message senders for the entire group of participating farmers had these corresponding characteristics: they are always eager to learn new things and usually have tried a number of ways until they find the farming method that they were looking for, a method that gives greater yield at lower costs with less use of chemical insect pest killers and without burning straw, which makes farmers themselves healthier. These farmers do the same thing: they do not burn rice straw but compost it. Most of them use the alternative wetting and

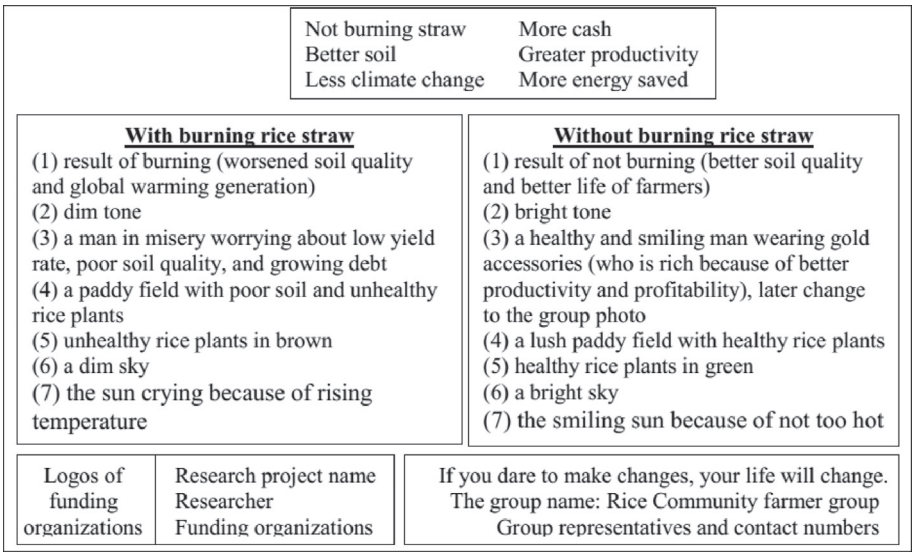

Figure 4 Communication material designed by the local people in Nong Phra

drying technique while only a few of them use tailor-made fertilizers as, for the latter, there are limitations on tools or technology or both that prevent farmers from utilizing them by themselves. Rather, when they turn to this farming method to mitigate climate change, the benefits that they earn are easily measurable (with clear amounts regarding income and costs saved), and their rice quality is high, making it sought after in the market and by consumers. These characteristics of the senders are also described in relevant studies on human media and communication networks as contributing to the credibility of a human media which takes a long time to build, results from power relations, often gets tested based on real-world performance, and grows from self-promotion. As human media, the senders who are suitable for agricultural communication need neither speaking skills on an official stage nor official social status, but instead, they need to be homophilic to gain trustworthiness, have a full understanding of their agricultural practice, and are ready to discuss it.

Knowledge from First-Hand Experience of Senders. Both groups of farmers in this study have tested their own methods of farming many times until they are certain about the positive results on their health, paddy field, and environment, so they selected these farming messages for dissemination.

Creation of the Right Media for Target Group. The right media for dissemination of knowledge, information, techniques, and guidelines on how to cultivate rice and mitigate climate change varies from one target group to another depending on the local context of each community. Illustrations should complement the written message by making it easier to understand and giving vivid examples of how to employ the farming technique that should be interesting and eye-catching, making the content more detailed and inviting. Any written message should be concise and easily understandable. After designing the message, both groups have come up with receiver-centered messages to make sure that they would be able to hit the target.

