

Economic Feasibility and Production Analysis of Ghanajeevamrit as a Sustainable Bio-Input for Rain-Fed and Dry Land Agro-Ecosystem in North Western Himalayan Regions

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ABSTRACT

Natural farming systems emphasize the use of indigenous microbial formulations to improve soil health and crop productivity while minimizing chemical inputs. Ghanajeevamrit, a solid formulation derived from cow and buffalo dungs, is increasingly promoted as a sustainable organic input in natural farming practices. The present study evaluates the production process and economic feasibility of manufacturing dry Ghanajeevamrit using locally available resources. Primary production data were collected from a pilot-scale unit operating under community extension activities. The analysis revealed that the total production cost for 300 kg of dry Ghanajeevamrit was ₹13,000, whereas the estimated market value was ₹15,000, resulting in a net profit of ₹2,000 per production cycle. Raw material costs accounted for a significant proportion of the expenditure, while packaging and labeling constituted the highest operational cost component. The results demonstrate that small-scale Ghanajeevamrit production can serve as a viable rural enterprise while promoting sustainable agriculture and reducing dependency on chemical fertilizers. The findings support the integration of bio-inputs in Rain-fed and Dry Land Agro-ecosystem in North western Himalayan Regions for improved soil fertility and environmental sustainability.

Keywords: Agro-ecosystem, Natural farming, Ghanajeevamrit, cost-benefit analysis, Rain-fed, sustainable agriculture.

INTRODUCTION

Agriculture in the twenty-first century faces the dual challenge of increasing food production while maintaining environmental sustainability. Over the past five decades, agricultural intensification through the extensive use of synthetic fertilizers, pesticides, and irrigation has significantly enhanced crop productivity worldwide. However, the long-term consequences of these practices include soil degradation, loss of biodiversity, declining soil organic matter, groundwater contamination, and disruption of natural ecological processes (Tilman et al., 2002; Foley et al., 2011; Lal, 2015). Excessive reliance on chemical fertilizers has also reduced soil microbial diversity and adversely affected soil health, particularly in fragile ecosystems such as mountainous and rainfed regions (Bhattacharyya et al., 2015; FAO, 2019).

The North-Western Himalayan region of India, encompassing states such as Himachal Pradesh, Uttarakhand, and parts of Jammu and Kashmir, is characterized by highly diverse agro-climatic conditions, steep topography,

and fragile mountain ecosystems (Singh et al., 2018). Agriculture in this region is predominantly rainfed, with more than 70 % of cultivated land dependent on monsoon precipitation (Sharma & Sharma, 2014). The rainfed and dryland agro-ecosystems of the North-Western Himalaya are particularly vulnerable to soil erosion, nutrient depletion, climate variability, and declining soil fertility (Tiwari & Joshi, 2012; ICAR, 2017). These challenges are further exacerbated by the limited availability of irrigation facilities, small landholdings, and the high cost of external agricultural inputs.

Sustainable soil fertility management is therefore essential for maintaining agricultural productivity in these fragile ecosystems. Traditional agricultural practices in the Himalayan region historically relied on locally available organic resources such as farmyard manure, compost, crop residues, and livestock-based inputs to maintain soil fertility (Dhyani et al., 2015). However, with the gradual shift toward chemical-intensive agriculture, the use of traditional organic inputs has declined in many areas, resulting in deterioration of soil structure and microbial activity (Lal, 2015; Bhattacharyya et al., 2015).

In recent years, there has been renewed interest in agroecological and natural farming approaches that promote the use of biological inputs and ecological processes to restore soil health and improve crop productivity (Altieri & Nicholls, 2017; FAO, 2019). Natural farming systems emphasize the utilization of locally available organic materials such as cow dung, cow urine, crop residues, plant extracts, and microbial formulations to enhance soil biological activity and nutrient availability (Palekar, 2016). These systems aim to reduce dependence on external chemical inputs while promoting ecological balance and sustainability.

