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## An assessment of cropping system patterns and soil fertility management in a sugarcane-dominated agroecosystem: Evidence from Ajara taluka, Maharashtra

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### Abstract

Agriculture constitutes the primary source of livelihood in Ajara Taluka of Kolhapur District, Maharashtra, where farming systems are shaped by high rainfall, landholding size, and market-oriented crop choices. The present study examines cropping patterns, seasonal cultivation practices, monocropping trends, and crop rotation strategies based on extensive field investigations conducted across 95 villages of the taluka. Primary data were generated through structured farmer interviews, group discussions, and consultations with Agriculture Department officials, Farmer Producer Organizations, Common Facility Centres, Panchayat representatives, and progressive farmers. The findings indicate that paddy dominates the Kharif season due to favourable rainfall conditions, while sugarcane has emerged as the principal year-round commercial crop across all farm categories. Small and medium farmers, constrained by limited land and labour availability, predominantly practice sugarcane and paddy based monocropping, whereas larger landholders exhibit relatively diversified cropping systems. Continuous cultivation of the same crops has led to declining soil fertility, nutrient imbalances, and increased vulnerability to pests and diseases in several locations. Minor crops such as ragi and chickpea are cultivated on a limited scale, largely for household consumption. Cashew cultivation was widely observed, particularly as a border crop, contributing to soil conservation under heavy rainfall conditions while providing supplementary income. The study highlights the growing dominance of sugarcane-based farming systems in Ajara Taluka and underscores the need for crop rotation-based interventions, integration of perennial border crops, and soil fertility management practices to enhance farm sustainability, resilience, and income stability.

**Keywords:** Ajara taluka, cropping systems, sugarcane monocropping, crop rotation, soil fertility, cashew, seasonal agriculture

### Introduction

Agriculture continues to play a central role in sustaining rural livelihoods and supporting economic stability in India, particularly in regions where favourable agro-climatic conditions and institutional support systems enable intensive cultivation. Cropping systems in such contexts are shaped by a dynamic interaction between biophysical factors such as rainfall patterns, soil characteristics, and water availability and socio-economic conditions, including landholding size, labour availability, and access to markets. Over time, these interacting forces have contributed to the increasing specialization of agricultural production, often resulting in the dominance of a limited number of commercially viable crops (Lal, 2015; Meena *et al.*, 2020) <sup>[11, 12]</sup>. In recent decades, the growing orientation towards market-driven agriculture has encouraged the expansion of monocropping systems, particularly in regions where farmers benefit from assured procurement and relatively stable prices. While such systems may enhance short-term farm income, their long-term implications for soil health and sustainability have raised significant concerns. Continuous cultivation of the same crop tends to accelerate the depletion of essential nutrients, reduce soil organic matter, and increase the incidence of pests and diseases, thereby affecting productivity over time (Singh & Sharma, 2019; FAO, 2024) <sup>[20]</sup>.

Evidence from intensively cultivated regions further suggests that input-intensive monocropping systems can weaken the resilience of farming systems, especially under conditions of climatic variability (Ritchie *et al.*, 2024)<sup>[18]</sup>.

In contrast, diversified cropping systems and planned crop rotation practices are widely recognized as effective strategies for maintaining soil fertility and promoting sustainable agricultural production. Crop rotation supports nutrient cycling, improves soil biological activity, and helps in breaking pest and disease cycles. The inclusion of legumes and other low-input crops within rotation systems has been shown to enhance nitrogen availability, improve soil structure, and sustain long-term productivity (ICAR, 2019; Nair, 2012; Thapa *et al.*, 2021)<sup>[7, 14, 22]</sup>. In addition, conservation-oriented practices associated with diversified systems contribute to improved soil carbon sequestration and more efficient use of resources in high-intensity agricultural environments (Sharma *et al.*, 2023; Frontiers in Sustainable Food Systems, 2024)<sup>[19]</sup>.

Despite these advantages, monocropping continues to persist in several agriculturally advanced regions due to economic compulsions, institutional influences, and constraints related to land availability. Farmers often prioritize crops that provide assured and immediate returns, even when such practices may compromise long-term soil health. This creates a persistent trade-off between economic viability and ecological sustainability, particularly in smallholder farming systems.

