Kasetsart Journal of Social Sciences 39 (2018) 414–421

Contents lists available at ScienceDirect

Kasetsart Journal of Social Sciences

journal homepage: http://www.elsevier.com/locate/kjss

Indicators for assessing social-ecological resilience: A case study of organic rice production in northern Thailand

Chaiteera Panpakdee [a, *], Budsara Limnirankul [b, 1]

[a] Center for Agricultural Resource System Research (CARSR), Faculty of Agriculture, Chiang Mai University, Chiang Mai 50200, Thailand
[b] Department of Agricultural Economy and Development, Faculty of Agriculture, Chiang Mai University, Chiang Mai 50200, Thailand

ARTICLE INFO

Article history:
Received 10 February 2017
Received in revised form 23 May 2017
Accepted 5 July 2017
Available online 23 July 2017

Keywords:
assessing resilience,
organic rice production,
resilience indicators,
social-ecological resilience,
technography

ABSTRACT

Resilience seems to permeate sustainable development discourse since its concept has been defined as a system's ability to adapt with change of all kinds. However, assessing a specific system's resilience requires a specific index as well, because the nature of resilience greatly relies on temporal and spatial scales. In this paper, the researchers present a set of indicators built using 53 organic farmers in four districts of Chiang Mai province. The farmers were selected using snowball sampling and were interviewed and observed iteratively regarding guidelines of social-ecological resilience in agro-ecosystems and technography, respectively, identifying components and features required to deal with the dynamic changes in organic rice production. The acquired data was then analyzed using qualitative data analysis, verifying the conceptual density, and converting the data into initial sets of codes showing the attributes relevant to the resilient properties. Consequently, 47 social-ecological resilience indicators were identified that are credible for serving as both quantifiable assessment and farmer guidance. These qualifications integrate the farmers' historic, technological, social, and ecological contexts, which are all vital factors for the farm's adaptation and transformation during a period of change.

Introduction

Organic rice production has always been praised because it significantly contributes to agricultural development and food security owing to the way that growing organic rice efficiently mimics the natural structure, and maximizes the reliance on farm-derived, renewable resources to achieve acceptable levels of integration amongst the humanely, environmentally, and economically sustainable systems (IFOAM, 2013). However, organic rice production is like other agricultural platforms with respect to uncertainty caused by unpredictable change to the social-ecological system.

To present how stochastic events affecting farmers in Thailand, consider the 8th National Economic and Social Development Plan (1997–2001) declaration which identified organic farming as a major theme for agricultural development. In order to achieve this goal, the government allocated a huge budget for carrying out a variety of projects concentrating on organic farming development. However, after the general election in 2011 that accompanied the establishment of a rice pledging scheme, such supportive projects had minimal instead of continuous promotion (Punyakul, 2013). Apart from the political instability which can have either a positive or negative effect, organic farming existence also relies on many factors. If change cannot be managed effectively, it may mitigate

* Corresponding author.
E-mail addresses: chaiteera.p@gmail.com (C. Panpakdee), budsara.l@cmu.ac.th (B. Limnirankul).
Peer review under responsibility of Kasetsart University.
[1] Co-first author.

http://dx.doi.org/10.1016/j.kjss.2017.07.003

the condition of long-term sustainable agriculture (Limnirankul & Gypmantasiri, 2011).

Admittedly in academic communities, there is no perfect solution that fits all agricultural problems owing to a solution depending on the agro-ecological and socio-economical contexts in which the problem is generated. A possible, effective solution is to integrate resilience in farmers' activities so they become less vulnerable. Though the way of resilience addressed has various definitions and operations, most of them share a common interest in adaptive capacity by utilizing lifelong learning and unremitting disturbance as the opportunity for development. Farmers who are thus enhanced with that quality tend to possess various location-specific alternative options to deal with change and pressures in a sustainable way. Nonetheless, building resilience against change takes time and requires a series of well-planned procedures. As recommended by Uday and Marais (2014) and Ciftcioglu (2017), developing a system's specific-context indicators is a preliminary step to monitoring and advising progress regarding that system's resilience.

