



Evaluation of Agroecological Performance across Geographical Aspects and Agroecological Transition Levels in Battambang Province, Northwest Cambodia

THEARA MAO*

Royal University of Agriculture, Phnom Penh, Cambodia

Email: mtheara@rua.edu.kh

SORITH HOU

Royal University of Agriculture, Phnom Penh, Cambodia

SAMNANG NGUON

Royal University of Agriculture, Phnom Penh, Cambodia

LUCIE REYNAUD

Group for Research and Technology Exchanges, Paris, France

SOVANN PAT

Group for Research and Technology Exchanges, Phnom Penh, Cambodia

RADA KONG

Department of Agricultural Land Resources Management, Phnom Penh, Cambodia

VENG SAR

Department of Agricultural Land Resources Management, Phnom Penh, Cambodia

GUILLEMETTE ARMINJON

L'Institut Agro Montpellier, Montpellier, France

AGNÈS COLBE

L'Institut Agro Montpellier, Montpellier, France

Received 12 December 2023 Accepted 3 January 2025 (*Corresponding Author)

Abstract Agroecology (AE) is the application of ecological concepts and principles to agricultural systems to increase their sustainability. This study aimed to conduct a multidimensional evidence-based evaluation of AE performance in Battambang Province, using the Tool for Agroecology Performance Evaluation (TAPE). The study investigated two main criteria: geographical aspects in Sangkae (lowland) and Rotonak Mondol (upland) districts and AE transition levels. We preclassified 120 farms into two AE transition level categories (high-AE and low-AE) as well as a non-project farm category. Results indicated that the mean characterization of agroecological transitions (CAET) score was low (37.42%). Among ten elements covering technical and social aspects in AE, the technical performance was lower which emphasize the studied farms relied on external inputs (fertilizers, pesticides, seeds, labor, and services). Farms in the study area are increasingly used agro-inputs for increased productivity, particularly in lowland areas, using an average of 5.4 types of pesticides. The economic performance in the upland area resulted in negative total income due to climate change risks (drought and flood), pest-causing yield loss, rising agricultural input costs, loss of price of agricultural products, and difficulty in selling agricultural products. To improve the performance of agroecology transition, farmers need to save their seeds to maintain internal inputs at the farms. In addition, promotion of AE practices with technological techniques should be widely adopted at the national level,

including encouraging farmers in the community to use less pesticides, adopt organic/natural fertilizers and pesticides, and apply ecological techniques.

Keywords agroecology, sustainability, TAPE, multidimensional, evaluation

INTRODUCTION

Agroecology (AE) is a comprehensive approach that considers ecological, and social principles and concepts in the development and management of food and agricultural systems. It aims to maximize interactions between plants, animals, humans, and the environment while taking into account the social issues that should be addressed for a sustainable and equitable food system (FAO, 2018).

In Cambodia, agriculture remains an important source of income for many Cambodians living in rural areas. Accounting for nearly 61% of rural people and 77% of rural households relying on agriculture, fisheries, and forestry for their livelihoods (USAID, 2024). There were some challenges in the Cambodian agroecological transition including a lack of knowledge and experience in AE, limited access to production factors and markets as well as policy support (ASSET, 2022). Cambodian farmers are particularly vulnerable to climate change including temperature rises, changes in precipitation patterns, and extreme weather events. To tackle the above challenges in the AE transition, this study aimed to generate evidence-based multidimensional knowledge for promoting the AE transition in Cambodia.

OBJECTIVE

This study aimed to conduct a multidimensional evidence-based evaluation of AE in Battambang province, northwest of Cambodia in terms of two main criteria, namely, geographical aspects and AE transition levels, using the Tool for Agroecology Performance Evaluation (TAPE) tool.

METHODOLOGY

By consulting with relevant stakeholders including the French Agricultural Research Center for International Development (CIRAD) team, currently implementing the project in the target area, the study was conducted in six targeted villages located in Sangkae (lowland with paddy rice production) and Rotonak Mondol (upland with cash and perennial crops) districts of Battambang province, northwest of Cambodia (Fig. 1).