The agricultural landscape of Ajara Taluka in Kolhapur District, Maharashtra, reflects these broader dynamics. The region is characterized by high rainfall and a strong institutional presence of cooperative sugar industries, which has led to the widespread adoption of sugarcane as a dominant commercial crop. At the same time, paddy cultivation during the Kharif season remains important for household food security. Field observations indicate that many farmers, particularly those with small and medium landholdings, rely on repetitive cropping patterns centered on sugarcane and paddy. While this strategy provides a degree of income stability, it also raises concerns related to soil nutrient imbalance, declining fertility, and reduced resilience of the farming system.

Although the importance of cropping system diversification and crop rotation has been widely acknowledged, there is still a lack of detailed field-based studies that examine these processes at a micro-regional scale, especially in high-rainfall areas such as Ajara Taluka. Most existing research has focused on broader regional trends, often overlooking local variations in farming practices and resource constraints. In this context, the present study aims to document prevailing cropping patterns, assess the extent of sugarcane-dominated monocropping, and examine the role of crop rotation and related practices in maintaining soil fertility and sustaining agricultural productivity. By drawing on field-level evidence and farmer perspectives, the study seeks to contribute to a more grounded understanding of sustainable cropping strategies suited to local conditions.

## Objectives

1. To document the existing cropping patterns and seasonal crop distribution across different farm categories in Ajara Taluka based on field-level observations.
2. To examine the prevalence and characteristics of sugarcane and paddy-based monocropping and evaluate farmers' crop rotation practices in relation to landholding size, labour availability, rainfall patterns, and economic outcomes.
3. To examine perceived impacts of continuous cultivation on soil fertility, pest incidence, and overall crop performance

as reported by farmers and field observations.

4. To study the role of subsidiary and border crops, particularly cashew, in supporting soil conservation, income diversification, and risk mitigation under high rainfall conditions.
5. To identify scope for crop rotation based and soil-friendly interventions that can enhance the sustainability, resilience, and income stability of farming systems in Ajara Taluka.

## Materials and Methods

### Research Design

The study adopted a descriptive and analytical research design based on primary field data to assess cropping patterns, seasonal cultivation practices, monocropping trends, and crop rotation systems in Ajara Taluka.

### Field Survey and Data Collection

The present study was grounded in an extensive field survey conducted across approximately 95 villages of Ajara Taluka, Kolhapur District, to capture the diversity of cropping systems, landholding patterns, and farmer practices. Prior to the field visits, preliminary consultations were undertaken with key stakeholders, including officials from the Agriculture Department, personnel at the Common Facility Centre (CFC), representatives of Farmer Producer Organizations (FPOs), and staff of the Taluka Tahsildar Office. These consultations provided essential baseline information regarding village distribution, predominant crops, irrigation availability, and the institutional support mechanisms that influence local agricultural practices.

A purposive and community-based sampling approach was followed for the selection of respondents. Farmers were identified with the assistance of Panchayat members, village heads, and local officials to ensure representation across different landholding categories, including small, medium, and large farmers.

Primary data were systematically collected using a combination of direct field observations, structured interviews with individual farmers, and participatory group discussions with cultivators. Additionally, consultations at the village level were conducted with Panchayat members and village heads to understand local governance structures and community-level agricultural management. This multi-pronged approach ensured comprehensive coverage of the taluka and allowed for triangulation of information from diverse sources, enhancing the reliability and validity of the findings. Efforts were made to include active cultivators from different farm size groups in order to capture variability in cropping patterns, resource use, and management practices across the taluka.

The data collected covered the following aspects:

- Cropping patterns and seasonal crop distribution (Kharif, Rabi, Zaid).
- Monocropping and crop rotation practices.
- Input use, including fertilizers and pesticides.
- Incidence of pests and diseases.
- Field-level constraints and management challenges.

