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Agroecological practice: The relevance of permaculture-based land-design for sustainability and resilience on the farm, a case study in Gopta village, West Bengal, India

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A sunny afternoon at the Vasudev Farm

"I want to understand the world from your point of view. I want to know what you know in the way you know it. I want to understand the meaning of your experience, to walk in your shoes, to feel things as you feel them, to explain things as you explain them. Will you become my teacher and help me understand?"

— James P. Spradley, ethnographer and anthropologist

(Spradley, 1979)

Abstract

Intensive agriculture does not only adversely affect farmland biodiversity but also causes rapid environmental degradation. Harmful chemicals involved in such high-yielding industrial agriculture have led to consumers' and the growers' poor health. Excessive dependency on machines has weakened the socio-cultural bond within the communities. Permaculture as an alternative farming system is based on ecological principles and hence may be more sustainable. Its design principles and value-based ethics utilise all available resources at the farm in an optimised manner without imposing any burden on the environment. In this explorative case study of Vasudev farm in Gopta Village in West Bengal, India, I investigated the effect of permaculture-based land design (PLD) on the given farming system's sustainability and resilience. I also questioned the PLD strategies being used and the future of such practices. This participatory action research (PAR) included transect walks, participatory observations, semi-structured interviews, and a visioning workshop. My research questions looked at the PLD's relevance in the given farm for its sustainability and resilience. My inquiry leads to the identification of three integrals to be relevant at the given farming system: 1) implementing a holistic approach, 2) developing an in-depth understanding for maximum usage of the multifunctional farm structures and resources, and 3) working on conservation and adaptation strategies by creating an ecological web and crucial interlinking factors of the farming system. The research findings suggest that the present Vasudev farming system's sustainability and resilience have improved during the last five years and is also prepared to grow amidst future challenges and aspirations.

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I thank my teachers Anna Marie Nicolaysen and Geir Lieblein from NMBU, for supervising my research with their invaluable feedback and guidance. I also thank the teachers Tor Arvid Breland and Charles Francis and student advisor Cathrine Strømø for all their support.

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I express my most profound appreciation to the farmers who participated in the focus group (in the picture below) for their active participation and humble generosity.

From left: The author, the trainer Badshah from DRCSC and the farmer Vasudev with his mother, son, daughter and wife.

Finally, I want to thank my family and friends, for their unconditional love and support, without whom it would not have been possible for me to do this research.

Abbreviations

PLD	Permaculture based land designs
PPE	Permaculture principles and ethics
SRI	Sustainability and resilience indicators
PAR	Participatory action research
ELT	Experiential learning theory
FFS	Farmer field school
IPM	Integrated pest management
INM	Integrated nutrient management
NGO	Non-governmental organisation
DRCSC	Development research communication and services centre
COVID-19	Coronavirus disease - 2019

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Chapter1. Introduction

Intensive agriculture adversely affects farmland biodiversity (Vanbergen and Initiative, 2013) and causes environmental pollution by releasing greenhouse gases (Hathaway, 2016). There is a need to design alternative farm systems based on ecological principles and hence more sustainable (Ferguson and Lovell, 2014).

An agroecological farm as a living and integrated system (figure 1) is like a miniature world with natural ecologies that are carefully put to work collectively and strategically (Vandermeer, 1995). Several ecologies such as environmental (natural and manmade), economic, and social continuously interplay to keep the dynamic system moving (Lockyer and Veteto, 2013). The nature of these systems, including their super-systems, sub-systems, structures, and functions, is such that the whole system gets affected if any part is touched. These are complex systems dealing with plants, animals, and humans at various trophic[1] levels (Altieri, 2000).

Permaculture could be a good option to implement the notions of agroecology. This practice utilises all available resources effectively without imposing any burden on the environment (Ferguson and Lovell, 2014). The concept of permaculture was developed in Australia (Mollison et al., 1991) and integrates household systems with multi-storey and genetically diverse trees, shrubs, ground crops, and aquaculture systems. A wide variety of species characterises a well-functioning permaculture system: varied and plentiful yields of food, fibre, and other valuable products, enough ecological complexity and stability to be self-sustaining using local, renewable resources. A multilayered ‘food

[1] The term “trophic level” is used to describe the position of an organism in the food web of an ecosystem.

forest' would be a typical permaculture system description (Hudson, 2009). This system seems to be more successful in tropical countries like India, where most agriculture is not done on a larger scale, and a wide range of genetic diversity (in both crops and other food plants) is found.

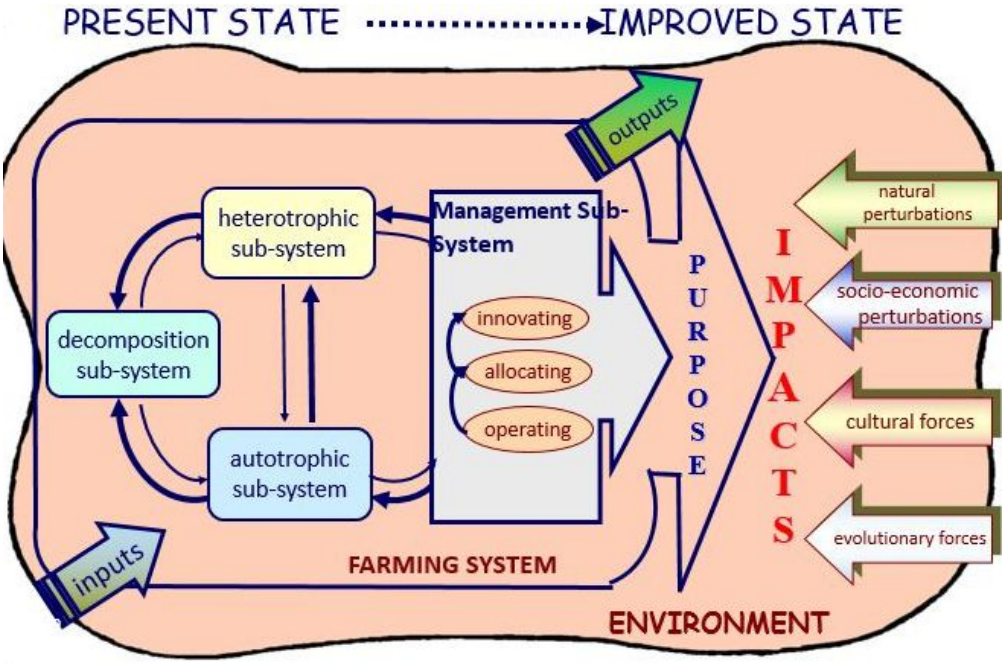


Figure 1: A model of farming as a human activity system (Tor Arvid Breland, 2016)

The transition to diversified and ecologically sustainable small-scale production systems has been addressed by (De Schutter, 2012); (Kremen and Miles, 2012) and (Wilson, 2008). An agroecological transition is regarded as a multi-sector project (Marques et al., 2010) and (Piraux et al., 2010) because it operates at multiple temporal and spatial scales and involves diverse communities. Both traditional and innovative practices may contribute to this transition (Altieri, 2004); (Rosset et al., 2011) and (Koohafkan et al., 2012) . Permaculture practices promote permanent and sustainable solutions for the farming system by creating social cultures for agricultural systems (Pickerill,

2013) and generates awareness in response to environmental crises in general and to food crises in particular (Fiebrig et al., 2020).

Two different interpretations of permaculture have been identified by Rhodes (2012), 1) original permaculture, which aims to create a forest garden in which plants, animals, and humans live in harmony, and 2) *design permaculture*, which is a kind of compromise that uses natural processes to create a sustainable living space and ecosystem, following ecological principles in a more structured way. The latter is a significant and necessary adaptation of the 'pure' notion (Rhodes, 2012). The exploration during my thesis is dealing with the second interpretation.

Permaculture-based land design (PLD) may lead to landscape transformations (Robertson, 2020) within the farming system based on permaculture principles and ethics (PPE). Permaculture has three ethics and twelve design principles that have been distilled through Mollison, Holmgren, and researchers' works. (see appendix 6). The permaculture systems' achievements and knowledge are often criticised for being overreaching and oversimplifying (Ferguson and Lovell, 2014). Consequently, one way to understand the relevance of permaculture land-based design at the farming system level can be by checking the permaculture design impacts on sustainability and resilience parameters.
Agroecological practices are often propounded to be sustainable; they apply ecological concepts and principles to agroecosystems' design and management (Gliessman et al., 1998). Figure 2 indicates how the agroecosystem's background themes and context lead to agroecological structures and functions. The indicators and the conditions of sustainability can be found from the agroecosystem's structures and functions.

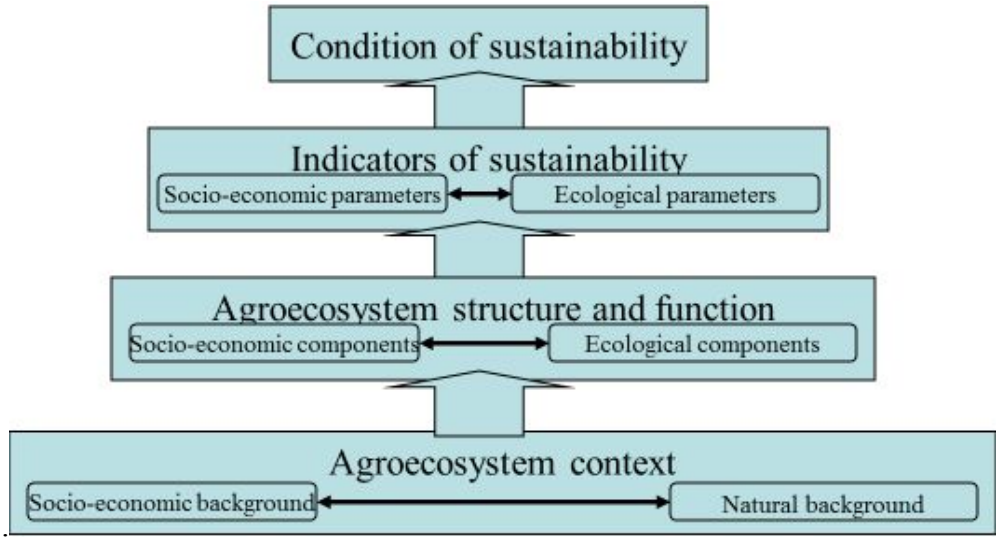


Figure 2: Sustainability analysis (Gliessmann, 1998)

According to Wezel, sustainability in its broadest sense is a transition through the three consecutive stages of efficiency increase, substitution, and redesign (Wezel et al., 2013). The efficiency implies using a minimum level of inputs in crop management, which yields maximum crop productivity. Here efficiency concept is a multidimensional one, as it encompasses economic, social, and ecological perspectives. Once efficient agroecological practices are identified, the farmstead moves to substitute the hitherto used crop and land management practices to those more environmentally viable. The final stage of transition is a structural change in the farming system, including innovations. Innovations can also be in the form of a rediscovery of traditional practices that were long forgotten.

The systemic sustainability analysis model (SSA) suggests the sustainability indicators' flow for a complex system (figure 3). Themes collected from the system are first interpreted and then implemented for the system's benefit (Bell and Morse, 2013).

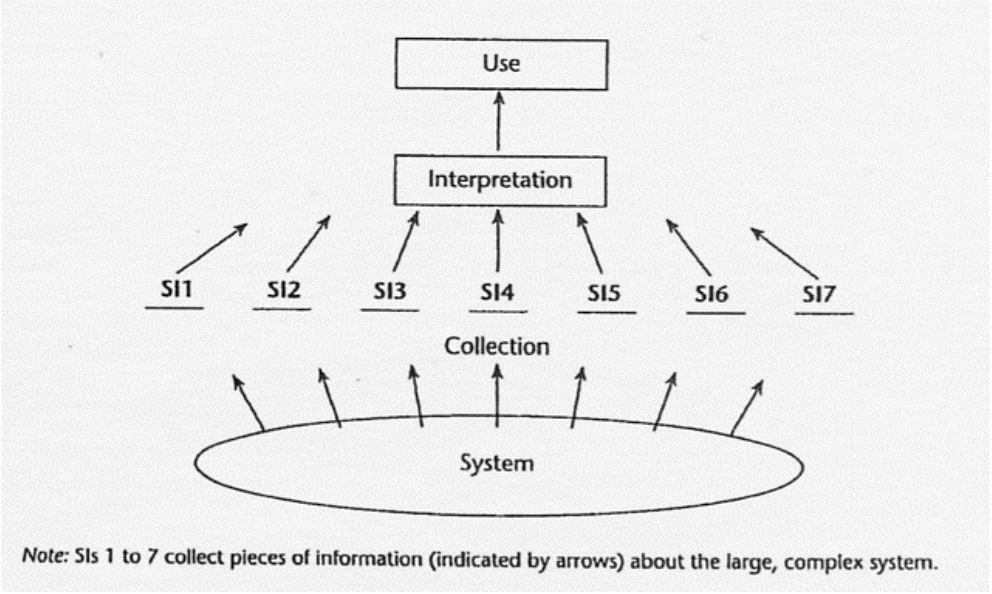


Figure 3: The concept behind Sustainability indicators Sis (Bell and Morse 1999)

Based on these defined concepts, I assessed the sustainability of the farming system under study. The sustainability and resilience indicators (SRI) have been used to measure the farming system's success. My research's sustainability indicators are economic growth, production growth, social growth, cultural growth, environmental growth, and ecological growth (OKIGBO, 1989). The resilience indicators used in the farming system are its buffer capacity, adaptive capacity, and self-organising capacity (Carpenter et al., 2005) and (Milestad and Darnhofer, 2003). Sustainability and resilience are somewhat similar concepts; sustainability's conservation goals are opposed to the adaptation goals of resilience (Cheer and Lew, 2018).

There is a wealth of literature dealing with permaculture in various parts of the world. In the Indian scenario, the harsh effects of intensive farming and the impacts of agrochemicals have been studied by (Chakrabarti et al., 2015) and (Basu et al., 2016) but the practice of permaculture in India has not been described much in the literature. One exception in this respect is a study done

by (Palaniappan et al., 2016), which explores farmer views about alternative farming through interviews.

Like India, most tropical countries are dependent on agriculture, where many pollinator-dependent vegetable crops are grown (Bhattacharya and Basu, 2018). Highly diversified agricultural practices are predominant in these countries due to minimal landholdings, on an average of 1.42 ha by an Indian farmer (Chand et al., 2011). Most of India's farmers are small and marginal farmers (Chand et al., 2011) and (Kadapatti and Bagalkoti, 2014). Each farmer's farming practices are conducted according to the market needs, and the character of their landholdings may also lead to a highly diversified and seasonal pattern in crop production (Kalaiselvi and Kalyani, 2012). Water availability also directs the seasonal cropping patterns in areas where most vegetable farmers are dependent on the monsoon for cultivation (Sharma et al., 2010). The stagnation in production and food scarcities has resulted in a lack of care for farmlands leading to other severe issues like declining water resources, poor soil health, loss of biodiversity, and wildlife habitats. The lives of peasants have become increasingly complex, and there have been years when 3-4 million peasants have suffered from food shortage while tens of thousands of hectares of land were left uncultivated (Mishra, 2007).

This study's central theme is the relevance of permaculture-based land-design in running a small-scale organic farming system (Narasanna, 2013). I critically study the structures, strategies, and scope of permaculture-based land designs and investigate whether they are sustainable and resilient in the present and for the future at the given small-scale farming system in West Bengal**.**

In my study, I aim to provide credible knowledge to the scientific community and the region's small and marginal farmers. I attempt to provide the readers with a better understanding of PLD practices in the local context. Through this

action research, I helped the participants develop a shared vision for the farming system and devise a potential action plan that would strategically assist them in the future.

Research Questions

1. How relevant are ‘permaculture-based land designs’ for the sustainability and resilience of the given farming system?
2. How are the farmers using ‘permaculture-based designs’ to achieve sustainability and resilience for the given farming system?
3. What can be done to improve further the current situation at the given farming system, and how?

The above research questions lay the foundation for the following chapters. In the next chapter, I will write about the context in which the research has taken place. The methodology chapter will explain how participatory action research methods have been applied using Kolb’s learning cycle and theory from phenomenology (Francis et al., 2013). In the methods chapter, I also write about the qualitative methods I have used, like transect walks, interviews, and a visioning workshop to collect data at the Vasudev farm. Then I write about how these collected data were analysed to reach the final results. In the results chapter, I show how permaculture-based land designs are being used at the farm and then discuss their sustainability and resilience. The concluding chapter has a summary of the main findings. Lastly, I sum-up the document with my reflection at the end of the concluding chapter.

Chapter 2. Context

West Bengal is located in east India and is a state which depends predominantly on agriculture. The primary crop grown is paddy, while many vegetable and fruit crops are also cultivated. The agricultural land crisis is a prominent issue in the state. The increase in human population and urbanisation is escalating the cost of land and farmers' pressure to sell their land (Nielsen, 2010). Many farmers have lost their quality farmlands due to monoculture, climate change, and land grabbing (Lohar and Pal, 1995) and (Nielsen, 2010). Although there are green tribunals to protect greenery (farms and forests) from getting cemented for urbanisation, Bengal has lost a lot of its arable space and spatial diversity. Both the farmers and the pollinators struggle for their existence, while the food demand is ever mounting. Food insecurity is very much prevalent in West Bengal except in medium farms (Karmakar and Sarkar, 2014). The increasing population and related need for a quality food supply-chain, including storage and distribution, require holistic and relevant land usage approaches (Fadaee, 2019). This research will explore the farmer's situation and investigate this complex issue's roots through a case study.

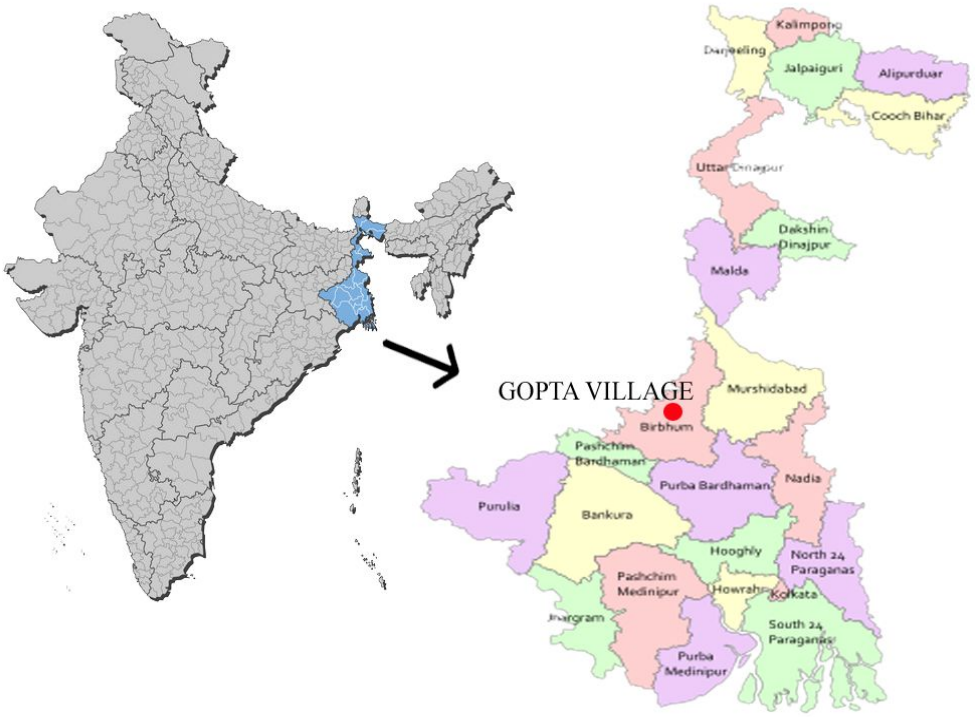


Figure 4: (left) Indian state of West Bengal (in blue), and (right) Gopta Village (in red dot) at Birbhum District, West Bengal.

The study site (figure 4) is a Gopta village farm located in Birbhum District, West Bengal, India. The study location's topography is slight undulating plane land situated at the fringes of the Chotanagpur Plateau. The climate of the state is typically tropical; hot and humid summers and dry winters. The annual average rainfall is 1,307 mm (Majumder et al., 2010). The agriculture in this belt is chiefly of an intensive type. Large paddy fields are found along those some vegetables, such as brinjal, bottle gourd, pumpkin, okra, potato, and some native crops are cultivated (Let, 2011). Speaking with the local farmers during my initial meeting, I was told that the nearby villages' farms apply a high level of pesticide and chemical fertiliser inputs.

*Figure **5:** (left) View of the agroforest (right) View of the paddy field.*

*Figure **6:** (left) View of the vegetable farm (right) View of the pond.*

*Figure **7:** (left) View of the paddy field (right) view of the trellis for growing vegetables.*

However, the study farm (figures 5, 6 and 7) is organic, managed by a local marginal farmer named Vasudev Hazra. It is a thirty-year-old farm. Earlier Vasudev's father used to run it, but after his demise Vasudev is now running it for approximately 25 years. Vasudev's family consists of five members, including himself, his mother, wife, a son and a daughter. The farmer family is trained and supported by the non-governmental organisation Development Research Communication and Services Centre (DRCSC) for almost eight years now.

