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Capacity development training workshop on crop simulation modelling and effects of climate risks on agricultural production systems in Southeast Asia

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ABSTRACT

Southeast Asia (SEA) has experienced frequent floods and droughts, posing severe challenges for farmers, agricultural scientists and extension officers. Consequently, crop modelling has become imperative in developing agricultural production systems and making informed decisions at the field level. The Decision Support System for Agrotechnology Transfer (DSSAT) can be effectively utilised at both farm and regional levels to assess the influence of climate change on production across different spatial scales. Moreover, it supports planning adaptation strategies tailored to the needs of farmers. The one-week hands-on training workshop aims to enhance technical and scientific proficiency in crop simulation modelling and evaluate the effects of climate risks on agricultural production systems in Southeast Asian countries such as Cambodia, Lao PDR, Thailand and Vietnam. A total of 62 participants from the selected countries, including Singapore and Ethiopia, were joined in the training. Among them were 48 male and 24 female individuals, comprising researchers, students, scientists, academicians and extension officers. The participants predominantly acquired knowledge of crop simulation modelling techniques by utilising existing case examples and lecture materials from the DSSAT foundation. Furthermore, the training workshops establish research networks and collaborations among the participant countries, facilitating the exchange of scientific knowledge related to innovative farm management practices and fostering interactions between local agricultural communities and scientists.

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KEYWORDS CROP MODELLING, DSSAT TRAINING, AGRICULTURAL PRACTICES, COLLABORATION, NETWORKS, SOUTHEAST ASIA

HIGHLIGHTS

- Crop modelling assists in identifying management options for maximising sustainable agricultural systems.
- Knowledge exchange between scientists, strengthening research networks and promoting regional agricultural development.
- Develop farmers' interactions with scientists to enable improved agricultural practices and mitigate climate variability and risks.

1. INTRODUCTION

Climate change poses a significant challenge to the agricultural sector, particularly in tropical areas that heavily rely on agriculture as a primary source of livelihood for countries in the Southeast Asia region, including Cambodia, Lao PDR, Vietnam, Indonesia and Thailand, where hundreds of millions of rural poor depend on agriculture as their main economic activity. Numerous studies indicate that these regions experience substantial yield losses due to climate change, particularly in rainfed and flood-prone areas, as observed in various climate change scenarios (Le Toan et al., 2021; Vinke et al., 2017; World Bank, 2013). In recent years, increased attention has been given to the risks associated with climate change and climate variability, threatening food production security (Kang et al., 2009; Kumar et al., 2022). It is crucial to prioritise research on sustainable food production systems under climate change, especially for developing countries. Changes in agricultural production as a result of climate change and climate variations can significantly impact both regional and global food production. Therefore, it is urgent to determine the impacts on crop production (Fischer et al., 2002; Gitz et al., 2016; Hoogenboom, 2000; Howden et al., 2007; Kang et al., 2009; Tao et al., 2009; White et al., 2011) to develop effective and innovative strategies.

The agricultural system models are crucial in developing sustainable land management practices in diverse agroecological and socio-economic conditions. Several crop models are integrated into decision support systems to assess alternative management practices (Tsuji et al., 1998). Field and farmer experiments require substantial resources and often need to provide sufficient information in terms of spatial and temporal coverage to identify suitable and practical management approaches (Jones et al., 2017). However, dynamic crop models are primarily available for major crops such as food, feed and fibre. The models simulate biotic stresses like pests, diseases and weeds, making them valuable for various applications ranging from on-farm management to regional assessments of climate variability and climate change impacts. Nevertheless, only a few models support precision agriculture research and practice by incorporating the heterogeneity of farmers' field conditions (Basso et al., 2013; Jones et al., 2017). The development of compatible models for multiple crops, considering historical and future weather data to predict crop yields (Bannayan et al., 2003; Chang et al., 2023; Ziliani et al., 2022), has led to the design of the Decision Support System for Agrotechnology Transfer (DSSAT) (Jones et al., 2003, 2017; Hoogenboom et al., 1994).

