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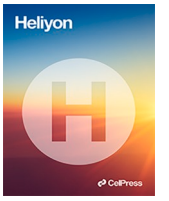

Case report

Exploring innovation for sustainable agriculture: A systematic case study of permaculture in Nepal

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ABSTRACT

As the adverse consequences of the industrial/modern agricultural framework, which encompasses high-input agrarian production and intensive cultivation, are increasing, an alternative is essential. Permaculture is a bunch of sustainable practices that incorporate an assortment of components and promote comprehensive and multi-polycultures including perennial plants, high degrees of biodiversity, crop-animal integration, whole watershed management, and self-sustaining on-site energy production, all of which straightforwardly affect the sustainable approach and promote ecological parameters. This case study attempts to better comprehend the local knowledge in terms of planning and fostering a permaculture system that considers their work, culture, and environmental concerns. In particular, this research focuses on the combined ideology, actual practices, and co-opting nature of three Nepalese permaculturists. The current study employs the notion of imaginaries to comprehend how permaculture may supplant the present agricultural system. Therefore, the study promotes and urges agricultural actioners to create profound and emotional associations with the planet, as well as their creativity and imagination, to impact good natural change.

1. Introduction

Amongst human endeavours, the most fundamental and essential is agriculture. Agricultural frameworks that have been intensified can produce vast amounts of food, but their long-term viability is in doubt [1–3]. The idea that agricultural systems would need to adapt is widely acknowledged as climate change continues to dominate the scientific debate. Intensive farming techniques have grievous ramifications for the environment and society overall [1,4]. Permaculture, as an alternative to large-scale agriculture techniques, furnishes an international network with a solutions-oriented approach to sustainability, with the goal of "designing and developing sustainable communities in harmony with natural ecosystems" [3,5]. Permaculture has been acknowledged as a new ecological paradigm of sustainable practices in an assortment of fields, including environment, organic farming, forestry, agriculture, landscape, engineering, and city planning [6]. Permaculture is a term formed from the words "permanent" and "agriculture", coined by Bill Mollison and David Holmgren in the 1970s and 1980s [6–10], is acquiring ubiquity as a natural resource management strategy [6,11]. Permaculture is the product of an innovative amalgamation of frameworks thinking and planning based on a knowledge of natural ecosystem processes, conventional small-scale mixed agriculture, low-influence innovation, and redistributive civil rights into

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a versatile, interlinked dynamic design system for designing and implementing a self-sustaining human network [6,10,12]. Its ideas and strategies are fundamentally casual, different, and unregulated, and they are disseminated through networks of practitioners [9]. Permaculture has historically demonstrated the most effective on small, local, and individual levels, which is both a strength and a shortcoming. While local activity is critical to sustainable progress, it cannot be the exclusive domain of impact. To develop sustainable prospects, more foundational types of plans and associations, from provincial to public to worldwide, are required [10].

The core principle of permaculture is that humans can diminish or supplant energy and pollution-intensive industrial technology, especially in agriculture, via careful, employment of biological resources, and holistic design modelled after natural ecosystems [9,13]. Permaculture sees nature in an inventive manner and then applies it functionally. Therefore, it has the effect that it depicts. Permaculture assemblages most evidently foster this image of nature in the manner they socially organize themselves, purposefully and reluctantly fabricating social configurations that resemble natural environments, which can be termed eco-mimicking [14]. It is a coherent and explicit set of designs that supports the abstraction of "the Spiral of Intervention". This philosophy is based on the idea that nature ought to sprint its course with the least amount of human interference possible. It's a dynamic mindset that goes beyond "less work, more prominent outcome" [15].

The permaculture approach to production accentuates variety and multifunctionality, through the execution of polycultures and perennial crops, land use expansion, and whole-agroecosystem integrated water management [16]. It is a normally exploratory endeavour in manners that propose close connections to formal review. Its interventions are experimental at all levels; each design instance is distinct [17]. Managing a permaculture system, on the other hand, entails constantly watching and settling the ever-changing interactions between the natural entities that make up the system [9]. For instance, If Asian wasps kill bees, it is desirable to over acquaint chickens to hunt the wasps, thereby providing the hens' protein needs, then apply synthetic chemical pesticides. Similarly, each of the plants in the association corn/bean/squash has at least one purpose: to provide food. When grown together, however, each provides a beneficial presence for the other two: bean roots supply nitrogen, corn gives an accommodating tail to the bean to develop and obtain daylight, and squash leaves, which form a canopy over the ground, assist with directing soil moisture and slow the growth of contender plants. This is a brilliant illustration of alternative instructions for replacing today's industrial agriculture [9].

In 1986, the Institute for Sustainable Agriculture Nepal (INSAN) collaborated with Agricultural Project Services (APROSC) and Win rock International to organize the first permaculture design course training facilitated by Bill Mollison in Kathmandu. Subsequently, numerous permaculture workshops have been held, and permaculture has become a common term for various sustainable farming activities in Nepal [18,19]. These advancements are part of an information cycle that continuously seeks to improve itself and provide better service to user groups. After encountering difficulties with a top-down approach for a few years, the first real farmers' design course was held in 1995, where farmers collaborated with other farmers on permaculture design [20]. The Nepal Permaculture Group (NPG) was established in 1992 to bring together NGOs and individuals who are independently engaged in sustainable agriculture, organic agriculture, and permaculture. Although the NPG is a significant milestone in the organic agriculture movement in Nepal, there are only a few organizations/individuals explicitly working with permaculture models [19]. Table 1 illustrates some of those instances of permaculture implementation in Nepal.

In Nepal, the dominant development industry advocates for chemical-intensive farming using the approach of 'industrial agriculture', which has several drawbacks in terms of diminishing the biophysical system's ability to manage various risks and

Table 1
List of some organizations and farmers utilizing permaculture in Nepal.