Permaculture designs at Vasudev's farm are implemented under the guidance of Ardhendu Shekar Chatterjee. He is certificated in permaculture (learning from Rosemary Morrow, Australia, and Chris Evans, United Kingdom) and Ecological Agriculture (learning from ETC Foundation, Netherlands). He is one of the founding members of DRCSC, which was formed in 1982.

DRCSC is a resource centre for collecting, collating, and disseminating knowledge and skills regarding sustainable agriculture and alternative livelihood. However, since 1992, DRCSC has focused on improving the rural poor's food and livelihood security through scientific management of natural resources and community-based initiatives based on principles and actions that are environmentally friendly, economically appropriate, socially just, and developed through cooperation. Presently, DRCSC works with local NGOs and Mutual Cooperation Groups to implement various projects and programs. While DRCSC focuses on imparting the necessary skills to the farmers for sustainable agriculture, my research focuses on the permaculture land design aspects and their sustainability and resilience.

The research fieldwork and data collection were carried out during the lockdown phase of the COVID-19 pandemic crisis in July 2020. A few months before, on May 20th, the super cyclone Amphan, the biggest natural calamity

ever, had hit the state (Majumdar and DasGupta, 2020). As I spoke to Vasudev, I realised that the farm's situation was challenging due to the double burden of natural and biological disasters. The daily sales had fallen, and there was a discontinuity in the daily labour force. There was a shortage of both the demand and supply of farm produce. It became more crucial for me to research whether and how the farm (including the farmer family) sustained such a critical situation.

Chapter 3. Methodology

I studied the Vasudev farm's permaculture-based land design transformations, considering its usefulness in sustainability and resilience, using a qualitative research design framework. An open-ended case study was chosen because it is exploratory and based on the "*desire to understand complex social phenomena,*" as Yin writes (2009, p. 4). The inductive and open-ended case-study (Yin, 2013a) was combined with participatory action research (PAR) to expand my role from the mere observer and interviewer to that of a participant, a facilitator, an insider, and a team member (Francis et al., 2015). During the research, the focus group consisted of Vasudev, his mother, his wife, his son his daughter, his neighbour named Uday and the permaculture trainer named Badshah from DRCSC. They are active practitioners in the Vasudev farming system and together hold the responsibility of the future development of the farm. So, there were eight participants (including me, as a part of participatory action research) during the research process.

Implementing the PAR approach (see Figure 9) and a soft systems methodology (Méndez et al., 2013), combined with Kolb's cycle of experiential learning (Kolb, 2014), was applied for finding the critical themes up to conceptualising improvements in the human activity systems at the Vasudev farm. Further, Kolb's experiential learning theory (ELT) was also helpful in order to organise both the fieldwork and the final documentation categorically (see Figure 8).

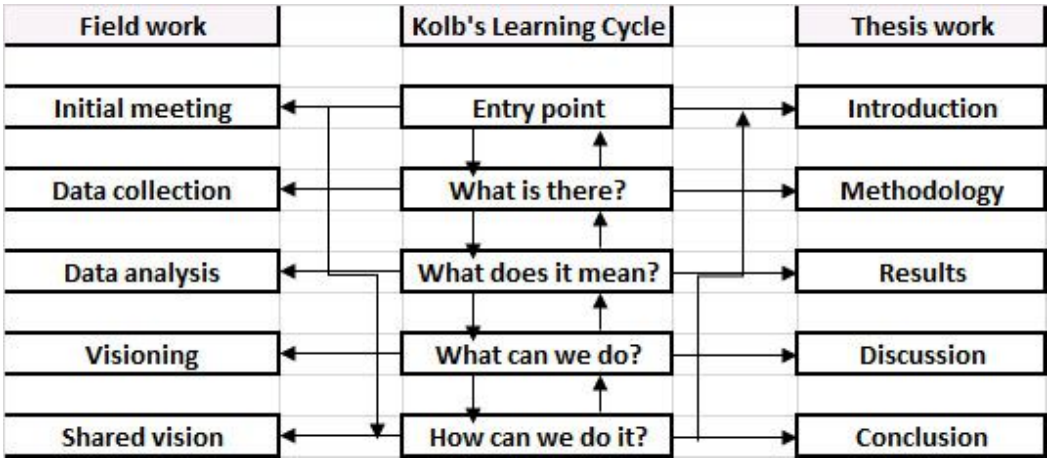


Figure 8: Conceptual model with the five stages for the fieldwork and thesis work using Kolb's learning cycle.

Study Methods

Using the ELT supported the study to build a holistic perspective. It included experience, perception, cognition, and behaviour. "*Learning is the process whereby knowledge is created through the transformation of experience*." (Kolb, 2007). Thus, the multidimensional, inductive, flexible, and adaptive methods have been used to learn and explore how we can further improve the current situation (Diane and Charles, 2004) and make the empirical research comprehensive and descriptive.

I used phenomenology (Francis et al., 2013), five senses, and five skills. Using the theoretical framework, I made a comparative table to measure the farming system's SRI compared to each of the PLD structures, noted during my initial meeting stage. This table was distributed to the focus group on day one and was filled by them in plenary (Gliessman and Tittonell, 2015) on day three of the research schedule.

Chapter 3. Methodology

The PAR procedure, including experiential learning, phenomenon-based learning, and theoretical knowledge, had five main stages (figure 9), as mentioned below, along with the timeline:

Step by step research process framework along with timeline (inspired from Kolb's Learning Cycle).			
SN	**Research stages**	**Qualitative research tools and strategies used**	**Month**
1	**Icebreaking stage**		
	Initial meet	Informal meeting for rapport building. Gaining first impressions of the study site.	Apr-20
2	**Data collection stage**		
	Five senses and five competencies: *observation, participation, dialogue, reflection and visioning*	Experience from staying and working at the farm. Building cordial relation with the focus group.	Jul-20
	Transect-walk: *observation and reflection*	Realtime cross-sectional elevations, site map, detail blow-ups and photography	
	Semi-structured interview	Interview guide and videography	
	Workshop: *refection and visioning*	PLD vs. SRI comparative table, rich pictures, guided imagery and videography	
3	**Data analysis stage**		
	from Transect-walk	Rich pictures, labelling, coding and categorising	Aug-20 to Oct-20
	from Interview	Transcription, labelling, coding and categorising	
	from Workshop	Rich pictures, labelling, coding and categorising Transcription, labelling, coding and categorising	
	Triangulation	Relevant theory + Transect-walk + Interview themes + Workshop	
4	**Visioning stage**		
	from Workshop	Envisioned farm situation rich pictures for 2025	Jul-20
5	**Shared-vision stage**		
	from Workshop	Plan of action for coming years till 2025	Jul-20

Figure 9: Table showing the sequence and details of applied research methods.

The methods used: transect-walk observations, interviews, and the workshop held phenomenology as the study's core philosophy. The experiential learning method's cycle was designed for the data collection to be flexible to the emerging themes and patterns and closely understand the purposeful farm systems.

The research was carried-out in Bengali, which is the local language in West Bengal. The research tools (mentioned later) such as interview guide, guided

imagery and sustainability comparative chart were framed in Bengali. The English versions are attached in the appendix.

The use of these methods at Vasudev's farm is explained stagewise:

1 **Icebreaking stage:** During this stage, the initial meeting (Yin, 2013b) was arranged to build rapport with the farmer, the family, the neighbours, and the trainer. This initial meeting also supported me in becoming familiar with the study site's physical and cultural dynamics. Besides, the meeting led to reflection (Francis et al., 2015) upon preconceived notions and whether or not there was a need to redesign any part of the project.

2 **Data collection stage:** This was the second stage in the research process. I applied the strategies mentioned below:

a. **Five senses with five competences** involvement: Theoretical constructs based on attitude, cognition (think), emotion (feel), and behaviour (act) were built during each of the three days' stay at Vasudev farm. This approach was at the heart of the core methods like transect walk, semi-structured interview, and the workshop. These skills were practised throughout the data collection process, including the phenomenological approach (Østergaard et al., 2010) with Kolb's experiential learning cycle. I was learning open-mindedly to explore the Vasudev farming system and find answers to the research questions. The five senses used were touch, hear, see, smell, and taste for the phenomenological approach. The five vital agroecological skills used were observation, reflection, participation, dialogue, and visioning. There was no particular order in which these senses and skills were applied (figure 10), but reflections were rooted in the practice of each.

Chapter 3. Methodology

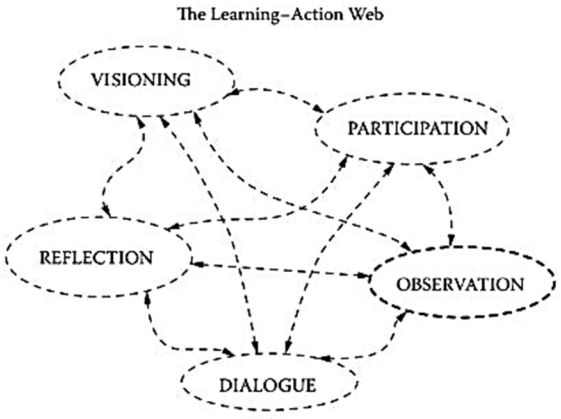


Figure 10: Conceptual model showing the connection between the five essential agroecology skills. Adopted from (Francis et al., 2015)

Observation: A non-judgemental approach was maintained while experiencing the Vasudev farming system's prevalent features. Observation skills were explicitly used during transect walk and participatory observations during my farm work participation (mentioned later). It involved taking notes and photographs and drawing sketches of the current spatial diversity at the farm and making a bird's-eye view sketch (to include the farm's length and breadth) along with a few sectional-farm drawings (to have depths and heights). This process helped me view spatial diversity and related design patterns. For example, earlier, Vasudev grew only paddy (small root), but now he has many vegetables, animals, crops and trees (with diverse spatial needs).

Figure 11: Observation at Vasudev's vegetable garden (left) and cattle shed (right).

Reflection: Qualitative research tools like daily learning-logs, note-making, conceptual models, and rich pictures (Francis et al., 2011) of the phenomenological experiences in the Vasudev farming system were used. Resource flow/cycling diagrams (Gliessman, 1990) were developed to show locations, interlinks, and interdependency of the farm's spatial resources, farm activities, and farm systems.

Participation: The project followed an action-oriented approach, so my physical presence in the research field and involvement in the farm's daily routine were vital. The engaging activities at the farm required me to be proactive, spontaneous and flexible. As a part of participatory observation, I was also alert about observing existing phenomenon at the farm. A participatory visioning session with the farmer family was conducted to support their future aspirations. As a facilitator, I participated in the workshop and helped the workshop participants collectively make the shared vision as an action plan for their envisioned future (Lieblein and Francis, 2013).

Figure 12: (left) participation in checking the cow for bugs. (right) Cow brought to the outfield.

Dialogue: The communication between the farmer Vasudev and me started from the first stage, at our initial meeting. The use of dialogue helped me convince him to allow for the research during the lockdown phase of the COVID-19 crisis. I could explain to him the health safety measures to be taken during the

research. I maintained a fair balance between listening and speaking, creating space for each other's viewpoints and collective learning. Dialogues should have equal participation from all the participants; otherwise, it could turn into polarised communication.

Figure 13: Dialogue between (left to right) Badshah, me and Vasudev over the PLD at the farm.

Visioning: During the focus group, I asked the participants to think about what would be required in the future and how they could achieve that. They looked to the Vasudev farm's current phenomenon for a clearer image of a better tomorrow. Through the guided imagery (appendix 7) during the visioning workshop, I facilitated the participants to build a shared vision (figure 36).

b. **Transect-Walk (Day 1)**: Observation walk through the research site was vital for collecting current data from the Vasudev farm. I had Vasudev accompanying me to the walk and explain his work around the farm. I looked at the two directions of observation, one was to observe outward towards the existing permaculture-based land design phenomenon that was applied for sustainability and resilience at the farming system, and the second was to look inward towards my prerequisites to enable my understanding of the existing farm phenomenon (Lieblein et al., 2012). Observations as a research method

are incomplete without reflection. Daily reflection logs about the observation walk were crucial and later helped me during the data analysis (will be discussed in the data analysis section). Photography during the transect walk was also used to record observed existing physical features of the farming system. The observed patterns, themes, and inter-relationships were sketched as rich pictures, conceptual models, and mind maps (like maps, sectional elevations, and blow-up details).

Figure 14: Transect walks with Vasudev during the daytime with ample sunlight in the background.

During the lunch break, I distributed blank photocopies of my predesigned comparative table (see appendix 8) to each of the focus group members. I explained to them the SRI parameters and PLD features mentioned in the table. I asked them to reflect upon the content and share their opinions in the plenary on the 3rd day of the research schedule.

c. **Semi-structured interviews (Day 2):** The open-ended qualitative interviews, the primary source for collecting data, were conducted (Østergaard et al., 2013). The interview guide had been prepared to inquire about the sustainability and resilience of the farming system. Accordingly, the questions were segregated based on the design aspects as well as social, economic, environmental, and

production-related aspects (Diane and Charles, 2004). The open-ended semi-structured interview guide included both the pre-existing and the emergent questions relevant to the research question (Kvale and Brinkmann, 2009). Separate questionnaires were made for the farmer and his family, the neighbour and the permaculture trainer (attached in appendix 1). The interview guide was submitted to the Norwegian Centre for Research Data (NSD) when I registered the study prior to conducting it.

Figure 15: Interview session with Vasudev during day 2 of the research.

The interviews were video-recorded and transcribed later during the data analysis stage. Video recording was better than note-making, as it neither interrupted the interviewer nor distracted the participant while answering (Salliou and Barnaud, 2016). In addition, I could observe the facial expressions and gestures to understand the participants' feelings during the interview sessions. Framework analysis was used for data analysis.

d. **Workshop (Day 3):** Another qualitative method used for data collection at the Vasudev farming system was the workshop. Unlike the transect walk and interviews, this method took one step forward to look at the farming system's future state. It was conducted on the third day. The workshop had two sessions:

- Reflection on the current situation, and

- Visioning the future situation.

Reflection session: The focus group participants were first asked to individually share their reflections on the farming system's SRI compared to each of the PLD structures, as experienced by them in the last five years. Then, Vasudev was asked to fill the table box by box after discussing in plenary and building consensus over each box. He was given five colour shades to mark the five conditions: excellent, very good, average, bad and poor. The table (figure 16) below represented various SRI parameters' and PLD structures' in five situations assessed by the focus group.

Figure 16: Colour boxes indicating various farm conditions during day 3 of the research.

Next, five chart papers (the first for Vasudev and his wife, the second for his children and mother, the third for the neighbour, the fourth for the trainer and the fifth for me as facilitator) were stuck to the mud-wall using a jute rope outside the entrance of Vasudev's house. The participants were asked to divide the paper space into two halves, the upper half for the current situations and the lower half for the future situation.

To visually express the current situation, they were asked to draw a rich picture (see appendix 2) based on the above findings from the comparative table and to look for the inter-connections. The complex themes were patterned into a visual image by the focus group members, who had vast experiential knowledge about the Vasudev farm. The rich pictures suggested a good connection between the various farm structures. The agroecological flows and cycles could be seen in the sketches. The outcomes of the current situations' rich pictures were discussed individually and in plenary. The explanations of the outcomes were video recorded for further reflection and analysis.

Visioning session: Using the guided imagery (see appendix 7), the participants were taken on time-travel into 2025. Again, they were asked to make rich pictures of the permaculture-based land design implements used in the farming system and the inter-connections in the year 2025. The visioning session helped the focus group to connect the present farm situation to the future farm situation. The drawn rich pictures were helpful for the group to understand each other's aspirations and commitments better. Like earlier, the outcomes were again discussed individually and in plenary. The explanations of these outcomes were also video recorded for further reflection and analysis.

Combining central themes from the four drawings and the plenary discussions for the year 2025 were brought together and further categorised into social, economic, environmental and agronomical aspects.

This served them as their shared vision and collective goal-setting for the action plan for the coming next five years.

Figure 17: (left) Vasudev explaining his rich picture. (right) Uday explaining his rich picture.

The workshop in itself had a complete learning cycle based on ELT; it served multiple purposes, as it led to:

- reflections and data collection through the comparative table, rich pictures, and the participants' oral explanations both individually and in plenary,

- data analysis by categorising pressing themes,
- results by building consensus and accepting those categories in the plenary,
- visioning through guided imagery,
- responsible action (Lieblein and Francis, 2007) through a shared vision.

3. Data analysis stage: Data collected from each method were analysed separately. Data from the transect walk were in the form of rich pictures, field notes, photographs and daily reflection logs. Interview data were in the form of transcripts, videos and reflection notes. The workshop data were in the form of rich pictures, videos and reflections (mine and other participants'). To bring commonality, I converted all the data from each of the methods to English text format. I could also convert all the rich pictures to English text. Converting it seemed more appropriate, as this strategy helped me to triangulate the data quickly. The chart below (figure 18) shows the details about how the three categories were reached. The codes highlighted in grey were the standard codes across all three methods.

	Day 1	Day 2	Day 3
Methods	**Transect walk**	**Semi structured interviews**	**Visioning workshop**
Research tool used:	Observation Photography Reflection	Interview guide Videography	Guided Imagery Videography Reflection
Data collected as:	Rich Pictures Photographs Field notes Daily reflection logs	Videos Trancriptions Daily reflection logs	Rich Pictures Videos Trancriptions Daily reflection logs
Conversions:	Visual to text format	Vocal to text format	Visual and vocal to text format
Catergory 1:	**Implementing a holistic design approach to the practice**		
Codes:	**Vasudev farming system and current practices**	**Vasudev farming system and current practices**	**Vasudev farming system and current practices**
	Zones and proximities	**Zones and proximities**	**Zones and proximities**
	Sectors	**Sectors**	**Sectors**
	Neighbouring farms	Neighbouring farms	Watershed
			Earlier practices
			Global market
Catergory 2	**Applying an in-depth understanding of design to the practice**		
Codes:	**Placements**	**Placements**	**Placements**
	Orientations	**Orientations**	**Orientations**
	Surfaces and textures	**Surfaces and textures**	**Surfaces and textures**
	Attachments		Colours
	Colours		
	Physical patterns		
Catergory 3	**Building a conservation-adaptation strategy**		
Codes:	**Time**	**Time**	**Time**
	Energy	**Energy**	**Energy**
	Materials and technology	**Materials and technology**	**Materials and technology**
	Agroecology	**Agroecology**	**Agroecology**
	Local Labour		Local politics

Figure 18: Table showing the data analysis process for the applied research methods.

After the conversion of all the data to text (English), the same data analysis process was followed for each of the three methods; the six steps (Löfgren, 2013) that I followed are mentioned below:

Step 1: Firstly, the transcripts, reflections logs and field notes were compiled accurately and meticulously read (Thomas, 2003) for relevant sentences and sections.

Step 2: The words and phrases taken from the sentences and sections were labelled as the farmer's activities, concepts, opinions and processes (Hsieh and Shannon, 2005).

Step 3: Then, based on the research questions, I decided which codes (Morgan, 1993) were the most important and created three relevant categories by bringing several codes together.

Step 4: I decided these were the most relevant categories across all the three methods suited to the research question and looked at how they were connected.

Step 5: There is no hierarchy among the categories, so I marked them as Category 1, Category 2 and Category 3, without a hierarchy.

Step 6: Lastly, triangulated (Triangulation, 2014) the analysed data based on the standard codes and categories across the three methods.

Three days of farm-stay with the application of more than one research method each day, combined with the five critical agroecological skills and usage of five senses, helped me to collect critical qualitative data. Following Kolb's learning cycle, the fourth (visioning) and fifth (action plan) stages were covered during the workshop session. Some part of the data analysis has been done later, outside the study field (for example, transcribing and coding the interview). Except this, all the planned participatory action research processes were performed at the Vasudev farming system itself.

Chapter 4. Results

	Fish ponds (1)	Livestock shed (2)	Paddy fields (3)	Vegetable garden (4)	Agro-forest (5)	House (6)	Compost unit (7)	Neighbour hood (8)	FFS (9)
Economical growth									
Savings (A)									
Sales (B)									
Profit (C)									
Income (D)									
Production growth									
Product diversity (E)									
Quality (F)									
Quantity (G)									
Social growth									
Family (H)									
Neighbours (I)									
Prestige (J)									
Recognition (K)									
Cultural growth									
Education (L)									
Skill (M)									
Knowledge (N)									
Relationships (O)									
Environment growth									
Soil health (P)									
Pollinators (Q)									
Ground water (R)									
Ecological growth									
Energy, nutrients and water cycles and flows (S)									
Food chains and webs (T)									
Biodiversity, adaptation and interactions (U)									
Resilience growth									
Buffer capacity (V)									
Adaptive capacity (W)									
Self-organising capacity (X)									
	(1) Fish ponds	(2) Livestock shed	(3) Paddy fields	(4) Vegetable garden	(5) Agro-forest	(6) House	(7) Compost unit	(8) Neighbour hood	(9) FFS

Colours	Conditions
Green	Excellent
Yellow	Good
Orange	Average
Red	Bad
Brown	Poor

Figure 19a (above) Comparative table representing the cross-sectional view of the current farm PLD structures compared to farm sustainability and resilience parameter for the last five years. (left)Table showing the colours used for the various measures of strength.