Combine the Strengths of Scientific Knowledge and Indigenous Knowledge for Rice Farming to Mitigate Climate Change

Knowledge that is to be communicated to promote farming methods that ease climate change should be drawn and designed based on the combined strength of scientific knowledge and indigenous knowledge. The alternative wetting and drying technique is an example of the combination of scientific knowledge and indigenous knowledge, developed from the observations that farmers from Rang Nok subdistrict made in their own paddy fields between two types of land: wet and wet/dry. Such observations have led to the conclusion that rice plants grow better and faster and are less disturbed by insect pests in wet/dry land. They consulted one another in small groups to collect more data and made further observations to find out when the paddy field should be wet and when it could be dry until they became certain that the paddy field could be left dry sometimes. As a result, they shared this knowledge within their group and have utilized this technique since then. Later, the government agencies started working in coordination with academic institutions to promote the alternative wetting and drying technique among farmers. They pointed out the benefits of this technique while also providing scientific explanations to farmers on how the technique works. This combined use of scientific knowledge and indigenous knowledge has made the farmers feel more confident in implementing the technique on their paddy fields, as well as distributing the knowledge to and sharing their experience with their fellow farmers after the technique has proved to be water-saving, cost-saving, and productivity-enhancing.

Another example is the integration of using the tillage with residue incorporation and the use of liquid organic fertilizer with the aim to accelerate decomposition and add organic matter to the soil. Since the farmer leaders adopted

this new method, they observed changes in soil condition and rice yield and found that fermenting the rice straw instead of burning it results in a loamy soil which can be felt by setting foot on it, and that their rice plants have grown stronger, are less likely to fall over, and they are faced with fewer insect pests, compared to the burning-rice straw technique. With the scientific knowledge provided by agricultural experts and personal observations, the farmers are much more confident in the technique of composting rice straw instead of burning it.

Strengthen the group(s) of farmers to Drive the Community

Apart from technical and financial support from outside the community, establishing farmer groups and strengthening them through knowledge sharing processes, as well as cooperating to help members cope with challenges on a regular basis are key to driving and sustaining the economic growth of a community. This idea is in agreement with the notion of community empowerment by Israel, Checkoway, Schulz, and Zimmerman (1994). In addition, the farmers in the study area have made combined use of scientific knowledge and indigenous knowledge to come up with a new farming method that brings positive effects to the community, which is a way of empowering the community.

Promote Social Support Factor

According to Heaney and Israel (2002), social support does play a crucial role, which was the case in the project involving the farmer groups from Rang Nok subdistrict and Nong Phra subdistrict. Social support may come in different forms: information support, instrumental support through activities such as workshops, training programs, field demonstration, and in-class learning, emotional support through recognition, and appreciation for the combined use of scientific knowledge and indigenous knowledge. As an example, appraisal support gives feedback or affirmation or both concerning the results of implementation. Some farmers from Rang Nok subdistrict talked about their best impression of finding the effective farming practice of leaving the field under wet/dry conditions (as mentioned above regarding the combination of SCK and IDK) and sharing with their group members. The group leader, thus, explained about the technique, citing scientific knowledge and pointing out the benefits of the technique which had already been tested with agricultural experts. They also went on to admire how the group has managed to employ the method without straw burning, to compost rice straw, and to use herbs to repel insect pests.

Conclusion and Recommendations

The agricultural sector plays roles in GHGs emission and CO_2 absorption, so it is supportive for a community to reduce GHGs by advancing agricultural communication. This study explored a practical agricultural communication framework for climate mitigation by utilizing the qualitative research methods of documentary research, focus group discussion, in-depth interview, and community-based participatory communication covering both SCK and IDK. The concepts of science communication, integrated knowledge translation, and participatory communication were employed to frame and propose a participatory agricultural communication model for practical climate mitigation. The key findings showed that SCK and IDK can be mutually beneficial. The communication patterns of climate mitigation agriculture can be divided into three main phases: 1) planning, 2) interventions, and 3) monitoring and empowerment. The main senders were the successful farmers employing the farming practices of not burning rice residues, using rice straw compost, and alternative wetting and drying. The messages were related to their farming practices, focusing on a practical and understandable message and graphical explanations. Vinyl banners were selected as a communication material to make the message the most noticeable areas in their communities. The communication guidelines for the SCK on rice farming to mitigate climate change were: using the participatory communication strategy; a combination of the strengths of SCK and IDK; strengthening the groups of farmers to drive the community; and promotion of the social support factor. This research identified three tasks to improve agricultural communication for climate mitigation: the promotion of knowledge management, increased knowledge on agricultural systems and ecosystems regarding rice farming, and consideration of multimedia implications.