Practitioners	location	Initiation date	Size	Model	Design elements
Individuals					
Tulsi Prasad Baral	Malepatan, Pokhara	1970	0.15 ha	Integration model	Kitchen garden, Vegetable farming
K·B. Gurung	Damauli, Tanahu	–	–	Agroforestry model	Fruit production, Fodder production
Khadga Regmi	Bhantanpur, Nepalgung	–	–	Integration model	Fishery, Vegetable farming, Livestock production, Agroforestry
Brinda Rai	Sankhuwasabha	–	–	Sustainable farming practice	–
Organizations					
Jajarkot Permaculture Programme (JPP)	Mid−West Nepal	1988	Employed in 150 villages	Community training-based model	Fruit & vegetable production, Kitchen Garden, Beekeeping, Weaving, Drinking water systems, Agroforestry, Local culture, Leather cottage industry
Himalayan Permaculture Center (HPC)	Surkhet & Humla	2010	Works with 850 households	Households & Community training-based model	Fruit nursery, Beekeeping, Cash crops, Composting, Tree planting, Covering food, House cleaning, Hygiene
Hasera Agriculture Farm	Kavrepalanchowk	–	Works with 20 households	Community development model	–
Namuna Prangarik Krishi Sahakari Sanstha	Arba, Pokhara	2010	Works with 60 households	Inclusive farming model	Vegetable production

References: [18,20,21,23,24].

uncertainties. Farmers are not receiving profitable prices for their products and are compelled to incur high expenses for fertilizers and pesticides [21]. Hence, there is enormous potential for implementing permaculture in Nepal. The country possesses abundant resources that can be integrated into the permaculture model on farms. However, these resources frequently go unnoticed or unused due to the orientation towards commercial agriculture or the shift from subsistence to modern industrial agriculture [19,22]. The implementation of permaculture techniques enhances farmers' capacity to grow organic crops to meet their food and nutritional requirements and access local markets to sell surplus produce. This approach can also improve crop yields while promoting social, environmental, and economic advantages [19,20]. Additionally, a farmer who has adopted permaculture practices noted that "*I use less fuel, have better meals, few pests in the garden, visit the forest less because more fodder and fuel is coming from my land and best of all, my rice production has increased from ten to twelve hundred KGs without any extra costs*" [20]. Overall, the image suggests that permaculture can be a relevant alternative for Nepalese farmers compared to the current industrial agriculture practices.

Therefore, the purpose of this study is to unpack the general structure of permaculture and explores the function of its elementals, such as ecological insights, design principles, exercises, and morals. Additionally, to illustrate the three instances that depict permaculture as a characteristic affinity with applied versatility research. This paper portrays the permaculture development in Nepal, a predominantly agrarian nation. It imparts the state of permaculture at a local level in three different geographical areas in Nepal, which is presented through the voices and perspectives of the permaculturists in contextualized format.

2. Permaculture ethics and principles

Permaculture activists invest energy in another's locales, sharing seeds as well as experience-based information about how to try the development's thoughts and morals [25]. Ethics and principles can be blended in a variety of ways and under a variety of circumstances [26].

2.1. Permaculture ethics

Permaculture provides a reasonable ethical framework for all of its designs, which is the foundation of the permaculture paradigm [2,17]. They essentially depict the accompanying three gist: every part of the framework performs various obligations. Second, the system's preferred functions are maintained by many components. Third, everything in the framework is connected to all the other things [8]. Permaculture is a utilitarian ethic and value-based system that gives an eco-driven redefinition of the expression "sustainable management," as well as affirmation of the socio-biological and financial ethos [27]. It is based on regenerating environments and their constituent living things, addressing individuals' requirements, and decently and evenhandedly disseminating permaculture framework results [28]. Permaculture means to re-interface individuals with nature to create positive changes through regenerative techniques [29], guided by three principal ethics often described.

2.1.1. Earth care

The first ethical principle, "earth care," will undoubtedly evolve and pervade all elements of permaculture. It centers around making courses of action for all ecosystems to persist and develop since people can't flourish without a healthy planet [15,26]. It underlines the significance of a healthy planet as the foundation for human prosperity and healthy human habitats [26,30]. To enhance sustainability and respectful utilization of natural resources, including the sustaining of soil, woods, and water, working with nature and forestalling environmental damage [2,31,32]. It addresses Mollison and Holmgren's mentality of " working with nature rather than against it " [33].

2.1.2. People care

The second ethical guideline, "people care" alludes to meeting people's basic and existential needs so that they can live a decent life without causing harm to the environment [15,30,33]. Dealing with oneself, one's family, and one's local area: helping out others, supporting individuals who need admittance to good food and clean water, and building sustainable frameworks that create life's necessities are only a couple of models [2,31]. It underscores the significance of people approaching the assets they expect for their prosperity and fundamental necessities. It features the worth of collaboration and kinship in having a cheerful and healthy existence [26].

2.1.3. Fair share

The initial two ethical standards are combined in the "fair share" ethic. It all boils down to accepting that natural resources are finite and must be shared equally among humans, animals, and plants, as well as between present and future generations [2,15,26,30]. The idea of "putting limits to consumption and reproduction and dispersing excess" was initially associated with the concept of fair shares within a worldview in which nature is abundant yet additionally restricts [26,33]. Fair share depicts itself through an insightful proverb i.e., "A man, who has vanquished himself might behave appropriately at any opportunity in an acceptable manner". A man like this is appropriately considered "a living artist" [32].

2.2. Permaculture principles

Permaculture is an assortment of twelve principles that serve as a design framework while allowing for a variety of solutions to be utilized in different circumstances [2,33]. These principles provide us with the tools which would permit us to redesign our

surroundings and discover answers to a range of challenges. Each of these principles has its distinct viewpoint, and the combination of all principles is intended to accomplish overall system balance [12,26]. These standards aid in the development of agricultural and social systems that replicate the diversity, multi-usefulness, and self-guideline of natural ecosystems and harmonize more intimately with ecological systems to enhance sustainability [28,30,32]. The twelve principles of permaculture design as shown in Fig. 1, are outlined as.

2.2.1. Observe and interact

Configuration starts with the careful and sustained study of the environment [2]. It takes account of different seasons, times of day, and civilizations. Ways of drawing in and creating with natural patterns are addressed [26,34,35].

2.2.2. Catch and store energy, nutrients, and water

This principle urges people to make maximum use of the environment's energy [35]. Solar panels and wind turbines are ideal instances of this hypothesis since they capture energy and water while they are abundant and store them for critical crossroads [2,31, 35]. Renewable methods of generating energy and utilizing ought to be focused on. Energy, which permits us to work, should never be squandered [26,34].

2.2.3. Obtain a yield

This concept ensures that the system is as self-sufficient as feasible in producing essentials [2]. Agricultural production is expected for freedom and continuation. Yields are positive and form positive feedback loops [34]. An attitude shift happens when there is a yield since individuals are more propelled to give when there is an overflow since the concern of scarcity is lifted [35].

2.2.4. Apply self-regulation and accept feedback

Addressing the idea implies creating sufficient negative feedback loops to maintain a healthy system equilibrium [2,35].

