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INTEGRATING AGROECOLOGY FOR SUSTAINABLE FARMING SYSTEMS IN DEVGAD TALUKA, SINDHUDURG DISTRICT, MAHARASHTRA

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ABSTRACT

Agriculture in India faces rising challenges from climate change, soil degradation, and socio-economic pressures. Agroecology, blending ecological principles with farming, offers resilience by improving productivity while sustaining natural resources. This study assesses the role of agroecological practices in Devgad Taluka, Sindhudurg District, Maharashtra, a region shaped by its rugged coastline, laterite plateaus, and cultural heritage. Using field surveys, household interviews, participatory rural appraisal, and secondary data, the study evaluates impacts on productivity, soil health, biodiversity, water management, and socio-economic outcomes. Results reveal that crop diversification, organic soil amendments, rainwater harvesting, and biodiversity management significantly enhanced yields, soil organic carbon, and water retention, while also increasing household incomes and food security. However, constraints such as fragmented landholdings, limited awareness, and weak infrastructure impede wider adoption. The paper concludes that Devgad has strong potential to serve as a model for agroecology-based farming in coastal India, demonstrating how ecological integrity, economic viability, and social equity can converge for long-term sustainability.

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- **INTRODUCTION:**

Agriculture in the twenty-first century stands at a decisive crossroads. Rapid climate change, biodiversity loss, and degradation of soil and water resources threaten food production systems worldwide (FAO, 2018; IPCC, 2022). The Green Revolution provided impressive gains in food production but has also left behind a legacy of excessive chemical dependence, monoculture practices, declining soil fertility, and socio-economic inequalities (Altieri, 2018). Farmers across India, especially smallholders, are experiencing declining returns, ecological stress, and market vulnerabilities. This situation demands innovative farming systems that combine productivity with ecological integrity. Agroecology has emerged as a transformative response. Defined as the application of ecological concepts to agricultural systems, agroecology integrates traditional wisdom with modern ecological science (Wezel et al., 2009). It encompasses crop diversification, organic soil management, natural pest regulation, and participatory decision-making, thereby offering a pathway to sustainability and resilience (Gliessman, 2015). In many parts of the world, agroecological transitions have demonstrated improvements not only in yields but also in farmer incomes, community food security, and ecosystem health (Pretty et al., 2018).

Within India, agroecology resonates with long-standing traditions of mixed cropping, community water management, and organic soil amendments. Yet, policy frameworks remain heavily oriented toward chemical-intensive models. Against this backdrop, Devgad Taluka of Sindhudurg District, Maharashtra, provides a fertile case study. The region, known for its world-famous Alphonso mangoes, also grows paddy, pulses, and horticultural crops. Despite its ecological richness, it faces vulnerabilities including rainfall variability, soil degradation, and lack of infrastructure (Government of Maharashtra, 2021). Farmers are increasingly adopting agroecological methods, motivated by both ecological necessity and market opportunities. This paper investigates the contribution of agroecology in Devgad Taluka. It examines how practices affect productivity, soil health, biodiversity, water management, and socio-economic outcomes. By combining quantitative data with qualitative insights, the study aims to highlight pathways for scaling agroecological transitions in coastal India.

- **OBJECTIVES OF THE STUDY:**
  - To assess the role of agroecological practices in enhancing productivity, food security, and ecological sustainability in Devgad Taluka.
  - To identify challenges and recommend integrated strategies for sustainable farming through conservation, infrastructure, and community participation.

- **METHODOLOGY:**

The study adopted a mixed-methods convergent parallel design, integrating quantitative measurements with qualitative perspectives to ensure a holistic understanding of agroecological adoption and its outcomes. A purposive sampling approach was employed to capture the agroecological diversity of Devgad Taluka. Between 8 and 12 villages were selected to represent distinct ecological settings, including lateritic plateaus, river valleys, and coastal zones. Within these villages, 200–300 households were randomly chosen and stratified by landholding size and adoption status (adopters vs. non-adopters). In addition, 20–30 key informants—such as agricultural extension workers, NGO staff, and farmer leaders—were interviewed to provide expert insights.

Quantitative data collection involved measuring crop yields through sample harvests, assessing soil organic carbon (SOC) at two depths (0–15 cm and 15–30 cm), monitoring water availability across seasons, and evaluating biodiversity using species counts and the Shannon diversity index. Complementing this, qualitative data were collected through household surveys that captured information on income, food security, and input use. Focus group discussions (8–10 sessions) with farmers were organized to explore perceptions, constraints, and benefits of agroecological practices, while participatory rural appraisal (PRA) tools such as resource mapping and seasonal calendars enriched the analysis with community-driven perspectives. Secondary data, including government reports, climatic records, and previous studies, were also reviewed to strengthen contextual understanding. For data analysis, quantitative variables were subjected to statistical testing, including t-tests and regression models, to assess the significance of observed differences.