The lowland area of Sangkae district is located near the Kanghot irrigation system which is used for two rice cultivation that allows for gravity-fed irrigation and pumping (Kong and Castella, 2021). Water availability is a major concern in some villages during the first or second rice cycle. Changing the rice cropping system has a significant negative influence on the ecosystem due to the increased use of chemical fertilizers and pesticides (Phoeurk et al., 2020). Approximately 98% of households use chemical pesticides for rice farming to protect pests and diseases while 90% of farmers use chemical herbicides (Kong and Castella, 2021). Rice is the main crop grown in this area and livestock farming is commonly raised.

In the upland area of Rotonak Mondol district, farmers can cultivate two cycles of crop each year. Farmers farmed annual cash crops (cassava and maize) and perennial crops (mango and longan). There has recently been an increase in the use of pesticides for off-season perennial crop production with polluted water sources and underground water (Kim and Peeters, 2020). Drought occurs frequently and has impacts on crop yields, particularly in 2015 and 2019 (Kong and Castella, 2021).

The study was conducted between May to August 2023 using the TAPE questionnaire installed in the Tablets for data collection in the fields by trained data enumerators. TAPE has four main steps (i) Step 0 – we organized focused-group discussions (FGDs) with relevant stakeholders and desk review; (ii) Step 1 – we surveyed the characterization of agroecology transition (CAET) to emphasize the 10 elements of AE; (iii) Step 2 – we surveyed the 10 core criteria of AE performance from five key dimensions to generate evidence on the multidimensional performance of AE; (iv) Step 3 – we

organized a participatory analysis with relevant stakeholders in the study area to validate the results and explore potential levers to improve AE transitions.

The study covered two main criteria, namely, geographical aspects and AE transition levels, through a combination of qualitative and quantitative investigation. A total of 120 farms were predefined in geographical aspects such as lowland (Sangkae) and upland (Rotonak Mondol), including 60 AE farms and 60 non-project farms were selected as farmers of CIRAD and Water Resources Management and Agroecological Transition for Cambodia Program (WAT4CAM). For AE farms, we classified the farms into two AE transition levels including medium-high (high-AE) and low-medium (low-AE) based on the CIRAD project's data. These levels indicated the AE performance of each farm in the CIRAD project. For non-project farms, we selected the farms that have similar characteristics to AE farms for comparison (i.e., farm size and production system).

The data were analyzed using R-studio. Step 1 – the data analyzed the CAET scores and correlation. Step 2 – each criterion was calculated and scaled by using the traffic light approach where “3 = desirable”, “2 = acceptable”, and “1 = unsustainable”. Step 3 – we analyzed by using a participatory analysis workshop with relevant stakeholders in the study area.

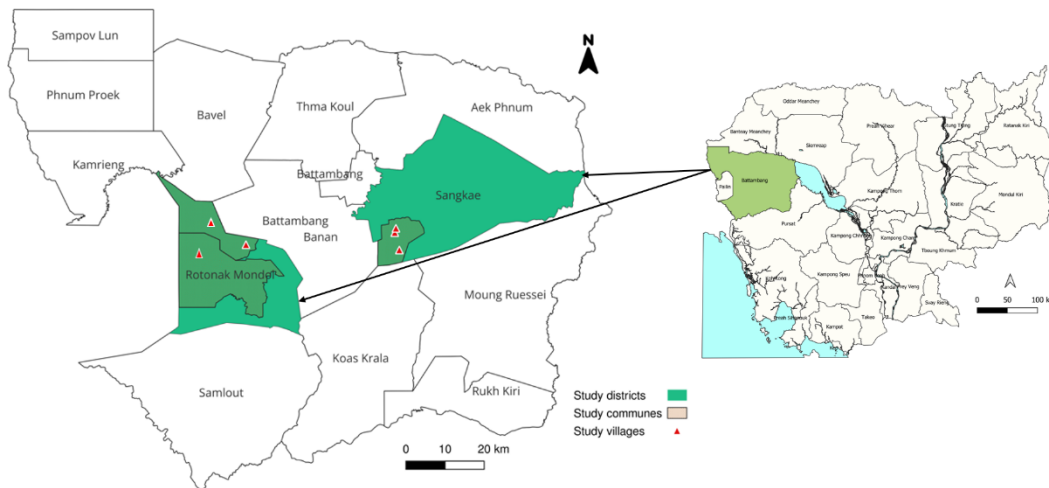


Fig. 1 Map of six targeted villages in Sangkae and Rotonak Mondol Districts of Battambang Province