Recommendations for Agricultural Communication to Mitigate Climate Change

1) Knowledge management—which ranges from goal setting and knowledge sharing, to recording and the distribution of knowledge—is a powerful tool to empower the farmer group or network, allowing them to have the necessary and enhanced knowledge to use and share with their fellow farmers and to improve the efficiency of their farming methods to mitigate climate change.

2) Local farmers should be knowledgeable about agricultural systems and ecosystems regarding rice farming to be able to integrate the practice of climate mitigation agriculture into their daily lives.

3) An agricultural communication network needs to be developed to mitigate climate change via multimedia and involving human media, a group or network of farmers, local authorities, the local administrative organization, community media, smartphones and the Internet. Human media, particularly farmer leaders or smart farmers or both who are close to their community can act as intermediaries to persuade their fellow farmers to try the new farming techniques to mitigate climate change. An established group or network of farmers, coupled with strong group activities such as frequent knowledge sharing activities, has allowed farmers who serve as human media to effectively share and disseminate the knowledge with their fellow farmers in the neighborhood, which could expand to cover a wider network of farmers.

In addition, a simple information technology system should be incorporated with the Internet and mobile

networks with the aim of making it easier for farmers to access the knowledge at reasonable costs (most probably via their smartphones). A government agency should take charge of building this support system and its connection with mobile network providers, as well as promoting the system among the public in order to enable full use of the system by everyone. The government agency should also work to monitor and evaluate the quality of the system, measure the satisfaction levels of users, and listen to farmers' suggestions on how to improve the system and respond to users' needs. As the Internet is of great use to groups or networks of people who frequently share their knowledge in their group, it is still helpful when some farmers who are not good at technology can still learn from their group and ask their fellow farmers who enjoy using the technology in their casual talk. In the meantime, any government agencies whose responsibility includes agricultural promotion should work together with academics, researchers, and the private sector who are interested in agricultural promotion to collect, categorize, and manage the body of knowledge (both scientific knowledge and indigenous knowledge) on agricultural practices that helps to mitigate climate change in order to be able to implement the systematic communication of the knowledge. The body of knowledge should include solutions to everyday challenges as well as addressing crises in rice farming, which could be the result of climate change, and it should also be constantly developed to keep up with the ever-changing climate and disseminated through channels that were discussed earlier.

Conflict of Interest

There is no conflict of interest.

Acknowledgments

This work was supported by the Thailand Research Fund (TRF) and Mahidol University, grant number: TRG5880123. Moreover, the authors would like to thank the reviewers for their comments to improve this manuscript.

References

Arunrat, N., & Pumijumnong, N. (2017). Practices for reducing greenhouse gas emissions from rice production in northeast Thailand. *Agriculture, 7*(1), 4.

Arunrat, N., Pumijumnong, N., & Hatano, R. (2017). Practices sustaining soil organic matter and rice yield in a tropical monsoon region. *Soil Science & Plant Nutrition, 63*, 274–287.

Arunrat, N., Wang, C., & Pumijumnong, N. (2016). Alternative cropping systems for greenhouse gases mitigation in rice field: A case study in Phichit province of Thailand. *Journal of Cleaner Production, 133*, 657–671.

Cannon, K. J., Specht, A. R., & Buck, E. (2016). Agricultural communications programs: A national portrait of undergraduate courses. *Journal of Applied Communications, 100*(1), 22–32.

Challinor, A. J., & Wheeler, T. R. (2008). Crop yield reduction in the tropics under climate change: Processes and uncertainties. *Agricultural and Forest Meteorology, 148*, 343–356.

Felt, L. J., Dura, L., & Singhal, A. (2014). Cultural beacons in health communication: Leveraging overlooked indicators and grassroots wisdoms. In D. K. Kim, A. Singhal, & G. L. Kreps (Eds.), *Health communication: Strategies for developing global health programs* (pp. 334–351). New York, NY: Peter Lang.

Fischhoff, B. (2013). *The sciences of science communication*. Retrieved from http://www.pnas.org/content/110/Supplement_3/14033.full.pdf.

Gadgil, M., Berkes, F., & Folke, C. (1993). Indigenous knowledge for biodiversity conservation. *Ambio, 22*(2–3), 151–156.