One of the most widely promoted microbial formulations in natural farming systems is Jeevamrit, a fermented microbial culture prepared from fresh cow dung, cow urine, jaggery (unrefined sugar), pulse flour, and soil microorganisms. Jeevamrit acts as a biological catalyst that stimulates the proliferation of beneficial soil microorganisms and enhances nutrient mineralization processes (Palekar, 2016; Subhash & Reddy, 2018). Studies have demonstrated that microbial formulations derived from indigenous cow-based inputs can significantly improve soil microbial biomass, nutrient availability, and crop growth (Sreenivasa et al., 2010; Babalad et al., 2017).

Despite its agronomic benefits, the liquid form of Jeevamrit presents certain practical limitations. The formulation has a relatively short shelf life and requires immediate application after preparation. Moreover, transportation and storage of large volumes of liquid formulations are often inconvenient for farmers, particularly in remote and mountainous regions where infrastructure and transportation facilities are limited (Reddy, 2020). These constraints have led to the development of Ghanajeevamrit, a solid and concentrated form of Jeevamrit that can be easily stored, transported, and applied in agricultural fields.

Ghanajeevamrit is prepared by converting fermented Jeevamrit into a dry formulation through mixing with cow dung and subsequent drying under shade conditions. The resulting product contains a rich consortium of beneficial microorganisms that enhance soil microbial activity and nutrient cycling (Babalad et al., 2017; Reddy, 2020). When applied to soil, Ghanajeevamrit promotes the multiplication of beneficial microbes, improves soil structure, and enhances the availability of essential nutrients such as nitrogen, phosphorus, and potassium (Sreenivasa et al., 2010; Sharma et al., 2020). These properties make it particularly suitable for rainfed and dryland agro-ecosystems, where maintaining soil organic matter and microbial activity is crucial for sustaining crop productivity.

In the North-Western Himalayan region, livestock plays an important role in integrated farming systems, providing valuable organic inputs such as cow dung and cow urine (Singh et al., 2018). The availability of these resources makes the region well-suited for the production of cow-based bio-inputs such as Jeevamrit and Ghanajeevamrit. Furthermore, community-based production of such inputs can provide additional income opportunities for rural households and farmer groups, thereby contributing to rural livelihoods and sustainable agriculture (Altieri & Nicholls, 2017).

The promotion of bio-input enterprises based on locally available organic materials has been recognized as an effective strategy for strengthening sustainable agriculture and rural entrepreneurship (FAO, 2019; ICAR, 2017).

Small-scale production units can supply farmers with affordable organic inputs while generating employment opportunities in rural areas. However, despite the growing popularity of Ghanajeevamrit in natural farming systems, scientific documentation regarding its production economics, cost structure, and profitability remains limited, particularly in the context of the Himalayan region.

Understanding the economic feasibility of such bio-input production systems is essential for promoting their large-scale adoption. Economic evaluation helps determine whether small-scale production units can operate sustainably and generate sufficient returns to support rural enterprises. In the context of the rainfed and dryland agro-ecosystems of the North-Western Himalaya, such analyses are particularly important because farmers often have limited financial resources and rely heavily on low-cost agricultural inputs.

Therefore, the present study was undertaken to evaluate the production process and economic feasibility of Ghanajeevamrit manufacturing based on primary data obtained from a pilot-scale production unit. The study specifically focuses on assessing the cost of raw materials, production expenses, and profitability associated with small-scale Ghanajeevamrit production.

The objectives of the present study are to document the preparation and production process of Ghanajeevamrit using locally available organic resources, to evaluate the cost of raw materials and production involved in manufacturing Ghanajeevamrit as well as to assess the economic feasibility and profitability of small-scale Ghanajeevamrit production for sustainable agriculture in the rainfed and dryland agro-ecosystems of the North-Western Himalaya.