There have been various aspects of organic rice production, but in Thailand, no previous study has focused on social-ecological resilience indicators to monitor the resilient degree of organic rice production. The researchers therefore realized that such study was important, and the objective was to present indicators built from organic farmers' perspectives, resulting from the farmers' pragmatic implementation of farm management.

Literature Review

The theory of resilience was first described in the annual review of ecological systems as the persistence of a system and its ability to withstand change and still maintain the original domain. However, it is difficult to let systems operate themselves and they will eventually accomplish the behaviors of stability and resistance. The systems require the capacities of learning and adaptation including a high degree of self-organization and network connectedness, which have been dubbed as the three critical characteristics to accomplish the system's controllability (Holling, 2001).

Since that article on the three characteristics to build resilience systems has been disseminated, the three characteristics have been further developed to build a framework for understanding and assessing a dynamic relationship between humans and the environment because the resilience concept takes the roles of ecological and natural dimensions including institutions, social capital, and leadership into consideration. Importantly, those characteristics have been compiled in adaptability based on incremental, iterative, and experiential processes and decision making. The resilience concept proposes a vision of sustainable development paired with a set of skills to cope with anthropogenic and natural vulnerability including catastrophic events such as temperature variation, rising input price, and human trends (Jiggins & Rölling, 2000).

When a number of the studies of social-ecological systems' resilience were analyzed, Folke, Colding, and Berkes (2003) found that there are four important properties in building resilience: (1) learning to live with change and uncertainty; (2) nurturing diversity in its various forms; (3) combining different types of knowledge and learning; and (4) creating opportunity for self-organization and cross-scale linkages. The four properties' processes encompass practices and social mechanisms which interact with each other across temporal and spatial scales to prevent resilience loss (Brunner & Regamey, 2016). Therefore, this qualification is not only applied quantitatively, but also to guide the sustainable way of reducing vulnerability through adaptation and transformation during a period of dynamic change.

Methodology

Study Area and Sample Size

The study was carried out during June 2015 to May 2016 in four of Chiang Mai province's districts (Mae Rim, Mae Taeng, San Sai, and Phroa) where organic rice production is predominant (DOAE, 2013). Fifty-three organic farmers were selected using snowball sampling to provide the data. This method helped us to ensure that all informants were small-scale, semi-subsistence farmers who were representative of most Thai farmers (McConnell & Dillon, 1997), and had the range of knowledge to develop indicators through participatory processes (Babbie, 2001).

Data Collection

The meaning of resilience is frequently associated with scientific terminology, and has been considered difficult for ordinary people to understand. The farmers in this study were thus informed of the details about resilience concepts and dimensions and the expected outcomes. The semi-structured interviews began with asking the farmers to indicate a desirable version of organic rice farm that they considered had the capability of resisting and adapting in an active way to dynamic changes in both sudden and long-term events. Then the desired format had to be coupled simultaneously with the components and in-depth descriptions that could help sustain their farm's identity, functions, and structures.

To capture more components particularly relevant to adaptations, the behavior-based indicators in agro-ecosystems (Cabell & Oelofse, 2012), and scenario analysis based on plausible disturbances (Enfors, Gordon, Peterson, & Bossio, 2008) were applied to formulate strategic questions. The farmers were requested to describe their farm history and to offer a vision of the implementation of adaptations were their farm to be affected by the indeterminate future simulation, for example: “Why do you use organic rice production?”, “Do you have more plans in order to achieve the state of the desirable farm?,” “From your memory, which factors and constraints caused change to the farm?” and then “Which strategies were adapted to enable the farm to undergo those changes?” These questions and the responses can be used to develop social-ecological resilience indicators. The practices implemented on-farm are in a theoretically dynamic progress, which is established from interactions between social and natural forces, and has an assumed linkage with knowledge to deal with difficult events in organic rice production (Darnhofer, 2010).

Lastly, to ensure that none of the components confounded the approach, especially the interactions between farmers and technological usage, technography (Jansen & Vellema, 2011) was simultaneously conducted during the interviews. All collected fieldwork data were recorded and notes taken. This process was continued until the empirical saturation of results had been achieved.

Data Analysis

The interviews and the observations were recorded and notes taken. These data were transcribed into descriptive and reflective data that were suitable for converting into useful meaning of units following three procedures of qualitative data analysis: (1) data reduction; (2) data display; and (3) drawing conclusions (Miles & Huberman, 1994).