Particular emphasis was placed on engaging with active cultivators of paddy and sugarcane, the dominant crops in the region, to document detailed information on cropping patterns, seasonal practices, input use, and decision-making processes. Observations included plot-level assessments of crop health, irrigation practices, soil management, and crop rotation or monocropping trends. By combining qualitative insights from

farmer narratives with quantitative measurements of landholding size, crop area, and cultivation intensity, the study generated a nuanced understanding of the prevailing agricultural systems in Ajara Taluka.

The field-based methodology enabled the identification of site-specific challenges such as nutrient depletion, pest pressures, and constraints associated with small and medium landholdings, while also capturing farmers' adaptive strategies, including border cropping and partial crop rotation. The use of multiple sources of information farmer interviews, group discussions, and institutional consultations facilitated effective triangulation, thereby improving the reliability and consistency of the findings. The study followed a mixed-method approach by combining qualitative insights from farmer interactions with quantitative data on landholding size, crop area, and cultivation intensity. Descriptive statistical tools, including percentages and frequency distribution, were used to analyse the data and identify key patterns across farm categories.

### Variables and Parameters Studied

The study systematically documented a range of variables to comprehensively understand cropping systems and associated agricultural practices in Ajara Taluka. Data were collected on landholding size and farm category, which provided insights into how the scale of operations influences cropping decisions, input usage, and adoption of rotational practices. Detailed records of cropping patterns and seasonal crop distribution were maintained to capture temporal variations in crop selection across Kharif, Rabi, and Zaid seasons.

Special emphasis was placed on identifying sugarcane and paddy-based monocropping practices, as these dominant crops shape the economic and ecological dynamics of local farming systems. Crop rotation sequences and fallow practices were examined to evaluate the extent to which farmers diversify crops to maintain soil fertility and reduce pest and disease pressure. Border cropping practices, with particular reference to cashew cultivation, were documented to assess their role in soil conservation, income diversification, and risk mitigation under high-rainfall conditions.

Soil-related issues, including nutrient constraints and pest incidence, were systematically recorded through field observation and farmer reporting. Additionally, adaptive and management strategies employed by farmers such as plot division, intercropping, and crop rotation adjustments were captured to understand how cultivators respond to biophysical limitations and economic pressures. Farmers' perceptions of long-term changes in soil health, productivity trends, and yield responses to repeated cropping were also carefully documented, providing a valuable socio-agronomic perspective to complement empirical field measurements.

### Methodology - Data Analysis

The collected data were compiled and analysed using descriptive statistical techniques such as frequency distribution, percentages, and averages to identify patterns and trends in cropping systems across different farm categories. Quantitative information on landholding size, crop area, monocropping frequency, and rotation practices was analysed to quantify the prevalence of specific agricultural practices and their spatial distribution across the taluka.

Qualitative insights derived from farmer interviews, group discussions, and village-level consultations were systematically integrated with quantitative observations to interpret variability in cropping patterns and adaptive management strategies. This

combined approach facilitated the identification of relationships between farm size, resource availability, and cropping decisions, while also highlighting context-specific challenges such as nutrient depletion, pest pressure, and economic vulnerability.

By triangulating empirical measurements with farmer-reported experiences, the study ensured that the findings reflect both the ecological realities and socio-economic dimensions of agriculture in Ajara Taluka. This comprehensive methodology provided a Proper foundation for assessing the sustainability of sugarcane-dominated systems and evaluating the potential benefits of crop rotation and diversified cropping interventions.

### Existing Cropping Patterns and Cultivation Practices

#### Cropping Patterns Across Farm Categories

Field investigations across Ajara Taluka revealed that cropping practices are closely linked to landholding size, labour availability, and economic considerations, resulting in distinct patterns among small, medium, and large farmers. Large landholding farmers typically adopt diversified cropping systems, dividing their holdings into multiple plots to facilitate crop rotation, intercropping, and staggered planting schedules. This approach allows them to optimize resource utilization, mitigate risks associated with crop failure, and maintain soil fertility through varied cultivation practices.