MATERIALS AND METHODS

Study Area

The present study was conducted as part of community outreach and sustainable agriculture initiatives implemented by the Directorate of Community Services, Career Point University, Hamirpur, Himachal Pradesh, India. The study area lies within the North-Western Himalayan region, characterized by hilly terrain, fragile ecosystems, and predominantly rainfed agricultural systems. Agriculture in this region largely depends on monsoon rainfall, and the majority of farmers practice mixed farming systems integrating crop cultivation with livestock rearing (Singh et al., 2018; Sharma & Sharma, 2014).

Livestock resources, particularly indigenous cattle, provide essential organic inputs such as cow dung and cow urine, which are traditionally used for soil fertility management. These resources form the basis for the preparation of microbial formulations used in natural farming systems (Palekar, 2016). The availability of such locally sourced materials makes the region suitable for the preparation of bio-inputs like Jeevamrit and Ghanajeevamrit for sustainable agriculture.

Raw Materials Used

The preparation of Ghanajeevamrit was carried out using locally available organic materials commonly used in natural farming systems. The principal raw materials included fresh cow dung, cow urine, legume flour (pulse flour), jaggery (unrefined sugar), water, and local soil microorganisms. Fresh cow dung serves as a rich source of beneficial microorganisms and organic matter, while cow urine provides essential nutrients and growth-promoting compounds. Jaggery acts as an energy source for microbial growth during fermentation, whereas legume flour supplies nitrogen and proteins required for microbial multiplication (Palekar, 2016; Sreenivasa et al., 2010).

Water is added to facilitate microbial fermentation and to create a suitable medium for microbial activity. Soil microorganisms naturally present in the environment further contribute to the microbial diversity of the formulation. Together, these components form a nutrient-rich microbial culture that enhances soil biological activity and nutrient availability when applied to agricultural fields (Subhash & Reddy, 2018; Sharma et al., 2020).

Preparation Method of Ghanajeevamrit

The preparation of Ghanajeevamrit was carried out following the standard procedure recommended in natural farming practices (Palekar, 2016). The process involved four major stages: preparation of Jeevamrit, solidification, drying, and packaging.

Initially, Jeevamrit was prepared by mixing fresh cow dung, cow urine, jaggery, and legume flour with water in a suitable container. The mixture was thoroughly stirred to ensure uniform mixing of all ingredients and then allowed to undergo fermentation for 48–72 hours under shade conditions. During this fermentation period, microbial populations rapidly multiply and form a biologically active culture capable of enhancing soil microbial activity (Sreenivasa et al., 2010).

Following fermentation, the liquid Jeevamrit was converted into a solid form by mixing it with additional fresh cow dung. The mixture was kneaded thoroughly to obtain a uniform consistency and then shaped into small granules or cake-like structures. This process helps in converting the liquid microbial formulation into a solid and easily manageable product.

The prepared granules were subsequently shade-dried for several days to reduce moisture content and achieve a stable dry form. Shade drying is preferred to maintain the viability of beneficial microorganisms and to prevent excessive loss of microbial activity due to direct sunlight (Reddy, 2020).

After complete drying, the Ghanajeevamrit granules were packed in 1 kg khadi bags and labeled for storage and distribution. The packaging material was selected to ensure adequate ventilation and preservation of microbial viability during storage. The final product can be easily transported and applied to agricultural fields, making it suitable for farmers in remote mountainous regions where transportation and storage of liquid formulations may be difficult.

Economic Analysis

An economic assessment was conducted to evaluate the feasibility of small-scale Ghanajeevamrit production. The analysis was based on primary production data obtained from the pilot production unit. Various cost components involved in the production process were identified and quantified.

The total production cost included expenses related to raw materials, transportation, labor, manufacturing operations, packaging and labeling, and processing unit and storage charges. Raw material costs were calculated based on the quantity of cow dung, cow urine, jaggery, and legume flour used in the preparation process. Transportation costs included expenses incurred in collecting raw materials from nearby locations.

Labor costs accounted for activities such as raw material handling, mixing, fermentation management, shaping of granules, drying, and packaging. Additional operational expenses included manufacturing charges and packaging costs associated with labeling and packing the final product into 1 kg bags.