Based on the first two processes, the descriptive and reflective data were analyzed in detail, and assigned into the initial sets of codes displayed by mind maps, showing the components relevant to the resilience attribute in agroecosystems. Then the sets of codes were analyzed to sort out the complicated data, and aggregated into the classified codes of the same qualifications. In the third procedure, the groups of the classified codes, which were already organized in the same groups of resilient components, were verified and classified regarding the four vital properties of resilience (Folke et al., 2003), as classifying in that way not only interacts across temporal and spatial scales, but also favors recommending farmers to require strategies that must be responsive to change. In this study, the outcomes of the collected data were called social-ecological resilience indicators (SERIs).

Results

There were 47 SERIs obtained from the data analysis: Eleven SERIs were grouped into the 1st vital property of resilience, while the 2nd, 3rd, and 4th properties contained 10, 15, and 11 SERIs, respectively (Table 1). Following are details based on the researchers' interpretation summary to indicate the four properties' focus area that farmers should consider, and to identify how these operate in building resilience, which was the expected goal of our study.

Learning to Live with Change and Uncertainty

This property relates to each individual's qualities needed to capabilities and perceptions on adaptation and flexibility. Therefore, most of the SERIs proposed by the participating farmers were composed of essential factors and strategies for self-empowerment in both the short and long term.

In the short period, the farmers acutely recognized the power of education from both formal and non-formal platforms, as well as gender equality in accessing education as required. More educated farmers are potentially able to perform better in decision making and farm management than others who are less educated, as the former are theoretically capable of broadening their minds to new knowledge, skills, and opportunities.

To maintain long run learning, however, education must be conducted in an enthusiastic and constant fashion called inquisitive mind for lifelong learning (IMLL). Inquisitive mind and lifelong learning complement each other, since lifelong learning in dealing with change requires the motivation of an inquisitive mind. Therefore, IMLL is critical for building farmers' resilience; it allows the farmers to acquire a variety of adaptations stimulated by their mental capacity, which will consistently generate learning behavior for new things. In addition, natural capital such as land tenure and basic farm tools were suggested as an indispensable part to complement the educational opportunity through self-learning and on-farm experimentation. If the farmers were unable to own these assets, they would be confronted with many restrictions to develop their learning in preferable ways.

Nurturing Diversity in its Various Forms

According to the reviewed literature, nurturing diversity is always cited as one of the three key properties of all resilient systems (Holling & Gunderson, 2002). This property offers a kind of buffer capacity, which can help a system undergoing change to maintain its identity, functions, and structures by providing a number of alternatives to manage shocks and stresses (Darnhofer, 2010). In the current study, nurturing diversity has implications for economic, financial, social, and ecological contexts.

From the economic viewpoint, its definition is relevant to building alliances for establishing cooperative networks in order to increase the chance of selling products. Collaborative networks of either governments or partner companies are considered useful to help farmers strengthen their robustness to change by supplying necessary support such as inputs, information, trading, knowledge, and technologies in needed time. A shortcut to establish a resilient farm is gaining an organic certificate and a guaranteed maximum price advocated by partner institutions. Such a financial promise of contract farming is advantageous since it ensures following a set plan and investment in both necessarily basic and advanced farm tools. This is to attain future viability and to provide their living during the recovery period of the farming timescale.

Regarding ecological contexts, growing diverse rice varieties was congruently recommended, reasoning that farm specialization is serious case of declining biodiversification and food security resilience. An example is that the rice consumption behavior of northern people generally varies with age and personal preference. The elders prefer consuming local glutinous rice due to its flavor and high amount of production yield in comparison with other sourced rice varieties. In fact, such local rice varieties have virtually disappeared from the study areas due to market demand. Consequently, a huge reduction in the household's food security and ecological abundance leads to the lack of its regionally adapted characteristic for

Table 1
List of social-ecological resilience indicators of organic rice production (SERIs)