The DSSAT cropping model system stands out for its exceptional ability to accurately predict crop yields, assist farmers in developing long-term strategies (Tsuji et al., 1994) and support governments in agricultural planning (Hoogenboom, 2000). Moreover, it enables informed decision-making at the farm scale and helps assess the effects of strategies on the economic benefits of rural development (Heady et al., 1958; Heady & Dillon, 1964; Jones et al., 2017). The model outputs are typically compared with local experimental data to evaluate model performance and determine the genetic characteristics of local crop varieties. DSSAT can be utilised at the farm level to determine the impacts of climate change on production and identify potential adaptation practices for farmers.

It can also be employed at the regional level to assess the effects of climate change at different spatial scales, provided accurate input data are available for the specific region.

The DSSAT crop simulation modelling provides valuable strategies and technologies for building cropping systems that are more resilient to the impacts of climate change. The one-week hands-on training promotes capacity building and increased collaboration between scientists, communities and stakeholders. Consequently, the DSSAT crop modelling training workshop can help identify management options that maximise sustainable agricultural systems. However, these models are primarily used by agricultural scientists and extension officers who work with farmers and policymakers. Farmers, particularly those who are more risk-averse, may be less inclined to experiment and adopt new strategies. Therefore, crop models and their recommendations can generate further agricultural information that improves farming practices and provides efficient guidance to farmers in mitigating the risks of climate variability and other challenges.

In order to build capacity and develop risk management strategies in the Southeast Asia (SEA) region, the project aimed to strengthen agricultural adaptation and develop agronomic models that significantly benefit food systems. In contrast, strengthening adaptation capacity requires acknowledging farmers' needs and introducing targeted innovations to create resilient and sustainable agricultural production systems. The objectives to achieve this main goal are:

1. Provide a one-week hands-on practical exercise to properly use and apply DSSAT and its associated crop simulation models to solve agricultural management problems.
2. Identify appropriate and promising technologies and develop suitable strategies to make agricultural production systems profitable, sustainable and resilient using crop simulation methods.
3. Analyse farm production using DSSAT tools to verify inputs and simulate productivity.
4. Strengthen technical and scientific capabilities by enhancing collaboration between the National Agricultural Research System (NARS), policymakers, local communities and international organisations.

2. METHODOLOGY

Enhancing stakeholder capacity involves active participation, monitoring progress, analysing outcomes and implementing adaptive measures. Technical stakeholders will contribute by collecting local agricultural data for calibrating and evaluating crop models, while regional stakeholders will assess the representativeness of model results for spatial upscaling. This coordination among scientists, policymakers, NARS staff, students and local communities will enhance cropping systems. The training programme will lead to behavioural changes and improved communication of information to agricultural producers promptly. Therefore, a one-week hands-on will support significant policy reforms to address the challenges faced in the agricultural sector.

The proposed capacity development training follows a specific methodology, outlined as follows.

2.1. Target participants and selection procedure

The capacity development project involved a series of one-week training workshops held in various locations. In 2019, the first workshop took place in Vietnam, with 21 participants from 13 provinces. The second workshop was organised in Chiang Mai, Thailand, with 20 participants, including one each from Ethiopia and Singapore. The final training workshop was conducted in Bangkok, Thailand and had 21 participants from three countries: Cambodia, Indonesia and Lao PDR in 2023 (Table 1). The selection criteria for participants included their educational background, work experience in agricultural crop systems and a minimum of two to three years of professional experience in a related field. It was also essential for participants to be currently employed in universities or institutions within their respective countries, possess basic computer skills and have a good command of the English language. During the training workshops, participants had the opportunity to interact with farmers in Vietnam and engage in discussions about the challenges and issues they faced in their farm fields and crop yields. This practical interaction provided participants with real-world insights and fostered a deeper understanding of the problems encountered by farmers.

2.2. Training material and software

The participants selected for the programme receive the DSSAT software and a one-week training module that includes hands-on exercises and lectures on a range of topics such as weather, potential crop production, crop genetic coefficients, nitrogen-limited and water-limited crop production, risk evaluation, sustainability applications

TABLE 1. Year-wise DSSAT training programme in Southeast Asia.