Qualitative data were systematically analysed through thematic coding to identify recurring patterns and farmer perspectives. Triangulation between quantitative and qualitative datasets enhanced the robustness and credibility of the findings. Finally, results were shared with local stakeholders through workshops, enabling validation, feedback, and collaborative reflection on the implications for sustainable farming practices.

- **STUDY REGION:**

Devgad Taluka, located between 16°22′N latitude and 73°23′E longitude, spans an area of 768 km² along the picturesque Konkan coast of Maharashtra. Geographically, the taluka is situated in the southern part of Sindhudurg district, bordered by Malvan taluka to the north, Kankavali to the east, and the Arabian Sea to the west and southwest. This coastal location provides both opportunities and challenges for agriculture, as saline ingress, monsoon intensity, and estuarine dynamics strongly influence land use. The physiography of Devgad is highly diverse, comprising laterite plateaus, fertile river valleys, estuaries, tidal creeks, and sheltered bays. Coastal patches often face salinity stress, while inland areas are marked by gently undulating terrain and terraced fields. Such variations create distinct agroecological niches within a relatively compact geographical space.

Climatically, Devgad experiences a humid tropical monsoon regime with an average annual rainfall of 3,610 mm, concentrated mainly between June and September. Temperatures range from a mild 16.3 °C during winter to about 33.8 °C in summer, supporting diverse cropping systems. Administratively, the taluka encompasses 96 villages and a single urban centre, forming a semi-rural socio-economic landscape. According to the Census of 2011, the population stood at 120,909, with a literacy rate of 86.4% and a favourable sex ratio of 1,051.

Economically, Devgad is known for its globally renowned Alphonso mangoes, which command high export value. Alongside horticulture, paddy and pulses form the backbone of food security, while fishing provides supplementary income. These ecological and socio-economic characteristics, combined with its distinct administrative boundaries and physiographic diversity, make Devgad an ideal site for exploring the integration of agroecological principles into farming systems.

- **RESULTS AND DISCUSSION:**

The adoption of agroecological practices in Devgad Taluka demonstrated significant improvements in both agricultural productivity and ecological sustainability. Diversified cropping systems, particularly the intercropping of horticultural crops with paddy and pulses, enhanced yield stability and reduced pest incidences. These results corroborate Altieri's (2018) assertion that diversified systems enhance resilience by minimizing risks associated with monocultures. Organic soil management through compost application and green manuring further contributed to improved soil fertility, reflected in increased soil organic carbon (SOC) levels. Water conservation measures—including bunding, contour farming, and rainwater harvesting—effectively addressed seasonal water scarcity, particularly in lateritic plateau zones. Ecological surveys revealed greater crop and tree species richness, alongside higher abundance of beneficial insects, thereby strengthening natural pest regulation and overall ecosystem stability.

Household surveys and focus group discussions (FGDs) confirmed that adopters of agroecological practices benefited from enhanced food security, diversified incomes, and reduced dependence on external inputs. In contrast, non-adopters remained more vulnerable to climate variability due to reliance on chemical inputs. Nevertheless, challenges such as limited awareness, fragmented landholdings, inadequate infrastructure, and inconsistent policy support continue to constrain widespread adoption. Stakeholder consultations underscored the importance of integrated approaches that align ecological conservation with community participation and eco-friendly infrastructure development. Although the ODOP (One District One Product) initiative has been effective in branding Alphonso mangoes, extending policy support to diversified crops and value-added products remains essential for strengthening resilience and farmer livelihoods.

- CROP PRODUCTIVITY AND DIVERSIFICATION:

Comparative yield assessments indicated that agroecological plots consistently outperformed conventional ones (Table 1).

Table 1. Crop yield comparison between agroecological and conventional plots (kg/ha)

Crop Type	Agroecological Plots (Mean ± SD)	Conventional Plots (Mean ± SD)	% Increase
Paddy	3,250 ± 150	2,850 ± 180	14.0%
Horticulture	1,450 ± 120	1,200 ± 130	20.8%
Pulses	850 ± 70	700 ± 60	21.4%

Source: Compiled by researcher, 2024-2025.

Paddy yields improved by 14%, while pulses and horticultural crops showed even larger increases of 21.4% and 20.8%, respectively. The higher gains in pulses and horticulture highlight the potential of diversified systems to not only stabilize production but also improve dietary diversity and market opportunities. These outcomes validate the role of diversification in reducing monoculture risks and promoting nutrient cycling, consistent with findings by Altieri (2018).

- SOIL HEALTH AND FERTILITY:

Agroecological management also enhanced soil health, as evidenced by higher SOC levels in both surface and sub-surface soils (Table 2).

Table 2. Soil organic carbon (%) in agroecological vs. conventional plots

Depth (cm)	Conventional SOC (%)	Agroecological SOC (%)
0–15	1.8	2.1
15–30	1.5	1.7

Source: Compiled by researcher, 2024-2025.