A cost–benefit analysis was performed to determine the economic viability of the enterprise. The total production cost was compared with the estimated market price of the final product. Net profit was calculated by subtracting the total production expenditure from the total sale value of 300 kg of dry Ghanajeevamrit. This economic evaluation provides insights into the potential profitability of Ghanajeevamrit production as a rural enterprise and its suitability for promoting sustainable agriculture in rainfed Himalayan agro-ecosystems (FAO, 2019; ICAR, 2017).

RESULTS:

Total Expenditure for Production of 300 Kg Dry Ghanajeevamrit

S. No.	Expenditure	Quantity	Cost (₹)
1	Raw cow dung	10 quintals	1000
2	Transportation (To & Fro)	50 km	1000

3	Jeevamrit preparation	200 liters	2000
4	Labor (loading, unloading, manufacturing)	5 persons	2000
5	Packaging and labeling	300 khadi bags (1 kg)	6000
6	Processing unit and warehouse charges	Per month	1000

Total Production Expenditure = ₹13,000

Raw Material Cost for Production of 1 Kg Ghanajeevamrit

S. No.	Item	Quantity	Rate (₹)	Total Cost (₹)
1	Fresh cow dung	4 kg	5	5
2	Cow urine	100–200 ml	10	10
3	Legume flour	100–200 g	20	20
4	Jaggery	10 ml	5	5

Total Raw Material Cost = ₹40 per kg

Production Cost for 1 Kg Ghanajeevamrit

S. No.	Item	Rate (₹)	Total Cost (₹)
1	Manufacturing cost	5	5
2	Packaging and labeling	5	5

Total Production Cost = ₹10 per kg

Total Production Cost per Kg

Total cost per kg = Raw material cost + Production cost

₹40 + ₹10 = ₹50 per kg

Cost–Benefit Analysis

Parameter	Value
Total production	300 kg
Sale price per kg	₹50
Total sale value	₹15,000
Total production cost	₹13,000

Net Profit = ₹15,000 – ₹13,000 = ₹2,000

DISCUSSION

The findings of the present study indicate that the production of Ghanajeevamrit is economically feasible at a small scale and can serve as a viable bio-input enterprise for farmers in rainfed and dryland agro-ecosystems. The total production cost for 1 kg of Ghanajeevamrit was estimated to be ₹50, which is comparatively lower than the price of many commercially available organic fertilizers and microbial bio-inoculants. The relatively low production cost is primarily attributed to the use of locally available organic resources such as cow dung, cow urine, jaggery, and pulse flour, which are commonly accessible in rural farming systems. Similar observations have been reported by Subhash and Reddy (2018) and Palekar (2016), who highlighted that cow-based microbial formulations used in natural farming significantly reduce agricultural input costs while maintaining soil fertility.

The economic analysis further revealed that packaging and labeling constituted the largest proportion of the total production cost, accounting for a major share of the overall expenditure. This finding suggests that optimizing

packaging methods or adopting cost-effective packaging materials could further enhance the profitability of Ghanajeevamrit production. Small-scale farmer groups or rural enterprises could reduce these costs through bulk packaging systems or cooperative marketing strategies. Similar economic patterns have been reported in studies evaluating small-scale bio-input production units, where packaging and distribution costs often represent a significant portion of the total expenditure (FAO, 2019; ICAR, 2017).

The production methodology adopted in the present study follows the natural farming principles described by Palekar (2016) and involves a sequence of microbial fermentation and solidification processes. The flowchart of Ghanajeevamrit preparation (Figure X) illustrates the systematic stages involved in the production process, beginning with the collection of raw materials such as cow dung, cow urine, jaggery, and pulse flour. These materials are first used to prepare Jeevamrit, a liquid microbial culture that undergoes fermentation for approximately 48–72 hours. During this period, microbial populations multiply rapidly due to the availability of carbon and nitrogen sources provided by jaggery and pulse flour (Sreenivasa et al., 2010).