Country	Male	Female	Total
2019			
Vietnam	17	4	21
Thailand*	4	14	18
Ethiopia**	1		1
Singapore**	1		1
Total	23	18	41
2023			
Cambodia	6	1	7
Indonesia	4	3	7
Lao PDR	4	2	6
Thailand		1	1
Total	14	7	21

Note: *, ** The workshop was a collaborative effort with Chiang Mai University. Funding from the APN-GCR project supported 15 out of the 20 Thai participants. The participants from Ethiopia and Singapore self-funded their participation in the workshop.

and sequential and spatial applications. DSSAT v4.8.2 is a software that features 42 crop simulation models and efficient data management tools. It helps simulate crop growth, development and yield by considering soil-plant-atmosphere dynamics. The updated version introduces new tools that enable users to create and manage experimental, soil and weather data files. It also includes enhanced application programmes that allow seasonal, spatial, sequence and crop rotation analyses. These analyses help assess economic risks and environmental impacts related to irrigation, fertiliser management, climate variability, soil carbon sequestration and precision management.

2.3. Experimental data

A minimum dataset of experimental data is required for the hands-on exercises using the crop modelling model. Existing datasets, such as soil data, daily weather data and farm management data from institutions like the University of Florida, Gainesville and Chiang Mai, Thailand, are utilised. Participants are encouraged to bring their datasets, including field and crop management data (cultivar, planting date, spacing, irrigation, fertilisation, etc.), climate data (daily temperature, precipitation, solar radiation) and soil data (surface and profile characteristics, water holding capacity, nitrogen content, organic matter, etc.), to simulate crop yield conditions under different weather and management practices.

3. RESULTS AND DISCUSSION

Table 1 presents the results of the DSSAT training programmes conducted in Southeast Asia in 2019 and 2023. The table provides information on the number of male and female participants from each country and the total number of participants in each programme.

In 2019, the training programmes took place in Vietnam and Thailand. Vietnam had a total of 21 participants, with 17 males and four females. There were 18 participants in Thailand, comprising four males and 14 females. Additionally, there was one participant from each country, Ethiopia and Singapore, bringing the total number of participants to 41. The workshop held in Vietnam attracted 21 participants from thirteen provinces in Vietnam, including Ca Mau, Hau Giang, Soc Trang, Long An, Kein Giang, An Giang, Ben Tre, Tay Ninh, Tien Giang, Vinh Long, Can Tho, Bac Lieuand Dong Thap. These participants were young and dynamic researchers, academicians, scientists, engineers and extension officers affiliated with government institutes, universities and organisations.

In 2023, the training programme was held in Chiang Mai, Thailand and included participants from Cambodia, Indonesia, Lao PDR and Thailand. Cambodia had seven participants, consisting of six males and one female. Indonesia had seven participants, with four males and three females. Lao PDR had six participants, comprising four males and two females. Lastly, Thailand had one female participant. The total number of participants in the 2023 programme was 21. The group consisted of academicians, young researchers, students and extension officers from Southeast Asian countries actively involved in agriculture, plant breeding, agroforestry and hydrological issues. The participants' diverse backgrounds contributed to a rich and engaging learning experience. The training programme effectively equipped them with the tools to enhance cropping system management and develop more sustainable and resilient agricultural production systems in Southeast Asia. The participants from Vietnam had the opportunity to engage with farmers and learn about their concerns, such as improving yield gaps during droughts and floods

FIGURE 1. Interactive session between farmers and scientists.

(Figure 1). The importance of using tolerant varieties and technology packages and conducting rice value chain analysis was highlighted.