2.2.5. Use and value renewable resources

A diverse utilization of renewable assets at an acceptable degree of usage can help us restrict our consumption [34]; such as sunlight, rainwater, and strategies that recover soil and minimize foreign inputs [2,31].

2.2.6. Produce no waste

As the population grows, recycling, composting, and trash reduction become more crucial [2,31]. For example, the process of photosynthesis creates no waste in nature. This is the gist of this philosophy, which is to make zero waste and use it as much as feasible [34,35].

2.2.7. Design from patterns to details

For effective design, identify the patterns that naturally occur and fill in the specifics later [2,35]. For instance; A fruit tree, should be surrounded by other plants in the garden. Such as green beans or squash crawling up the pine tree. Herbs, spices, and other flowers might be planted at the foot of the tree to attract beneficial insects or supply nutrients to the soil (forming a symbiotic relationship) [26,

Fig. 1. Illustrative representation of permaculture ethics and principles (Modified from [36]).

35].

2.2.8. Integrate rather than segregate

This necessitates the comprehension of intricate natural linkages and the viable exploitation of such interactions [33,34]. Rather than implementing monocultures, design with synergistic interactions in mind, such as mutually beneficial polycultures ought to be considered [2].

2.2.9. Use small and slow solutions

More modest frameworks are simpler to oversee than bigger ones, permitting them to properly utilization of local resources and produce more long-haul results [2,34]. It likewise empowers genuine criticism and discretion [26,35].

2.2.10. Use and value diversity

Monoculture-based societies are vulnerable to unforeseen change. Permaculture aims to comprehend the past, present, and future potentials of biological and cultural diversity [34]. A few plants, for instance, promote the supply of nitrogen, a fundamental part of rich soil, while others attract pollinating insects [35]. Since diversity enhances resilience, the system is less prone to failure [2].

2.2.11. Use edges and value the marginal

The area where multiple zones meet is frequently the most intriguing and innovative (6). As opposed to excusing the negligible, we ought to look to utilize its diversity and production [34].

2.2.12. Creatively use and respond to change

There is an evolutionary component to all ecological systems. Notice changes in the climate and mediate at the proper overall setting [2,31,34].

3. Ecological impacts of industrial/modern agriculture

Agriculture, in many respects, may be considered the last outskirts of modern upheaval in numerous ways [2]. While the current farming system has been demonstrated to be exceptionally useful, it has additionally had overall natural and social consequences [37]. For example, industrialized agricultural systems are annihilating biodiverse conditions, contaminating water, forming dead zones in oceans, gambling with human wellbeing through pesticide exposures and disease outbreaks, delivering toxins into the food cycle, and contributing to global warming [38]. The industrial agriculture system utilizes unsustainable amounts of water, fossil fuels, and topsoil [39,40]. Significant greenhouse gas emissions, biodiversity loss, broad manure, and pesticide contamination, soil loss and degradation, dwindling pollinators, and human health hazards are a couple of the ecological impacts of current farming [2,37]; which are further illustrated briefly.

3.1. Monoculture, chemical usage, and loss of diversity

To ease mechanized farming, huge fields of just a single crop variety are cultivated which is tend to be a monoculture. External inputs, including notably chemical fertilizers and pesticides, are significantly required in these artificially simplified ecosystems. Chemical fertilizers high in NPK fertilizers deplete the soil of key micronutrients over the long haul and wipe out valuable soil living beings that guide in supplement move to plants [2]. Similarly, pesticides, while initially enhancing yields, become less effective over time as pests develop resistance to them, and they frequently kill soil microbes and fungi, as well as beneficial species that help control destructive creatures [2,39]. It takes longer to measure and results in the extinction of animals, fisheries, pollinators, and human ailments [2].

3.2. Greenhouse gas emissions and climate change

Climate change and agriculture are two interconnected peculiarities that happen on a worldwide scale. Global warming initiatives have a substantial influence on agricultural circumstances, such as temperature, precipitation, and glacier runoff [41]. The world population is expected to reach 9 billion by 2050, with food consumption expected to quadruple from present levels [38]. Agronomic operations in general contribute to the phenomena of global warming by releasing greenhouse gases into the atmosphere and changing land cover, both of which alter the surface's albedo and the radiation balance [2,41]. According to the Intergovernmental Panel on Climate Change, agriculture is directly responsible for around 20% of human-generated greenhouse gas emissions [39]. Land-use changes account for around 14% of absolute human-caused greenhouse gas emissions, and quite a bit of this land advancement is for agricultural purposes [2,39]. Methane, carbon dioxide, and nitrous oxide gases are produced by farming activities, such as livestock management, rice paddies creation and maintenance, sugar cane burning, and soil bacterial nitrification-denitrification [41,42]. As a result, the expected perils of climate change have expanded, and the natural equilibrium has been disturbed [15,43].

3.3. Water consumption

Agriculture consumes 85% of the freshwater on the planet. A single kilogram of wheat requires around 1300 gallons of water,

whereas rice requires 3000 L, beef requires 15,500 L, and a single 50g bag of salad requires approximately 50 L. Green revolution hybrids perform poorly than many traditional cultivars in the absence of extra water and chemical fertilizers. The viability of these crops will become increasingly doubtful as freshwater grows scarcer [2].

3.4. Deforestation

The explanations behind eliminating forest areas are numerous. Conversion of forest land to agriculture and ranches, as well as urban areas and hydrocarbon exploitation, are only a few of the reasons [41]. When forests are replaced by agricultural land for crops or animals, atmospheric carbon sequestration is reduced [41,44]. The environmental services provided by forests, such as biodiversity, soil protection, and subsurface water recharge, are difficult to compare to the monetary return derived from agriculture due to the differing value systems [38,39,41].

3.5. Soil degradation

Soil quality is dynamic, and it might change rapidly relying on soil features, climate conditions, land use, and agricultural techniques. Overgrazing, cover removal, topsoil loss, salinization, and nutrient depletion are all processes that kill plants and degrade soil [41]. Currently, modern agriculture practices are adding to the debasement of basic ecological processes that support life on earth, for example, environmental change, biosphere integrity loss, damaging land system alterations, and phosphorus and nitrogen manure eutrophication of oceans [37,41].

3.6. Eutrophication

When surplus runoff of nutrients is leached into water bodies, algae quickly proliferate. Algae devour all of the nutrients needed by other aquatic organisms. When an algal population reaches its pinnacle, it begins to die, forming a layer of anoxic conditions known as the 'death zone, which is harmful to aquatic life [41,43]. The deterioration of water bodies is also caused by the quality of industrial wastewater effluents [45].