After fermentation, the liquid formulation is mixed with additional cow dung to obtain a semi-solid mixture that can be shaped into granules or cakes. This step facilitates the conversion of liquid Jeevamrit into a stable solid formulation known as Ghanajeevamrit. The granules are then dried under shade conditions to preserve microbial viability and prevent excessive heat exposure, which could otherwise reduce microbial activity (Reddy, 2020). The final product is packaged and stored for distribution to farmers. This process enables easier handling, transportation, and longer storage compared with the liquid form of Jeevamrit, making it particularly suitable for remote rural regions and mountainous farming systems (Subhash & Reddy, 2018).

Microbial formulations such as Jeevamrit and Ghanajeevamrit play a significant role in improving soil biological activity and nutrient availability. Previous studies have demonstrated that the application of cow-based microbial formulations enhances soil microbial biomass, increases enzymatic activity, and promotes nutrient mineralization processes (Sreenivasa et al., 2010; Babalad et al., 2017). These microbial processes contribute to improved soil fertility and better crop performance, particularly in soils with low organic matter content. The promotion of beneficial microorganisms also helps restore soil ecological balance and improve soil structure (Lal, 2015).

The importance of such bio-inputs is particularly evident in rainfed and dryland agricultural systems, where maintaining soil organic matter and microbial activity is essential for sustaining crop productivity. In the North-Western Himalayan region, agriculture is largely dependent on rainfall and is characterized by fragile soils that are vulnerable to nutrient depletion and erosion (Singh et al., 2018; Sharma & Sharma, 2014). The adoption of microbial bio-inputs such as Ghanajeevamrit can therefore play a crucial role in improving soil health and enhancing resilience of farming systems to climatic variability.

The cost distribution analysis presented in Figure X further highlights the relative contribution of different expenditure components involved in the production of 300 kg of Ghanajeevamrit. The analysis clearly shows that packaging and labeling account for the largest share of the total production cost, followed by labor and Jeevamrit preparation expenses. Raw material costs such as cow dung and cow urine remain relatively low due to their availability within local farming systems. This cost structure demonstrates that Ghanajeevamrit production can be implemented with minimal financial investment, making it accessible to small and marginal farmers.

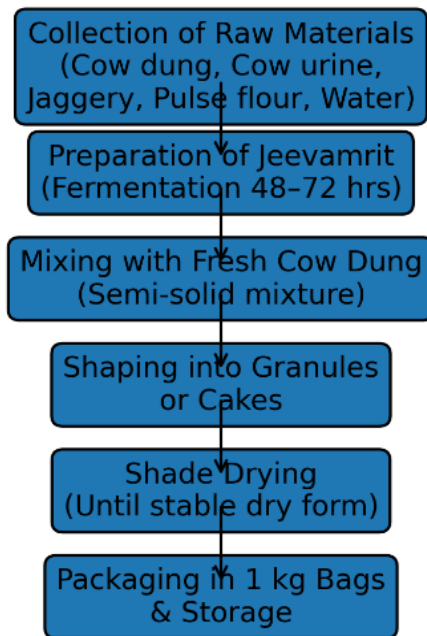
In addition to its agronomic benefits, the production of Ghanajeevamrit offers promising opportunities for rural entrepreneurship and community-based enterprises. Small-scale production units operated by farmer groups, cooperatives, or community organizations can supply affordable organic inputs to local farmers while generating additional income. The promotion of such decentralized bio-input production systems has been recognized as an important strategy for strengthening sustainable agriculture and rural livelihoods (Altieri & Nicholls, 2017; FAO, 2019).

Overall, the results of the present study demonstrate that Ghanajeevamrit production represents a low-cost, environmentally sustainable, and economically viable approach for supporting natural farming systems. By utilizing locally available organic resources and simple production techniques, farmers can reduce dependency

on chemical fertilizers while improving soil fertility and farm profitability. The integration of such bio-input production systems into community-based agricultural programs could contribute significantly to the promotion of sustainable agriculture in rainfed and mountainous regions.