Chapter 4. Results

Part-1 of my result chapter embraces the first research question to identify whether the given PLD farming system is sustainable. Part-2 of this chapter holds my second research question's answer. I looked at the design aspects used for PLD application to achieve sustainability and resilience in the farming system. And lastly, Part-3 of this chapter answers my third research question: how the farm's present situation could be improved for a better future.

Part-1

The first research question is: How relevant are 'permaculture-based land designs' for the given farming system's sustainability and resilience? I tried to look at this in two different ways. Firstly, by comparing each of the SRI categories to each of the farming system's PLD structures (figure 19a and 19b) for the last five years. The different colour boxes have been used to indicate different situations. Colour green, yellow, orange, red and brown indicates excellent, good, average, bad, and low conditions. The comparative table (figure 19a) is separately elaborated in detail in appendix 9. Secondly, by comparing the functional flows amongst each of the various PLD structures for their past, present and envisioned future (figure 20).

In the below chart (figure 19b), the sustainability and the permaculture land-design variables have been explicitly compared to their various health condition (excellent to poor) at the farming system level. The boxes' numeric figures indicate the number of times the individual variable appeared compared to the various health conditions (data derived from figure 19a).

Overall, most of the sustainability and resilience variables were found to be in excellent condition (68 points), with cultural growth being the most effective (15 points). Also, most of the permaculture structures were found to be in

excellent condition (68 points), with agro-forest being the most effective (15 points). The above comparative table (figure 19b) is separately elaborated in detail in appendix 10.

Sustainabity Variables:	Excellent	Good	Average	Bad	Poor	Total
Economical growth	6	9	13	6	2	36
Production growth	7	4	12	4	0	27
Social growth	8	8	12	8	0	36
Cultural growth	15	13	4	4	0	36
Environment growth	11	1	4	0	11	27
Ecological growth	9	6	2	1	9	27
Resilience growth	12	7	2	3	3	27
Total	68	48	49	26	25	216
PLD Variables:	**Excellent**	**Good**	**Average**	**Bad**	**Poor**	**Total**
Fish ponds	12	5	1	5	1	24
Livestock shed	2	6	12	2	2	24
Paddy fields	7	6	9	2	0	24
Vegetable garden	13	9	1	1	0	24
Agro-forest	15	3	5	0	1	24
House	5	4	6	5	4	24
Compost unit	7	6	2	5	4	24
Neighbourhood	3	7	10	0	4	24
FFS	4	2	3	6	9	24
Total	68	48	49	26	25	216

Figure 19b: Comparative table representing individual scores of the sustainability and PLD structures

In the below diagram, it is shown how the various PLD structures were found to be connected. Apart from having multiple individual functions for the farm, they support each other through the various functional flows. The mapping is done for the past, present and the envisioned future farm situations.

Black outlined boxes, and arrows indicate the past situation of the farm on the map. There were only paddy fields in the past. Vasudev used to sell some produce to the village market and keep some food for his family. The straw and mud from paddy fields were used in home preservation.

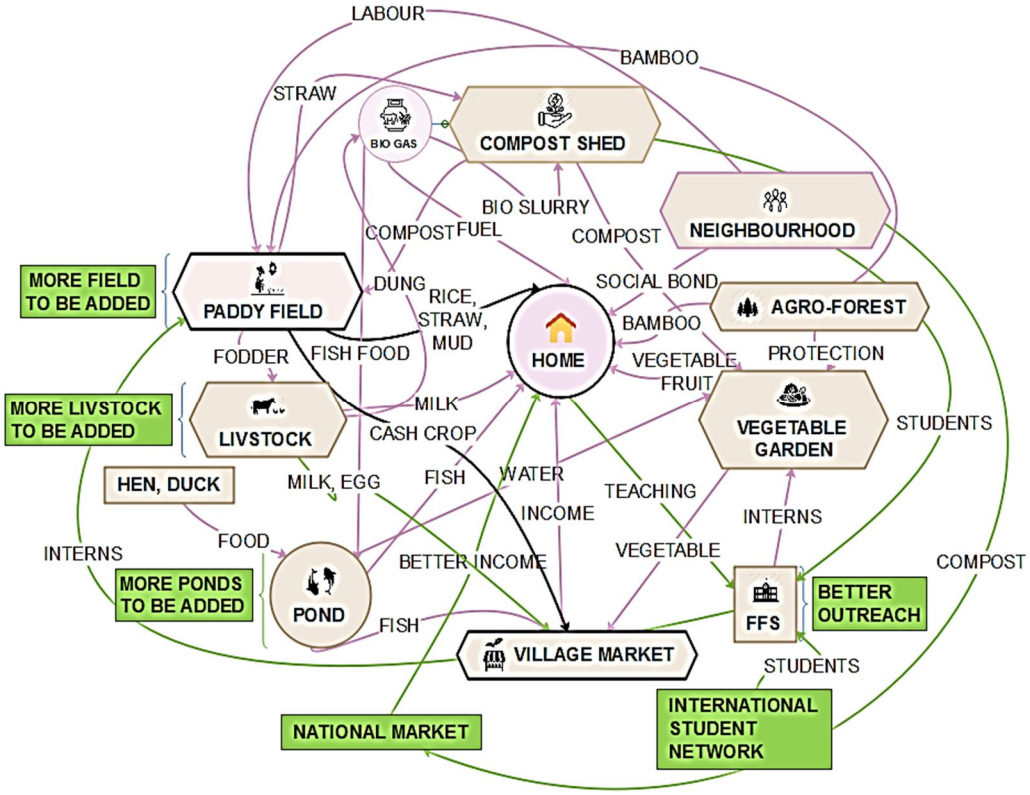


Figure 20, An agroecological web: Resource flow and functions mapping for the various permaculture structures at the Vasudev farming system

Pink outlined boxes and arrows are used to represent the present situation in the diagram. Vasudev started using permaculture methods for farming in 2015. He introduced some critical permaculture structures to the farm, such as the vegetable garden, to fulfil the family's nutritional requirements. He is selling some of the vegetables in the village market. Vasudev has taken ponds on lease and started fishery-booth for their consumption and selling in the village market. He introduced livestock such as cows and goats for milk and hens and ducks for eggs. The dung and the litters are being used as food for the fish. He made a compost unit to produce organic fertilisers for the paddy field and the vegetable garden from the green waste. From the compost unit, he receives

biogas as fuel for cooking at home. He involved his neighbours by giving them opportunities to help him on the farm and share some of the produce. Together with the neighbours, some portion of the land was converted into an agroforest. The agroforest allows him to harvest products like bamboo and fuelwood, and in addition, it protects the vegetable garden from north-easterly winds. During weekends, the neighbourhood's primary school is being used as a farmer field school, wherein Vasudev shares knowledge about permaculture to aspiring students from the district.

Vasudev has a vegetable garden from where he has been harvesting vegetables for consumption, and by selling some of those products in the market, he obtains an income. From his fishponds, he is getting fish for consumption for his family, and by selling the additional fish, he is earning a good income. Vasudev has cows, hens, and goats as his livestock members. The hens and ducks are mostly staying in and around the pond for food, and their litter is providing nutrient-rich feed for the fish. The cow dung is being used in the biogas unit and for vermicompost making. From the livestock, some milk and eggs are brought home for their consumption. Fodder for the cows and goats are collected from the paddy-fields and also from where Vasudev collects straw for compost making. Vasudev gives some of his farm products, like vegetables and fish, to his neighbours, who are helping him in the vegetable garden and the paddy fields. The villagers who have attended training with Vasudev at the FFS have started to apply the permaculture knowledge to their farms.

The green outlined boxes and arrows depict the future state of affairs, as envisioned by the farmers. Vasudev told me that he wanted to spread his experiential knowledge through FFS at national and international levels. He also told me he wanted to sell his farm products in the national market and increase the number of paddy-fields and ponds.

Part-2

Addressing the second research question, this part of the results section discusses the various PLD features and design strategies applied to the ground considering the Vasudev farming system's sustainability and resilience. I immersed myself in finding the existing farm phenomena using my experiential knowledge. I focused on the PLD themes that are supporting and motivating the farmers to achieve overall success. The three emergent themes that stood out during the collected data analysis stage were identified and categorised with their respective codes. Methods' triangulation was further used to interpret them as results finally. The thematic codes (figures 21, 22 and 23) identified during data analysis were triangulated to achieve relevant categories as results in this section.

- The first identified theme (figure 21) is related to the design approach. It is about the holistic approach that is being applied at the Vasudev farm.
- The second theme (figure 22) relates to the design elements and principles. It is related to the in-depth understanding and use of design details.
- The third identified theme (figure 23) is related to the conservation and preservation at the farm. It is about adapting as per the present needs of the hour and conserve for the future.

Selected Quotes	Codes	Category
"All the managerial works are divided within the family for different jobs like my mother sees the rice cultivation. My wife and son look after the vegetable garden, and I work on the fishponds."	Systemic approach	Holistic approach
"The paddy straws are given to cows as food, and cow dung is used for making compost and fertilisers. The recycling of waste outputs as inputs goes on at the farm."		
"The collective efforts of multitasking subsystems keep our farming system running, just like my mother keeps all of us healthy at home."		
"The rice field is beside my organic fertilizer-making pit. The dry straw and the many different organic fertilizers are brought down there without any difficulty. "	Zones	
"The organic fertilizer unit is located behind the cowshed and my house. Next to it is my vegetable garden, so that house members can easily take care of the animals and vegetables. "		
"I have many ponds on the roadside to efficiently harvest the rainwater. The vegetable gardens are near the pond. The crops use the rainwater filled in the ponds."		
"The sun's path is followed while planning anything at the farm."	Sectors	
"The northwesterly winds and monsoon winds can't do us any harm, because there are agroforests in the east-west border."		
"We cultivate vegetables at the right time, and if you want to grow summer vegetables in winter, then the vegetable bed are made such that they get enough sunlight. "		

Figure 21: 1st set of extracts from the interview, dialogues and rich pictures' narrations

Selected Quotes	Code	Category
"There are 3-4 layers of cropping in the vegetable garden. Under the ground is turmeric, over the land are cover crops, then herbs and the climber plants. "	Placements	Design details
"I cultivate vegetables on higher beds to prevent crop damage during rain. This year we have extreme rains and, I have grown good produce in this way.. "		
"We are cultivating vegetables on the bamboo roofs and bamboo trellis over the ponds, such that these spaces can be utilised."		
"The vegetable garden slopes are directed towards the pond, so excess water falls into the pond, and the crops are not damaged. "	Orientations	
"The cowshed floor slope is set on the specific side so that the cow urine can be collected and we can use it for making pesticides. "		
"The edges of the rice field are raised so that we can cultivate some vegetables there as well. I also grow vegetables on the edges of the ponds. "		
"My vegetable garden soil is loose and porous. The good soil structure helps my vegetable garden, as it supports better root growth and aeration for the beneficial microbes."	Surfaces and textures	
"We keep the crops well mulched during the summer; this slows evaporation and adds organic matter to the soil."		
"The porous soil of the grow beds help us in water absorption, and the tight muddy soil of the roads and cowshed helps in directing the water to the catch points."		

Figure 22: 2nd set of extracts from the interview, dialogues and rich pictures' narrations

Selected Quotes	Code	Category
"My father used to cultivate using chemicals so that we could survive the shortage of food and money. I started farming using organic inputs from 2015 to save my children's future."	Time	Conservation and adaptation
"We follow the crop calendar for what to cultivate in which month. There are some vegetables which are grown all year round."		
"We work along with the sun timings on the farm. Watering is done at the sunrise, and organic pesticide sprayed like neem oil is sprayed at sunset."		
"The compost unit makes biogas for us used for cooking."	Energy	
"North-south direction is followed while making the grow beds, which helps crops absorb enough sunlight through the day."		
"Taking work from animals keep them healthy and saves us money and dependency on petrol/electric machines. Oxes plough the paddy fields and chickens are ploughs the vegetable garden for us."		
"We used local indigenous methods for most of our activities and inputs at the farm. Like the making of biogas."	Material and technology	
"We have taken mud to build the walls of our home and rice straw for the roof of my house; I learned this from my father. Both of these materials are in-house and eco-friendly."		
"The organic fertilisers and the pesticides are made in-house using the farm resources."		

Figure 23: 3rd set of extracts from the interview, dialogues and rich pictures' narrations

Implementing a holistic design approach to the practice: In figure 21, it can be seen through the selected quotes from the focus group that the farmer is practising permaculture with a holistic and systemic approach. The three prominent thematic codes selected under this category are:

- **Systems approach:** The focus group called this approach the "human-eye perspective" because it uses socio-cultural wisdom, empathy, scientific knowledge and spiritual consciousness. The figure shows some explicit quotes extracted from the interview that indicates how they holistically approach the farm. Vasudev has mentioned the work distribution, farm inputs, and the farm sub-systems (see appendix 3) in the selected texts.
- **Zones:** The focus group called this approach the "bird's-eye perspective" as it refers to the ground view of the field of action from the sky. The internal proximities and pathways between the vital sub-systems within the farming system's arbitrary boundaries are managed using 'zones' (see appendix 4). The figure shows some explicit quotes extracted from the interview that indicated how they approached zones at the farm. Vasudev has mentioned the paddy fields' locations and connectivity, the compost making unit and the ponds in the selected texts.
- **Sectors:** The focus group called this approach the "worm's-eye perspective" because it refers to looking at the forces functioning upon the field of action from the landscape. The external forces and their pathways affecting the farming system are managed using sectors as a PLD strategy. Having an aerial view of the farm using sectors helps them pre-plan for the farm resources' external forces. The figure shows some explicit quotes extracted from the interview that indicate how they approach 'sectors' (see appendix 5) at his farm. Vasudev has mentioned the sun path, the north-westerly winds, and the cropping seasons in the selected quotes (figure 21).

Applying an in-depth understanding of design to the practice: In figure 22, it can be seen through the selected quotes that Vasudev is practising permaculture with an eye for in-depth detail in the design. A comprehensive understanding is built for the individual sub-systems' role within the farming system.

This category of results deals with each farm structure working as a sub-system in the Vasudev farming system. I focus on the detailed aspects associated with their specific coherent functions in the whole system. In the focus group, the participants carefully designed to support their farming system efficiently. The selective views provided an in-depth understanding of the individual sub-systems' role within the farming system. The three prominent thematic codes selected under this category are:

Placement and profile: The focus group called this the physical location and positioning of a sub-system in the whole system so that it is ecologically meaningful. This order helps the concerned sub-system as well as the other sub-systems connected to it. All the sub-system's collective standings make the whole system function to its fullest for a more extended period. There are horizontal placements, and then there are vertical placements (above, on, and below) depending on the requirements.

Figure 22 shows some explicit quotes extracted from the interview that indicate how the focus group used the knowledge of 'placement and profile' on the farm. Vasudev has mentioned the multilevel cropping, raised beds, and roof-top cultivation in the selected texts

It is also essential to understand the resources' nature and their multiple functions for fruitful placement. Figure 24 is extracted from field notes jotted down during the transect walk at the farm.

Nature	**Resources/ Sub-system at Vasudev Farm**
Abiotic and non-movable	Soil minerals, groundwater salts
Abiotic and movable	Farm tools, tractor, money
Biotic and non-movable	Forest, perennials, pond, farmland
Biotic and movable	Humans, livestock, pollinators
Energy care	Sunlight, wind, sound, rainfall
Ecology care	Swales, berm, air, soil, pathways

Figure 24: Physical and biological aspects of the Vasudev's farm resources 1

I found that the placements are created in a way that the movable resources like the humans, livestock, and pollinators (in the above table) encircle the immovable resources. At the same time, the flow of energy and ecological relations connect them. They, in turn, result in maximum use of the available resources. I observed at Vasudev farm that the circular-bed guild (not a perfect circle) was successfully thriving with various companion plants of different functions, heights and lifespans, being planted together to grow as a family. They are like a mini jungle system, which is self-sustaining. It requires less watering and fewer nutrition inputs. Central perennial trees hold the soil together and pull water from the underground aquifer. Legumes provide nitrogen. Cover crop keeps the soil humus and soil biodiversity. Flowering plants attract pollinators and repel harmful pests. The fruiting creepers provide ample food for the growers.

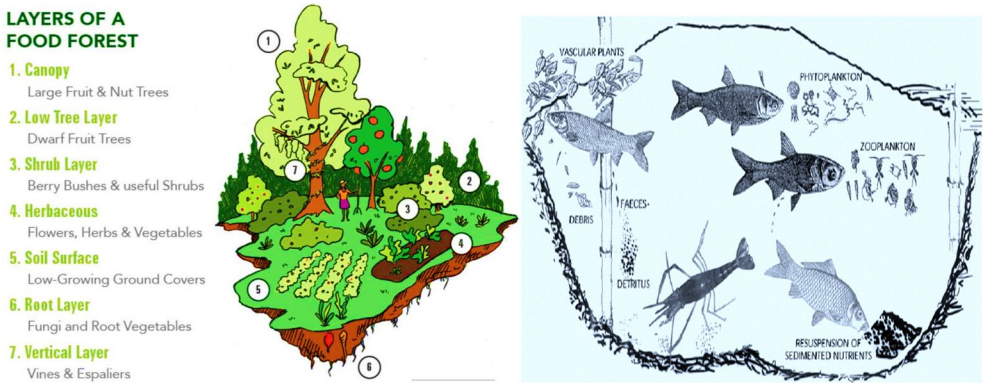


Figure 25: The use of multilevel crops and fish farming at the Vasudev farm, images adapted from www.habitatalgarve.com

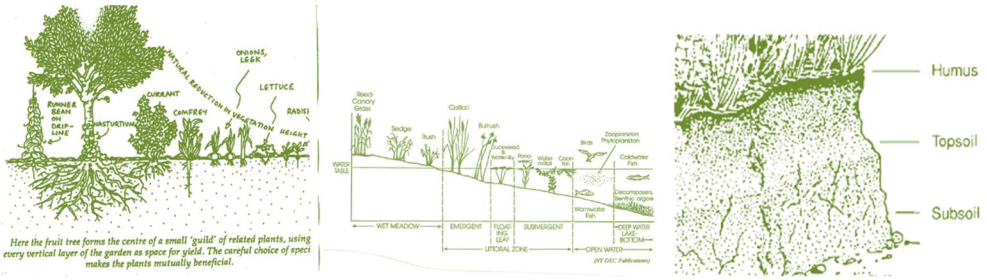


Figure 26: The use of soil and plant profiles at the Vasudev farm, images adapted from *www.amanziforfood.co.za* (left and centre) and *www.algaebase.org* (right)

The images (figure 25 and 26) above indicate multi-layered (circular bed guild) farming and multi-layered fish farming at the Vasudev farming system. In addition, there is the sectional cut-outs and blow-up pictures of the landscape's vertical and horizontal profiles. I tried to study the profiles to know what existing within the system is not visible to the naked eyes.

- **Orientation and geometry:** The focus group called orientation as the direction in which the sub-systems face in order to best suit their functionality, growth, existence and surrounding sub-systems' health. At the same time, they regarded the geometric patterns to be the basis of all physical design elements incorporated and implemented on the farm. The geometric elements consist of

points, lines, angles, edges, shapes, forms, and surfaces. Figure 22 shows some explicit quotes extracted from the interview that indicated how the focus group used the knowledge of ‘orientation and geometry’ on the farm. Vasudev has mentioned the vegetable garden’s directions, the cowshed and the rice fields in the selected texts.

At Vasudev farm, the correct orientation and geometry concepts are used to enhance the performance of the farm structures. The sub-systems’ functions and collective systemic ecology support collecting more energy and attaining longevity. The north-south oriented seedbeds at Vasudev farm help the crop get uniform sunlight throughout the day, as the sun has an east-west path. They lead to healthier plants and timely fruiting.