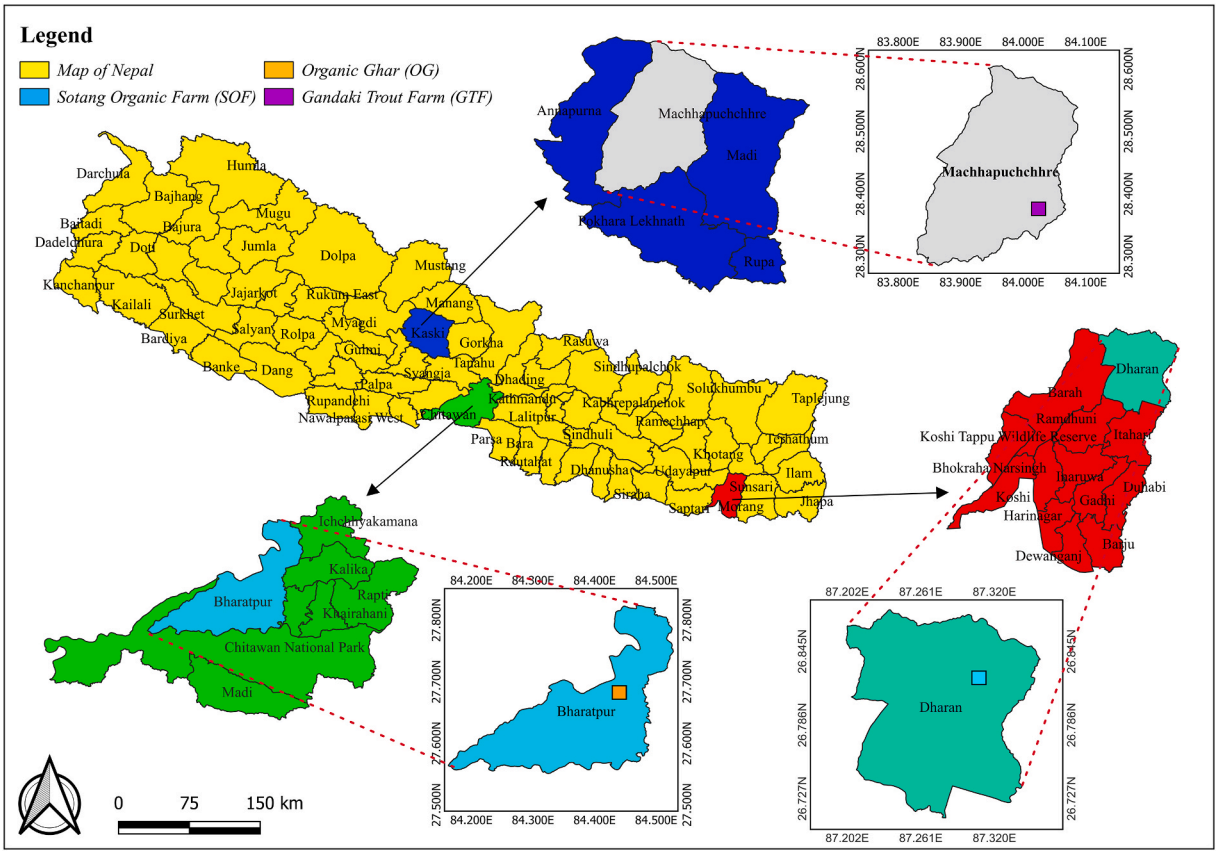

Fig. 2. Above depicts the geographical location of the case study sites, namely the Gandaki trout fish Farm (GTF), Sotang organic farm (SOF), and Organic Ghar (OG).

3.7. Soil erosion

Because growing grain for this business takes so much acreage, feedlot cattle, and industrial animal agriculture, in general, deplete topsoil [39], overgrazed and nutrient-depleted fields expose the surface to erosion by preventing the proper growth of vegetation [41].

3.8. Water-logging and salinity

Many low-rainfall places have been transformed into agricultural wonderlands, at least in the short term, thanks to irrigation [42]. Excessive irrigation, on the other hand, might have an environmental cost in the form of waterlogging and salinization. Irrigation water contains salts that deplete the soil's productivity over time [39]. Similarly, rice fields' saturated soil is ideal for methanogenesis, which releases methane into the atmosphere [41].

To limit those ecological impacts (above-mentioned) of the industrial agricultural system, a pioneering concept is introduced also known as the alternative agricultural system i.e., permaculture.

4. Materials and methods

4.1. Study areas

This study was carried out at three different geographical locations throughout Nepal. The first study was carried out near the village Basantar (Dharan, Nepal; 26.821024, 87.300660), which experiences a sub-tropical climate with an average annual rainfall of 39.74 in. The second study was carried out near the village Sripur (Bharatpur, Nepal; 27.640319, 84.371023), which also experiences a sub-tropical climate with a mean annual rainfall of 114.2 in. Likewise, the third study was carried out near Sardikhola (Puranchour, Nepal; 28.329634, 83.978499), which experiences a temperate climate with an average rainfall of 39.37 in. Under these locations, the general permaculture practices and descriptions in those farms were addressed and uniformly examined. The geographical positions and general description of the study sites are presented in Fig. 2.

4.2. Study methodology

The idea of permaculture was created by Ref. [46] as an integrated, dynamic system of perennial or self-perpetuating plant and animal species beneficial to man. According to Ref. [47], permaculture has evolved to the point that it is now defined as "consciously