A comprehensive six-day training workshop focused on various aspects of DSSAT modelling is shown in Table 2. The workshop was to provide participants with practical skills and knowledge in utilising DSSAT for agricultural analysis and decision-making (Figure 2). The training commenced with an introduction to DSSAT and its applications, followed by installing the latest version of DSSAT 4.8 software and an overview of the file system. Participants delved into different facets of crop production, including the simulation of water-limited and nitrogen-limited production processes in soil and plants. They also gained insights into weather data inputs and utilities, soil data management and the creation of files for water and nutrient balance. The sessions further covered topics such as uncertainty, risk assessment, best management practices and sustainability in agricultural systems. The participants underwent an intensive training programme with in-depth learning and practical exercises. The training programme's significant focus was on crop modelling, encompassing the simulation of crop rotations and long-term experiments. Participants acquired skills in using the DSSAT software to model phenological development, conduct sensitivity analyses and simulate basic growth processes (Figure 3). They also delved into the concepts of genetic coefficients and cultivar sensitivity, learning how to estimate these coefficients and employing calibration techniques using tools like the Generalised Likelihood Uncertainty Estimation (GLUE) tool.

Spatial modelling applications were also explored, with participants learning to perform seasonal and spatial analyses using DSSAT. Participants are encouraged to apply their knowledge to their own experimental data and gain practical insights into modelling climate change and predicting in-season crop yield. Throughout the training, participants engaged in exercises and received feedback on their software usage. The sessions provided a platform for knowledge exchange, with country-specific presentations and discussions on applications and requirements related to climate change and climate variability.

On the other hand, we gathered feedback from participants about their satisfaction with the session content, benefits gained from the training workshop and suggestions for improvement using Google Forms. According to the results, 81.0% rated the DSSAT training workshop as "Extremely Good," while 19.0% rated it as "Very Good." These ratings indicate widespread appreciation for the workshop's success in exceeding participant expectations (Figure 4). The training proved insightful for participants, as they gained valuable knowledge of DSSAT software, modelling interpretation skills, a fundamental understanding of theory and expanded modelling concepts. Participants found the training useful in various applications, including PhD studies, introducing their course

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TABLE 2. Day-wise DSSAT programme agenda on crop simulation modelling and effects of climate risks on agricultural production systems.

Session	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Morning (8:00–12:00)	Registration Introduction of resource persons and participants Workshop goals, course outline, schedule History and overview of DSSAT & examples of applications Installation of DSSAT version 4.8 software Overview of DSSAT	Potential crop production Feedback on exercises and software Weather data inputs and utilities WEATHERMAN Using WEATHERMAN Minimum data set concept Learning the DSSAT File System Concept of crop genetic coefficients species vs. ecotype vs. cultivar coefficients	Feedback on exercises and software Simulating water-limited production soil and flood water balance in rice Soil data inputs and utilities Creating soil data files Soil data files and utilities	Feedback on exercises and software Simulating nitrogen-limited production processes in the soil Simulating nitrogen-limited production processes in the plant Creating FileX: Water and N balance ON Nitrogen-limited crop production	Feedback on exercises and software Uncertainty, Risk, BMPs, and Sustainability Creating FileX for Seasonal Analysis Seasonal Analysis	Feedback on exercises and software Cropping Systems – Simulating Crop Rotations Creating FileX for a Crop Rotation Simulation Creating a Crop Rotation or Sequence FileX Using XBuild Simulating Crop Rotations in Long-term Experiments Case Study – Chiang Mai, Thailand

Continued on next page

TABLE 2. *Continued.*

Session	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Afternoon (13:00–18:00)	Running crop models in DSSAT Simulating phenological development Introduction to Sensitivity Analysis Tool Sensitivity Analysis Tool Simulating basic growth processes Creating FileX: Potential crop production Simulating potential crop production	Genetic Coefficients – CROPGRO & CERES Cultivar sensitivity analyses Estimating genetic coefficients, concepts Tools for estimating cultivar coefficients GLUE Tool Cultivar coefficient calibration using the GLUE Tool	Creating FileX: Water balance ON Water limited production Experimental data collection - Model Evaluation Experimental data files and utilities Creating crop measurement files for model evaluation Calibration and evaluation of the DSSAT models using in-season growth analysis data	Continue with nitrogen-limited Crop production Modelling soil organic matter Creating FileX: Water and N balance ON Continue with nitrogen exercise	Spatial modelling applications Creating FileX for spatial analysis 1. Seasonal analysis 2. Spatial analysis 3. Work with your personal experimental data	Climate change and climate variability Creating FileX for modelling climate change Creating FileX for in-season yield prediction Country's presentation and discussion on applications and needs

FIGURE 2. Practical exercise sessions and results verification among participants.