Medium-sized farmers, while exhibiting some diversification, largely follow traditional paddy-sugarcane sequences. Economic dependence on sugarcane as a stable source of income often limits the adoption of alternative crops, although occasional rotations with minor cereals or pulses are practiced to supplement household food requirements. In contrast, small farmers, constrained by limited land and labour, predominantly engage in monocropping. Paddy is cultivated during the Kharif season primarily for household consumption, while sugarcane serves as the principal year-round cash crop. Minor crops such as ragi, chickpea, and groundnut are cultivated on a limited scale, mainly to fulfill subsistence needs rather than for commercial purposes.

Crop rotation practices in Ajara Taluka vary with farm size and resource availability. Small and medium farmers often partition their land into multiple plots to allow rotation between sugarcane, paddy, and minor crops such as pulses or coarse cereals. While these rotations help distribute labour demand, manage risk, and maintain soil productivity to some extent, the predominance of sugarcane limits the overall effectiveness of these strategies. Large farmers demonstrate greater flexibility, implementing diverse rotational sequences that combine cash crops, cereals, and legumes to optimize soil fertility and reduce pest and disease incidence.

Cashew cultivation represents a strategic component of cropping systems in the taluka. Small and medium farmers predominantly plant cashew along field bunds as a border crop, whereas larger farmers often dedicate separate plots for commercial cashew cultivation. Beyond its economic value, cashew plays a critical ecological role by reducing soil erosion, improving organic matter content through leaf litter, and stabilizing field boundaries under heavy rainfall conditions. Its consistent income stream functions as a risk-buffer, particularly during years when seasonal crops are adversely affected by climatic variability or pest outbreaks.

Overall, the cropping patterns observed in Ajara Taluka reflect a complex interplay between agro-climatic suitability, market incentives, landholding size, and farmer adaptation strategies. While sugarcane-based monocropping provides economic stability, the study highlights the need for more systematic crop

rotation, diversification, and integration of perennial crops such as cashew to enhance soil health, resilience, and long-term sustainability of local farming systems.

### Seasonal Cropping Patterns

Seasonal cropping patterns in the taluka reflect the region's high rainfall and irrigation availability. During the Kharif season, paddy dominates due to reliable monsoonal precipitation, while ragi is grown on marginal or upland plots by a few farmers. The Rabi season is largely devoted to sugarcane management, including harvesting and maintenance activities, with chickpea grown by a minority of farmers. The Zaid season is characterized by intensive care of perennial crops, with sugarcane exhibiting active vegetative growth and cashew harvests contributing to supplementary income.

### Crop Rotation Practices

In Ajara Taluka, crop rotation represents a key adaptive strategy through which farmers strive to balance household food security with income generation, particularly under conditions of limited landholding. Observations from the field indicate that small and medium farmers often subdivide their land into multiple plots to implement rotational cropping. For example, farmers with around two acres typically dedicate one plot to sugarcane, a second to paddy, and a third to supplementary crops such as ragi or chickpea. This structured sequencing of crops serves several agronomic and economic purposes: it helps maintain soil fertility, facilitates more even distribution of labour across different seasons, and mitigates financial risks by diversifying sources of income.

Large landholders exhibit greater flexibility in implementing crop rotation due to the availability of more extensive land resources. They are able to integrate a broader range of crops and employ more complex rotational sequences, thereby optimizing nutrient cycling and reducing pest and disease pressure. In contrast, smallholders, constrained by land scarcity and strong economic dependence on sugarcane, often follow narrower crop sequences, which may limit the restorative benefits of rotation.

Despite these limitations, the persistence of traditional crop rotation practices across all farm categories highlights farmers' awareness of the importance of sustaining soil productivity over the long term. Even within the constraints of small-scale holdings, these practices demonstrate a pragmatic understanding of ecological principles and indicate that crop rotation remains a viable approach for maintaining soil health, improving system resilience, and supporting the economic stability of farming households in the region.

### Cashew Cultivation as a Border and Risk-Buffer Crop in Ajara Taluka

Cashew cultivation constitutes an important component of farming systems in Ajara Taluka and is practiced across all categories of farmers. Field observations indicate that small and medium landholding farmers predominantly grow cashew along field bunds as a border crop, whereas large landholding farmers often allocate separate plots for cashew as a principal or supplementary commercial crop. The widespread adoption of cashew is largely attributed to its low input requirement, minimal management needs, and favourable market returns during the harvesting season.