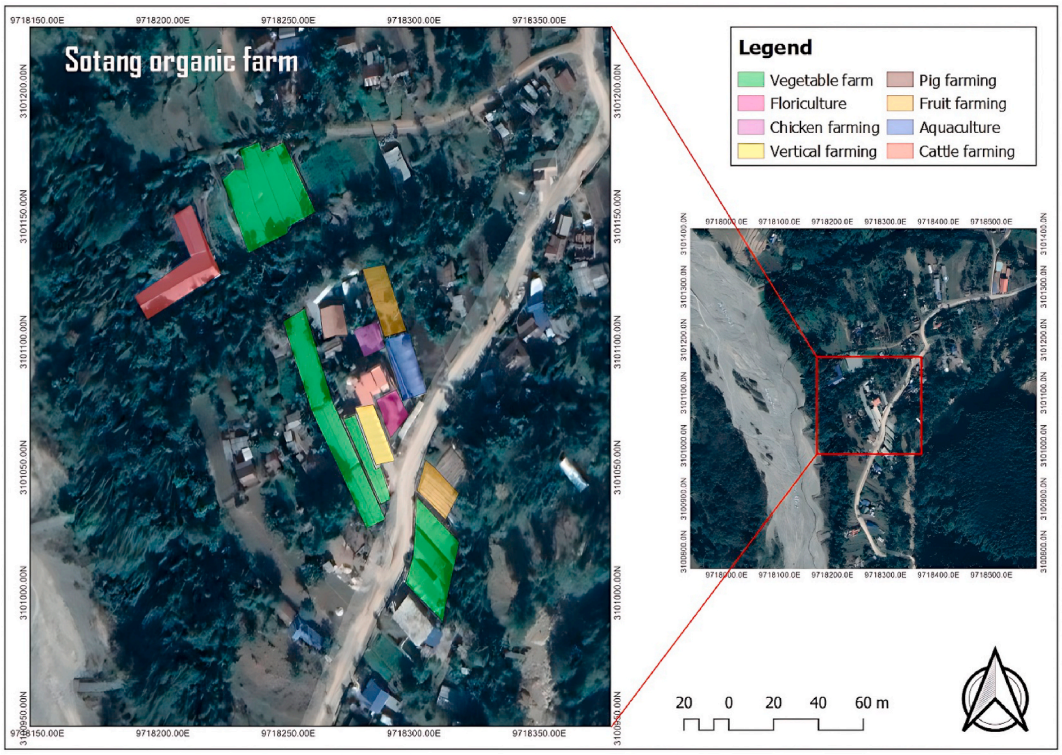

Fig. 3. Orthophotoplan of the studied site (Sotang organic farm).

built landscapes that imitate the pattern and connections seen in nature while generating an abundance of food, fibre, and energy for meeting local requirements." The research began with assessments of the literature on the theoretical background as well as the current state of the permaculture network in Nepal. The research methodology used in this study includes the selection of an area with an agricultural land use environment, observation and analysis of land use, crops, and settlement, using the conceptual content analysis method [48,49]. This research primarily focuses on the personal motivations, knowledge exchange, and experiences of permaculture practitioners. Three case studies were selected as an appropriate analytical approach to collect the necessary in-depth information [12]. The study is based on permaculture experts who have been working for over a biennium in Nepal. To assess each practitioner's designs and social interventions in the Nepalese agricultural sector, case studies for each one were created by looking at relevant papers, conducting in-depth interviews, and visiting farms. Three ethical criteria—earth care, people care, and fair share—were used to evaluate their accomplishments [50]. The practitioners' social and design initiatives in their different communities serve as our observational variables. In addition to the observational technique, we also conducted in-depth interviews with the practitioners to gather primary data. To further investigate the similarities between the design procedures, social interventions, and their results, we gathered secondary data from journals, books, and blogs and used conceptual and relational content analysis.

5. Permaculture in Nepal

5.1. Sotang Organic Farm (SOF)

The Sotang organic farm was created in 1998 by Mr. Krishna Rai. The cultural practices are directly based on the permaculture model. They produce multiple products, use only organic amendments and no pesticides or mineral fertilizers, and achieve high yields. The total farm size is about 2.032 ha and only 40% of the land is used for cultivation area. The other 60% is occupied by animal farms, as shown in Fig. 3.

Initially, he was encouraged to utilize agrochemicals, such as chemical fertilizers, insecticides, pesticides, herbicides, vitamins, and hormones, due to a long-held belief that these chemicals would increase crop yield and productivity. The initial results appeared to support this belief, as productivity increased substantially after the implementation of these chemicals. However, this increase was not sustainable, and crop yields began to decline rapidly. Additionally, the cost of producing farm products increased, resulting in a smaller profit margin. Furthermore, the use of agrochemicals had adverse effects on consumer health due to the consumption of contaminated farm products, ultimately leading to economic losses for the farm. In light of these challenges, he sought guidance from agricultural experts and researchers, who recommended the adoption of permaculture as a potential solution. In 2005, he began implementing permaculture techniques on their farm, which were later adopted by 150 other farmers. The implementation involved the production and use of vermicompost, composted manure, liquid manure, and integrated pest management tools to control and manage pests and diseases.

As they continued to implement permaculture techniques, they recognized that soil health is a key factor in the agricultural sector, impacting crop health and productivity. They subsequently focused on improving the soil's health through the use of organic materials produced on the farm, which fostered soil health and microbial activity while enhancing soil biodiversity. He also realized that human activities have been disrupting the ecosystem's balance, resulting in adverse effects on human health. As a result, the farm now produces 100% certified organic products and engages in hydroponics, cattle farming, pig and fish farming, vertical farming, poultry rearing, and floriculture, among other practices, as shown in Figs. 4–7. His success in producing his basic needs and marketable surplus from an average-sized farm is based on his observation of nature, emphasis on self-reliance, and analysis of markets and consumers.

Continuing the very trend, the farm has the potential to achieve massive social and economic success. The farm can improve the livelihood of a large number of people via employment. Farm activities over a long period can also improve the surrounding environmental conditions. The farm has an excellent layout, which can be very helpful for someone willing to start or set up a permaculture farm. Soon, the farm has the potential to not only meet the domestic demand for organic produce but also export its products to foreign

Fig. 4. Illustrates the hydroponic cultivation method employed at the farm.

Fig. 5. Depicts the vertical farming method used at the farm.

Fig. 6. Displays the practice of animal husbandry specifically cattle rearing on the farm.

Fig. 7. Showcases aquaculture or fish farming as a major activity carried out on the farm.

countries.

5.2. Organic Ghar (OG)

Chandra Prasad Adhikari is an owner of Organic Ghar known for its organic farming/permaculture. But it was not the scenario some years ago. His fathers and grandfather analyzed the demand for agro-products and in contrast to that, the decline in production of

the farm output started using chemical fertilizers to boost the yield and productivity of the farm. Although they found a significant rise in the yield and productivity, soon after the application of chemicals the tenure didn't last for long. The yield reduced massively. This led the farm to critical situations and eventually they realize that the usage of chemicals to foster productivity is the lone reason for the decline of production. Therefore, the revolutionary concept of permaculture was introduced on the farm in the year 2020, to sort out their miserable phase, as shown in Fig. 8.

After the introduction of the permaculture system in the farm activities, the yield didn't rise as much as they would have expected as soil condition was brought to its worst due to excessive use of chemicals but they knew they must stick with the system for a longer period to get a better result and they did so. They stopped using the chemical fertilizer ever since they came to know its hazardous effect on soil and the ecosystem. They formed a group of 80 families and started the concept of permaculture within the community practically. Overall, an area of 2.02 ha was added to the production area, as shown in Figs. 9 and 10. They started using organic manures like vermicompost, bi-products of livestock, crop residue, Farmyard manure, etc to raise crops. The farm itself produces enough amount of vermicompost that can be used throughout the community. Vermicompost is extracted after sorting out the worms out of the compost using nets, as shown in Fig. 11. Earthworms are also reared in good quantity.

