Original Research Article

Six Social Evolutions of Sustainable Swidden Agricultural Design in the Indonesian Highlands

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ABSTRACT

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| The research develops a sustainable model for farmers transitioning to the Indonesian highlands using design thinking. The study uses a qualitative methodology with a systematic literature review approach. The data comes from journals indexed by Sinta, Google Scholar, Web of Science and Scopus in the last decade. Data analysis uses Evidence-Based Software Engineering (EBSE) while data analysis techniques with design thinking models include six social evolutions empathy, exploration, elaboration, exposure, execution, and expansion. The findings of the study show the stages of empathy are social, cultural, and economic challenges of highland farmers in Indonesia. The exploration stage explores satellite technology and agroforestry, supporting nature preservation and improving farmers' welfare. Through elaboration, the development of training modules and technological support ensure long-term sustainability. The exposure phase of policy testing and community outreach introduces the benefits of agroforestry practices, while execution emphasises the implementation of collaborative policies between farmers, governments, and related institutions. Lastly, expanding the implementation of solutions has proven to be effective in involving the younger generation and building a network of sustainable farmer communities in various regions in Indonesia. The implications of research with a design-based thinking approach create a more effective and relevant solution to the needs of local farmers. Further research explores the role of digital technology in supporting sustainable agriculture as well as further evaluation of the long-term success of implemented policies. |

*Keywords: Design Thinking, Highland, Indonesia, Swidden Agriculture, Sustainable*

1. INTRODUCTION

Highlands are unique ecosystems that have high biodiversity, mainly due to cooler environmental conditions, sufficient rainfall, and altitude variations that create microhabitats for various species of flora and fauna (Schulze et al., 2019). These factors create a range of microhabitats, allowing various species of plants and animals to thrive in specialized niches. The variation in altitude leads to distinct climate zones, fostering unique adaptations in flora and fauna, and supporting a wide array of ecological interactions. As a result, highlands often act as refuges for endemic species and contribute significantly to regional and global biodiversity.

In 2023, it is recorded that the highlands in Indonesia have great potential in the agricultural sector with a usable land area of around 6.8 million hectares (ha), of which around 45% consists of hills and highlands (Ministry of Agriculture, 2023). This geographical condition supports various types of agricultural businesses, especially horticulture such as vegetables, fruits, and plantation crops that require cool temperatures and fertile soil, making it the main source of water for downstream regions, with more than 60% of the global freshwater supply coming from mountains and the creation of crucial ecosystems for the sustainability of the environment and human life by producing more than 60% of the national supply of vegetables and fruits (FAO, 2019; BPS, 2023).

Based on data from the 2023 Agricultural Census released by the Central Statistics Agency (BPS), the number of smallholder farmers in Indonesia has increased significantly in the last decade (Ministry of Agriculture, 2023). In 2013, there were 14.25 million small or *gurem* farmer households, and this figure increased to 16.89 million households in 2023, showing an increase of 18.54% (BPS, 2023). This increase is allegedly closely related to the narrowing of agricultural land caused by land conversion and land fragmentation due to the inheritance process. This phenomenon poses a serious challenge for Indonesia's agricultural sector, especially to increase the productivity and welfare of smallholder farmers, especially for smallholder farmers who incidentally have narrow land (FAO, 2023; Alena et al., 2023).

Swidden agriculture in Indonesia is a traditional agricultural practice that is still practised by some indigenous communities involving clearing forest land by cutting down and burning vegetation, then planting it with food crops before moving to other locations after soil fertility decreases (Choir et al., 2018; Rosmalah et al., 2023). Although these methods are considered to be suitable for the lifestyles of local communities and can maintain the sustainability of ecosystems on a small scale, the practice of shifting fields faces major challenges in the modern context, especially related to deforestation, land degradation, and government regulations on forest conservation.

The increase in the number of smallholder farmers, namely farmers with very narrow land (less than 0.5 hectares), contributes to the increase in the practice of shifting farming as an adaptation strategy to land limitations. Because the land they own is insufficient for sustainable agriculture, many smallholder farmers are turning to a mobile farming system in search of more fertile land to increase their yields (Arifin, 2015). These practices, while they can increase short-term productivity, often hurt environmental sustainability, such as land degradation and deforestation, leading to a decrease in soil fertility in the long term (Hidayat, 2013; Adijaya, 2020). In addition, the uncertainty of land ownership and limited access to modern agricultural technology make smallholder farmers increasingly dependent on traditional agricultural systems that are less efficient (Ataribaba et al., 2020). Therefore, the increasing number of smallholder farmers not only accelerates the pace of field farming but also poses challenges in realizing sustainable agriculture.