RESULTS AND DISCUSSION

As shown in Table 1, the AE performance was low in the study area with a mean of CAET score 37.42%, except for a small number of farms (8.33%) obtaining a CAET score over 50%. Based on the classification of AE transitions made by Lucantoni et al. (2023), we could conclude that the overall CAET scores of this study are considered as non-agroecological transitions (less than 50%). The ranging from 50-60%, 60-70%, and higher than 70% are considered as incipient AE transition, in transition to AE, AE transition, respectively. According to similar studies conducted by Kim and Peeters (2020) and ECOLAND (2021), the CAET score was 55% and 45.23%, respectively. The overall CAET score in the study area has decreased by year since 2019.

The element of AE's social aspects performed better than the technical aspects, especially synergies, recycling, and efficiency elements (Table 1). In other words, most farms were dependent on external agricultural inputs including fertilizers, pesticides, seeds, labor, and rental services. Input expenditures (seeds, fertilizers, and pesticides) were 656.35 USD and 321.70 USD per hectare in lowland and upland, respectively. Its ratio was high, especially in the lowlands with around 45% of total expenditures.

Across geographical aspects and AE transition levels, predefined high-AE farms in both upland and lowland areas obtained an identical score while non-project farms in the lowland performed the

lowest (Table 1). This could be explained by the predefined farms in the project practicing the Conservation Agricultural (CA) technique.

According to Table 1, the element of culture and food tradition and circular and solidarity economy in the lowland (high-AE) received better performance than the upland (high-AE). In the lowland, local markets were active and accessible where some products were produced and sold locally, providing farmers with access to a diverse diet of food groups.

Table 1 CAET score (%) based on geographical aspects and AE transition levels in Battambang province

Ten (10) Elements of AE	*AE performance	Upland			Lowland		
		High-AE	Low-AE	Non-project	High-AE	Low-AE	Non-project
Diversity	41.80	53.30	40.80	41.90	48.80	42.50	32.70
Synergies	35.30	44.60	37.10	34.20	44.60	35.80	26.00
Efficiency	24.50	35.00	20.80	24.00	32.10	25.40	17.50
Recycling	29.30	39.20	27.50	26.50	36.20	31.70	23.30
Resilience	33.50	42.50	29.00	32.10	41.40	33.10	28.80
Culture and Food Traditions	48.40	51.70	46.70	48.30	53.30	48.90	45.00
Co-creation and Sharing of Knowledge	39.40	51.70	35.60	35.80	56.70	37.20	31.10
Human and Social Values	49.10	55.40	47.90	49.40	50.80	48.80	45.60
Circular and Solidarity Economy	33.80	38.90	31.10	31.40	41.10	33.90	31.10
Responsible Governance	39.20	45.00	36.10	39.40	45.60	37.80	35.00
Overall CAET	37.42	45.70	35.30	36.30	45.10	37.50	31.60

Source: Field survey, 2023; Explanation: *refers to the AE performance of all farm systems assessed.

Figure 2 shows that the mean CAET scores of upland and lowland areas were distinct, but not significantly different. The upland score was higher at 38.40% than the score of the lowland at 36.50%. The predefined high-AE farms obtained higher CAET scores compared to low-AE and non-project due to the AE transition levels known as predefined samples from project partners with better AE performance.