Gagliardi, A. R., Berta, W., Kothari, A., Boyko, J., & Urquhart, R. (2016). Integrated knowledge translation (IKT) in health care: A scoping review. *Implementation Science, 11*(38), 1–12.

Heaney, C. A., & Israel, B. A. (2002). Social networks and social support. In K. Glanz, B. K. Rimer, & F. M. Lewis (Eds.), *Health behavior and health Education: Theory, research, and practice* (pp. 185–199). San Francisco, CA: Jossey-Bass.

Howden, S. M., & O'Leary, G. J. (1997). Evaluating options to reduce greenhouse gas emissions from an Australian temperate wheat cropping system. *Environmental Modelling & Software, 12*(2–3), 169–176.

Israel, B. A., Checkoway, B., Schulz, A., & Zimmerman, M. (1994). Health education and community empowerment: Conceptualizing and measuring perceptions of individual, community control. *Health Education Quarterly, 21*(2), 149–170.

Kaewthep, K. (2006). *Agricultural communication in Thailand: The overview of research projects during 2001–2004*. Bangkok, Thailand: Thailand Research Fund (TRF). [in Thai]

Maelinda, D., & Noorlidah, A. (2008). Antioxidant from maize and maize fermented by *Marasmiellus* sp. as stabiliser of lipid-rich foods. *Food Chemistry, 107*(3), 1092–1098.

Magadza, C. H. D. (2000). Climate change impacts and human settlements in Africa: Prospects for adaptation. *Environmental Monitoring and Assessment, 61*(1), 193–205.

Pan, G. X., Zhou, P., Li, Z. P., Smith, P., Li, L. Q., Qiu, D. S., et al. (2009). Combined inorganic/organic fertilization enhances N efficiency and increases rice productivity through organic carbon accumulation in a rice paddy from the Tai Lake region, China. *Agriculture, Ecosystems & Environment, 131*(3–4), 274–280.

Pengprang, K., & Kaewthep, K. (2006). Participatory communication: From concept to practices. *Communication Arts Journal, 23*(3–4), 66–77. [in Thai]

Prabnakorn, S., Maskey, S., Suryadi, F. X., & Fraiture, C. D. (2018). Rice yield in response to climate trends and drought index in the Mun River Basin, Thailand. *The Science of the Total Environment, 621*, 108–119.

Ray, H., Axtell, J., & Porter, D. (n.d.). The agricultural communication process. Retrieved from http://pdf.usaid.gov/pdf_docs/PNABE456.pdf.

Rowe, G., & Frewer, L. (2005). A typology of public engagement methods. *Science, Technology & Human, 30*(2), 251–290.

Schoenhoff, D. M. (1993). *The barefoot expert: The interface of computerized knowledge systems and indigenous knowledge systems*. Westport, CT: Greenwood Press.

Shrestha, S., Chapagain, R., & Babel, M. S. (2017). Quantifying the impact of climate change on crop yield and water footprint of rice in the Nam Oon Irrigation Project, Thailand. *The Science of the Total Environment, 599–600*, 689–699.

Singhal, A., & Rattine-Flaherty, E. (2006). Pencils and photos as tools for communicative research and praxis: Analyzing Minga Peru's quest for social justice in the Amazon. *International Communication Gazette, 68*(4), 313–330.

Uddin, M. (2016). The role of communication in agricultural development in Pakistan. *Media Asia, 17*(2), 59–69.

Wassmann, R., & Dobermann, A. (2007). Climate change adaptation through rice production in regions with high poverty levels. *Journal of SAT Agricultural Research, 4*(1), 1–24.

West, T. O., & Post, W. M. (2002). Soil organic carbon sequestration rates by tillage and crop rotation: A global data analysis. *Soil Science Society of America Journal, 66*, 1930–1946.

Wilby, R. L., Whitehead, P. G., Wade, A. J., Butterfield, D., Davis, R. J., & Watts, G. (2006). Integrated modelling of climate change impacts on water resources and quality in a lowland catchment: River Kennet, UK. *Journal of Hydrology, 330*(1–2), 204–220.