SOC levels increased by 12–15% under agroecological management, particularly in the top 15 cm of soil. This improvement enhances nutrient availability and water retention capacity, thereby contributing to greater resilience against climatic fluctuations. These results align with TERI (2018), which reported similar improvements from organic amendments, underscoring the ecological and economic value of soil conservation practices.

- WATER MANAGEMENT AND CONSERVATION:

Seasonal water availability was substantially higher in agroecological farms (Table 3).

Table 3.

Season	Agroecology	Conventional
Pre-monsoon	500	350
Monsoon	1,200	1,000
Post-monsoon	700	450

Seasonal water availability (L/ha) in agroecological vs. conventional plots

Source: Compiled by researcher, 2024-2025.

Water retention improved by 43% in the pre-monsoon, 20% during the monsoon, and 55% in the post-monsoon season under agroecological management. These results indicate that practices such as bunding, farm ponds, and rainwater harvesting not only reduce runoff but also extend water availability into drier months. The post-monsoon improvement is particularly significant, as it reduces dependency on groundwater pumps and enhances cropping possibilities in rainfall-dependent regions like Devgad.

- BIODIVERSITY AND PEST REGULATION:

Biodiversity indicators showed marked improvements in agroecological plots (Table 4).

Table 4. Biodiversity indices in agroecological vs. conventional plots

Indicator	Agroecology	Conventional
Crop Species Richness	6–8	3–4
Tree Species Richness	5–7	2–3
Beneficial Insect Abundance	45–55	20–25
Shannon Diversity Index (H’)	2.4	1.6

Source: Compiled by researcher, 2024-2025.

Agroecological farms supported nearly twice the number of crop and tree species and hosted over twice the abundance of beneficial insects compared to conventional plots. The higher Shannon Index (2.4 vs. 1.6) illustrates a more stable and resilient ecosystem. Farmers also reported an increase in pollinators and natural pest predators, which reduced pesticide use. These findings resonate with Pretty et al. (2018), who emphasize biodiversity’s role in maintaining ecosystem services and advancing sustainable intensification.

- SOCIO-ECONOMIC IMPACTS:

Agroecological adoption also yielded significant socio-economic benefits (Table 5).

Table 5. Socio-economic benefits of agroecology adoption

Parameter	Agroecology Adopters	Non-Adopters	% Difference
Average Household Income (INR/yr)	3,50,000	2,75,000	27.3%
Food Security Score	85	60	41.7%
Dependence on Chemical Inputs (%)	30	75	-60%

Source: Compiled by researcher, 2024-2025.

Household incomes among adopters were 27.3% higher than non-adopters, driven by yield gains and access to premium organic markets. Food security scores improved by 41.7%, reflecting enhanced dietary diversity and year-round food availability. Dependence on chemical inputs declined by 60%, lowering production costs and reducing health risks. Regression analysis ($R^2 = 0.62$, $p < 0.01$) confirmed that agroecology adoption significantly predicted both household income and food security. These findings support Gliessman (2015), who argues that agroecology strengthens livelihood security while sustaining ecological resilience.

- **FINDINGS:**

The study demonstrates that agroecology significantly strengthens farming systems in Devgad Taluka across ecological, agronomic, and socio-economic dimensions. Crop diversification enhanced productivity by 14–21%, with particularly notable gains in pulses and horticultural crops, thereby reducing risks associated with monoculture and climatic stress. Soil organic carbon increased by 12–15%, improving nutrient availability, water retention, and overall soil resilience. Water conservation practices such as bunding, farm ponds, and rainwater harvesting raised water availability by 20–55% across seasons, reducing dependence on groundwater extraction. Biodiversity nearly doubled, with higher crop and tree species richness and a greater abundance of beneficial insects, reinforcing ecosystem services and natural pest regulation. Socio-economic outcomes were equally significant: adopters reported higher household incomes, greater food security, and substantially reduced reliance on chemical inputs. Yet, barriers—including limited farmer awareness, fragmented landholdings, weak infrastructure, and inconsistent policy support—restrict broader adoption, underscoring the need for integrated strategies, institutional support, and targeted incentives to mainstream agroecology.

- **CONCLUSION:**

Agroecology presents a transformative pathway for strengthening Devgad's farming systems by simultaneously advancing productivity, ecological health, and rural resilience. Practices such as crop diversification, organic soil enrichment, rainwater harvesting, and biodiversity conservation have generated tangible benefits, including improved yields, enhanced soil fertility, greater water retention, and stronger ecosystem services. These outcomes demonstrate the potential of agroecology to reduce dependence on external inputs while fostering climate adaptability. However, realizing its full potential requires supportive policy frameworks, investment in rural infrastructure, and participatory knowledge-sharing platforms that empower farming communities. With its rich ecological base and cultural heritage, Devgad is uniquely positioned to serve as a model for coastal agroecology in India, aligning ecological integrity with economic viability and social equity to secure a sustainable agricultural future.

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