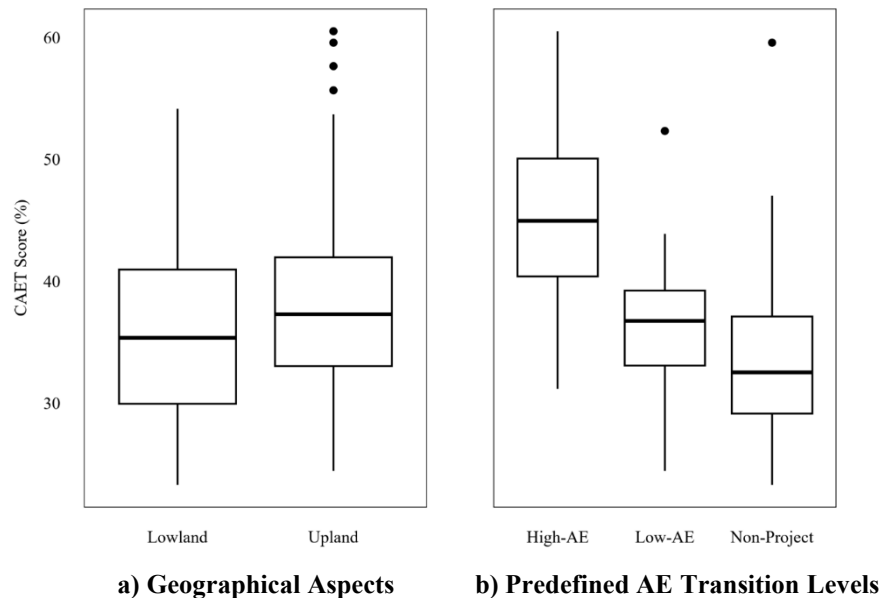


Fig. 2 Boxplots with mean CAET score

Based on the traffic light in Table 2, land tenure for men and women was obtained at an acceptable level in both criteria which suggested that most of them have either ownership or perception of their land security. The land tenure for men and women obtained acceptable levels in the high-AE while land tenure for women was higher than men for low-AE and non-project. Based on local authorities, land tenure in the lowland area is a certificate of exploitation (soft title) of land that is facilitated by village and commune chiefs.

Most farmers received an unsustainable level of pesticide exposure, meaning that they use highly hazardous pesticides (Class I) with less than four of the listed mitigation techniques (mask and protection gear) (Table 2). In addition, 78.33% of farmers thought that pesticides are important for agricultural production. According to FGDs, pesticide-based production was reported in both areas with an average of 6 applications and 5.4 types of pesticides. Local authorities reported that farmers have limited knowledge of the pesticide's application due to a lack of training, applying based on neighbors' experiences and instruction from input sellers.

For the dietary diversity dimension, farmer's households consumed an acceptable level in the lowland. From the AE transitional level, only those with high AE have accessed acceptable dietary status within the last 24 hours (Table 2). Only 25.80% of all respondents consumed 7 out of 10 food groups or desirable levels. In contrast to lowland farmers, upland farmers are more dependent on the self-produced food in their diverse farms as it was also reported of limited access to local markets.

The social and cultural dimensions consisted of women's empowerment and youth employment opportunities. Women's Empowerment in Agriculture Index obtained acceptable results across the two criteria (Table 2). However, youth employment opportunities were indicated at an unsustainable level for both criteria which means that young people were less interested in agricultural activities and willing to migrate for opportunities. According to FGDs, migration in the upland was higher than in the lowlands in the targeted villages interviewed. An estimated 30% of people in the upland migrated to Phnom Penh, Sihanoukville, and neighboring countries (Thailand) to find jobs, and only 10% to the lowlands.

In the environmental dimension, agricultural biodiversity was obtained at an unsustainable level for both criteria (Table 2). The upland and high-AE farms had better soil health at an acceptable level due to the CA technique that has been promoted in this area for almost 15 years to improve soil quality and better crop yield with reduced chemical inputs. Whereas, the lowland obtained traffic lights close to acceptable levels even though the CA technique was recently promoted in 2020.