Shifting farming in Indonesia's highlands has become one of the main problems affecting environmental and socio-economic sustainability (Wijayanto et al., 2023). In the highlands, the cultivated land tends to be limited and easily affected by climate change, so the long-term impact is more pronounced (Syafruddin et al., 2022). Therefore, there is a need for more structured design and policies to reduce the negative impacts of mobile farming, such as the application of sustainable agricultural techniques, improved land use management, and education to farmers about the importance of nature conservation to maintain the balance of the ecosystem and the sustainability of agricultural production in the future (Susilawati, 2012).

Sustainable shifting farming in the highlands is an agricultural system that utilizes the pattern of moving to plant crops alternately so that the soil can recover and continue to support agricultural productivity in the long term (Rahman et al., 2017). This system is widely applied in highland areas, which usually have limited soil conditions and high rainfall.

In general, in mobile farming, farmers will open new land in different locations after the old land is no longer productive. However, the sustainable concept in this system aims to maintain the balance of nature and ensure that the process of changing fields does not damage the environment. The characteristics of sustainable farm farming include (Li & Nath, 2024):

1. Wise Management of Natural Resources

Sustainable shifting farming emphasizes the importance of environmentally friendly and efficient management of natural resources. Farmers use natural resources wisely by paying attention to the balance of the ecosystem, such as avoiding overexploitation of land and forests. The goal is to maintain soil fertility and the sustainability of agricultural production in the long term.

1. Plant Rotation

One of the characteristics of sustainable field agriculture is the practice of crop rotation, which is planting various types of crops alternately on the same land. This rotation helps maintain soil fertility by reducing dependence on one type of plant and avoiding deterioration in soil quality due to fatigue. In this way, each plant can support each other in improving soil conditions.

1. Soil Nutrient Return

In sustainable farming of moving fields, it is important to restore the nutrients lost from the soil after the planting period. This is done by planting plants that can improve soil fertility, such as ground cover plants or plants that can bind nitrogen. This practice aims to maintain the balance of nutrients in the soil so that it remains productive without sacrificing its quality.

1. Simple Use of Technology

Technology in sustainable field farming tends to be simple and environmentally friendly. Farmers prioritize the use of traditional tools and techniques that are cost-effective and do not damage the environment. This technology includes the use of manual farming tools, natural irrigation systems, and the selection of local crop varieties that are more resistant to local natural conditions.

Farmers moving to the highlands often face high risks that have a significant impact on sustainable social, economic, and ecological aspects (Willmott et al., 2023). Socially, this practice can lead to cultural shifts and tensions with local communities due to competition for natural resources and poorly managed land use. Economically, migrant farmers often face uncertainty in agricultural yields due to climate change and soil degradation, which reduces long-term productivity. Ecologically, this practice has the potential to damage biodiversity and cause soil degradation, which has an impact on the stability of local ecosystems. This condition threatens the sustainability of the lives of local communities and farmers who depend on stable and productive natural resources. The research gap in the context of shifting field agriculture in the Indonesian highlands lies in the lack of understanding of the long-term impact on ecosystem sustainability and the effectiveness of implementing sustainable land management models.

Several previous studies on the use of highlands or mountains for farmers to move, where Schmidt-Vogt (2001) Examining the magnitude of population growth in northern Thailand has forced farmers in the lowlands who practice permanent wet rice cultivation to switch to short-rotation shifting farming in the foothills with qualitative methods and policy review approaches in Thailand. Then Li and Yang, (2022) to know the development of migrant farming in Laos with this landlocked mountainous range during the two decades 2000–2020 with a quantitative approach and time series data. For this reason, this study aims to design sustainable highland farming in Indonesia. The novelty and significance of this research lies in the emphasis on the importance of more structured design and policies in overcoming the problem of shifting field agriculture in the highlands of Indonesia.

2. material and methods

The study used a qualitative method with a literature review. Data collection used secondary data from international journals indexed by Scopus, Google Scholar, Web of Sciences and SINTA published between 2011 and 2023 with the keyword "sustainable swidden agriculture in the highlands". Data analysis used a systematic literature review (SLR). Data analysis techniques are used for planning, implementation and reporting (Linnenluecke et al., 2020).