Resilience property	Component	SERI	What to consider
Learning to live with change and uncertainty	Being prepared themselves for unpredictable events	1. Educational level	▪ Degree of educational accomplishment
		2. Rice farming experience	▪ Number of active years in both organic and conventional rice production
		3. Occupational skills	▪ Number and degree of required skills to accomplish the on-farm tasks
		4. Gender equality	▪ Degree of women involvement in educational equality and decision making
	Reasonable investment to reduce risk	5. Investment in farm assets	▪ Number of investments in farm equipment and kinds of risk management e.g. social security insurance and health insurance
		6. Investment in basic farm equipment	▪ Number of units of basic farm equipment
	Know how to use familiar resources	7. Utilization of ecological services	▪ Number and degree of benefits gained from ecological services
		8. Additional exploitation of existing water resources	▪ Number of strategies used to exploit greater benefits from existing water resources e.g. surface and ground water irrigation
	Being open minded and willing to make changes on the farm	9. Inquisitive mind for lifelong learning	▪ Degree of collective action, trust and solidarity in the society, number of accessible social networks for participation and types of media (newspaper, TV, radio, ICTs), number of household members involved in farming and/or social networks
		10. Organically oriented mindset	▪ Switch to organic rice production must be driven by either health or environmental concerns, not economic income
		11. Land tenure	▪ Percentage of land use holding
Nurturing diversity for reorganization and renewal	Diversity of bio-diversification	12. Diversity of plant species	▪ Number and variety of planted crops e.g. food crops, herb, firewood, construction timber, natural insecticide crops, degree of important plant protection
		13. Diversity of rice varieties for production	▪ Number of planted rice varieties
	Diversity of economic opportunities	14. Diversity of income sources	▪ Number of income sources considering both on and off-farm
		15. Diversity of marketing channels	▪ Number and type of accessible markets e.g. market organized by farmers, market organized by civil institutions, and market organized by partner companies, and the distance between the farm and key markets within the province
		16. Ownership of guaranteed price and organic certification	▪ Ownership of guaranteed price and organic certification
		17. Given honorific address	▪ Number and type of honorific addresses given from institutions
	Diversity of resources	18. Diversity of water resources	▪ Number and degree of usable water resources
		19. Diversity of credit sources	▪ Number with accessibly legal credit sources, and number with debt

(*continued on next page*)

Table 1 (*continued*)

Resilience property	Component	SERI	What to consider
			independence from those legal credit sources
	Diversity of information sources	20. Diversity of information sources	▪ Number and degree of accessible information sources
	Diversity of partners and relationship types	21. Diversity of collaborative networks	▪ Number, type and degree of collaborative networks e.g. non-affiliated network (neighbors and fellow farmers); commodity consumer networks; governmental and university-based networks
Combining different types of knowledge for learning	Acquiring knowledge from science and indigenous knowledge	22. Knowledge designed by a bottom-up approach	▪ Number and degree of appropriate courses designed by locals
		23. Heritage of indigenous knowledge	▪ Degree of documenting and transmission of indigenous knowledge
		24. Existence of dialect and local traditions	▪ Degree of speaking local dialect to others, and degree of maintaining local traditions
	Obtaining knowledge from self-efforts	25. A variety of learning approaches	▪ Number and degree of educational platforms for learning e.g. self-study and experiments, workshops, on farm trial
		26. Obtaining knowledge through the second form of agricultural employment	▪ Ownership of the second agricultural employment, and number of benefits gained from that employment e.g. training sessions, inputs and collaborative networks
		27. Effective use of ICT	▪ Degree of accessible ICT, and number of benefits gained from the ICT e.g. time economy, more access to resources, information and knowledge
	Adaptive capacity	28. Adaptation	▪ Number of introduced adaptations into the farm, and degree of shocks and stresses solved by the adaptations
		29. Value added products	▪ Number of processed rice products
		30. Organizing financial flows with the household account	▪ Degree of recording household account/number of using the household account data for significant decision making on farm activities
		31. Reasonable farm scale	▪ Effective ratio between land used and amount of household labor
		32. Securing consumer confidence	▪ Number of strategies conducted for building loyal consumers e.g. face-to-face interaction, holding organic rice fair, public relations through printed media and labeling
	Time availability for learning	33. Being full-time farmer	▪ Having off-farm employment or not
		34. Marital status and independence of children	▪ Having a spouse to support farm activities or not, and having children who cannot take care of themselves in the household or not
	Living in the environment favorable for learning	35. Number of farming generations	▪ Number of household ancestors who produced rice