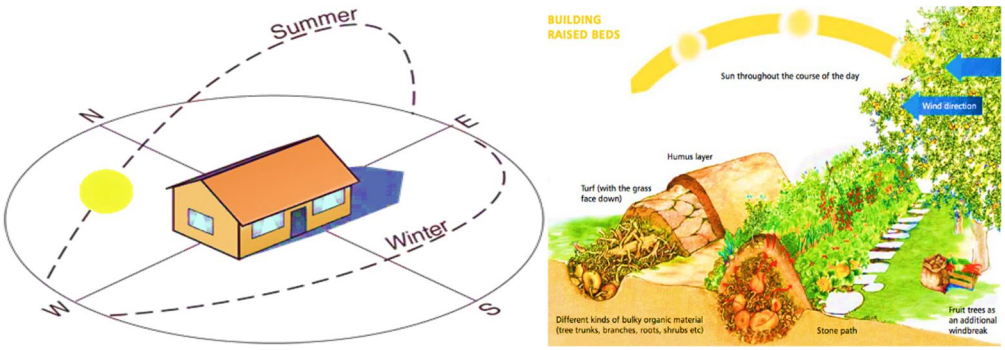


Figure 27, The use of the sunlight-orientation house and raised beds at the Vasudev farm, images adapted from www.permaculture.co.in

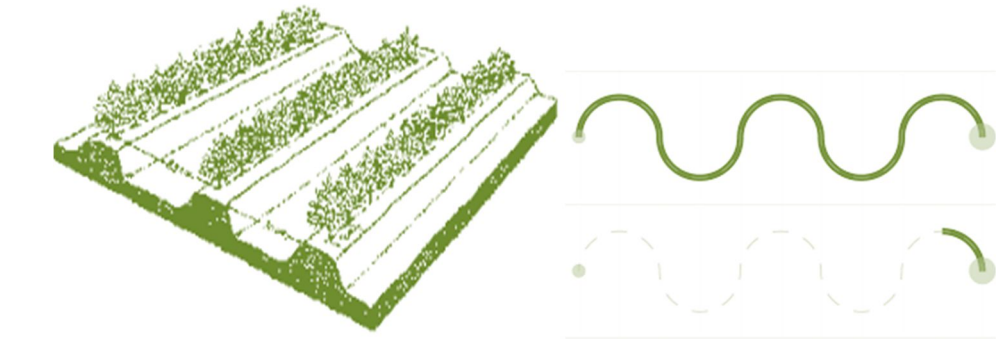


Figure 28: The use of curvilinear lines for seedbeds at the Vasudev farm, images adapted from wgbis-ces-iisc-ernet.in (left) and www.ihk.de.net (right)

The images (figure 27 and 28) above indicate the **orientation** of the house and raised beds. The outlined **line** of the seedbeds is curvilinear so that there is a slower water flow, which results in better water absorption leading to water conservation implications.

I observed that to build an ecology close to the natural ecology, the focus group members avoided consecutive lines at Vasudev farm. Non-linear lines such as wavy, branching, spiral, curved, circular, and cyclic are predominant to replicate natural patterns.

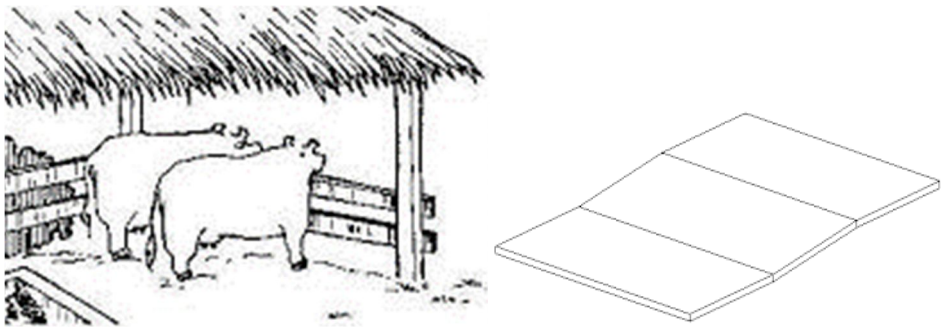


Figure 29, The use of slopped mud flooring for cowshed at the Vasudev farm, images adapted from www.smallfarmersjournal.com

The images (figure 29) above indicate the sloping **angle** of the cowshed flooring beds. The farmer saved the cows from getting hurt by making the cowshed mud-flooring with a cushioning slope instead of the flat cemented flooring and right-angled steps they could save the cows from getting hurt. The gradient further helped them collect cow urine for making bio-pesticides. This finding shows that creating natural slants helps restore natural habitat conditions for the livestock and support waste management.

I observed that the Vasudev farm is designed such that the bends, slopes, and slants are smoother and hence comfortable for the users during work as well as long-lasting.

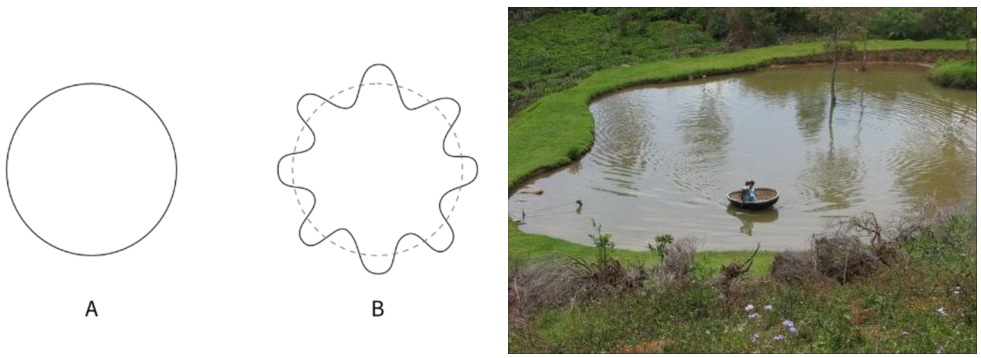


Figure30: The use of irregular edges at the Vasudev farm, images adapted from thepilcrow.net (left) and www.nps.gov (right)

The images (figure 30) above indicate the **edges** of the fishponds. At Vasudev farm, curvy pond edges could easily withstand and divert the harsh winds, plus it created a longer-length boundary for the pond. The curvilinear boundaries, as compared to the right-angled edges, showed to have a longer life and higher available opportunity in each system.

I observed that the more extended border developed richer biodiversity for the pond and resulted in improved fish-harvests. Edges as the boundaries were the receiving/entry or releasing/exit points of the farm structures. The nature-

patterned edges were both ecologically and economically supportive of the focus group.

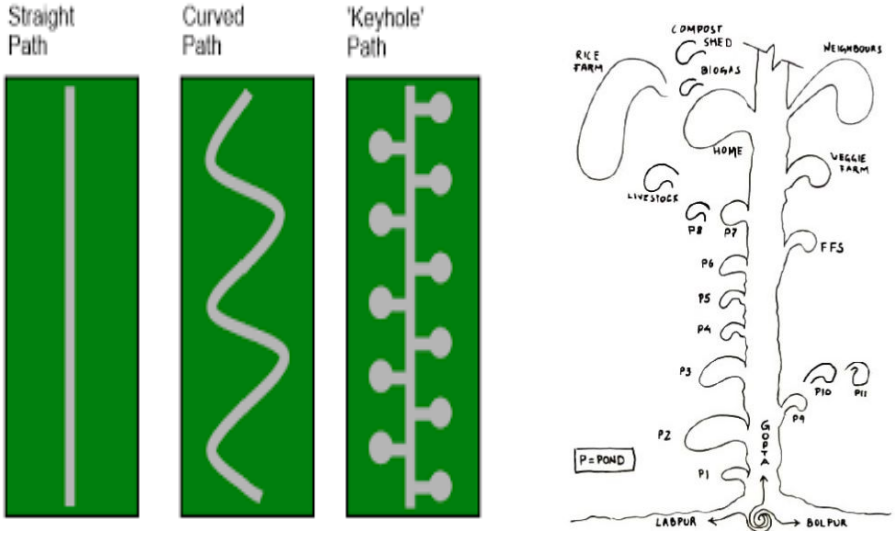


Figure 31: Images adapted from www.yokohama-online.com (left) and my sketch of Vasudev farm (right)

The images (figure 31) above indicate the **shape** of the Vasudev farming system. The raw muddy roads of Vasudev farm have a combination of curvy and keyhole patterns. They have natural ecologies working, where curved lines make wavy, spiral, and circular shapes.

I observed that this design strategy reduces the land area spent on making pathways and walkways; instead, it increases the land area spent on integrated-farming of food, fibre, and fuel. In return, this leads to better yield and a closer ecological network within the various farm structures.

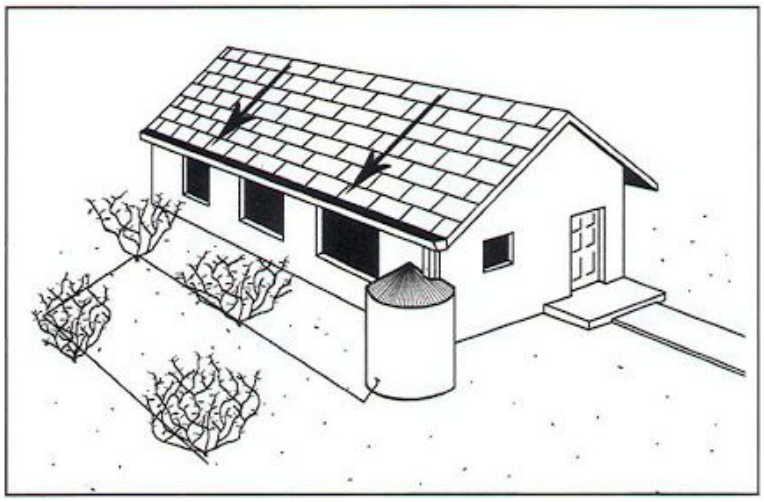


Figure 32, The use of corrugated shaped roofing tiles at the Vasudev farm, image adapted from www.takecareoftexas.org

The image (figure 32) above indicates the physical **form** of the homestead. The corrugated roofs are fitted to the farm homesteads in the village. The slope is to withstand and wade-off the harsh flowing winds and grow creepers and vines. The excess water slides down from the roof to the collection pipes installed for water harvesting.

I observed that including sloping forms tackle the physical structures strength issues that can be rewarding both ecologically and economically.

Surfaces and texture: The focus group called 'surface' as the visible 'layers', including the outer layers and inner layers of the farm's structures. The surface's texture depends on the function it plays, rough-textured surfaces are being used to achieve friction, and smooth surfaces are being used for the faster run-off. Compact surfaces quickly reflect, and porous surfaces are idle absorbents.

Figure 22 shows some explicit quotes extracted from the interview that indicate how the farmer uses the knowledge of 'surfaces and texture' on the farm. Vasudev has mentioned the vegetable garden's soil, the mulched soil, and the cowshed mud flooring in the selected texts.

Figure 33, The use of mulching at the Vasudev farm, images adapted from www.webmd.com *(left),* www.feedipedia.org *(centre) and wgbis-ces-iisc-ernet.in (right)*

The image (figure 33) above indicates the **surface and texture** on the farm. Straw mulching is extensively used for weeds management, water retention, and controlling transpiration.

I observed how mulching could add biomass to the farm soil after decomposition, increase biodiversity, carbon, and other nutrients. This practice seems rewarding both ecologically and economically.

Building a conservation-adaptation strategy: In figure 23, It can be seen through the selected quotes that Vasudev is practising permaculture with an eye for the future in the design. A comprehensive understanding is built for the collective role of the sub-systems within the farming system.

This category of results deals with the agroecological web (figure 20) functioning by inter-linking the Vasudev farming system's vital components. I tried to focus on the detailed aspects associated with their specific coherent

functions in the whole system. The farmer was carefully applying these PLD strategies to support their farming system efficiently. The three prominent thematic codes selected under this category are:

- **Time:** Participants in the focus group understand that with time the farm components like the labours, animals, structures and machines would either retire or depreciate depending on the component type. The general phenomenon that what was there yesterday is not there in the present, and what is in the present may not be seen tomorrow. As the network grew at the Vasudev farm, some of its components were taken out, and some new elements were added. In some sub-systems, this happened over a day and for some elements over a month or a year. That varied from case to case. But ecological connections stay unless there is a collapse due to a natural calamity. All the farm structures are connected through time, and there is never the same time again. Thus, the participants agree that conserving and adapting to time is inevitable.

  Figure 23 shows some explicit quotes extracted from the interview that indicated how they managed time factors to develop the farming system. Vasudev mentioned farming during his father's time. He mentioned the seasonal calendar and the daily routine in tune with the sunlight and seasons for greater efficiency at the selected texts' farming system.

Figure 34, The use of seasonal calendar at the Vasudev farm

The image (figure 34) above shows the **monthly calendar** used on the farm. The calendar was made to understand and compare the main farm activities to months. It shows a slow-down in production during summers. It shows the reduced speed at which plants are made to absorb nutrients through organic fertilisers. The natural growth rate is retained, and the crop calendar is maintained as per the seasons, climate, and crop rotation strategies.

Vasudev's mother argues, "*The life stages of the various components at Vasudev farm and their role in the farm ecology could affirm that the system had efficiently sustained itself in the past 30 years and was capable of living a longer life in the future*". She mentioned that compared to conventional farming functions, Vasudev farm functions are more time-consuming to carry on, for example, their primary tasks like production, pest control, nutrient management, and overall management.

Yet, the farmer and the trainer agreed that PLD practises were lesser time-taking, more functional and more productive in the long-run. They had

observed a faster recovery of crops from diseases and better resilience to climate stress.

- **Energy**: Vasudev says, “All the components within the farming system are connected through energy.” He explains that as the permaculture designs focus strongly on clean and renewable energy sources, so a well-planned strategy to maximise the energy entrance from the natural sources was enhanced. I noticed that the wider entry-span and multiple catching points were created on the ground to facilitate this. The natural ponds at the farm are an ideal example of this. Non-renewable energy was being used only during the lack of natural options.

  I observed that the entered renewable energy at the Vasudev farm was extensively harvested, used, and conserved for the future. Participants in the focus group closely note the ecosystem services’ energy and the human-made energy for their entry-points and exit-points. The farmer family try to slow-release the entered energy by creating loops and longer paths, such that it stayed longer within the system. Even when it exited, the idea was to recycle it, and thus the waste was carefully managed. The practice was environmentally and economically suitable and also supported production.

  Figure 23 shows some explicit quotes extracted from the interview that indicate how they managed energy generation, energy harvest and usage to develop the farming system. Vasudev mentioned farming during his father time. He mentioned the generation of biogas from the compost unit, harvesting the maximum amount of sunlight and animal labour usage at the farming system in the selected texts.

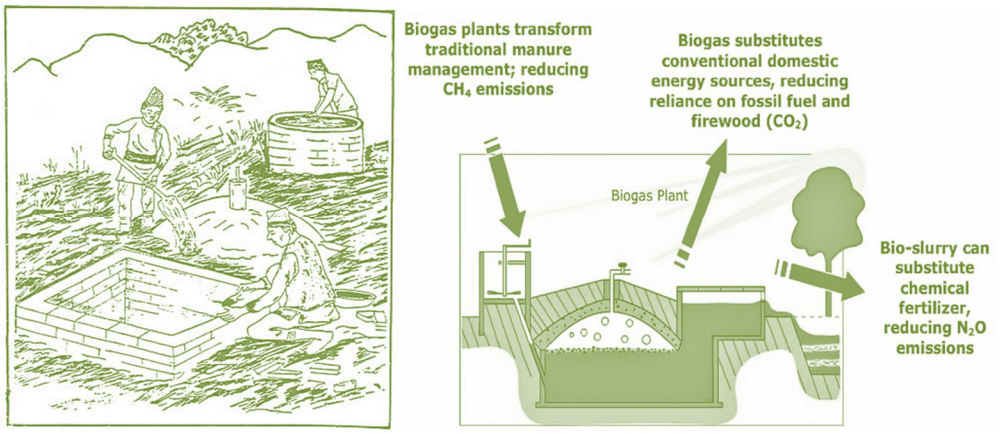


Figure 35, The use of biowaste composter at the Vasudev Farm, images adapted from www.nzdl.org(left) and www.nexusfordevelopment.org(right)

The images (figure 35) above shows the **energy generation** from crop residues and animal excrement on the farm. The biogas unit served many purposes at Vasudev farm. It provided biogas fuel to the household for cooking. It made nutrient-rich bio-slurry, which was used as organic fertiliser, and it managed the organic wastes from the farm.

- **Materials and Technology:** The focus group realises that if the energy was the Vasudev farming system's lifeline, then the materials and technology were its carriers. The Vasudev farming system components are connected through material and technology, which were mostly from inhouse resources. They were naturally grown, eco-friendly, environment-friendly, and user-friendly.

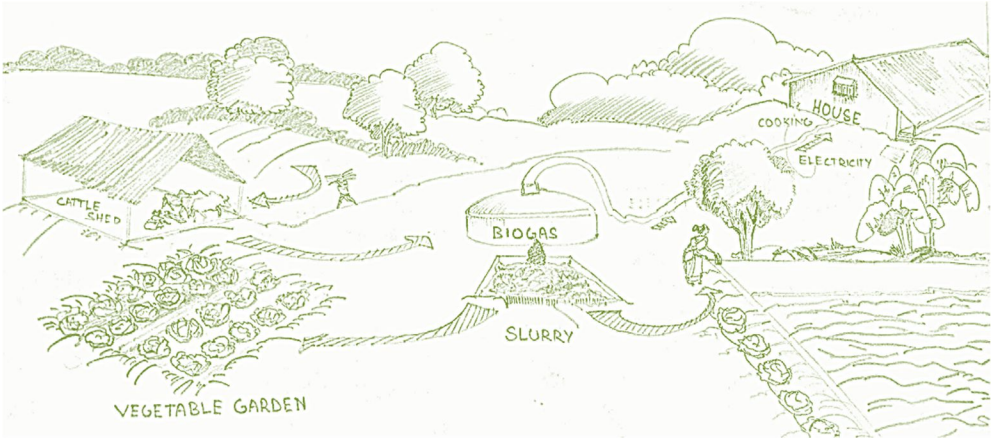


Figure 36, The sketch showing the use of indigenous material and technology at the Vasudev farm

The images (figure 36) above show the application of **materials and technology** on the Vasudev farm. Technologies that integrated and closely-looped various farm structures and multiple functions were consistently used. IPM (integrated pest management) and INM (integrated nutrient management) are such examples. Bamboo was extensively used as it was a porous, breathable, decomposable material. It was sturdy and grown locally as a component within agroforestry. It was being used as live-fences and windbreakers while being planted. It was used as construction material after being harvested. Other biodegradable materials used for production and construction were farm by-products, cow-dung, mud, terracotta, straw, hay, timber, cotton and jute. Some examples of conservations from a material and technology point of view are water conservation, soil conservation and soil moisture conservation.

It was observed that the simple indigenous techniques using homegrown bio-inputs and local labours were seemingly slow in the present. Still, they supported the farming system for an extended period. The idea is to create an automated and self-managed techno-system within the farming system. The

farm was open to include new technology but not exclude the time-tested ones until the new one was old enough to prove its sustainability. That was a slow inclusion. Notably, no material was purchased from the market; instead, produced materials were regularly supplied to the market. The practice was environmentally and economically suitable.

Part-3

My third question was to find what can be done further to improve the given farming system's current situation and how it can be done. As mentioned in the method's chapter, using the visioning workshop, I had facilitated the farmers to reach a shared-vision (figure 37), then getting the prioritisation of the envisioned goals and finally setting-up yearly targets (figure 38) through dialogue and discussions in plenary.

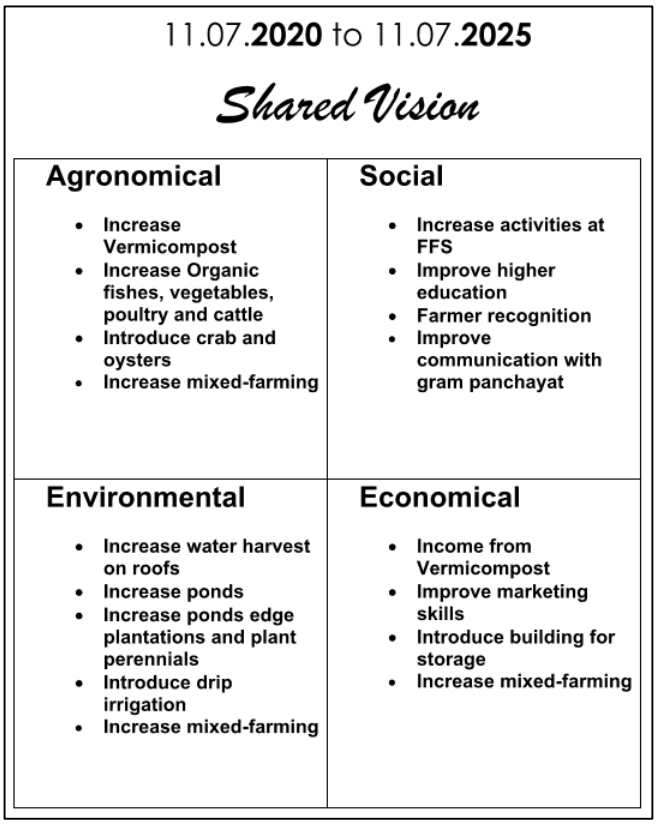


Figure 37, The shared-vision of the focus group

The image (figure 37) above shows the **shared vision.** I had helped the focus group participants to sort their visions into four categories: agronomical, social, environmental, and economical.

While discussing visions from the four categories in plenary, it was found that:

- Organic food such as fish, vegetables, chicken, and organic fertilisers (like vermicompost and cow dung compost) should be increased under the **agronomical** category.
- More effort was required to increase higher education and the farmers' recognition in the **social** category. The farmer's field school needed to be more engaging, and the panchayat (local government) should be approached for their support and participation.