They have managed beehives on their farm which not only support better pollination of the crops or plants but also marketing of honey (about 550–1000 lbs.) quantity annually provided as an extra income source for the farm. Furthermore, the rearing of black soldier flies for research and development is also carried out by the farm aided by National Innovation Center (NIC) and supported by Agriculture and Forestry University (AFU), as shown in Fig. 12. The grown larvae are utilized to feed the indigenous chicken that effectually supports the nutritional intake and gives better carcass results. Eventually as "the fruits of patience are sweet" all the hard work and patience of sticking to the permaculture concept paid off sweetly for the farm. The productivity of this farm has gone higher to meet its own as well as marketing demand too.

The farm is wasting no expenses on any agrochemicals to control diseases or pests because of the matter of "Back to nature, the nature itself balances the pest and natural enemies to prevent loss of crops due to diseases and pest outbreaks- Chandra Prasad Adhikari".

Following the ongoing trend of permaculture, the upcoming days or years for this farm will certainly be much brighter. The soil health will reach its peak fitness, resulting in the production of much healthier corn at a significantly reduced cost, which will invite more benefits from the farm business. Due to sound agricultural practices, the environmental conditions will also improve. The expanding area under cultivation will tend to employ a large number of people, and hence their livelihoods will improve along with the farm's social and economic status. Raising black soldier flies and feeding them to indigenous chicken breeds to improve carcass-related traits can be beneficial to other poultry farms. Therefore, other farmers can learn something new along with permaculture practices.

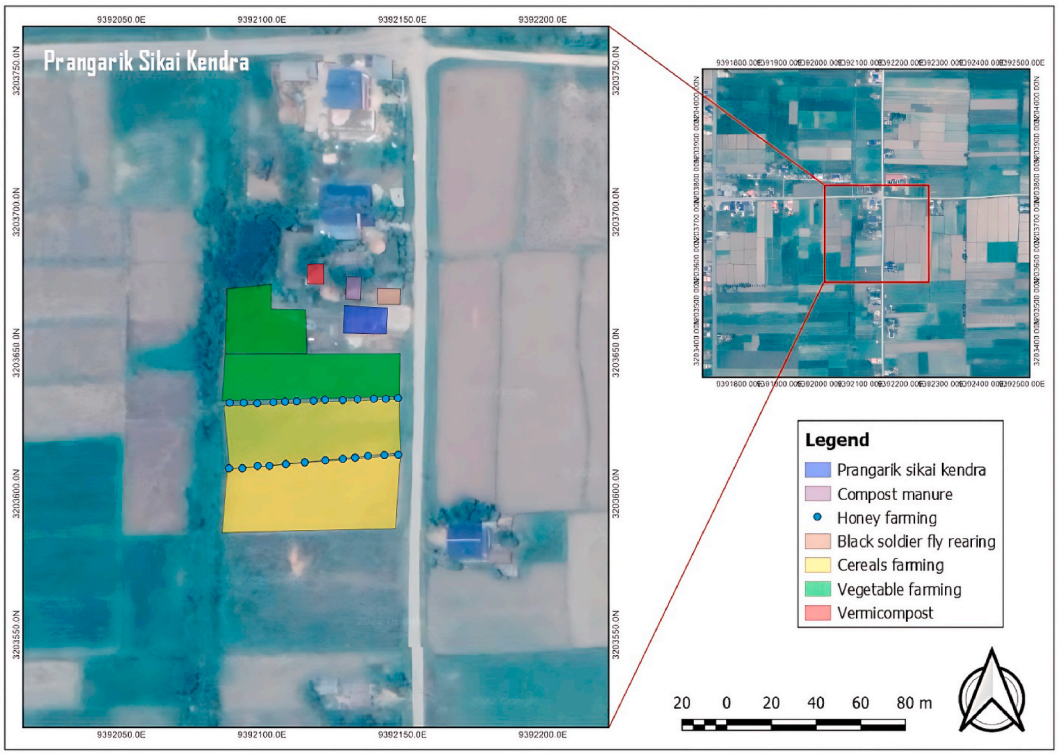

Fig. 8. Orthophotoplan of the studied site (Organic Ghar/Prangarik Sikai Kendra).

Fig. 9. Illustrates a substantial acreage exclusively allocated for the cultivation of rice.

Fig. 10. Showcases an extensive area covered with paddies.

Fig. 11. Illustrates the process of vermicompost production on the farm, wherein fishes raised in the surrounding pool are utilized to generate nutrient-rich compost.

5.3. Gandaki Trout Farm (GTF)

Being situated in the Kaski district Gandaki trout farm is one of the provenances with an area of 4 ha, as shown in Fig. 13. The most popular trout farm is well known for its culture and production of rainbow trout (*Onchorhynchus mykiss*). It was established in the year 2010 by Lachhin Gurung. He was motivated by the growing demand for trout in the market but not so appreciable production to meet

Fig. 12. Portrays the breeding of black soldier flies for potential applications in sustainable waste management.

this rising demand. He along with his workers started the farm with a very small investment of 1–2 lakhs. They excavated two ponds initially for the production which later grew in number and size as the farm flourished. They designed and constructed the farm in such a way that it not only has higher production of trout fish but also utilizes the prospect of agritourism and agriproduct production in Kaski, as shown in Figs. 14–17. The feed for fish has been formulated here itself but the raw materials are imported from India. It includes fish meal, brown soybean (30%), wheat (17%), and Rice husk (14%). Out of which almost 30% of the feed constitutes are produced on the farm.

The necessary crops are raised on the farm utilizing the water coming out of the fish pool as it contains nitrogenous byproducts from fish. This helps in better production of the crops to be utilized in the feed formulation and the cycle goes on. This helps in the production of organic crops and further minimizes the expenditure of the farm. The seeds of the fish are produced on the farm in the breeding house. They have managed separate structures and pools for various stages of fish for better handling and production. Freshwater keeps circulating in the ponds structures which is a basis of raceway culture.