Table 1 (*continued*)

Resilience property	Component	SERI	What to consider
		36. Number of neighboring organic farmers	▪ Number of organic farmers in the community, and number of the local farmers who can potentially teach organic rice production know-how and techniques
Creating opportunity for self-organization and cross-Scale linkages	**Farm level:** Being dependent on available resources	37. Dependence on household resources	▪ Amount of household resources used to nourish the farm
		38. Self-rice seed production	▪ Dependence on self-rice seed production or not
		39. Dependence on rice and dietary materials self-produced	▪ Degree of self-production of rice and dietary materials consumed within the household
		40. Dependence on household labor	▪ Percentage of household labor used on farm activities
		41. Rice field location	▪ Degree of exposure caused by nearby chemicals and non-agricultural sector to rice fields
	Community level: Co-usage of livelihood assets	42. Co-operative farming	▪ Type of assistance obtained from collaborating with networks e.g. bargaining power and avoiding economic pressures
		43. Knowledge exchange through networks	▪ Number of accessible networks for knowledge exchange/degree of knowledge learned efficiently through the networks, number of methods used for knowledge exchange e.g. knowledge exchange within or via cross networks
		44. Dependence on locally productive inputs	▪ Degree of using productive inputs either sold or produced at the local
		45. Dependence on local food systems	▪ Degree of locally sourced food consumed within the household
		46. Mutual labor exchange	▪ Degree of using mutual labor exchange to produce organic rice
	Cross-scale level: Opening up networks with the governments	47. Favorable support from the governments	▪ Degree of satisfaction with central and local government supports in required aspects of producing organic rice

protecting rice farms against crop diseases and pest outbreaks (Di Falco & Chavas, 2008).

Combining Different Types of Knowledge and Learning

It is apparent that knowledge is indispensable for resilience, because strategic implementations in the forms of farm-care and business plans, including suitable decisions and solutions, are unlikely to conquer the intended results in the end where farmers have no knowledge to use as the fundamental to develop those strategies (Gallopin, 2006).

In this study, many ways were identified to learn knowledge. Besides formal education through training, seminars, and information and communication technology (ICT), knowledge was delivered through indigenous knowledge. Indigenous knowledge is considered outdated and unlike scientific knowledge which can provide an apparent outcome of testable explanations. However, according to the farmers, indigenous knowledge is still a valuable legacy for producing organic rice, because it was built upon practical knowledge of past experience, and delivered from previously skilled generations. Consequently, it provides a set of no charge-adaptations based on location-specific actions which are more favorable for dissemination and implementation amongst people in that community.

In addition, being an employee of agricultural organizations is seen by us as another critical ingredient of resilience building owing to the farmers having the potential to obtain overall-good assets for building resilience where they grow organic rice and simultaneously work in a second form of agricultural employment, for example, as local soil scientists. In this case, what they get paid was not only for training sessions, but also for other kinds of services and cooperative networks. These advantages, particularly the development of new knowledge, affect not only those local soil scientists, but include their neighboring farmers. Practically and theoretically, it is an advantage if an organic farmer is surrounded by other proficient organic farmers. Seeing their neighbors applying adaptations, motivate these farmers to try new things, especially if the adaptations are noticed as having positive consequences.

Importantly, knowledge enhancement involves both quantitative and qualitative matters, so the methodology for learning and training should be designed using a bottom-up approach, which allows farmers in different agricultural systems to develop a specific set of knowledge based on their social-ecological contexts. For example, in this study, foreign languages were suggested by those farmers who have done direct marketing at toxic-free organic markets. They considered that doing their organic rice businesses in Chiang Mai, which is a prime tourism destination for international visitors, would be greater if they could speak either English, Japanese, or Chinese.

Creating Opportunity for Self-organization and Cross-scale Linkages

This property involves farmers' self-organization capacity at various levels in order to find innovative solutions to address the farm's negative effects resulting from external factors such as changing policies, price fluctuations, and extreme climatic variations (Tilt, 2016). In this study, the SERIs belonging to the fourth property are comprehensive. The levels of farm, society, and policy for growing organic rice are embedded in both agro-ecological and social-ecological systems.