- Then, water harvest, pond edge plantation, mixed farming should be increased, and drip irrigation should be done under the **environmental** category.
- Lastly, an increase in overall marketing and increased vermicompost sales was to be done. Some PLD structures need to be made of brick and mortar. Mixed farming should be increased under the **economic** category too.

Priority	**Steps**
1st priority:	Take more land and ponds for the mixed farming and organic produce of vegetables, fish, and poultry.
2nd priority:	Also, for the mixed farming and organic compost making, add more cows, goats, hens, and ducks to the livestock
3rd priority:	Sell products like- milk, eggs, and fertiliser in the national market.
Period	**Action plan**
1-2 Years	- Mix farming on a large scale - Make organic composts on a large scale - Water harvesting
2-3 Years	- Marketing and sale of organic products in the local market - Ponds edges maintenance - Drip irrigation
3-5 Years	- Marketing and sale of organic products in the national market - High outreach of FFS - Stronger relation with the local government

Figure 38 The action plan made by the focus group

The image (figure 38) above shows the **action plan.** I had further helped the focus group to prioritise and make yearly goals out of their categorised shared-

vision. They decided that breaking the goals into five years' time period to be the most suitable and manageable for them.

While prioritising the four categories in plenary for a step by step growth, it was found that:

- Adding more land and pond was the 1st priority.
- Adding more livestock was the 2nd priority.
- And, adding more products for sale for the national market was the 3rd priority.

While setting detailed yearly goals to the prioritised list of visions in plenary, it was found that:

- The first year should be given to making enough vermicompost, harvesting enough water, and practising mixed-farming on a larger scale.
- The second-year: start selling organic food and fertilisers in the local market, set up drip irrigation in the fields, and improvise production from the ponds' edges.
- From the third year onwards, start selling the organic farm produce in the national market, increase social outreach through FFS and finally build stronger ties with the gram panchayat[2] for their support and engagement.

[2] Gram panchayat is a grass-root level democratically structured political body that governs the villages in India.

Chapter 5. Discussion

As an alternate farming system, permaculture is now being widely adopted and practiced worldwide (Rhodes, 2012). All over the world farmers and scientists are working towards preserving soil and are taking the path of cocreation of nature and her principles of diversity (Shiva, 2020). Through this detailed study of Vasudev's farming system, I have understood the impact of permaculture in making such a change, as mentioned by Shiva (2020). The purpose of this qualitative case study was to explore whether permaculture land design application on a given farming system is relevant to the system's sustainability and resilience.

This chapter includes discussing the significant findings related to the various land design strategies employed in the given farming system and how they helped achieve sustainability and resilience. Also included is a discussion on how to further improve the situation of the given farming system. The chapter ends with discussing the study's limitations and the areas for future research.

The results of this qualitative study offer a glimpse into the Vasudev farming system for its sustainability and resilience obtained using permaculture land designs. The three research questions were asked to better understand the status quo. I probed the relevance of the existing multiple 'permaculture structures,' the existing 'permaculture design strategies,' and 'the future prosperity' of having such a farming system. I summarise the study's main findings one by one as per the sequence of the research questions.

Interpretation-1

The finding for the first research question suggests that the various PLD structures at the Vasudev farming system have mixed (ranging from excellent

to poor) results regarding the sustainable and resilient parameters (figure 19a and 19b).

The functional interrelations amongst the various PLD structures and their performance as a single farming system have shown constant improvement (figure 20).

It is important to note that in terms of economic growth, the permaculture approach, when merged with other dimensions of human development, has proved beneficial for the sustainability of the economic system (Válek and Jašíková, 2013). Even here, I have seen that income is exceptional in the areas where the seasonal plantation is practiced, like the fish-ponds, vegetable gardens, and paddy fields. In contrast to this, the permanent structures like the farm-field school fared poorly in current income. This is attributed to the reason that natural ponds are much more multifunctional than the farm-field school. Natural ponds also fared well in terms of profit, as they require low investment, and there is a presence of high-biodiversity.

Smallholder farmers adopt agroecology more to respond to food security issues than any conscious desire to adapt to climate change (Zazu and Manderson, 2020). When I talk of productional growth, the results show the status of the various farm structures in terms of their ability to usher quality, diversity, and quantity to the farming system. The pond, cattle shed, compost unit, house, and neighbourhood have good productional growth. Apart from regular products like eggs, milk, fishes, cereals, fruits, and vegetables, the farmers are also focusing on production from the other farm structures. The house and the neighbourhood do not produce directly but support in value-addition to the raw produce, which is a part of the production cycle—for example, making vermicompost, honey, fruit jams, pickles, and ghee (clarified butter).

Chapter 5. Discussion

Permaculture practices support community organisations and education so that people work their passions and interest and create interactions (Solkinson et al., 2016). A similar case of social growth can be observed here. The table defines a very high favourable social growth in the agro-forest and weak growth in the ponds and compost units. The agro-forest was taken care of by the whole Gopta village community, served as a community resource, and led to high social interactions between the farmers and the community. The pond and compost unit did not attract much social interaction, as ponds were taken on personal lease and the compost unit built was small and could accommodate only a few workers at a time.

It was a very short period for observing the cultural growth but considering the comparative table (figure 19a and b) filled by the focus group members, I have found that the farm-field school was marked as the most favourable spot for cultural growth. According to the table, in the last five years, cultural growth is in better condition than the other sectors. At the same time, remarkable skill growth was happening across all the farm structures. The school gave them a focused platform for education, learning relevant skills, gaining new knowledge from others' experiences, and building lasting professional relationships. Vasudev trains the young and interested teenagers of the village regarding farming methods. He also takes them as interns to build on their experiential knowledge.

According to Hathaway, The widespread adoption of permaculture principles significantly reduces energy, pesticide, and freshwater usage while simultaneously restoring degraded soil, sequestering large quantities of carbon, creating more biodiverse agricultural systems, and satisfying human needs for healthy, nutritious food (Hathaway, 2016). The results from the Vasudev farm show excellent soil health at cereal fields, vegetable gardens, and agroforests

when it comes to environmental growth. It shows very well to moderately up to the mark status for the underground water across all the farm structures. Organic inputs and strategies like crop rotation, integrated nutrient management, and integrated pest management were used. Such strategies help make the soil porous and fertile, and it is allowing the seepage of rainwater to fill the underground aquifers. Pollinators are being seen throughout the year because of the multiple seasonal, annual, and perennial plants.

Speaking of ecological growth, the informants marked that the agro-forest and vegetable gardens are more likely ecological friendly. The natural cycles of the environment are better-taken care of in these areas. Hence, both the vegetable garden and the forest landscape have been balanced by combining soil and water surfaces to support both plant and animal life. Other structures have either the soil (e.g., cereal fields) or the water surface (e.g., ponds). Certain non-biodegrade materials (e.g., cement and plastic sheets) save specific structures from regular wear and tear. Cement structures like the compost units, houses, schools, and neighbourhoods were marked as environmentally degrading for the focus group's farming system.

In this study, the agroforest, ponds, and vegetable garden has been marked the most favourable as resilient structures. In contrast, the school structures and the house have been marked as least resilient—the former consists of more natural living systems and has self-organising capacity during stress. For example, trees in their agro-forest naturally use their buffer capacity by adapting to winter winds and shreds their leaves to withstand the season. On the other hand, the schools and the house structures are less resilient because they depend on the farmer’s management skills.

The above discussion shows mixed results across various sustainability and resilience criteria. FFS was marked well in terms of cultural growth but lacked resilience and economic growth. It is accepted by the focus group as FFS is not primarily designed to earn money. As Vasudev said, "*Clearly, not all the structures are designed to perform the same task, so expecting the similar results from each of the structures is not justified*."

His mother further added, "*It is the interdependency and the collective balance of these PLD structures working as sub-systems that make our whole farming system as one strong system. But suppose any PLD structure is not functioning well for which it has been implemented initially; in that case, it is a matter of concern for us*." I observed fewer pollinators near the ponds, and the farmers think this is not a very good sign, and they decided to work on this soon.

Interpretation -2

The second research question results suggest using a holistic approach (figure 19), design elements (figure 20), and conservation and adaptation strategies (figure 21). The focus group had carefully applied permaculture ethics and design principles to support them towards achieving sustainability and resilience. Here, speaking of resilience, I have to mention this particular notion that resilience is a means to preserve a given system or community (Aiken, 2017).

Using a holistic approach, I found that the focus group best described this approach as looking at the farming system with perspectives over-arching the entire farming system. As put down by White, "*To proceed holistically is to see things like units, as complete, as wholes, and to do so is to oppose the dominant tendency of our time. This analytic spirit breaks things down into constituent parts to see how they work*" (White, 1984). Vasudev said, *"The views enable us to see the whole canvas (farm resources and conditions) at once."* As

mentioned in the results chapter, they used systems view, zones, and sectors to plan and mobilise their farm resources.

During the transect walk, I realised that as his ponds and vegetable garden are on the roadside, it is easy to sell products in the market, as the market is nearby the main entrance road.

He told me*, "The rice field is beside my organic fertiliser making pit so that dry straw and many organic matters are bought there without any difficulty."*

I saw that his fertiliser making pit is located behind the cowshed. His house and vegetable garden is next to it so that dung can quickly be taken to the pit and family members can take care of it. I also saw that ponds are beside the road, so that they make that rainwater fill these.

Vasudev told me*, "The monsoon wind can't harm the farm, as the agro-forest is in the east-west border. The wind can't enter because of the tall trees".*

Speaking of design elements, the focus group carefully looked into each of the farm's resources for their inherent properties before thinking about how to put them to work at the farm. Vasudev told me that they cultivate in multiple layers, whether it is the croplands or the fishponds. The in-depth and detailed knowledge of the land profiles (figure 26) helps the farmer family increase returns from the farm resources (Holmgren, 2020).

He continued, *"I tend vegetables on higher beds to prevent crop damage during rain, this year, we have extreme rainfall, and I have grown good produce by this process."* He told me he would cultivate vegetables upon the pond by making a bamboo roof.

He told me about every plot's orientation; the slope of the vegetable garden directed to the pond and the floor of cowshed are referred to a specific side to collect urine as they make pesticide by it.

In the interview, he said to me, "*The edges of the rice field are raised so that we can cultivate some vegetables there as well. I also grow vegetables in the high ground of the edges of ponds"*. I came to know from the interview that he has suitable soil for rice cultivation in the rice field and in the vegetable garden for vegetable cultivation. However, the village soil is muddy and compact.

Empirically, the Indian permaculture movement illustrates the manifestation of the permaculture movement in a country with an ongoing agrarian crisis and high levels of poverty and environmental degradation (Fadaee, 2019), which makes it more important to conserve. When speaking of conservation and adaptation, the focus group understands the need to conserve for the future and to be adaptable to changing situations. They are working on conservation and adaptation strategies by creating an ecological web and building interlinkages amongst crucial farming system factors like time, energy, materials, and technologies.

During the interview, I asked Vasudev about various crops' timings, and he told me*, "There is an annual rule of what to cultivate in a month, which we follow so that there are some vegetables all year round."*

He told me about his daily timetable, "*We understand our work daily and go to work, usually in the morning we provide water and fertilisers, and in the afternoon, we spray neem oil as a pesticide."*

I asked him about the energy and utilisation in his farm, and he told me, "*We make biogas from the cow dung in the house so that we don't have to rely on petrol.*" He also told me, "*The whole of sunlight falls on the vegetable plants, and the crops can absorb enough sunlight."*

For farm material utilisation, he said, *"We are culturing the vines on the bamboo roof so that we can grow more vegetables under it."*

He has taken up the rice land soil, built a home, and used rice straw as the roof of his house, which can be used as fertilizer after it is rotten-up. He again explained, *"I made the biogas from the cow dung in the house used for cooking, and extra cow dung is used in organic fertiliser."*

Thus, the permaculture design principles (see appendix 8) guide him in understanding and developing ecological design patterns for the farm (Gliessman, 1990). The Vasudev farming system's design elements are cautiously focused on the vital systems' strategic placement, making its agroecological web denser and more substantial. The crops and land use must be placed to reflect the in-site heterogeneity, including the land's topography (Mollison, 1988). Some notable design implementations at the Vasudev's farm include cow-dung composting, live fencing, mulching, crop rotation, crop sequencing, integrated organic farming, natural slopes for water-harvesting ponds, and irrigation bio-gas chambers. These are all incorporated in the farm keeping in mind the principles mentioned above. The strategic placement brings harmonic interrelations and smoother functioning between the farm elements, the structures, and the systems both from a sustainability and a resilience perspective (Francis et al., 2003).

Interpretation -3

Lastly, addressing my third research question, the various permaculture land design strategies and structures' collective application continuously supports sustainability and resilience. Also, keeping in mind the PPE (appendix 6) of using small and slow solutions, education and awareness should be valued, and efforts to increase such awareness can be considered. The focus group look to play a supportive role in the future of the Vasudev farming system.

To have a shared vision, the focus group participants discussed their visions in front of each other and then came to a plenary consensus. They found it to be a beneficial way of having a collective notion.

Vasudev's mother told me, *"I have grown old, and my grandchildren have the latest information about organic farming from across the world through their mobile phones, so their participation and views are equally important in the present."*

Having a specific action plan**,** setting realistic goals and achieving several small successes often help (LAKSHMI KP, 2016). I tried to facilitate the focus group to transform their shared vision into a step-by-step action plan for the coming five years. The action plan helped them build a road map to reach their desired future with clarity and confidence.

Vasudev told me, *"We have come up with very inclusive and all-encompassing visions on the paper; I should paste a copy on the front wall to keep us all reminded, focused, and united."*

Vasudev wanted to increase the scale of farming and vermicompost-making in upcoming years. He also explained to me by drawing rich-pictures that he would sell compost in the forthcoming 2-3 years in the local market and make drip irrigation through-out the farm and increase productivity from the ponds' edges. Some works like products selling in the national market, making high outreach of FFS, and adding more fields and ponds will take more time, but the group was determined to make it happen in the future.

Despite these diverse benefits of permaculture, I have to mention that permaculture is not prescriptive, rather site-specific and individually and communally responsive (Morrow, 2006). While we enjoy the benefits, we cannot overlook the criticisms that have been put forward by several scientists previously. In the words of Ferguson and Lovell, "Permaculture has

overreaching and oversimplifying claims about the achievements and state of knowledge represented by the permaculture system" (Ferguson and Lovell, 2014). In addition, permaculturists have repeatedly been criticised for inflating the land and labour productivity of complex polycultures and perennial systems. The permaculture literature often overlooks the dangers involved in maintaining extremely complex agroecosystems, these fundamental loopholes, among a few others, subject this approach to criticisms and oppositions. However, I believe that permaculture deserves a closer look. I want to reinstate that permaculture is a development strategy with numerous proven applications (Lockyer and Veteto, 2013).

Validity and reliability

Reliability was always a not concern in this qualitative research. The focus group participants' answers were always the same if the same question was asked twice, as the focus group participants were also the active farming practitioners at the Vasudev farmer. Thus, the consistency of the data has not been a worry during this action research.

Now the validity of the research depended on three key factors (Buchbinder, 2011) :

- the focus group's bias, that is, their unwillingness to share the actual information or say whatever I wanted to hear to please me,
- my bias, that is, my preconceived notions due to my previous experience, background, and assumptions, and
- reactivity bias, that is, my influence due to my physical presence at the research site.

I was aware that the biases mentioned above could affect the results. To minimise these biases, I tried to build a trust relationship with farmers using

dialogues as a research tool. I tried to participate in farm activities to become one amongst them. I left my past beliefs to immerse myself in the explorative experiential learning from the Vasudev farming system's existing phenomenon. To get the results' consistency and accuracy, I used multiple methods to collect data and got these results triangulated. Kolb's learning cycle has guided this research from the beginning to the end. I did not take a break in between the research schedule, with back-to-back three days maintained the research's consistency. Prolonged involvement could increase researcher bias: the participants and I could build general assumptions. I kept the focus group-size small for accuracy and kept the same group for all the methods for consistency. I always checked with them before interpreting the data, whether during the workshop or while categorising the interview and rich picture data.

Value, scope, and significance

The study's value to the Vasudev farming system could be that many key PLD facets such as the structures, strategies, and scope of the system were touched during the research. I observed that the members of the focus group had gained confidence in their attitude towards their work. The participatory action research methods were intriguing and engaging. The methods reflected what was there, what was going on, and what needs to be done. The results could be valuable to them as now they know what needs to be done and when that needs to be done in an organised and participatory manner. The study results could bring valuable knowledge to the nearby farmer communities who could learn from the Vasudev farming system. Though the research methods' scope was limited only to the Vasudev farming system, the scope of the results' impact could be far-reaching.

Industrial, intensive, and conventional agriculture has caused us much harm (Neumann, 2019). This project's contribution to the scientific community is to make qualitatively researched knowledge from West Bengal available, especially for existing and aspiring permaculturalists and agroecologists. Existing permaculture literature is often criticised for over-claiming results (Ferguson and Lovell, 2014). This study should form at least foundational knowledge for new farmers while adopting permaculture as regenerative farming. Vasudev's farming system has been adaptive from time to time in their practice. They keep modifying the design strategies to best suit their situation.

I tried to also bring positive contributions to the practising farmers, dialogue for the betterment, and collectively find solutions to the existing complex farm situations (Taylor Aiken, 2017). During the research, the dialogues have opened doors to an exchange of expertise, insights, and sharing of indigenous knowledge (Roux-Rosier et al., 2018), which may further lead to possible future collaborations and responsible action (Lieblein and Francis, 2007); (Østergaard et al., 2010).

Implications

This study shed some light on how the Vasudev farming system is using PLD for sustainability and resilience. However, the relevance of such a practice is disputed from the yield-oriented agrarian aspect. The results showed the Vasudev farming system to be overall self-sustained and resilient. It is currently a small-scale farm, so PLD practices are needed to redesign, adapt, and conserve when it comes to large scale production for serving and supporting a more extensive community. With the existing production he supports the family, and Vasudev can sell in the local village market. They use simple hand tools and sometimes the animals for the field works. Renewable energy-based

machinery and technology that do not cause pollution or make them dependent on an external supplier could be introduced.

The Vasudev farming system's social fabric is well-knit; it is a community based on humanitarian ecology; it cares for its people. The cultural thread embroiders the three generations (Vasudev, his parents, and his children) of farmers. The family took pride in the numerous roles they played to build and sustain their work collectively. The neighbours and the trainers felt responsible for their functions towards the whole system. The farm is doing well in terms of its key-role players' overall wellbeing, whether it is their external social relations or inner self-esteem.

Learning from the situations from which Vasudev and his family have risen and is rising, it can be suggested that using PLD practices helped overcome poverty to a great extent. As Vasudev had said, "We had a small mud house; my father used to grow some paddy for our survival. But today, we sell paddy along with so many other things. The PLD has helped us to utilise better each day, each structure, each labour (including animals), each space and each rupee leading to reduced wastage, increase production."

The implications from these results could be used in extreme situations where the community or families are suddenly left with nothing at all. The results of this case-study could be considered while planning the rehabilitation of farmers who are starting from zero investment. The results show that the practice is beneficial for marginal and small-scale farmers. The natural landscape and natural resources within their farming system are often their only support system for farming.

PLD farming could also better apply to environmentally-conscious farmers looking for a balanced system instead of just increasing the production scales.

Chapter 5. Discussion

The study indicates Vasudev and his family's decreased dependency on big corporates or local government for food, water, housing, energy, and income.

Strengths

Using Kolb's learning cycle as the framework for the research was very helpful. ELT guided me on what to look for and when. Using the PAR approach to gain experiential knowledge from the existing farm phenomenon was supportive. This approach helped in getting on-ground data in real-time. A social bond and relationship based on trust were formed. Having just one farm and five members in the focus group helped to go deeper into the research site's existing theses and phenomenology. Triangulation of methods helped me increase the validity of the study. I used multiple research methods, especially for the results' validity; I learned to work with the enormous data collected in the process single-handedly.

Limitations

This section discusses how my study could be improved and not just think of limitations as weaknesses. After this section, I would write about 'further studies,' so in this section, I will write about potential weaknesses in my research.

I had just one focus group; having one more focus group could have given me the opportunity to compare my results from the two groups. Having more than seven members in the focus group could have increased the information and given me more data to work with. Only Vasudev was interviewed in-depth, and the focus group members were interviewed briefly. Also, I could have interviewed them more than once for better consistency and reliability. Some quantitative methods could have been added to triangulate data and increase the

trustworthiness of the results. The research was carried out in the Bengali language and then transcribed and translated to the English language. There could be some deviations from the exactness in descriptions of the process' situations.

Although the research schedule, field dynamics, and participants could also be a limitation, I had planned and chosen them while writing the thesis proposal. But I realised that one needs to be adaptive to the unforeseen that may prevail due to natural phenomena. As mentioned above, the research was carried out during the lockdown phase of the Corona pandemic. It was challenging to convince the focus group initially, but later they allowed me a three-day visit for the research. Public transport was not functioning at that time, and having private transport took a toll on my available personal funds.

During the research we maintained safety precautions like washing hands regularly, avoiding touch, wearing masks, and maintaining physical distancing. None of us got infected, but this limited my qualitative research from natural and freehand processes.