This study uses a qualitative method with a descriptive approach. While data analysis uses a systematic literature review (SLR). Where the type of research is to identify, evaluate and interpret all sources of research data on the formulation of the problem to be studied (Kitchenham et al., 2009). On the other hand, SLR is defined as a way of synthesising scientific evidence to answer research questions transparently by including published sources with research objectives (Lame, 2019). Meanwhile, in collecting data using the systematic literature review method from secondary data in the form of research results and research findings qualitatively or quantitatively (Snyder, 2019).

The beginning of SLR is the development of Evidence-Based Software Engineering (EBSE), which enters the realm of software engineering with the following process: (Nightingale, 2009).

1. Planning

At this point, it is important to know what is needed to conduct a literature review. This is not the same as reading a book that we do not know what it contains and want a "surprise" when we finish it. Before reading a scientific paper, we need to know what it contains. Note that this is just a summary. Finding a research question is the second step in this section. This is what underlies the literature study.

1. Implementation

At this step, he will search for literature sources. This includes finding research, selecting primary research, assessing the quality of books, collecting data and monitoring it at all times and collecting data. Often, SLR uses "search" media that already exists in some indexers.

1. Reporting

At this stage, well-organized literature material is created. Often, hundreds of sections are broken down into dozens, and dozens are ready to be read and analysed. There are usually three steps. The first is a database search, which uses free or paid online indexers to find hundreds of pieces of information. Second is a review of the abstract, title, and keywords that are poured into numbers. Third, there are about thirteen complete reviews in this study, and the number does not have to be too many.

The SLR research methodology is carried out following the steps outlined by Piper (2013) as follows:

1. Develop a series of research questions.

This study consists of three research questions (HLM) as follows:

1. What is the problem with swidden agriculture in the Indonesian highlands? (HLM1)
2. What strategies are applied to overcome the problem of sustainable swidden agriculture in the Indonesian highlands? (HLM2)
3. How recommended is a design for sustainable swidden agriculture in the Indonesian highlands that can be implemented? (HLM3)
4. Conduct a comprehensive literature review in response to the research questions posed.

The literature search technique was carried out on various national and international journal search platforms. To simplify the process of finding relevant material, the researcher used a set of predetermined criteria that were by the research questions. Therefore, any findings from the literature that did not meet these criteria would be removed from the study.

The criteria determined in the study using the SLR approach are as follows:

* 1. The data used is only related to the regulatory problems of swidden agriculture in the Indonesian highlands, including various types of difficulties, tactics used to overcome them, and the effectiveness of the strategy.
  2. Data was obtained from the websites https://scholar.google.com/, https://sinta.kemdikbud.go.id/, https://mjl.clarivate.com/, and www.scopus.com.
  3. The data used ranges from 2014 to 2024.

1. Evaluating and filtering literature that is considered appropriate.

This stage involves searching and selecting comprehensive material that is relevant and able to answer the research questions.

The literature data found in this study will be assessed using a screening procedure that is under the predetermined quality assessment standards. The screening will be carried out as described below:

1. Regulatory problems of swidden agriculture in the Indonesian highlands (specifically related to HLM1)
2. The right strategy used to overcome regulatory problems of swidden agriculture in the Indonesian highlands from 2014 to 2024 (specifically related to HLM2)
3. Recommendations used to address swidden agriculture in the Indonesian highlands from 2014 to 2024 (specifically referring to HLM3)

For each question mentioned above, the corresponding answer value will be given below in each journal article.

1. Y (Yes): for journal papers that meet HLM (publication),
2. X (No): for journal articles that do not meet HLM.

From the SLR, 18 articles were obtained. The screening was carried out with 7 published articles, so those included in the analysis were 11 journals identified from the screening results that were confirmed to answer the research questions. The following process provides a clearer visualisation of the stages involved in the screening process as shown below:

Recorded from Scopus, Google Scholar , WoS & SINTA Database (n=18)

**Identification**

**Screening**

Records Screened (n=18)

Record Excluded (n=7)

Full-text Articles Access for Eligibility (n-11)

Article Included in Review (n=8)

**Including**

**Fig 1. Literature Screening Process**

Source: (Lame, 2019)

1. Analyse and synthesise findings from literature research.

The process of synthesising and analysing research literature consists of categorising, evaluating, and presenting material in a research report. The purpose of collecting relevant information is to provide material for discussing research findings.