Eventually, all the efforts and patience to stick with their farm strategies/permaculture led them to their success. Now, they have an

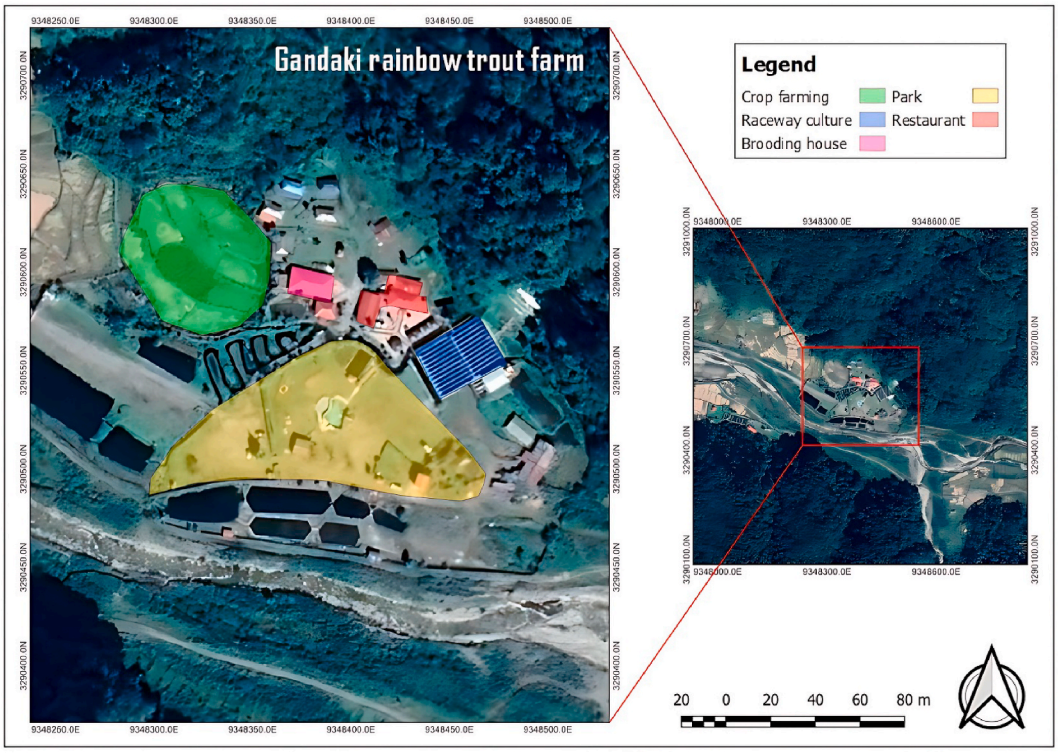

Fig. 13. Orthophotoplan of the studied site (Gandaki trout fish farm).

Fig. 14. Provides a visual representation of the aesthetically pleasing landscape and comprehensive perspective of the study site.

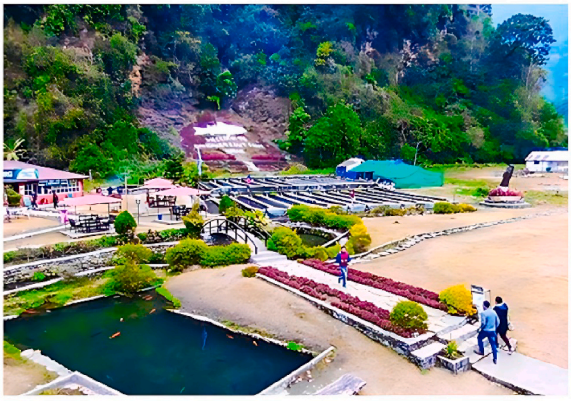

Fig. 15. Showcases the stunning scenery and holistic viewpoint of the farm, as captured through the lens of the observer.

Fig. 16. Displays the utilization of closed raceway culture for the purposeful cultivation of trout.

income of 2–3 lakhs per month and a team of 22–23 workers who handle the farm brilliantly making the farm well known not only in the Kaski district but also all around the globe. His farm is one of the pioneer farms which is capable to promote agritourism. With the arrival of international and national tourists, albeit in higher numbers, as well as the increased demand from customers in Pokhara itself for trout, the business is picking up smoothly.

The Gandaki trout farm shows a promising potential to be one of the most visited tourism sites for domestic as well as international explorers because of the eye-catching elements employed in its establishment, operation, and management. The farm will have an

Fig. 17. Portrays the use of a closed raceway culture technique to rear trout in a controlled aquatic environment.

extended profit margin because of its systematic raising practices and additional services for the customers. The farm can add additional subcenters for marketing purposes, which will increase the number of people employed and profit. Very soon, the farm will occupy a major share in trout fish production and marketing, following the same trend.

6. Discussion

Utilizing conceptual content analysis, our study revealed some shared themes and issues among the three permaculture practitioners [51], including enhancing biodiversity, reducing crop losses, producing multiple crops, improving food security, developing ecological balance, enhancing living conditions of neighbours farmers, and decreasing reliance on external supplies. Analysis of permaculture ethical principles of earth care, people care, and fair share demonstrated that Organic Ghar (OG) most effectively implemented design principles (91.67%), followed by Sotang Organic Farm (SOF) (83.33%) and Gandaki Trout Farm (GTF) (47.22%), as depicted in Table 2. Our results indicated that OG and SOF were able to promote both the quantitative and qualitative growth of other farmers in their community. These findings are consistent with previous studies [12,21,48,52–56]. Likewise, GTF seems to adhere its primary competence as a tourism operator and utilizes sustainable practices as a point of differentiation in commercial business. GTF also demonstrated that environmentally-conscious tourists are willing to seek out agricultural sustainability [57]. When considered in light of the agrarian crisis and the relational content analysis of the three permaculturists [58], our results suggest that permaculture design interventions offer viable solutions to address farmers' crises in Nepal against industrial agriculture. Our study highlights the success of permaculture design in promoting food security, access to clean food, income generation, and local diversification. Despite this, permaculture design has yet to be integrated into agricultural education in Nepal. Therefore, we advocate including permaculture education in the current agricultural educational domain in Nepal. Although permaculture is still in its infancy in Nepal, numerous international examples illustrate its application and relative benefits which are listed below.