Table 2 Seven of ten core criteria of AE performance from step 2 under geographical aspects and AE transition levels

Criteria	Governance		Health and nutrition		Society and culture		Environment	
	Land tenure for men	Land tenure for women	Exposure to pesticides	Dietary diversity	Women's empowerment	Youth employment	Agricultural biodiversity	Soil health
Upland	2.82	2.87	1.00	1.78	2.21	1.63	1.53	2.03
Lowland	2.60	2.72	1.02	2.07	2.50	1.27	1.08	1.97
High-AE	2.83	2.83	1.00	2.07	2.30	1.89	1.43	2.20
Low-AE	2.77	2.80	1.00	1.93	2.50	1.00	1.27	1.97
Non-project	2.62	2.77	1.02	1.85	2.32	1.39	1.27	1.92

Source: Field survey, 2023; Explanation: *traffic light indication: 1 – unsustainable, 2 – acceptable, 3 – desirable

According to Table 3, farms in the lowlands obtained a positive total income of 688.73 USD per hectare per year (in 2022) even though they faced environmental risks including flooding, insufficient water, and drought. However, upland farms received negative total income (-89.93 USD) due to unpredictable climate change (lack of rainfall and drought), the price of agricultural inputs increased in 2022, investment in insecticides, increased pests on maize with loss yields, declining product prices, and difficulty in finding markets. Nearly a quarter of farmers expressed having significantly reduced income. Some farmers (25%) reported increased income compared to the last three years, while 30% and 34.10% indicated that their income remained unchanged and decreased, respectively. Related to markets in the upland, most farmers sold raw maize and cassava to middlemen and traders with fluctuating prices. In 2021, the price of products was very cheap, e.g.,

0.19 USD per kilogram of maize and 0.07 USD per kilogram of fresh cassava. In contrast, in the lowlands, there is an agricultural cooperative that actively facilitates contract farming with local rice millers with a guaranteed marketable price of 0.25 USD per kilogram of rice. Sok et al. (2022) reported that the income of farmers in 2020 remained low due to facing natural disasters and loss of rice yields.

The participatory analysis with local relevant stakeholders determined different activities including enhancing the ability of farmers to save the seeds and reduce the wasting of inputs, strengthening AE practices at the national level with reduced chemical use, and promoting new technological practices such as no-tillage technique, cover crops or resistant seeds to minimize the yield and cut loss.

Table 3 Economic performance (USD per hectare per year) under geographical aspects and AE transition levels in 2022

Criteria		Gross production	Gross added value	Net added value	Agricultural income	*Total income
Geographical aspects	Upland	793.88	75.33	7.70	-269.03	-89.93
	Lowland	1846.58	598.85	549.78	281.75	688.73
AE transition levels	High-AE	1357.73	451.75	379.43	144.28	337.48
	Low-AE	1480.70	521.48	402.35	160.30	268.93
	Non-project	1287.15	204.13	145.63	-119.20	245.63

*Source: Field survey, 2023; Explanation: *All the production costs of farming are included with other activities.*

CONCLUSION

The CAET score was low, meaning that agroecological performance remained low regardless of geography. Predefined high-AE farms in lowland and upland areas received higher CAET scores compared to low-AE and non-project farms due to they had adapted to AE practices with the CA technique. The majority of the farms relied on external inputs while there was limited productivity and income. With good governance of land and opportunities for AE's products, it could provide a promising alternative for youth employment. Based on the participatory analysis workshop with stakeholders, it was exploring themes to improve AE transition in the study area including technical, marketing, and policy aspects. An available and stable market for both inputs and products was critical for farmers to improve the AE production system. The study implies that intensification of production based on the chemical inputs poses concerns on the health and environment. It is a need for farmers to consider designing a farm with reduced expenditure of inputs. In addition, agroecological transition could be improved by tracking with climate change adaptation context and through holistic approaches and broader collective actions and networks.

ACKNOWLEDGEMENTS

The study was supported by the Agroecology Learning Alliance in Southeast Asia (ALiSEA), Agroecology and Safe Food System Transitions (ASSET), and Uni4Coop, funded by the French Development Agency (AFD), the European Union (EU), the French Facility for Global Environment (FFEM), and the Directorate General for Belgium Development Cooperation (DGD). We would also like to extend our gratitude thanks to Dr. Raphaëlle DUCROT from CIRAD and Agroecology in Southeast Asia (ASEA) for providing fund support to the author to participate in the 15th International Society of Environmental and Rural Development.

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