1. Establish quality control.

The review of related literature and the results of the analysis of that literature, which are presented in the discussion and conclusion, constitute quality control. To mitigate potential bias in research findings, quality control is carried out through deliberations involving guidance and counselling from lecturers and group participants.

1. Compile a final report.

The final result consists of a research paper that has been submitted to an accredited journal.

The data analysis technique uses design thinking with the six social evolution models. The design thinking approach is often used to solve complex problems in a creative, human-focused, and iterative way. When applied in data analysis, design thinking can help identify solutions that are relevant to user needs, as well as generate more meaningful insights. The advantages of applying design thinking in data analysis are user-focused, collaborative, involving various stakeholders, iterative and innovative so that it can make solutions more creative, relevant, and effective in answering the complexity of problems focusing on user needs.

The analytical approach uses the *design thinking model social evolution 6* (SE6) as the evolution progress of social innovation by combining the evolution model 6 with the six-stage spiral model of social innovation (Murray et al., 2010). The goal can be to create a model by modifying the social innovation process to make it more accessible, intuitive and applicable to multidisciplinary sciences (Moreira et al., 2021).

The preparation of the six social evolution models and the social innovation spiral model, the definition of innovation and evolution as a logical form as the basis for forming or creating an ideal model according to the needs of its users. The following illustrations answer the objectives of this research:



**Fig 2. Six Social Evolution Model**

Source (Moreira et al., 2021)

In each phase, it needs to be defined so that each built in the model can be explained in detail as follows:

a) Empathy: Upcoming Challenges and Social Needs

b) Exploration: Idea Generation

c) Elaboration: prototyping, testing and development

d) Exposure: Project Presentation

e) Execution: Implementation and Evaluation of Impact

f) Expansion: systemic change

In general, the process model *design thinking* is the common thread that begins with the interview stage, then the formulation of the problem, creating a solution, making the solution as a *prototype* to test and finally testing the *prototype* so that it can solve the problem or not. (Syed et al., 2021).

This model was taken into consideration in providing recommendations for the expansion of swidden agriculture in the Indonesian highlands through swidden agriculture in the Indonesian highlands as a social innovation for swidden agriculture in highlands by proposing a model of its in Indonesia. This is adjusted to the approach of swidden agriculture in the Indonesian highlands through the principles of social, economic, ecology, conservation and impact in the long run. The characteristics that are considered appropriate for innovation and evolution whose context is by the number, composition, dynamics and available time (Pressman, 2019).

3. results and discussion

Based on the findings of the research concerning the theme of the problem, 8 review literature was obtained that answered the research objectives as shown in the following table:

**Table 1. Data Extraction Results**

|  |  |  |  |
| --- | --- | --- | --- |
| **Author's Name & Year** | **(PAGE 1)**  **Constraints** | **(PAGE 2)**  **Strategy** | **(PAGE 3)**  **Recommendations** |
| (Rosmalah et al., 2023) | The local wisdom of farmers in the highlands has faded or decreased. | The people of Wawonii Island manage their agricultural land with two agricultural patterns that are carried out from generation to generation, namely mixed planting patterns and monoculture planting patterns. | The government provides policies that support the preservation of local wisdom of the community that contributes positively to the balance of forest and land resources. |
| (Li & Nath, 2024) | Shifting field farming used to occur in temperate climates and is now almost exclusively occurring in the tropics, especially in developing countries in the highlands | The launch and implementation of the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries is encouraging top-down rethinking and rediscovery. | The need for free Landsat archives provides bottom-up support for consistent historical satellite observations. The emergence of the UN-REDD Programme and the free Landsat data policy can simultaneously bring together longitudinal and horizontal analyses of migratory field agriculture. |
| (Choir et al., 2018) | Local communities still practice rice fields and field agriculture (huma) on private land, forests produced by state-owned forest companies (Perhutani), and project land of state-owned electricity companies (PLN). | Local management of *huma* farming has been carried out every year by local communities by determining the location of huma plots, preparing land (cutting down shrubs and burning vegetation biomass), planting rice (*ngaseuk*) and other annual crops, weeding (*ngored)* and providing chemical fertilizers (mupuk), controlling pests, harvesting rice (made), and farmland. | With the nature of the *huma* agricultural agroecosystem, it can be predicted that the productivity, stability, equity, and sustainability of the huma agricultural system for the local community despite the UCPS hydropower project. |
| (Imang et al., 2018) | Agriculture with massive expansion of oil palm plantations, concessions for industrial plantations, and the unavailability of financial and political support from the government and  Wisdom in Land Management | The application of the agrosystem of the daleh field agricultural system can be practised effectively because it can increase land productivity and is also culturally acceptable. | The need for financial support and facilitation from the government to improve agricultural practices for local communities |
| (Swe & Nawata, 2020) | Local farmers in the fields move by clearing forest land through slash-and-burn techniques. | Safe use of land for land encroachers to prevent conflict with lowland populations and other external pressures.  Environmentally friendly agriculture and improved agricultural practices. Infrastructure development and community involvement as environmental conservationists | Additional support for farmers transitioning from farming to permanent farming with financial assistance, training, and ongoing resources.  Policies that recognise the rights of displaced farmers, while ensuring that mobile agriculture and permanent agriculture can coexist sustainably, respecting local customs and land-use practices. |
| (Leknoi et al., 2023) | Corn monocultures cause environmental problems such as deforestation and soil erosion, as well as social problems such as farmers' debt and dependence on some corporations. | The use of the Food and Agriculture Systems Sustainability Assessment Tool (SAFA) is applied to measure social sustainability across multiple dimensions including decent livelihoods, fair trade practices, labour rights, equality, human health and safety, and cultural diversity.  Identifying that farmers are subjected to unfair pricing and reliance on corporate buyers, limits their bargaining power. | Implement diverse farming practices. Fairtrade practices and equal employment conditions. There needs to be stronger attention to environmental degradation. It is essential to empower farmers. |
| (Rahman et al., 2017) | Transferable farming (slash-and-burn) is so inherent that it is reluctant to adopt agroforestry systems.  Farm-shifting fields often lack financial resources  There is no significant government or institutional support for the agroforestry system.  Farmers are hesitant because of the uncertain market  Farmers in the fields move to have limited labour and time, thus reducing agroforestry capacity. | The application of agroforestry financial feasibility (durian-cassava and teak-yam-maize systems) with mobile field farming. Farmers involved in agroforestry have higher incomes and greater land tenure guarantees. Agroforestry reduces the need for forest clearing and extraction of products (firewood, timber, and food). Government incentives such as capital investments, training programs, and technical assistance are needed to facilitate the transition to agroforestry. Community engagement programs can help change attitudes by demonstrating the long-term benefits of agroforestry. Traditional land-use practices must be integrated into agroforestry models to facilitate the transition for local farmers. | Government support in financial assistance and subsidies for farmers who switch to agroforestry. Develop training programs and agricultural extension services that focus on agroforestry best practices.  Establish cooperatives and market relations to ensure reasonable prices and reliable demand for agroforestry products. Introducing a certification scheme that encourages sustainable agroforestry practices.  Ensure agroforestry farmers obtain more permanent land rights to increase adoption rates. Implement policies that recognize tree ownership as a land ownership security mechanism. |
| (Ataribaba et al., 2020) | The farming system has changed significantly and caused a decline in agricultural land. | Encourage the harmonization of local wisdom with government regulations to protect land use rights and environmental conservation. Education and community involvement. Zoning and land management policies. Socio-economic empowerment  Ecotourism, sustainable agribusiness models, and community-based agricultural cooperatives.  Balancing economic growth with cultural sustainability. | The government combines customary land law with formal land use policies. Environmental Conservation implements land reforestation and rehabilitation programs. Community empowerment encourages local leadership participation. Youth involvement develops educational programs combining modern agricultural techniques with traditional knowledge.  Sustainable economic model with sustainable agroforestry and land-use systems |

These findings, it is analyzed with six social evolutionary models as an analytical approach to answer the research on designing sustainable farmland agriculture in the highlands in Indonesia as follows:

**Table 2. Six Evolution Model Analysis**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Empathy** | **Exploration** | **Elaboration** | **Exposed** | **Execution** | **Expansion** |
| The Sustainable Swidden Agricultural Design in the Indonesian Highlands | Identify the need for policies to preserve local wisdom and their impact on the balance of forest resources and migratory agriculture. Historical analysis with Landsat archives to understand agricultural and land-use patterns. | Developing strategies to support agriculture through policy, finance, and facilitation from the government. Assist farmers who want to transition to permanent farming with ongoing training and resources. | Educating the public about the benefits and challenges of agroforestry agriculture, as well as the importance of environmental conservation. Establish cooperatives and market relationships to ensure reasonable prices and stable product demand. | Implement policies that support land ownership rights for agroforestry farmers and introduce certification schemes. Implementation of reforestation programs, land rehabilitation, and agroforestry-based economic models. | Develop a sustainable economic model that integrates agroforestry and modern agricultural systems. Increase youth participation by combining modern agricultural techniques with traditional wisdom in educational programs. |

Based on the above analysis, it is necessary to explain in detail how the design of six evolutionary social models can provide a clear and measurable concept of the sustainability of highland mobile farming in Indonesia.

1. **Empathy**

Empathy is the first step in the design thinking process which is very important to understand the problems faced by farmers and communities in mountainous areas of Indonesia related to the practice of migratory agriculture. The empathy approach prioritizes deepening the needs and conditions faced by local communities, not only from the technical side of agriculture but also from social and cultural aspects. The same thing was revealed by Rahman et al., (2017) which emphasizes that the impact of all aspects needs to be anticipated so that they can feel the negative impact that will occur in the future.

At this stage, it is important to make direct observations of long-standing agricultural practices and interact with farmers through in-depth interviews. This process makes it possible to understand not only the challenges they face but also their views on nature conservation policies that often go against local customs that have been running for years. With this approach, the design of the developed solution can be more inclusive and by the needs of the community.

In Indonesia, especially in mountainous areas, swidden farming has been a part of social and economic life for a long time. Therefore, it is important to identify how farmers perceive proposed changes, such as policies related to conservation and nature conservation. For this reason, determining policies in a design is very necessary for Indonesia as a developing country, this is in line with the opinion of Adijaya (2020) through an empathic mechanism so that it is managed properly and rationally.

In this case, empathy allows designers to understand that the challenges faced by farmers are not only in the aspects of agricultural production, but also in aspects of survival, local wisdom, and cultural heritage. Thus, the empathy stage becomes a solid foundation for building solutions that not only consider technical aspects but also social and cultural sustainability for local communities.

In this context, empathy also opens up space to understand how government policies and external interventions affect the dynamics of farmers' daily lives. Research related to the use of design thinking in traditional agriculture shows that the success of conservation policies is highly dependent on how the policy integrates with existing traditional ways of life and practices. This is supported by research by Hidayat, (2013) which focuses on the sustainable integration between traditional and future societies in the highlands. Therefore, by taking an empathetic approach to farmers, the solutions that emerge later can be more effective in supporting the sustainability of swidden agriculture that prioritizes nature conservation without ignoring the basic needs of the local community. This is an important foundation for sustainable solution design.

1. **Exploration**

After the empathy stage, design thinking proceeds to the exploration stage, which aims to explore various alternative solutions that can be applied to overcoming previously identified problems. Exploration in the context of sustainable swidden agriculture includes finding solutions that not only consider nature conservation but also economic sustainability for farmers in Indonesia's mountainous areas. One effective way of exploration is through the analysis of past land use patterns using satellite technology such as Landsat archives. This data provides deeper insights into the changes that occur in ecosystems due to shifting agricultural practices. This is reinforced by Ataribaba et al., (2020) which pays attention to technological factors as an instrument in sustainable agriculture in the highlands. Thus, this data exploration can help identify areas of degradation and potential for improvement.

In addition, exploration also involves research on agricultural systems that can be applied to support sustainability in swidden agriculture. One approach that is becoming increasingly popular is agroforestry, which combines crops with forest trees. In this stage, various agroforestry methods that can be applied in Indonesia's mountainous areas are tested to see their effectiveness in increasing agricultural productivity and maintaining ecosystem balance. This exploration also includes a study on the successful use of environmentally friendly agricultural technology and the use of plant varieties that are more resistant to climate change. This is harmonized by Swe and Nawata (2020) by explaining that agroforestry has been shown to improve soil quality and prevent erosion, which is essential for sustainable agriculture in mountainous areas.