I had an option to either drop a few methods or chose to be fast with my methods. I chose the latter. This situation of making a choice was again a limitation in itself. It took more time and effort to do each of the participatory tasks at the research site. At times I had to hurry to sum-up the research sessions and move to the next session in line. This might have limited the openness that was required for the study.

Thus, the results may have these limits, wherein the things were a bit rushed-up. Also, the results are from the Vasudev farming system, which is currently a small-scale farm. As discussed earlier, mixed (qualitative and quantitative) methods and mixed approaches could further have enriched the results.

Recommendations

Vasudev farming system is currently a small-scale farm in a rural village, aspiring to grow their work-scale in the coming five years. I will like to study its growth in the coming years, if I get a chance to study further or engage in research. Plus, as a recommendation, I would suggest the PAR study of the farming system's sustainability and resilience for various other alternate farming communities like:

- The urban community farmers
- The community farmers at the village level
- The corporate farmers at the national level

I feel sustainability and resilience are common meeting points for all the alternate farming communities, whether natural or organic farming, permaculture, or precision farming. Studying sustainability and resilience of the farming systems using PAR serves a dual purpose. PAR, as an approach, has theoretical implications as well as participatory action orientations. The results would set benchmarks for other practitioners to learn or prompt the studied practitioners to improvise and sustain their farming. Plus, it would bring in the much-required change through immediate action, which is often the envisioned goal of any social research (Francis et al., 2016).

Chapter 6. Conclusion

The given farming system's sustainability and resilience have improved continuously because of the permaculture-based land-design. The farm is eco-friendly in terms of farm-space utilisation as the farmer uses permaculture design tools to support his farm aspirations. Various mitigation and permaculture spatial strategies have been well integrated. The usage of the holistic approach, application of design details in-depth, and creating an agroecological web through conservation and adaptation have been found in the case study. The focus group has prepared its shared vision and responsible action plan (Lieblein and Francis, 2007). They are looking forward to the future of the Vasudev farming system with determination and enthusiasm.

Reflections

In this section, I reflect upon my research journey from the beginning to the end. Designs have always appealed to me, so I chose to study how and whether the PLD are relevant to the Vasudev farm system. Are they helpful in bringing sustainability and resilience? Having done the study during the lockdown phase of COVID-19 had its challenges and implications. There were certain physical and logistical restrictions due to this. The data collection had to be finished within a shortened time and a heightened budget. Now, I reflect that this also allowed me to study the farming system and the focus group in their most challenging phase. They could give me undivided attention for three consecutive days. Had this been a normal situation, I do not think it would have been possible for the focus group to provide continuous time and energy. They would have been engaged in following their typical day to day schedule.

There are crucial choices that one has to make right at the beginning of the study. The choices include the choice of topic, the choice of the research

question, the choice of methodology, the choice of site, the choice of participants and the choice of relevant parameters to measure the results.

Before making the above choices, the literature study substantiates the choices and the results obtained later on. Like any other researcher, I followed these basic steps and learned that these are like inputs that we give to our research work to get an output that is reliable and valid to the scientific understanding. The resulted output has its implications, limitations, and suggestion for further action and research.

I chose to study permaculture because it is my personal interest to study design-based farming systems, as I mentioned above. With its ethics and principles, permaculture focuses on ecologically designing the farming system (Hathaway, 2016). Often, permaculture has been criticised for overestimating its achievements, so I wanted to study existing phenomena at the Vasudev farming system through my experience building and participation. My initial questions were: how can physical design solve the complex ground issues on the farm? How can I provide valuable participation for the change in farmers' life (Krebs and Bach, 2018)? The methodology and methods chosen by me were all in line with this notion. The important sustainability parameters like economic, agronomical, social, cultural, environmental, and ecological were chosen.

I learned that not mimicking simple natural shapes like slight curves and waves is fine but copying complicated natural shapes like petals and leaves for the land (fields and ponds) created stress such as increased labour, time, and energy. Linear lines, shapes, and structure were found to save farmers’ time, efforts, and energy, but this, in turn, decreases the crops’ resilience capacity as they are more prone to pests, diseases, and deficiencies. A fair balance helped the Vasudev farming system to overcome these challenges over the years.

Chapter 6. Conclusion

I realised that the Vasudev farming system's ecologies got complex with time due to newly-added structures and increased efficiencies of the old ones. Again, every structure with each of its functions was connected to everything else in the farming system. The system's dynamic nature was such that it was humanely impossible to monitor everything, so the farmer relied much on building natural ecologies that were self-reliant and resilient, for example, the agroforest and the natural ponds.

As a facilitator, I tried to build a bond with the focus group to trust, share the information freely, and guide the research. I do not know how impactful my research results will be to them directly. Still, my research tools like participation, dialogue, visioning, observations, and reflection will allow them to make the most out of me right away (Francis et al., 2015). I told them, "This research may finish with the thesis, but our relationship would continue till our 'shared vision 2025' is achieved, and even further."

References

AIKEN, G. T. 2017. The politics of community: Togetherness, transition and post-politics. *Environment and planning A,* 49, 2383-2401.

ALTIERI, M. A. 2000. Agroecology: principles and strategies for designing sustainable farming systems. *Agroecology in action*.

ALTIERI, M. A. 2004. Linking ecologists and traditional farmers in the search for sustainable agriculture. *Frontiers in Ecology and the Environment,* 2, 35-42.

BASU, P., PARUI, A. K., CHATTERJEE, S., DUTTA, A., CHAKRABORTY, P., ROBERTS, S. & SMITH, B. 2016. Scale dependent drivers of wild bee diversity in tropical heterogeneous agricultural landscapes. *Ecology and evolution,* 6, 6983-6992.

BELL, S. & MORSE, S. 2013. *Measuring sustainability: Learning from doing*, Routledge.

BHATTACHARYA, R. & BASU, P. Pollinator limitation and crop production: experimental observations on few economically important vegetable crops in West Bengal, India. Proceedings of the Zoological Society, 2018. Springer, 88-91.

BUCHBINDER, E. 2011. Beyond checking: Experiences of the validation interview. *Qualitative Social Work,* 10, 106-122.

CARPENTER, S. R., WESTLEY, F. & TURNER, M. G. 2005. Surrogates for resilience of social–ecological systems. *Ecosystems,* 8, 941-944.

CHAKRABARTI, P., RANA, S., SARKAR, S., SMITH, B. & BASU, P. 2015. Pesticide-induced oxidative stress in laboratory and field populations of native honey bees along intensive agricultural landscapes in two Eastern Indian states. *Apidologie,* 46, 107-129.

CHAND, R., PRASANNA, P. L. & SINGH, A. 2011. Farm size and productivity: Understanding the strengths of smallholders and improving their livelihoods. *Economic and Political Weekly*, 5-11.

CHEER, J. M. & LEW, A. A. 2018. Understanding tourism resilience: Adapting to social, political, and economic change. *Tourism, resilience, and sustainability: Adapting to social, political and economic change*, 3-17.

DE SCHUTTER, O. 2012. Agroecology, a Tool for the Realization of the Right to Food. *Agroecology and strategies for climate change.* Springer.

DIANE, R. & CHARLES, F. 2004. Multidimensional thinking: a prerequisite to agroecology. *Agroecosystems analysis,* 43, 1-17.

FADAEE, S. 2019. The permaculture movement in India: A social movement with Southern characteristics. *Social Movement Studies,* 18, 720-734.

References

FERGUSON, R. S. & LOVELL, S. T. 2014. Permaculture for agroecology: design, movement, practice, and worldview. A review. *Agronomy for Sustainable Development,* 34, 251-274.

FIEBRIG, I., ZIKELI, S., BACH, S. & GRUBER, S. 2020. Perspectives on permaculture for commercial farming: aspirations and realities. *Organic Agriculture,* 10, 379-394.

FRANCIS, C., BRELAND, T. A., ØSTERGAARD, E., LIEBLEIN, G. & MORSE, S. 2013. Phenomenon-based learning in agroecology: a prerequisite for transdisciplinarity and responsible action. *Agroecology and Sustainable Food Systems,* 37, 60-75.

FRANCIS, C., JORDAN, N., PORTER, P., BRELAND, T., LIEBLEIN, G., SALOMONSSON, L., SRISKANDARAJAH, N., WIEDENHOEFT, M., DEHAAN, R. & BRADEN, I. 2011. Innovative education in agroecology: Experiential learning for a sustainable agriculture. *Critical Reviews in Plant Sciences,* 30, 226-237.

FRANCIS, C., LIEBLEIN, G., GLIESSMAN, S., BRELAND, T. A., CREAMER, N., HARWOOD, R., SALOMONSSON, L., HELENIUS, J., RICKERL, D. & SALVADOR, R. 2003. Agroecology: the ecology of food systems. *Journal of sustainable agriculture,* 22, 99-118.

FRANCIS, C., ØSTERGAARD, E. & NICOLAYSEN, A. 2016. Learning agroecology through Involvement and reflection) Agroecology: a transdisciplinary, participatory and action-oriented approach. *Advances in agroecology series. CRC Press, Boca Raton*, 73-99.

FRANCIS, C., ØSTERGAARD, E., NICOLAYSEN, A. M., LIEBLEIN, G., BRELAND, T. A. & MORSE, S. 2015. Learning agroecology through involvement and reflection. *Agroecology: A Transdisciplinary, Participatory and Action-oriented Approach.* CRC Press.

GLIESSMAN, S. & TITTONELL, P. 2015. Agroecology for food security and nutrition. Taylor & Francis.

GLIESSMAN, S. R. 1990. Agroecology: researching the ecological basis for sustainable agriculture. *Agroecology.* Springer.

GLIESSMAN, S. R., ENGLES, E. & KRIEGER, R. 1998. *Agroecology: ecological processes in sustainable agriculture*, CRC press.

HATHAWAY, M. D. 2016. Agroecology and permaculture: addressing key ecological problems by rethinking and redesigning agricultural systems. *Journal of Environmental Studies and Sciences,* 6, 239-250.

HOLMGREN, D. 2002. Principles & pathways beyond sustainability. *Holmgren Design Services, Hepburn*.

HOLMGREN, D. 2020. *Essence of permaculture*, Melliodora Publishing.

HSIEH, H.-F. & SHANNON, S. E. 2005. Three approaches to qualitative content analysis. *Qualitative health research,* 15, 1277-1288.

References

HUDSON, R. J. 2009. *Management of agricultural, forestry and fisheries enterprises*, EOLSS.

KADAPATTI, R. & BAGALKOTI, S. 2014. Small farms and agricultural productivity-A macro analysis. *Int'l J. Soc. Sci. Stud.,* 2, 123.

KALAISELVI, V. & KALYANI, T. 2012. An Economic Analysis of Crop Diversification in Villupuram District, Tamil Nadu. *Language in India,* 12.

KARMAKAR, S. & SARKAR, D. 2014. Income inequality, poverty and food security in West Bengal, India. *Journal of Social Science Studies,* 1, 31-43.

KOLB, D. A. 2007. *The Kolb learning style inventory*, Hay Resources Direct Boston, MA.

KOLB, D. A. 2014. *Experiential learning: Experience as the source of learning and development*, FT press.

KOOHAFKAN, P., ALTIERI, M. A. & GIMENEZ, E. H. 2012. Green agriculture: foundations for biodiverse, resilient and productive agricultural systems. *International Journal of Agricultural Sustainability,* 10, 61-75.

KREBS, J. & BACH, S. 2018. Permaculture—Scientific evidence of principles for the agroecological design of farming systems. *Sustainability,* 10, 3218.

KREMEN, C. & MILES, A. 2012. Ecosystem services in biologically diversified versus conventional farming systems: benefits, externalities, and trade-offs. *Ecology and society,* 17.

KVALE, S. & BRINKMANN, S. 2009. *Interviews: Learning the craft of qualitative research interviewing*, Sage.

LAKSHMI KP, S. 2016. The Aranya Movement. *World Affairs: The Journal of International Issues,* 20, 66-75.

LET, S. 2011. Crop Diversification of Birbhum District: A Spatio Temporal Assessment. *Analyst,* 1, 2011.

LIEBLEIN, G., BRELAND, T. A., FRANCIS, C. & ØSTERGAARD, E. 2012. Agroecology education: action-oriented learning and research. *The journal of agricultural education and extension,* 18, 27-40.

LIEBLEIN, G. & FRANCIS, C. 2007. Towards responsible action through agroecological education. *Italian Journal of Agronomy,* 2, 83-90.

LIEBLEIN, G. & FRANCIS, C. 2013. Faculty prerequisites for dialogue-based education. *NACTA Journal,* 57, 72.

LOCKYER, J. & VETETO, J. R. 2013. *Environmental anthropology engaging ecotopia: bioregionalism, permaculture, and ecovillages*, Berghahn Books.

References

LÖFGREN, K. 2013. Qualitative analysis of interview data: A step-by-step guide. *Video file*.

LOHAR, D. & PAL, B. 1995. The effect of irrigation on premonsoon season precipitation over south west Bengal, India. *Journal of Climate,* 8, 2567-2570.

MAJUMDAR, B. & DASGUPTA, S. 2020. Let Bengal be heard: dealing with Covid and cyclone Amphan together. *South Asian History and Culture,* 11, 317-322.

MAJUMDER, M., ROY, P. & MAZUMDAR, A. 2010. An introduction and current trends of Damodar and Rupnarayan River network. *Impact of climate change on natural resource management.* Springer.

MARQUES, F. C., DAL SOGLIO, F. K. & VAN DER PLOEG, J. Constructing sociotechnical transitions toward sustainable agriculture. Symposium Innovation and Sustainable Development in Agriculture and Food (ISDA), Montp, 2010.

MÉNDEZ, V. E., BACON, C. M. & COHEN, R. 2013. Agroecology as a transdisciplinary, participatory, and action-oriented approach. *Agroecology and Sustainable Food Systems,* 37, 3-18.

MILESTAD, R. & DARNHOFER, I. 2003. Building farm resilience: the prospects and challenges of organic farming. *Journal of sustainable agriculture,* 22, 81-97.

MISHRA, I. N. 2007. Peasant in Marxism. *Indian Historical Review,* 34, 351-353.

MOLLISON, B. 1988. Permaculture: a designer's manual. *Permaculture: a designer's manual.*

MOLLISON, B., SLAY, R. M., GIRARD, J.-L. & GIRARD, J.-L. 1991. *Introduction to permaculture*, Tagari Publications Tyalgum,, Australia.

MORGAN, D. L. 1993. Qualitative content analysis: a guide to paths not taken. *Qualitative health research,* 3, 112-121.

MORROW, R. 2006. *Earth user's guide to permaculture*, Permanent Publications.

NARASANNA, K. 2013. A short report on the evolution of permaculture in India (with reference to Andhra Pradesh).

NEUMANN, D. 2019. Permaculture and socio-ecological transformation in Indian metropolises.

NIELSEN, K. B. Contesting India's development? Industrialisation, land acquisition and protest in West Bengal. Forum for Development Studies, 2010. Taylor & Francis, 145-170.

OKIGBO, B. 1989. Development of sustainable agricultural production systems in Africa. [sn].

References

ØSTERGAARD, E., FRANCIS, C. & LIEBLEIN, G. 2013. Practicing and preparing for stakeholder interviews. *NACTA Journal,* 57, 97.

ØSTERGAARD, E., LIEBLEIN, G., BRELAND, T. A. & FRANCIS, C. 2010. Students learning agroecology: Phenomenon-based education for responsible action. *Journal of Agricultural Education and Extension,* 16, 23-37.

PALANIAPPAN, G., KING, C. & CAMERON, D. 2016. Transitions to Alternate Farming: A Dialectic Study from Australia and India. *Indian Research Journal of Extension Education,* 10, 100-106.

PICKERILL, J. 2013. Permaculture in practice. *Environmental Anthropology Engaging Ecotopia: Bioregionalism, Permaculture, and Ecovillages,* 17, 180.

PIRAUX, M., SILVEIRA, L., DINIZ, P. & DUQUE, G. La transition agroécologique comme une innovation socio-territoriale. ISDA 2010, 2010. Cirad-Inra-SupAgro, 9 p.

RHODES, C. J. 2012. Feeding and healing the world: through regenerative agriculture and permaculture. *Science progress,* 95, 345-446.

ROBERTSON, D. J. 2020. Corridor Ecology: Linking Landscapes for Biodiversity Conservation and Climate Adaptation , Jodi A. Hilty, Annika TH Kelley, William Z. Lidicker Jr., and Adina M. Merenlender. *Natural Areas Journal,* 40, 189-190.

ROSSET, P. M., MACHÍN SOSA, B., ROQUE JAIME, A. M. & ÁVILA LOZANO, D. R. 2011. The Campesino-to-Campesino agroecology movement of ANAP in Cuba: social process methodology in the construction of sustainable peasant agriculture and food sovereignty. *The Journal of peasant studies,* 38, 161-191.

ROUX-ROSIER, A., AZAMBUJA, R. & ISLAM, G. 2018. Alternative visions: Permaculture as imaginaries of the Anthropocene. *Organization,* 25, 550-572.

SALLIOU, N. & BARNAUD, C. 2016. Landscape and biodiversity as new resources for agro-ecology? Insights from farmers' perspectives. *Ecology and Society,* 22, 1-10.

SHARMA, A., BURN, S., GARDNER, T. & GREGORY, A. 2010. Role of decentralised systems in the transition of urban water systems. *Water Science and Technology: Water Supply,* 10, 577-583.

SHIVA, V. 2020. Cocreating responsible food and agriculture systems. *Rethinking Food and Agriculture.* Elsevier.

SOLKINSON, D., HORDERN, A., WILSON, D. & CHI, K. 2016. SURFING THE NEW EDGE OF PERMACULTURE: Looby Macnamara, Robin Clayfield, Rosemary Morrow, and Robina McCurdy. *Communities*, 14.

References

SPRADLEY, J. P. 1979. The ethnographic interview. New York: Holt, Rhinehart & Winston. *LeCompte, MD (2000). Analyzing Qualitative Data. Theory into Practice,* 39, 146-156.

TAYLOR AIKEN, G. 2017. Permaculture and the social design of nature. *Geografiska Annaler: Series B, Human Geography,* 99, 172-191.

THOMAS, D. R. 2003. A general inductive approach for qualitative data analysis.

TRIANGULATION, D. S. The use of triangulation in qualitative research. Oncology nursing forum, 2014. 545.

VÁLEK, L. & JAŠÍKOVÁ, V. 2013. Time bank and sustainability: The permaculture approach. *Procedia-Social and Behavioral Sciences,* 92, 986-991.

VANBERGEN, A. J. & INITIATIVE, T. I. P. 2013. Threats to an ecosystem service: pressures on pollinators. *Frontiers in Ecology and the Environment,* 11, 251-259.

VANDERMEER, J. 1995. The ecological basis of alternative agriculture. *Annual Review of Ecology and Systematics,* 26, 201-224.

WEZEL, A., ARTHAUD, F., DUFLOUX, C., RENOUD, F., VALLOD, D., ROBIN, J. & SARRAZIN, B. 2013. Varied impact of land use on water and sediment parameters in fish ponds of the Dombes agro-ecosystem, France. *Hydrological sciences journal,* 58, 854-871.

WHITE, E. M. 1984. Holisticism. *College Composition and Communication,* 35, 400-409.

WILSON, S. 2008. *Research is ceremony: Indigenous research methods*, Fernwood Publishing.

YIN, R. K. 2013a. *Case study research: Design and methods*, Sage publications.

YIN, R. K. 2013b. Validity and generalization in future case study evaluations. *Evaluation,* 19, 321-332.

ZAZU, C. & MANDERSON, A. 2020. Agroecology and Climate Change Adaptation: Farmers' Experiences in the South African Lowveld. *African Handbook of Climate Change Adaptation*, 1-16.

Appendix 1:

Interview Questionnaire for the Farmer

Farmer Name:
Gender:
Age:
Education Level:
Family Size:

Farm Name:
Address:
Agroecological Zone: Warm and Moist Tropical
Vulnerability to natural disasters: high as per dw.com
Longitude:
Latitude:
Farm Size:
Cultivable area:
Permaculture Zones in the Farm:
Permaculture Sectors in the Farm:
Farm Resources list:

Permaculture land design (PLD)

1. When and where did you **first hear** about farmland designing and restructuring strategies?
2. Initially, what were the most important **reasons** to choose this method of farming?
3. Who gave you the formal **training**? What kind of **support** did you get from them?
4. To which sections did you **first start** to practice the acquired knowledge in your farm? Why did you select this area to begin with?

Appendix 1:

5. What are the various **implemented land design strategies** and their **utility** in your farm? Please elaborate in as many details as possible, regarding the previous and current structural maps.
6. Has the practice led you to any recent accomplishments or **innovations** on the farm that you would like to mention?
7. How do you know about new things that are happening in the field of agriculture? What are your sources of information?
8. Guided Activity: Draw two **farm-resource diagrams**: (i) before using land design strategies and (ii) after using land design strategies. Compare the two diagrams.