FIGURE 3. Comparing results: Risk analysis and adoption exercise by participants.

curriculum, testing crop production scenarios and addressing challenges like climate change. They also recognised its significance in improving crop production predictions and guiding farmers' and decision-makers' decisions. One key suggestion for improvement is to extend the training's duration. Participants expressed a desire for a more immersive learning experience, allowing them ample

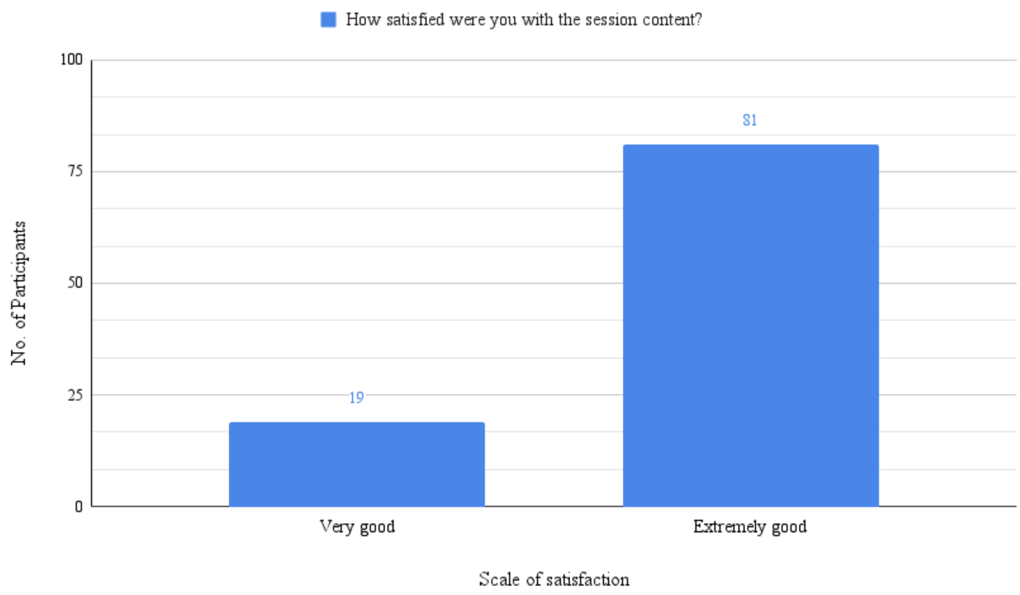

FIGURE 4. Participant satisfaction scale - Training workshop content.

time to grasp complex concepts, refine their skills and interact more with trainers. According to the feedback received, additional days for in-depth exploration and hands-on practice would provide a more comprehensive understanding of the material and align with the participants' expectations.

4. CONCLUSION

The six-day training workshop focused on DSSAT modelling, aiming to equip participants with practical skills and knowledge for agricultural analysis and decision-making. Participants learned about DSSAT and its applications, software installation and file system overview. They explored crop production, including simulating water-limited and nitrogen-limited processes in soil and plants. Weather data inputs, soil data management and water and nutrient balance were covered. The sessions also addressed uncertainty, risk assessment, best management practices and sustainability in agriculture.

The training emphasised crop modelling, including crop rotations and long-term experiments. Participants learned phenological development modelling, sensitivity analysis and basic growth processes simulation. Genetic coefficients, cultivar sensitivity and GLUE tool calibration techniques were explored. Participants worked with their own data, empowering them to make informed decisions and predictions in their agricultural practices. They gained insights into modelling climate change and in-season crop yield prediction.

Exercises and feedback were provided to enhance participants' software usage. Knowledge exchange occurred through country-specific presentations and discussions on climate change and variability. The training improved stakeholder capacity and facilitated collaboration among scientists, policymakers, NARS staff, students and local communities. It also led to behavioural changes and effective information dissemination to agricultural producers. Ultimately, the one-week hands-on training programme supports significant policy reforms and addresses the challenges faced in the agricultural sector, fostering sustainable and resilient agricultural practices.

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