At the farm level, the self-organization capacity resulted from the farmers' endeavor to apply both household and communal resources in enriching the farms in various aspects. For example, after rice harvesting, they mulched the rice field with the stubs and straw, and then ploughed this in as no charge inputs to nourish soil fertility. Another practice observed during data collection was the self-production of rice seeds to minimize unnecessary expense. This was not only done to demonstrate their self-reliance, but also helped prevent contamination of any unwanted rice supplied from untrustworthy sources. More importantly, farmers who are capable of producing certified rice seed, can increase their revenue by multiplying the foundation seed for sale to neighbors, agricultural cooperatives, and the governmental seed centers on a contract basis.

The wider level is strongly linked to the social capital competencies, which the farmers used to create new opportunities to avoid economic pressures. An important example witnessed in this study was a Mae Taeng farming group that jointly purchased an expensive rice milling facility. According to their view, such a critical strategy not only allowed them to do what big farms can do, but also enhanced the social fabric in the farming network, leading to condensation of other connections and cooperation in the future.

At the cross-scale linkages, the governmental institutional supports are significant. It is impossible for farmers to care for the farm and achieve their defined goals without the support of other labor. As suggested by the farmers, the government can improve organic rice production in many ways, for example, local government should commit attentively to distribute knowledge to the farmers through the establishment of farmer field schools to complete the learning cycle. In addition, establishing sound and sensible policies is required, such as developing organic rice markets and constructing related infrastructure. Consequently, farmers would be able to permanently maintain an organic transition for self sustainability and for the nation's health and the social environment.

Conclusion and Discussion

Initially, we were aware that attempting to assess resilience directly is similar to shooting at a constantly moving target, as the nature of resilience involves dynamic spatial and temporal contexts including multi-dimensional operations (Carpenter, Walker, Anderies, & Abel, 2001). Therefore, to make the study outcome more useful, the SERIs were built with the aim of notifying organic farmers and stakeholders of the apparent actions and factors available for building organic rice production resilience using a qualitative-oriented method. The results provide a pathway toward other types of agricultural production with not only the indicator framework based on resilience theories, but also a suitable approach of indicator development to monitor a system's bounce-back ability as it bridges the gap between farmers and the vital components of the social-ecological system.

Yet, our SERIs do not abandon quantitative assessment, but its application is required to be used with suitable complements owing to the need to be context-specific of resilience. For example, the SERIs about spatial contexts should be used with regard to how farmers in a farm system insulate their own ecosystem services and relevant vital components against change. In general, it includes a number of natural resources and a variety of diversity existing within the agro-ecosystem boundary. Such a way has been recommended, and pragmatically proven in acquiring reliable scaling responses to employ reliable questionnaires to assess the resilience of farm systems (Van Oudenhoven, Mijatovic, & Eyzaguirre, 2010).

The other scaling responses of SERIs, which are complicated and difficult to obtain a consensus on among the system owners, are paired with appropriate theories to identify the best outcome. In this study, an example of the indicator of inquisitive mind for lifelong learning belongs to the first property of resilience (Folke et al., 2003); we decided to match this indicator with the framework of LifeLong Learning for Farmers (L3F) (Thamizoli, Francis, Balasubramanian, Soundari, & Kamaraj, 2011). However, some of the L3F concepts, such as gender inequity in education were partly adapted based on the observations, because Thailand has apparently no such barrier to educational opportunity (Velkoff, 1998). In addition, the notion of financial capital was another part that was ignored because assessing social-ecological resilience needs to be separated from that factor which would presumably influence the response level (Bene, 2013). These endeavors were undertaken to make this indicator meaningful within the actual context, leading to precision and credibility in assessing the social-ecological resilience of organic rice production.

Conflict of Interest

There is no conflict of interest.

Acknowledgments

We are grateful to the Science and Education for Agriculture and Development Program of the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) for subsidizing the study funding.