Sustainability and resilience parameters

1 Economic

1. Do you observe a growing or a declining **pattern** in the total income and sales from the time you changed to land design implementations?
2. Is farm income more than the rent earned by letting out?
3. Are there any **new additions** to the earlier income sources from your farm? If yes, then please mention.
4. How many times in a year are you able to sell in the **market** now?
5. Which are the highest-**earning sources** at your farm, as compared to the past?
6. Do you have a fixed **range** for the annual income, or it varies a lot?
7. Are the farm's **input costs** reducing or increasing? And how?
8. Which are the most **expensive inputs** at your farm, as compared to the past?
9. Are you **reinvesting** the profits on the farm or saving them for future purposes? If both, then what is the approximate ratio?

Appendix 1:

10. Have you taken any **loan** or credit for farming? If yes, what is the pay-back plan?
11. Have you applied for any government subsidy, **support**, or other sponsorships? If yes, then please mention the purpose.
12. Do you have **insurance** for any of the farm implements? If yes, then please elaborate.
13. Do you feel to be economically **independent** and take care of your farm and your family's need?
14. Are there any economic challenges in this kind of farming? If yes, then please elaborate.

2 Agronomy / production

1. What the various **products from your farm**?
2. What crops are cultivated at **various land levels**?
3. How has your list of the planted crops and livestock **changed** over the years?
4. Are you able to grow **more varieties** than earlier? If yes, then how?
5. Are you able to grow **better quality** (shape, size, smell, colour, and taste) of food than earlier? If yes, then how?
6. Are you able to have a **round-the-year harvest**? If yes, then how?
7. Do you think the **land area** (sq. ft) of production has increased by using angular slopes and vertical heights/ depths?
8. How do you now **decide** regarding what to grow, as compared to the earlier situation?
9. What is the improvement in your **food basket diversity**? How many types of food do you eat now?

Appendix 1:

10. Has the **diversity of overall farm-products** increased from the time you adopted to land design implementations? Compare.
11. How is the **annual yield** of each of these products? Compare to the non-PLD period.
12. Do you think that farm crops and livestock are more **immune** to diseases and deficiencies? If yes, then how?
13. Do you maintain the **cropping calendar**? If yes, then please share.
14. What are the machines, tools, and **types of equipment** used on your farm?
15. Do you think PLD strategies better **support Organic farming** and Integrated Farming? If yes, then how?
16. Do you have a soil health card? How is the **soil condition**?
17. Has your **farm-input reduced** and lesser dependency on the market for substitutes?
18. What are the productional **shortcomings** in this kind of farming?

3 Environment/energy

1. What are your strategies for **water management**?
2. What are the **step-by-step strategies** employed from preparing the **soil** for sowing to final **harvesting** and up to selling in the **market**?
3. How has the **soil performed** to apply permaculture principles in terms of nutrients, biodiversity, compactness, structure, pH levels, and tilth?
4. How has the **water bodies** (surface and underground) performed with the application of permaculture principles? In terms of nutrients, biodiversity, and salinity.
5. Are the **crops and animals** able to withstand weather extremes like heavy rainfall, wind, humidity, heat, and cold? If yes, then how?
6. How has the natural **pollinator** population fared in recent times?

Appendix 1:

7. What are the various renewal and non-renewal sources of **energy** at your farm, and how much is your dependency on them?
8. Has **energy efficiency** improved over time?
   Example: using less energy of nonrenewal energy, recycling waste to produce energy, and storing sunlight and rainwater.
9. How have you managed to control **pollution** arising from within the farm boundaries?
10. What are **ecosystem services** you can notice at your farm? Example: food and water; regulating, such as the control of climate and disease; supporting, such as nutrient cycles and oxygen production; and cultural, such as spiritual and recreational benefits.
11. Is there any environmental harm in this kind of farming? If yes, then please elaborate.

4 Social

1. How is the **work culture** at the farm?
2. How many **workers** are working at the farm as compared to the situations before PLD adaptation?
3. What is the **ratio** between men and women working at the farm? Who does which works at the farm?
4. What are the **age** range and average age of the labours working at your farm?
5. Do you **hire labours** from the market? If yes, then why?
6. Do you feel that **your team** has enough skills to withstand future farm challenges? If yes, then how?
7. Are you willing to **educate and train** other farmers? If yes, then how?
8. How do your **neighbours** relate to you? Elaborate.

Appendix 1:

9. How well are you in connection with your village's **farmer community**?
10. Is your work earning you **prestige and recognition**? If yes, then elaborate.
11. Are you getting any support from the **local government** body? If yes, then how?

5 Health and Nutrition

1. What is the primary source of drinking **water** and daily **food**?
2. Do you think that your farm-grown food has more **nutritional value** as compared to market food? If yes, then how?
3. What are your strategies for **hygiene** maintenance at your farm?
4. What are the most common **diseases** or health issues found in your village? How has PLD supported you to mitigate them?
5. Do you often feel **mentally** stressed? Or are you usually content, peaceful, and happy?
6. Is there a rise or decline in your family's **medical** expenses?

6 Climate Change: Mitigation, Adaptability, and Conservation

Climate change is a natural phenomenon, but anthropogenic activities have accelerated the speed. Some examples are given below:

- Flood/ flash flood/ Saline water
- Global warming and rising sea level
- Extended summers and shortened winters
- Irregular monsoon season and insufficient rainfall
- Rising daily temperatures
- Pollution- air, water, and landscape
- Soil issues- chemical traces
- Urbanization

Appendix 1:

1. What are the **challenges** that you face related to this? And how are you dealing with them?
2. Has there been any **natural disaster** in recent times? If yes, then mention its effect on your farm.
3. What are your **preparations** for farm protection during any natural calamities?
4. Do you have a **contingency plan** for any emergency?

7 Pandemic Resilience

Coronavirus disease (COVID-19) is an infectious disease caused by a newly discovered coronavirus. It is declared a Pandemic by WHO.

1. What are the significant effects of lockdown on your farm? List the challenges, and how are you dealing with them?
2. Is there a shortage of food for your family on the farm during the lockdown?
3. Do you think PLD strategies gave you extra support or advantage as compared to the other farms nearby? How?

Interview Questionnaire for the Neighbour

Neighbour Name:

Neighbour since:

1. **Agrarian-** Do you think your neighbouring farm can grow sufficient food for their consumption as well as for the market sale? How?
2. **Social**- How is your relationship with your neighbouring farm? How much time do you spend together? Elaborate.

Appendix 1:

3. **Environmental**- Do you think your neighbouring farm is polluting the environment directly or indirectly? How?
4. **Economical**- Is your neighbouring farm doing well in terms of income and sales? How?
5. **Nutritional**- Have you noticed any physical or mental health-related issues or improvements with your neighbouring farm? Elaborate.
6. **Climate Resilience**: During the last calamity, how much time did your neighbouring farm took to recover? What is better or worse than other nearby farms?
7. **Pandemic Resilience**: During COVID-19 lockdown, are your neighbouring farm able to sustain themselves? How?

Interview Questionnaire for DRCSC Trainers and Permaculturist

Trainers name:
Trainer for the concerned farm since:
Project name:
Training Experience:

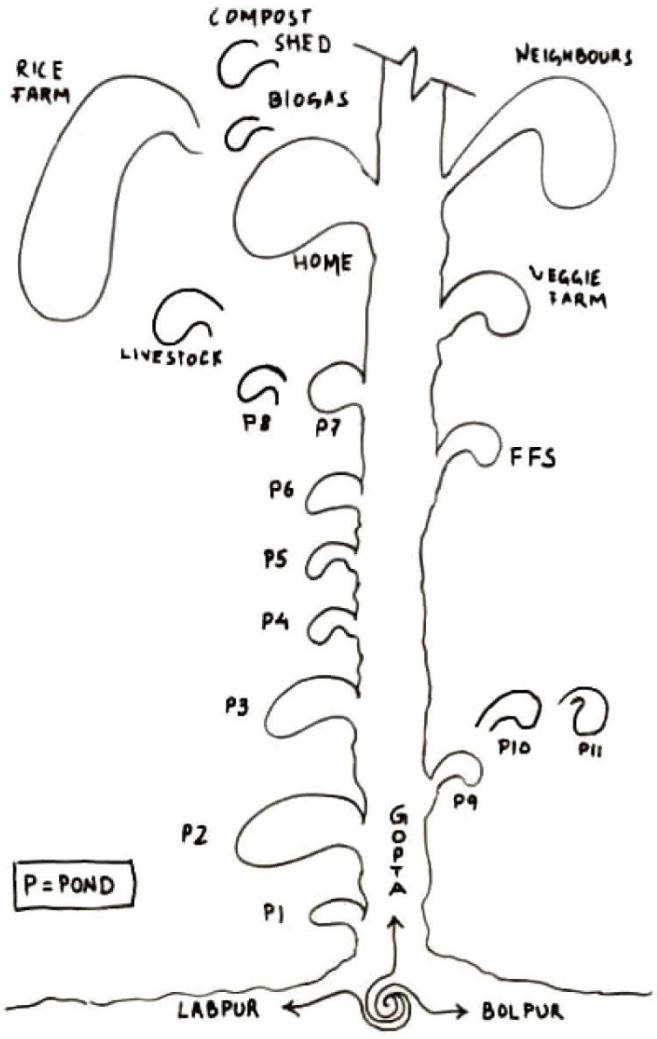
1. How had been your **experience** to date with concerned farm families while training and guiding them to apply PLD strategies on their farm?
2. What are the main **supporting and challenging aspects** of PLD strategies on their farm? Elaborate.
3. According to you, what is the future **scope** of their farm with PLD strategies being applied? Explain.

Appendix 2:

Appendix 2:

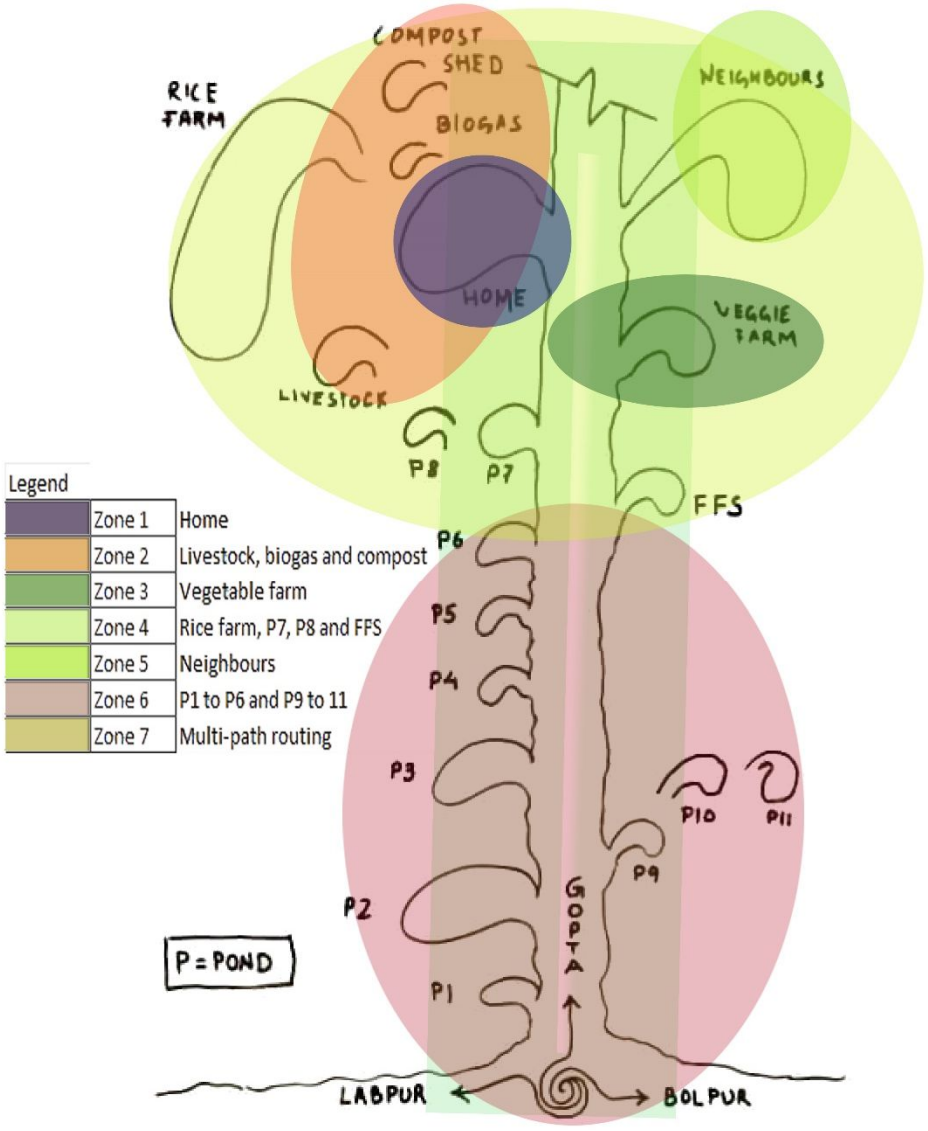
The **rich pictures** of the current situation and the Vasudev farming system's desired future during the visioning workshop. (top-left) by Vasudev and his wife, (the top-right) by Vasudev's mother, daughter, and son, (the bottom-left) by neighbour Uday and (bottom-right) by the DRCSC trainer Badshah.

Appendix 3:



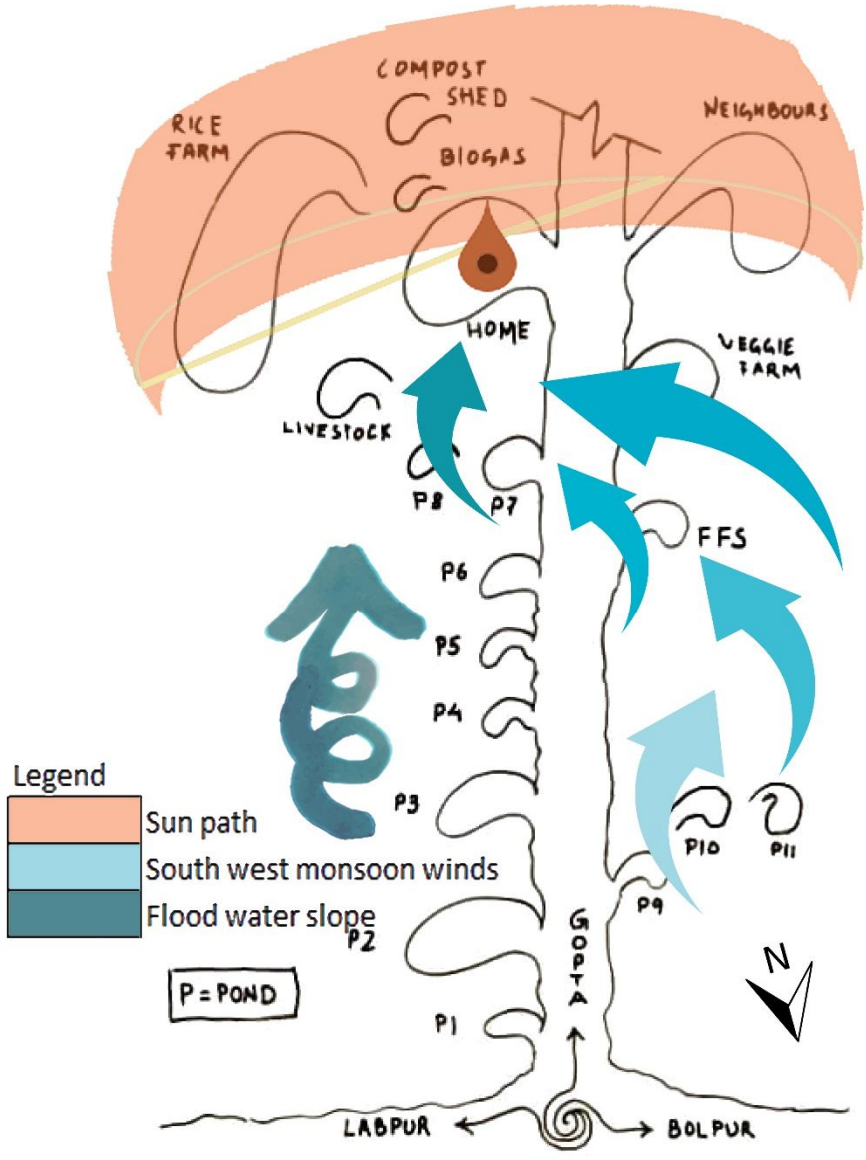
The above illustration was made to show the locations of the various **permaculture structures** in the Vasudev farming system. The structure's placements and sizes are drawn using my observations and reflections during the transect walk. It is not an exact map of the farm but a conceptual model.

Appendix 4:



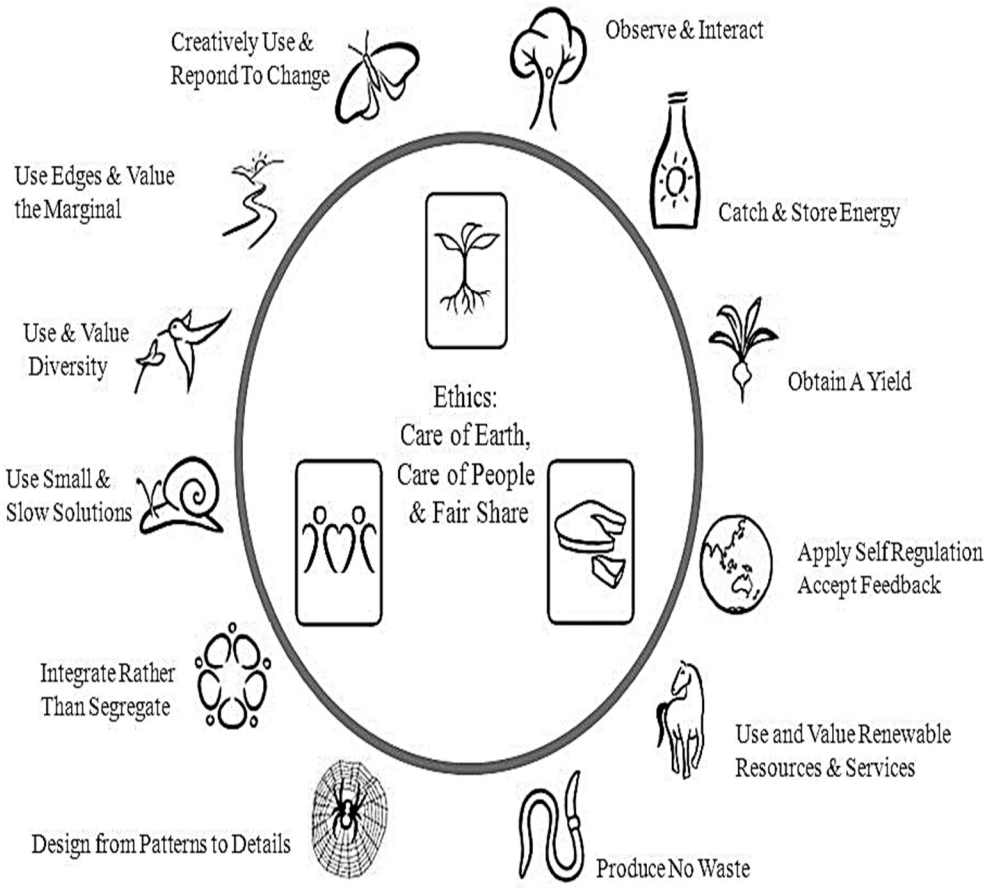
The above illustration shows the various active permaculture **zones**' locations, functions, and proximities to each other.

Appendix 5:



The above illustration shows the various active permaculture **sectors** such as the sun path, water slope, and wind flow directions to the Vasudev farming system.

Appendix 6:



The above illustration shows the three **permaculture ethics (**inside the ring) and the twelve **permaculture principles** (outside the ring), adapted from (Holmgren, 2002)

Appendix 7:

Visioning exercise with guided imagery

(adapted from M Parker's "Sustainable Norway" national conference**)**

Ask the participants to write the future date at the top of a blank paper as: **11 July 2025.**

1) **Read short relaxation exercise** (Dim the lights)

a. We request you to sit comfortably! 5 seconds
b. Slowly close your eyes. 5 seconds
c. Choose the most comfortable position to feel relaxed 5 seconds
d. Feel the weight of your body on the chair and the connection between your feet and the ground. Feel how relaxed your face muscles are. The back of the chair supports the weights of your body. 5 seconds
e. Be aware of your breath 5 seconds
f. Slowly take a deep breath in - hold – slowly release 5+5+5 seconds
g. Again, slowly take a breath in - hold – slowly release 5+5+5 seconds

2) **Mentally moving into the future** (Turn off the lights): Keeping your eyes closed, now**,** I will ask you to imagine that you can "travel" into the future. I'd like you to imagine that you are going fast forward to five years into the future to the year 2025.

   To make it easier for you to experience transitioning to the year 2025 mentally, I will invite you to imagine that you have your own unique "transportation to the future" vehicle. For example, it could be a magic carpet, a hot air balloon or a spaceship, anything that you want to fancy.