In addition, exploration at this stage can also involve collaboration between scientists, farmers, and other stakeholders to find more holistic solutions. By leveraging the local experience and knowledge possessed by farmers, solution design can be strengthened with a broader perspective. One good example of exploration is the development of a community-based farming model that integrates swidden practices with agroforestry systems while introducing new, more efficient technologies. Regarding the development of a similar agricultural model revealed by Imang et al., (2018) the emphasis on local knowledge, technology and agricultural models in an integrated system in field agriculture moves sustainably. This collaboration not only results in more relevant and applicable solutions but also strengthens community involvement in maintaining the sustainability of their ecosystems.

1. **Elaboration**

Once an alternative solution has been found in the exploration stage, the next stage is elaboration, which focuses on the development and further elaboration of the solutions that have been discovered. In the context of swidden agriculture, elaboration can involve designing more detailed solutions on the application of agroforestry and training needed by farmers to adopt more environmentally friendly agricultural techniques. For example, if the results of the exploration show that agroforestry systems can improve agricultural sustainability, the elaboration phase will focus on developing training modules that can help farmers understand and apply effective agroforestry techniques. This training includes the proper use of plant seeds, environmentally friendly fertilization techniques, and good forest management. The importance of training and mobilization of soft skills provides support in the transformation of the agricultural system in Indonesia, as the opinion of Choir et al., (2018) emphasises the level of knowledge and skills as well as awareness of what is being done today and its impact in the future.

In addition, the elaboration also includes the creation of support programs for farmers who want to switch from swidden farming practices to more permanent and sustainable agricultural systems. This program can be in the form of providing access to new technologies, such as more efficient modern agricultural tools or more water-efficient irrigation systems, that can help farmers make the transition. Research shows that support in the form of resources and knowledge is crucial in this transition process. Thus, the focus on human resource development in the field agriculture system in Indonesia is a priority as emphasized (Li & Nath, 2024). Therefore, the elaboration of solutions at this stage should focus on creating adequate infrastructure to support farmers in the long term.

Elaboration also needs to involve the evaluation of the success of agricultural models that have been tested in the exploration stage, paying attention to their effectiveness in improving ecosystem sustainability and community welfare. In this case, it is important to develop a measuring tool that can assess the social, economic, and environmental impacts of agroforestry implementation. For this reason, agroforestry transformation is the main thing in creating an ecosystem for local community structuring as revealed (Rosmalah et al., 2023). Thus, elaboration is not only about developing solutions but also about ensuring that they can be implemented practically and deliver tangible results in improving the sustainability of swidden agriculture in the mountains of Indonesia.

1. **Exposed**

Exposure is the next phase in design thinking that aims to test and introduce solutions that have been developed on a larger scale. At this stage, the solutions that have been tested and refined need to be confronted with real challenges in the field to see how they function in a broader context. In the case of swidden agriculture, exposure involves testing the implementation of policies that support agroforestry agriculture, such as the granting of land tenure rights or certification schemes for agroforestry farmers. This implementation aims to increase the motivation of farmers to switch to a more sustainable agricultural system. The function of mapping and distributing land for farmers is an interesting issue, on the other hand, the draft of the main agrarian law is a challenge in Indonesia, as the opinion is Nair, (2022) Developing agroforestry must rely on stable land reform. The exposure stage also involves an outreach process to the community and the government about the benefits of agroforestry practices and the importance of nature conservation.

The dissemination of clear and easy-to-understand information is very important in the exposure phase, as it can affect public acceptance of the solutions offered. Through the right campaigns and educational programs, communities can be given a better understanding of how agroforestry-based agriculture can help them improve agricultural yields while conserving nature. Related to developing a field agricultural system to adhere to sustainable nature conservation where Erni (2008) underlines the importance of agroforestry being included in the educational curriculum. In the latest research, exposure serves as a mechanism to disseminate the necessary information so that various stakeholders, including farmers, governments, and communities, can work together to support the implementation of sustainable solutions. Therefore, exposure is not just about testing in the field, but also about building a deep collective awareness of the importance of sustainable agriculture.

Exposure also involves a broader impact analysis of the solutions that have been implemented. For example, at this stage, a survey can be conducted to evaluate the community's acceptance of policy changes or the use of agroforestry techniques. In addition, according to McNeely, (2013), It is also very important to see how existing policies interact with the social, economic, and cultural aspects of the community. With the data obtained from the exposure phase, solutions can be more mature and adjusted to the needs and realities in the field, so that the implementation of sustainable programs can be carried out more effectively.