References

Babbie, E. (2001). *The practice of social research* (9th ed.). Belmont, CA: Wadsworth Thomson.
Bene, C. (2013). Towards a quantifiable measure of resilience. *IDS Working Paper, 434*, 1–27.
Brunner, S. H., & Regamey, A. G. (2016). Policy strategies to foster the resilience of mountain social-ecological systems under uncertain global change. *Environmental Science and Policy, 66*, 129–139.
Cabell, J. F., & Oelofse, M. (2012). An indicator framework for assessing agroecosystem resilience. *Ecology and Society, 17*(1), 18.
Carpenter, S., Walker, B., Anderies, J. M., & Abel, N. (2001). From metaphor to measurement: Resilience of what to what? *Ecosystems, 4*, 76–81.
Ciftcioglu, G. C. (2017). Assessment of the resilience of socio-ecological production landscapes and seascapes: A case study from Lefke region of north Cyprus. *Ecological Indicators, 73*, 128–138.
Darnhofer, I. (2010). Strategies of family farms to strengthen their resilience. *Environment Policy and Governance, 20*, 212–222.
Di Falco, S., & Chavas, J. P. (2008). Rainfall shocks, resilience, and the effects of crop biodiversity on agroecosystem productivity. *Land Economics, 84*(1), 83–96.
DOAE. (2013). *Basic agricultural information of Chiang Mai province 2012*. Chiang Mai, Thailand: Author.
Enfors, E. I., Gordon, L. J., Peterson, G. D., & Bossio, D. (2008). Making investment in dryland development work: Participatory scenario planning in the Makanya catchment, Tanzania. *Ecology and Society, 13*(2), 42.
Folke, C., Colding, J., & Berkes, F. (2003). Building resilience and adaptive capacity in social-ecological systems. In F. Berkes, J. Colding, & C. Folke (Eds.), *Navigating social-ecological systems*. Cambridge, UK: Cambridge University Press.
Gallopin, G. (2006). Linkages between vulnerability, resilience and adaptive capacity. *Global Environmental Change, 16*, 3.
Holling, C. S. (2001). Understanding the complexity of economic, ecological, and social systems. *Ecosystem, 4*, 390–405.
Holling, C. S., & Gunderson, L. H. (2002). *Panarchy: Understanding transformations in human and natural systems*. Washington, DC: Island Press.
IFOAM. (2013). *Principles of organic agriculture*. Bonn, Germany: Author.
Jansen, K., & Vellema, S. (2011). What is technography? *Wageningen Journal of Life Sciences, 57*, 169–171.
Jiggins, J., & Rölling, R. (2000). Adaptive management: Potential and limitations for ecological governance. *International Journal of Agricultural Resources, Governance, and Ecology, 1*(1), 28–42.
Limnirankul, B., & Gypmantasiri, P. (2011). *Agricultural innovation in supporting organic rice production system of smallholder farmers in Northern Thailand* (Research Report). Bangkok, Thailand: National Science and Technology Development Agency.
McConnell, D. J., & Dillon, J. L. (1997). *Farm management for Asia: A systems approach*. Rome, Italy: Food and Agriculture Organization of the United Nations.
Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis*. Thousand Oaks, CA: Sage Publishing.
Punyakul, V. (2013). *Overview of Thai organic agriculture 2011–2012*. Bangkok, Thailand: Earth Net Foundation and Green Net Cooperative.
Thamizoli, P., Francis, H., Balasubramanian, K., Soundari, H., & Kamaraj, K. (2011). *Learning for farming initiative longitudinal study tracing the lifelong learning for farmers activities in Tamil Nadu, India*. India: Commonwealth of Learning.
Tilt, B. (2016). Dams and population displacement on China's upper Mekong river: Implications for social capital and social-ecological resilience. *Global Environmental Change, 36*, 153–162.
Uday, P., & Marais, K. B. (2014). Resilience-based system importance measures for system-of-systems. *Computer Science, 28*, 257–264.
Van Oudenhoven, F. J. W., Mijatovic, D., & Eyzaguirre, P. (2010). Social-ecological indicators of resilience in agrarian and natural landscapes. *An International Journal of Management of Environmental Quality, 22*(2), 154–167.
Velkoff, V. A. (1998). *Women of the World: Women's education in India*. Washington, DC: US Department of Commerce, Economics and Statistics Administration.