Appendix 7:

Please take a few seconds now to create an image of the vehicle you think would be most exciting to travel into the future with. (pause)

Now I would like you to see yourself standing on the farmland outside of this cottage. Feel the air. Notice the colour of the leaves. Notice whether it's sunny or cloudy.

Now notice that your own very unique vehicle is also on the farmland and only a few meters away from you. Please take a careful look at it. Walk around and admire it. (pause)

Now climb into it or on it. And make yourself as comfortable as possible. Prepare for take-off. Allow your vehicle to slowly and gently lift you off the ground. A little bit higher. So high that you notice that when you look down, you can see **the vegetable garden**, **the compost unit, and the livestock shed**. Notice **the ponds** and **the agroforests** on the other side of the road and how they look this time of year.

Now, looking down over **the neighbourhood**, you find you are coming closer to **the farmer field school**. Off in the distance on the way to Bolpur - you see a glimpse of **the local village market**.

Notice now that your vehicle is beginning to move slower and that you are gradually beginning to float downwards, ever so gently.

The time has come for you to prepare to land.

Allow yourself now to quickly and slowly go in for a landing on your beautiful green **paddy fields**.

3) Description of the future scene – five years ahead in time - Role as oneself five years older: Now that you have landed safely. Take a look around you. Today is **July 11, 2025**. You are five years older! And undoubtedly, five years wiser!

Appendix 7:

About twenty meters off to your right, you see the farmer field school building. It appears to be beautiful. Looking at it from the outside, what is it that impresses you?

Now feel yourself walking towards the main entrance to that building. Notice the large sign over the entrance. The sign says Gopta farmer field school: Sustainable and resilient farming practices.

Enter the building and walk towards the classroom. In front of the classroom, you see a sign with the words: "Success stories from the Gopta Village."

Standing in the classroom is the rural panchayat leader. Hear him saying in a loud, clear voice:

"Welcome to Success stories from the Gopta Village 2025". Today we are proud to announce that Sustainable agriculture in farming systems are firmly established within three significant farms in the village. All three farms are receiving recognition nationally and internationally for their outstanding achievements.

Connections between farmers and consumers have multiplied. In newspapers, blogs, and other media, we read glowing accounts about how people in the villages are involved in Sustainable agricultural activities in farming systems.

An outstanding achievement!

What's behind all of this? Without a doubt, the successful collaboration between the DRCSC trainers and local stakeholders - farmers, processors, distributors, and consumer groups, and governmental institutions and environmental organizations in the village.

We are fortunate to have here with us one of the local farmers who has established sustainable agriculture in their farming systems. He / She is

Appendix 7:

willing to share what is going on in the village and why it is a model for the rest of the country in advancing sustainable farming.

4) **Questions to envision**: The rural panchayat leaders: "You must feel extreme pride in having made such a difference in your farming system."

1) Knowing how much is going on today about sustainable agriculture and Permaculture-based land designs in your farming system, tell us what you are most proud of?

Just listen quietly to how you respond. You do not need to censor anything. (Pause)

2) In what specific ways are the neighbours in the village benefiting from this new situation? And the farmers at your farm, how are they benefiting?

Again, listen to how you respond. (pause)

3) What else do you see happening on your farm, which makes it today a model for the rest of the country about advancing sustainable agriculture?

Listen to yourself respond. Now you hear the rural panchayat leader concluding: Many thanks for your willingness to be with us today and share your insights. Now listen to the students in the classroom applauding – they are excited and inspired by all you have said.

5) **Closure**: Now see yourself walking slowly out of the classroom, out of the farmer field school, and out into the open air. Allow yourself to feel pride in having been asked to share what is going on in your farm where you and your family have made such an enormous and positive difference.

Appendix 7:

6) **Capturing images individually** (Turn on the lights): On the lawn, not far from the farmer field school, is a white-painted bench. See yourself sitting down on the bench.

I will now ask you to open your eyes. Remain silent, and please do not speak with your neighbour. You will now have time to note your responses to the questions posed by the rural panchayat leader.

(Write questions on flip-over so the participants can take a look in case they have forgotten.)

Remember – it is still **July 11, 2025**, and your responses describe the achievements that are now manifesting in the year 2026. Write your responses in the present tense, for example: what is happening today on my farm. Today the farmers are very pleased about it.

If, in addition to words, it feels easier to illustrate your responses by making a drawing or sketch, feel free to do so. There are coloured crayons. Feel free to make the drawing. This approach sometimes makes it more accessible. It does not matter if the drawings are simple or rough sketches.

You have plenty of time to do this. If you complete the writing/drawing before the others, remain in your chair and be completely quiet.

Appendix 8:

Appendix 8:

The **comparative table** below represents the current farm PLD structures compared to farm sustainability and resilience parameters written in Bengali.

পার্মাকালচার ল্যান্ড-ডিজাইন স্ট্রাকচার স্থায়িত্ব এবং স্থিতিস্থাপকতা সূচক	মাছের পুকুর (1)	গবাদিপশু-র শেড (2)	ধান ক্ষেত (3)	শাক সবজির ক্ষেত (4)	কৃষি বন (5)	বাড়ি (6)	কম্পোস্ট ইউনিট (7)	প্রতিবেশ (8)	এফ এফফ এস 9)
আর্থনৈতিক বৃদ্ধি									
সঞ্চয় (ক)									
বিক্রয় (খ)									
লাভ (গ)									
আয়(ঘ)									
উত্পাদন বৃদ্ধি									
পণ্যের বৈচিত্র্য (ঙ)									
মান(চ)									
পরিমাণ(ছ)									
সামাজিক বৃদ্ধি									
পরিবার (ঞ)									
প্রতিবেশি (ট)									
প্রতিপত্তি (ঠ)									
স্বীকৃতি (ড)									
সাংস্কৃতিক বৃদ্ধি									
শিক্ষা (ঢ)									
দক্ষতা (ণ)									
জ্ঞান (ত)									
সম্পর্ক (থ)									
পরিবেশ বৃদ্ধি									
মাটির স্বাস্থ্য (দ)									
পরাগরেণু (ধ)									
ভূগর্ভস্থ জল (ন)									
পরিবেশগত বৃদ্ধি									
শক্তি, পুষ্টি , জলের চক্র এবং প্রবাহ (প)									
খাবার চেইন এবং ওয়েবস (প)									
জীববৈচিত্র্য, অভিযোজন এবং মিথস্ক্রিয়া (U)									
সহনশীলতা বৃদ্ধি									
বাফার ক্ষমতা (V)									
অভিযোজিত ক্ষমতা (W)									
স্ব-সংগঠন ক্ষমতা (X)									
	মাছের পুকুর	গবাদিপশু-	ধান ক্ষেত	শাক সবজির	কৃষি বন	বাড়ি (6)	কম্পোস্ট	প্রতিবেশ	এফ এফফ

	অনেক বেশী
	বেশী
	মাঝারি
	কম
	অনেক কম

Instructions to the participants:

- Individually reflect upon the parameters mentioned below.
- Discuss in the plenary the parameters mentioned below.
- Build consensus over each box, then one participant from the focus group will colour the boxes one by one in the form.
- Use five colours: green, yellow, orange, red and brown, to mark the five conditions: excellent, very good, average, bad and poor.

Appendix 9:

The comparative table (figure 19a) described in detail:

Fishponds:

- In the **economic growth category,** savings are marked yellow (A1), which indicates that it is in good condition. The sales, profit and income are marked green (B1, C1 and D1), which indicates that they are in excellent condition.
- In the **production growth category**, product diversity is marked orange (E1), which indicates that it is in average condition. The quality and quantity are marked green (F1 and G1) colour, which indicates that they are in excellent condition.
- In the **social growth category**, the family, neighbour, prestige and recognition are marked by red (H1, I1, J1 and K1) coloured boxes, indicating that they are in bad condition.
- In the **cultural growth category**, education and knowledge are marked yellow (L1 and N1), indicating that they are good. The skill is marked with green (M1) colour, which indicates that it is in excellent condition, and the relationship is marked red (O1), which indicates it is in bad condition.
- In the **environmental growth category**, soil health and groundwater are marked green (P1 and R1), indicating that they are in excellent condition. And, pollinators are marked brown (Q1) which indicates that it is in poor condition.
- Energy, nutrients, water cycle flows, food chain and webs are marked green (S1 and T1), which indicates they are in excellent condition in the

Appendix 9:

ecological growth category. The biodiversity, adaptation and interactions are marked yellow (U1), indicating that it is in good condition.

- In the **resilience growth category,** adaptive and self-organising capacity are marked green (W1 and X1), indicating that they are in excellent condition. Also, buffer capacity is marked yellow (V1), indicating that it is good.

Livestock shed:

- In the **economic growth category**, savings and profit are marked orange (A2 and C2), indicating that they are in average condition. The sales are marked red (B2), which indicates that it is in bad condition and income is marked yellow (D2), which indicates that it is in good condition.
- In the **production growth category**, product diversity, quality and quantity are marked orange (E2, F2 and G2), indicating that they are in average condition.
- In the **social growth category,** family, neighbour, prestige, and recognition are marked orange (H2, I2, J2 and K2) colour, indicating that they are in average condition.
- In the **cultural growth category,** education and knowledge are marked yellow (L2 and N2), indicating that it is in good condition. Skill is marked green (M2), indicating that it is in excellent condition and relationship is marked red (O2) colour, which indicates that it is in bad condition.
- In the **environment growth category**, soil health and pollinators are marked brown (P2 and Q2), indicating that they are in poor condition. Groundwater is marked orange (R2), indicating that it is in average condition.
- In the **ecological development category**, food chains, webs, biodiversity, adaption and interaction are marked yellow (T2 and U2), indicating that

they are in good condition. Energy, nutrients, water cycle and flows are marked orange (S2) colour, indicating that it is in average condition.

- In the **resilience growth category**, buffer capacity is marked orange (V2), indicating that it is in average condition. Adaptive capacity is marked yellow (W2) which indicates that it is in good condition and self-organising capacity is marked green (X2) which indicates that it is in excellent condition.

Paddy fields

- In the **economic growth category**, savings are marked yellow (A3), indicating that it is good. Profit is marked orange (C3), indicating that it is in good condition and sales and income are marked green (B3 and D3), indicating that they are in excellent condition.
- In the **production growth category**, product diversity is marked red (E3), indicating it is in bad condition. Quality is marked yellow (F3), indicating that it is in good condition and quantity is marked green (G3), indicating that it is in excellent condition.
- In the **social growth category,** family, neighbour, prestige, and recognition are marked orange (H3, I3, J3 and K3), indicating that they are in average condition.
- In the **cultural growth category**, knowledge and relationship are marked orange (N3 and O3), indicating that they are in average condition. The skill is marked green (M3), indicating that it is in excellent condition and education is marked red (N3), indicating that it is in bad condition.
- In the **environmental growth category,** soil health and groundwater are marked green (P3 and R3), indicating that they are in excellent condition. Pollinators are marked yellow (Q3) which indicates that they are in good condition.

Appendix 9:

- In the **ecological growth category,** energy, nutrients, water cycle and flows are marked orange (S3), which indicates that they are in average condition. Food chains, webs, biodiversity, adaption and interaction are marked yellow (T3 and U3), indicating they are in good condition.
- Finally, in the **resilience growth category**, self-organising capacity is marked green (X3) which indicates that it is in excellent condition. Buffer capacity is marked orange (V3), which indicates that it is in average condition and adaptive is marked yellow (W3) which indicates that it is in good condition.

Vegetable garden:

- In the **economic growth category**, savings are marked orange (A4) which indicates that they are in average condition and sales are marked red (B4) which indicates that they are in bad condition, while profit is marked yellow (C4) which indicates that it is in good condition. Income is marked green (D4) which indicates that it is in excellent condition.
- In the **production growth category**, product diversity is marked green (E4), indicating its excellent condition. Quality and quantity are marked yellow (F4 and G4), indicating that they are in good condition.
- In the **social growth category,** family, neighbour, prestige, and recognition are marked yellow (H4, I4, J4 and K4) colour, indicating that they are in good condition.
- In the **cultural growth category**, education, skills, and knowledge are marked green (L4, M4 and N4), indicating that they are in excellent condition. Relationships are marked yellow (O4) which indicates that they are in good condition.

Appendix 9:

- In the **environmental growth category,** soil health, pollinators and groundwater are marked green (P4, Q4 and R4), indicating that they are in excellent condition.
- In the **ecological growth category,** energy, nutrients, water cycle and flows, food chain and webs and biodiversity, adaptation and interactions are marked green (S4, T4 and U4), indicating that they are in excellent condition.
- Finally, in the **resilience growth category,** buffer capacity is marked yellow (V4), indicating that it is in good condition. Self-organising capacity and adaptive capacity are marked green (W4 and X4), indicating that they are in excellent condition.

Agro-forest:

- In the **economic growth category,** savings and income are marked yellow (A5 and D5) which indicates that they are in good condition, then sales are marked brown (B5) which indicates that they are in poor condition and profit is marked orange (C5) which indicates that it is in average condition
- In the **production growth category**, product diversity is marked green (E5), indicating its excellent condition. Quality and quantity are marked orange (F5 and G5) which indicates that they are in average condition
- In the **social growth category** family, neighbour, prestige, recognition are marked green (H5, I5, J5 and K5), which indicates that they are in excellent condition.
- In the **cultural growth category**, education and relationship are marked orange (L5 and O5), indicating that they are in average condition. The skill is marked green (M5) which indicates that it is in excellent condition and knowledge is marked yellow (N5), indicating that it is in good condition.

Appendix 9:

- In the **environmental growth category**, social health, pollinators, and groundwater are marked green (P5, Q5 and R5), indicating that they are in excellent condition.
- In the **ecological growth category,** energy, nutrients, water cycle and flows, food chains and webs and biodiversity, adaptation and interaction are marked green (S5, T5 and U5) which indicates that they are in excellent condition.
- In the **resilience growth category,** buffer, adaptive and self-organising capacity are marked green (V5, W5 and X5), indicating that they are in excellent condition.

House:

- In the **economic growth category**, savings, income and profit are marked orange (A6, C6 and D6), indicating that they are in average condition. Sales are marked red (B6) which indicates that they are in bad condition.
- In the **production growth category**, product diversity, quality and quantity are marked orange (E6, F6 and G6), indicating that they are in average condition.
- In the **social growth category**, skill, and relationship are marked green (H6 and I6), indicating that they are in excellent condition. Education and knowledge are marked yellow (J6 and K6), which indicates that they are in good condition.
- In the **cultural growth category,** skills and relationships are marked green (M6 and O6), indicating that they are in excellent condition. Education and knowledge are marked yellow (L6 and N6), which indicates that they are in good condition.
- In the **environmental growth category,** soil health and pollinators are marked brown (P6 and Q6), indicating that they are in poor condition.

Appendix 9:

Groundwater is marked green (R6) which indicates that it is in excellent condition.

- Energy, nutrients, water cycle flows, food chains and webs are marked brown (S6 and T6), which indicates that they are in poor condition in the **ecological growth category**. Biodiversity, adaption and interaction are marked red (U6), indicating that they are in bad condition.
- In the **resilience growth category,** buffer, adaptive, and self-organising capacity are marked red (V6, W6 and X6), which indicates that they are in bad condition.

Compost unit:

- In the **economic growth category**, saving, profit, and income are marked yellow (A7, C7 and D7), indicating that they are in good condition. Sales are marked orange (B7) which indicates that they are in average condition.
- In the **production growth category**, quality and quantity are marked green (F7 and G7), indicating that they are in excellent condition and product diversity is marked yellow (E7) which indicates that it is in good condition.
- In **social growth category,** family, neighbour, prestige, and recognition are marked red (H7, I7, J7 and K7), indicating that they are in bad condition.
- In the **cultural growth category,** education and knowledge are marked yellow (L7 and N7), which indicates that they are in good condition. Skill is marked green (M7), indicating that it is in excellent condition and relationship is marked red (O7) colour, which indicates that it is in bad condition.
- In the **environmental growth category,** soil health and pollinators are marked brown (P7 and Q7) colour, indicating that they are in poor

Appendix 9:

condition and groundwater is marked orange (R7), indicating that it is in average condition.

- In the **ecological growth category,** energy, nutrients and the water cycle/flows, food chains and webs are marked brown (S7 and T7), which indicates that they are poor. Biodiversity adaption and interaction are marked green (U7), indicating that they are in excellent condition.
- In the **resilience growth category,** buffer, adaptive, and self-organising capacity are marked green (V7, W7 and X7), indicating that they are in excellent condition.

Neighbourhood:

- In the **economic growth category,** saving, profit, sales, and income are marked orange (A8, B8, C8 and D8), indicating that they are in average condition.
- In the **production growth category,** product diversity, quality and quantity are marked orange (E8, F8 and G8), indicating that they are in average condition.
- In the **social growth category,** neighbour and recognition are marked orange (I8 and K8) which indicates that they are in average condition and the family is marked green (H8) which indicates that it is in excellent condition. Prestige is marked yellow (J8) which indicates that it is in good condition.
- In the **cultural growth category,** skills and relationships are marked green (M8 and O8), indicating that they are in excellent condition. Education and knowledge are marked yellow (L8 and N8), which indicates that they are in good condition.
- In the **environmental growth change**, soil health and pollinators are marked brown (P8 and Q8), indicating that they are in poor condition.

Appendix 9:

Groundwater is marked orange (R8) which indicates that it is in average condition.

- In the **ecological growth category,** energy, nutrients, water cycle/flows, food chains, and webs are marked brown (S8 and T8), indicating that they are in poor condition. Biodiversity, adaption and interaction are marked yellow (U8), indicating that they are in good condition.
- In the **resilience growth category,** buffer, adaptive, and self-organising capacity are marked yellow (V8, W8 and X8), which indicates that they are in good condition.

Farm field school:

- In the **economic growth category,** saving, profit, and income are marked red (A9, C9 and D9), indicating that they are in bad condition. Sales are marked brown (C9) which indicates that they are in poor condition.
- In the **production growth category,** product diversity, quality, and quantity are marked red (E9, F9 and G9), indicating that they are in bad condition.
- In the **social growth category,** neighbour and recognition are marked orange (I9 and K9) which indicates that they are in average condition and the family is marked green (H9) which indicates that it is in excellent condition. Prestige is marked yellow (J9) which indicates that it is in good condition.
- In the **cultural growth category,** education, skills and knowledge are marked green (L9, M9 and N9), indicating that they are in excellent condition. The relationship is marked yellow (O9), indicating that it is in good condition.
- In the **environmental growth category,** soil health and pollinators are marked brown (P9 and Q9), which indicates that they are in poor condition.

Appendix 9:

Groundwater is marked orange (R9) which indicates that it is in average condition.

- In the **ecological growth category,** energy, nutrients and water cycle/ flows, food chains and webs, biodiversity adaption and interaction are marked brown (S9, T9 and U9), indicating that they are in poor condition.
- In the **resilience growth category,** buffer, adaptive, and self-organising capacity are marked brown (V9, W9 and X9), indicating that they are in poor condition.

Appendix 10:

The comparative table (figure 19b) described in detail:

Looking at the **sustainability variables**:

- The economic growth was found to be mostly in average condition (13 points) for most of the permaculture structures.
- The production growth was found to be mostly in average condition (12 points) for most of the permaculture structures.
- The social growth was found to be a mostly in average condition (12 points) for most of the permaculture structures.
- The cultural growth was found to be in excellent condition (15 points) for most of the permaculture structures, and in good condition (13 points) for some permaculture structures.
- The environmental growth was found to be either in excellent condition (11 points) at certain permaculture structures, or in poor condition (11 points) at some permaculture structures.
- The ecological growth was found to be either in excellent condition (9 points) at certain permaculture structures, or in poor condition (9 points) at some permaculture structures.
- The resilience growth was found to be in excellent condition (15 points) for most permaculture structures.

  Overall, most of the sustainability and resilience variables were found to be in excellent condition (68 points) with cultural growth being the most effective (15 points).

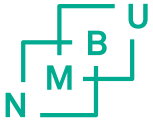
Looking at the **permaculture land design structures**:

- The fishponds were found to be mostly in excellent condition (12 points) for most of the sustainability and resilience parameters.

Appendix 10:

- The livestock sheds were found to be mostly in average condition (12 points) for most of the sustainability and resilience parameters.
- The paddy fields were found to be mostly in average condition (9 points) for most of the sustainability and resilience parameters.
- The vegetable gardens were found to be mostly in excellent condition (13 points) for most of the sustainability and resilience parameters.
- The agro-forests were found to be mostly in excellent condition (15 points) for most of the sustainability and resilience parameters.
- The farmers' home was found to be mostly in average condition (6 points) for most of the sustainability and resilience parameters.
- The compost unit was found to be mostly in excellent condition (7 points) for most of the sustainability and resilience parameters.
- The neighbourhood was found to be mostly in excellent condition (10 points) for most of the sustainability and resilience parameters.
- The farmer field school was found to be in poor condition (9 points) for most of the sustainability and resilience parameters.

Overall, most of the permaculture structures were found to be in excellent condition (68 points) with agro-forest being the most effective (15 points).



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