1. **Execution**

Execution is the stage at which a solution that has been prepared and tested is applied in real life. At this stage, policies that support sustainable agriculture, such as reforestation, land rehabilitation, and the development of agroforestry-based economic models, begin to be implemented. As the opinion Willmott et al., (2023) emphasized that execution requires close collaboration between various parties, including the government, non-governmental organizations, and the farmers themselves. In existing research, the execution of this program has been proven to improve agricultural sustainability and improve farmers' welfare. With adequate support, farmers can more easily access the resources and technology they need to run sustainable agriculture.

Execution also involves the implementation of various initiatives that can support the transition from agriculture to permanent agroforestry-based agriculture. For example, the government can provide incentives or subsidies for farmers who adopt environmentally friendly agricultural practices. In addition, according to research by Achmad et al., (2022) Focusing on training programs to improve farmers' skills in soil and crop management can also be introduced at the stage of sustainable agriculture in the highlands. Thus, execution is not only about running existing programs but also about creating an environment conducive to sustainable agriculture in the future.

Research also shows that good execution requires an effective monitoring and evaluation system to ensure that the program can achieve its goals. Measuring the outcomes and impacts of sustainable agriculture programmes is essential to identify whether the policies are providing significant benefits so that they can explain the extent to which farmers moving to the highlands in Indonesia can understand far from what the future holds for their farming businesses (Duffy et al., 2021). Therefore, execution requires a well-organized and evidence-based approach to ensure that the efforts made bring tangible positive change to farmers and the ecosystems around them.

1. **Expansion**

Expansion is the final stage in design thinking, which includes the expansion of solutions that have been successfully implemented to reach more farmers and other regions. In the context of swidden agriculture, expansion involves the development of a sustainable economic model that not only incorporates modern agricultural techniques but also involves the use of local wisdom. At this stage, local wisdom for the surrounding community is the main condition for farming to be sustainable, this is the opinion of Wijayanto et al., (2023) It is important to engage different levels of society, especially the younger generation, to introduce them to the potential of sustainable agriculture and the importance of nature conservation. Research shows that by involving youth in agricultural activities, sustainable programs have a greater chance of success and longevity.

Expansion also requires attention to capacity building and community participation in implementing solutions that have proven effective. Through proper education and training, communities in other regions can be taught to adopt techniques that can improve agricultural yields and at the same time maintain the balance of the ecosystem. Therefore, the same thing is in line with the results of the study Njurumana et al., (2021) explained that the expansion also includes efforts to create a network that connects farmers from different regions so that they can share their experiences and knowledge about sustainable agriculture.

The expansion stage must also pay attention to the diversity of conditions that exist in various regions because each region has different challenges and needs. In recent research, the expansion has focused on creating models that are flexible and can be adapted to local conditions. Thus, the expansion not only expands the range of solutions but also ensures that the solutions implemented can answer the challenges faced by various communities throughout Indonesia.

4. Conclusion

Research on the social evolution of sustainable shifting farming design in the Indonesian Highlands includes six important stages in the design thinking process, namely empathy, exploration, elaboration, exposure, execution, and expansion. The first stage, empathy, emphasizes the importance of a deep understanding of the challenges faced by farmers, both in terms of social, cultural, and environmental, to design inclusive and sustainable solutions. Exploration explores various alternative solutions through the use of satellite technology and agroforestry to improve nature sustainability and economic sustainability. The elaboration stage focuses on developing practical solutions and training necessary for the adoption of new techniques by farmers. Furthermore, exposure tests policy implementation and introduces solutions at a broader scale, while execution involves implementing policies and supporting resources to ensure sustainability. Finally, the expansion extends the sustainable farming model to more regions, by engaging the younger generation and paying attention to the local context. The implications of this study show that a design-based thinking approach can create more effective and relevant solutions to the needs of local farmers, but the limitations of this research lie in the difficulty of accessing representative data in all regions and the differences in social and economic conditions in each region. Further research is suggested to explore the role of digital technology in supporting sustainable agriculture as well as further evaluate the long-term success of the implemented policies.

Competing interests

The author declares no conflict of interest.

**DISCLAIMER**

Authors hereby declare that no generative AI technologies such as large language models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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