1. Kuala Ping serves as a clear example of successful permaculture design principles being implemented to achieve sustainable agricultural practices through the integration of local people, environment, and technologies, resulting in the proper preservation and protection of ecosystem resources in Malaysia [48].
2. Similarly, an international permaculture site in rural Bulgaria (Sing) demonstrated a model based on social and ecological relationships, which transformed rural livelihoods and benefited the local community [31].
3. Soneva, an eco-tourism service provider in Maldives and Thailand, implemented environmentally and socially conscious practices, such as composting leftover foods and wastes and eliminating chemical inputs, resulting in the production of a diverse range of fruits and vegetables [52].
4. Landscape redesigning and interventions utilizing permaculture principles in Odisha, India, improved the food supply, access to clean and healthy food, economic upliftment, and diversification of local commodities for 13 primitive tribes and 62 tribal communities [55].
5. The application of permaculture procedures in Le Bec-Hellouin, Normandie, France, led to improved nutrient availability and balanced reserves of soil organic carbon in the cultivated lands' uppermost soil [40].
6. Permaculture design played a significant role in conservation of soil and water resources contributing to ecosystem diversity in the management of reservoirs serving natural habitats for wildlife in Gibraleon, Tamera, and Vivencia Dehesa, Spain [59].
7. Rural tourism in Brasov, Romania, promoted the conservation of nature and environment along with agricultural systems through sustainable practices in the tourism sector of rural regions [30].
8. The residential area at Denai Alam, Shah Alam, Selangor, Malaysia, provides an opportunity for the local community to participate in permaculture design principles, with plans to incorporate aspects such as greywater treatment and various gardens (e.g., spiral herb and vegetable gardens) in urban permaculture [56].

Table 2
Evaluation of ecological well-being of the farms.

S·N.	Design principles		Farms that have implemented the preceding principles
Earth care			
1.	Observe and interact	Farm's design and management are based on careful observation and interaction with nature	SOF, OG, GTF
2.	Catch and store energy	Farm's energy requirements are met through on-site capture and storage	OG
3.	Obtain a Yield	Food produced on the farm meets the farm's dietary needs	SOF, OG, GTF
4.	Apply self-regulation and accept feedback	Farm's practices are shaped by natural feedback	OG, SOF
5.	Use and value renewable resources and services	Renewable resources and services are employed with an eye toward their long-term impact	SOF, OG, GTF
6.	Produce no waste	Waste is reused	OG, SOF
7.	Design from pattern to details	Design and management of the farm take natural patterns into account	SOF, OG, GTF
8.	- Integrate rather than segregate	Farm's elements and functions are carefully integrated	SOF, OG, GTF
9.	Use small and slow solutions	Small, and slow solutions are employed when making changes to the landscape design	OG, SOF
10.	- Use and value diversity	Farm is designed to increase and value species diversity	SOF, OG, GTF
11.	Use edges and value the marginal	Landscape is designed to maximize edges and margins, where different types of land meet	SOF
12.	Creatively use and respond to change	Landscape design also allows for flexibility and adaptability	OG, GTF
People care			
1.	Observe and interact	Farm seeks to foster good relationships with its neighbours	SOF, OG
2.	Catch and store energy	Inputs for the farm are produced locally	SOF, OG
3.	Obtain a yield	Farm's food is grown without chemical inputs	SOF, OG, GTF
4.	Apply self-regulation and accept feedback	Social and community feedback prompts changes in behaviour	SOF, OG, GTF
5.	Use and value renewable resources and services	Renewable community resources and services are used with an eye toward their long-term impact	SOF, OG
6.	Produce no waste	Waste is not sent to landfills	SOF, OG
7.	Design from patterns to details	Farm seeks broader community input in making design decisions	SOF, OG
8.	Integrate rather than segregate	Farm is open to the public, and partnerships are sought with other organizations	SOF, OG, GTF
9.	Use small and slow solutions	Community works collectively to resolve local issues	SOF, OG
10.	Use and value diversity	Respect is shown for people's choices related to ethnicity, sexual orientation, gender, age, religion, and culture	SOF, OG, GTF
11.	Use edges and value the marginal	Socially progressive marginalized movements are valued	SOF, OG, GTF
12.	Creatively use and respond to change	Action is taken to address social crises and solve problems in the community.	OG
Fair share			
1.	Observe and interact	Recognizing and responding to limits on production and consumption	–
2.	Catch and store energy	Farm inputs are generated on-site	OG, SOF
3.	Obtain a yield	Income is generated through on-site activities	SOF, OG, GTF
4.	Apply self-regulation and accept feedback	Fair share is employed in the consumption and distribution of resources	OG
5.	Use and value renewable resources and services	Money is not spent on non-renewable resources	OG, SOF
6.	Produce no waste	Waste is viewed as a resource	OG, SOF
7.	Design from patterns to details	Integrated systems are used to optimize productivity and efficiency	SOF, OG, GTF
8.	Integrate rather than segregate	Farm seeks to integrate its production with other local farms	OG
9.	Use small and slow solutions	Ecological management is employed to solve production problems rather than resorting to the use of chemicals	OG, SOF
10.	Use and value diversity	Diversity of income streams is generated on the farm	SOF, OG, GTF
11.	Use edges and value the marginal	Gaps in the market are considered when deciding which product streams to invest in	SOF, GTF
12.	Creatively use and respond to change	Creative problem-solving is employed to address production flow issues	SOF, OG, GTF

SOF: Sotang Organic Farm; OG: Organic Ghar; GTF: Gandaki Trout Farm.

These examples provide evidence of the potential benefits of permaculture design principles in various settings and highlight the need for greater focus on permaculture education, research, and practice in agriculture, landscaping, healthcare, and product design to address societal issues and create job opportunities in this era of climate crisis.

7. Conclusion

Designing and planning with nature is an ecosystem-based approach that demonstrates sustainable practices in diverse aspects. This permaculture system is involved in planning and fabricating by following the natural patterns of permaculture locales.

Subsequently, permaculturists should have a careful comprehension of the concepts of permaculture as well as the capacity to recognize the appropriate permaculture design pattern. Through this permaculture methods might be utilized to accomplish various objectives. As revealed in this study, permaculture can assist farmers to maintain livelihood activities and increase their ability to deal with environmental issues. It's likewise the key to boosting social and environmental resilience. Furthermore, by properly integrating a diverse range of aspects, the present agrarian framework might be uprooted and replaced with a more methodical, dynamic, and environmentally friendly system. Therefore, this case study entails a strong emphasis on adhering to the ethical angles and codes of permaculture to accomplish sustainability and supplant the modern/industrial agricultural system.

Author contribution statement

Shubh Pravat Singh Yadav: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper. Vivek Lahutiya: Conceived and designed the experiments; Performed the experiments; Wrote the paper. Netra Prasad Ghimire, Bishnu Yadav, and Prava Paudel: Performed the experiments; Wrote the paper.

Data availability statement

No data was used for the research described in the article.

Additional information

No additional information is available for this paper.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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