Beyond its economic value, cashew plays a significant ecological and protective role in the high-rainfall environment of Ajara Taluka. Planting cashew along field boundaries helps

reduce surface runoff and soil erosion during the monsoon season, thereby safeguarding cultivated fields. In addition, cashew provides a reliable supplementary source of income, contributing to household financial stability without competing for prime agricultural land.

Importantly, cashew functions as a "guardian" or risk-buffer crop within local farming systems. In years when seasonal crops such as paddy or sugarcane are adversely affected by excessive rainfall, pest incidence, or other climatic uncertainties, income from cashew harvests helps offset crop losses. This risk-mitigation function is particularly valuable for small and medium farmers, who face greater vulnerability due to limited land and economic resources.

The integration of cashew as a border and perennial crop reflects an adaptive farming strategy that combines economic benefits with soil conservation and risk reduction. Its role in enhancing system resilience underscores the importance of incorporating perennial border crops into sustainable cropping system planning in high-rainfall regions such as Ajara Taluka.

### Role of Cashew in Soil Fertility Maintenance and Risk Management

Cashew cultivation in Ajara Taluka contributes not only to farm income but also to the maintenance of soil health and the reduction of production risks in a high-rainfall environment. When grown as a border or perennial crop, cashew trees help stabilize field boundaries and reduce soil erosion caused by intense monsoonal rainfall. The extensive root system of cashew enhances soil aggregation and improves soil structure, thereby facilitating better water infiltration and reducing nutrient loss through surface runoff.

Leaf litter from cashew plantations adds organic matter to the soil, which plays an important role in improving soil fertility over time. Decomposition of fallen leaves contributes to nutrient recycling, particularly of nitrogen and potassium, and enhances microbial activity in the soil. These processes are especially beneficial in fields subjected to continuous cultivation of paddy and sugarcane, where repeated cropping often leads to nutrient depletion and declining soil quality.

From a risk-management perspective, cashew functions as a stabilizing component of the farming system. Income from cashew harvests provides financial support during years when seasonal crops are adversely affected by excessive rainfall, pest outbreaks, or market fluctuations. Unlike annual crops, cashew is less sensitive to short-term climatic variability once established, making it a reliable source of supplementary income. This risk-buffer function is particularly significant for small and medium farmers, who have limited capacity to absorb crop losses.

### Crop Rotation as a Remedial Strategy for Sustainable Farming

Crop rotation constitutes a critical agronomic strategy that involves the deliberate and sequential cultivation of different crops on the same land over time to sustain soil fertility and optimize resource utilization (Indian Council of Agricultural Research, 2019; Rattan Lal, 2015) <sup>[11]</sup>. In high-rainfall regions such as Ajara Taluka, where farming systems are heavily dominated by paddy-sugarcane sequences, repeated cultivation of the same crops has become a common practice, particularly among small and medium landholders. Such repetitive monocropping often results in the depletion of essential soil nutrients, degradation of soil structure, and increased susceptibility to pest and disease outbreaks, ultimately leading to

reduced crop performance and productivity (Singh & Sharma, 2019; Meena *et al.*, 2020) <sup>[20, 12]</sup>.

Implementing well-planned crop rotation systems offers an effective remedial approach to these challenges. By alternating crops with varying nutrient requirements and rooting depths, farmers can enhance nutrient cycling, improve soil physical and biological properties, and interrupt pest and disease life cycles (Rattan Lal, 2015; Thapa *et al.*, 2021) <sup>[11, 22]</sup>. Integrating legumes and low-input crops within these rotations further contributes to nitrogen enrichment and reduces dependence on synthetic fertilizers (Indian Council of Agricultural Research, 2019). Beyond soil health, crop rotation also enhances system resilience by diversifying production risks and stabilizing farm incomes, making it an indispensable tool for promoting sustainable agriculture in sugarcane-dominated landscapes such as Ajara Taluka.