Flowchart: Preparation of Ghanajeevamrit: Scientific production process of Ghanajeevamrit showing sequential stages including raw material collection, Jeevamrit fermentation, solidification, shade drying, and packaging.

Scientific Production Flow Diagram of Ghanajeevamrit



Cost Component Distribution in Ghanajeevamrit Production (300 kg batch)

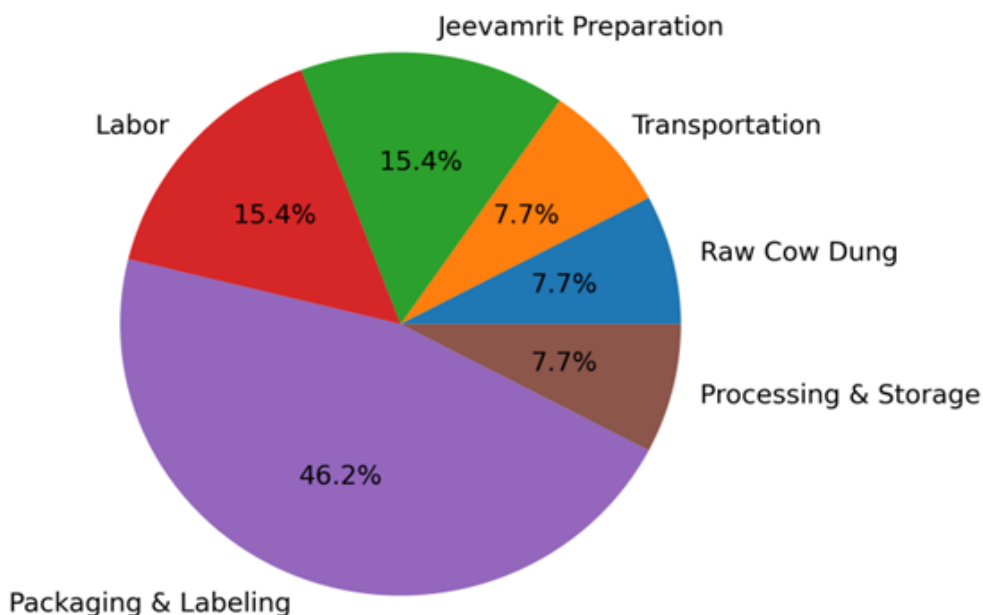


Figure. Distribution of cost components involved in the production of 300 kg Ghanajeevamrit. Packaging and labeling represent the largest expenditure component.

CONCLUSION

The present study evaluated the production process and economic feasibility of Ghanajeevamrit, a solid microbial formulation widely used in natural farming systems, with particular emphasis on its applicability in the rainfed and dryland agro-ecosystems of the North-Western Himalayan region. The findings demonstrate that Ghanajeevamrit can be produced using simple techniques and locally available organic resources such as cow dung, cow urine, jaggery, and pulse flour. These materials provide essential nutrients and microbial populations required for fermentation and the development of beneficial soil microorganisms.

The economic analysis revealed that the total production cost of Ghanajeevamrit was approximately ₹50 per kilogram, which is comparatively lower than many commercially available organic fertilizers and microbial bio-inputs. For a production batch of 300 kg, the total expenditure was estimated at ₹13,000, while the total sale value was ₹15,000, resulting in a net profit of ₹2,000. This indicates that small-scale production of Ghanajeevamrit is economically viable and can generate additional income for farmers and rural entrepreneurs. The cost distribution analysis further highlighted that packaging and labeling constituted the largest expenditure component, suggesting that improvements in packaging efficiency could further enhance profitability.

Beyond its economic feasibility, Ghanajeevamrit offers several agronomic benefits. The microbial formulations derived from cow-based inputs enhance soil microbial activity, improve nutrient cycling, and contribute to better soil structure and fertility (Sreenivasa et al., 2010; Babalad et al., 2017). These characteristics are particularly important in rainfed and mountainous agricultural systems, where soil fertility management is crucial for sustaining crop productivity (Singh et al., 2018; Sharma & Sharma, 2014). The use of such bio-inputs also reduces farmers' dependence on chemical fertilizers, thereby supporting environmentally sustainable agricultural practices (FAO, 2019; Lal, 2015).

Furthermore, the production of Ghanajeevamrit presents significant opportunities for community-based enterprises and rural livelihood development. Small-scale production units operated by farmer groups, cooperatives, or local institutions can supply affordable organic inputs to farmers while promoting sustainable agriculture and ecological balance. The integration of such bio-input production systems into agricultural extension and rural development programs could therefore play a key role in strengthening agroecological farming practices in the Himalayan region.

Therefore, the study demonstrates that Ghanajeevamrit production is a low-cost, environmentally sustainable, and economically feasible agricultural enterprise. Wider adoption of this bio-input could contribute to improved soil health, enhanced crop productivity, and increased income opportunities for farmers in rainfed and dryland farming systems.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this research work.

REFERENCES

1. Altieri, M.A. & Nicholls, C.I., 2017. The adaptation and mitigation potential of traditional agriculture in a changing climate. *Climatic Change*, 140, pp.33–45.
2. Babalad, H.B., Sreenivasa, M.N. & Dhanapal, G.N., 2017. Role of microbial inoculants in organic farming systems. *Indian Journal of Agricultural Sciences*, 87(3), pp.293–299.
3. Bhattacharyya, R., Ghosh, B.N., Mishra, P.K., Mandal, B. & Rao, C.S., 2015. Soil degradation in India: challenges and potential solutions. *Sustainability*, 7, pp.3528–3570.

4. Dhyani, S.K., Ram Newaj & Handa, A.K., 2015. Agroforestry systems in India: livelihood security and ecosystem services. *Indian Journal of Agroforestry*, 17, pp.1–14.
5. FAO, 2019. *Agroecology and Sustainable Agriculture*. Rome: Food and Agriculture Organization.
6. Foley, J.A. et al., 2011. Solutions for a cultivated planet. *Nature*, 478, pp.337–342.
7. ICAR, 2017. *Natural Resource Management in Himalayan Region*. New Delhi: Indian Council of Agricultural Research.
8. Lal, R., 2015. Restoring soil quality to mitigate soil degradation. *Sustainability*, 7, pp.5875–5895.
9. Palekar, S., 2016. *Zero Budget Natural Farming*. Amravati: ZBNF Research Foundation.
10. Reddy, S.R., 2020. Organic farming inputs and their role in sustainable agriculture. *Journal of Sustainable Agriculture*, 12(3), pp.145–152.
11. Sharma, S. & Sharma, R., 2014. Rainfed agriculture in Himalayan region. *Agricultural Reviews*, 35, pp.112–119.
12. Sharma, V., Singh, P. & Kumar, A., 2020. Microbial formulations in organic agriculture. *Journal of Soil Biology*, 40(2), pp.55–63.
13. Singh, S.P., Rawat, Y.S. & Tiwari, P., 2018. Sustainable agriculture in the Indian Himalaya. *Mountain Research and Development*, 38(1), pp.10–20.
14. Sreenivasa, M.N., Naik, N. & Bhat, S.N., 2010. Beejamrutha and Jeevamrutha: microbial formulations for organic farming. *Journal of Agricultural Science*, 23, pp.145–150.
15. Subhash, P. & Reddy, S.R., 2018. Natural farming practices and their role in sustainable agriculture. *Journal of Organic Farming*, 6(2), pp.45–52.
16. Tilman, D., Cassman, K., Matson, P., Naylor, R. & Polasky, S., 2002. Agricultural sustainability and intensive production practices. *Nature*, 418, pp.671–677.
17. Tiwari, P.C. & Joshi, B., 2012. Environmental changes and sustainable development in the Himalaya. *Mountain Research and Development*, 32(3), pp.213–223.