### **Principles of Crop Rotation in the Context of Ajara Taluka**

Effective crop rotation practices in the study area need to be tailored to local agro-climatic conditions, landholding size, and farmers' socio-economic realities. Alternating deep-rooted and shallow-rooted crops allows for more uniform extraction of nutrients from different soil layers, thereby reducing localized nutrient exhaustion. The inclusion of leguminous crops, such as pulses, after non-leguminous crops is particularly important for enhancing soil nitrogen through biological nitrogen fixation and improving overall soil fertility. Rotations that alternate input-intensive crops, such as sugarcane, with relatively low-input crops help reduce cultivation costs and lessen pressure on soil and water resources. Crop selection based on household consumption needs and market demand ensures economic viability, while problem-oriented crop choices are essential in erosion-prone and high-rainfall areas. Selecting crops suited to local soil types and climatic conditions improves crop performance and reduces the risk of crop failure.

Avoiding the successive cultivation of crops belonging to the same botanical family is critical for breaking pest and disease cycles, especially in systems dominated by cereals. Efficient planning of crop sequences also allows better distribution of labour and farm inputs throughout the year, which is particularly beneficial for small and medium farmers with limited resources.

### **Advantages of Crop Rotation and Diversified Cropping Systems**

The adoption of crop rotation and diversified cropping systems offers multiple agronomic, ecological, and economic benefits. By restoring and maintaining soil fertility, crop rotation improves nutrient availability and enhances microbial activity, contributing to sustained productivity. Diversified cropping reduces pest, disease, and weed pressure by disrupting the life cycles of crop-specific organisms, thereby lowering dependence on chemical control measures.

Improved soil structure and enhanced moisture conservation resulting from diversified root systems are especially valuable under high rainfall conditions, where soil erosion and nutrient leaching are common concerns. Crop rotation also enables better utilization of residual nutrients and organic matter left by preceding crops, improving overall resource-use efficiency.

From a risk-management perspective, diversified cropping systems reduce the likelihood of complete crop failure by spreading production risks across different crops and seasons. This, in turn, contributes to improved farm income stability and livelihood security. In the context of Ajara Taluka, the strategic integration of crop rotation into sugarcane-dominated systems

represents a viable pathway toward sustainable agriculture and long-term resilience.

### **Recommendations**

The findings of this study indicate that sustainable intensification of agricultural systems in Ajara Taluka requires targeted interventions focused on crop rotation, diversification, soil health management, and institutional support.

#### **Promotion of Scientifically Planned Crop Rotations**

The development and dissemination of locally adapted crop rotation models are essential for restoring soil fertility, enhancing nutrient balance, and mitigating pest and disease pressures in sugarcane-dominated systems. Rotational schemes incorporating legumes, coarse cereals, and low-input crops can reduce dependency on chemical fertilizers, improve soil nitrogen content through biological fixation, and maintain long-term productivity. Encouraging farmers to adopt these evidence-based rotation plans will strengthen system resilience while supporting economic viability.

#### **Farm Size-Specific Diversification Strategies**

Recognizing the constraints of land and labour faced by small and medium farmers, crop diversification approaches must be tailored to the scale of farming operations. Simplified, flexible rotation models that accommodate multiple crops within limited landholdings can help distribute labour demands, optimize resource use, and reduce risk associated with monocropping. Large landholders, with greater flexibility, can adopt more complex sequences that combine cash crops, food crops, and legumes to maximize both economic returns and ecological benefits.

#### **Strengthening Extension Services and Farmer Awareness**

Effective extension mechanisms are critical to improving farmer knowledge of soil health management, the long-term advantages of crop rotation, and the risks associated with repetitive monocropping. Field demonstrations, participatory training sessions, and advisory support can facilitate the adoption of improved cropping practices. Enhancing awareness among farmers will also promote adaptive decision-making, enabling them to respond to soil fertility changes, pest outbreaks, and climatic variability in a timely manner.

#### **Encouragement of Perennial Border Crops**

Perennial crops such as cashew provide multiple agronomic and economic benefits, particularly when cultivated along field boundaries. Their continued and expanded integration into farming systems can enhance soil conservation, reduce erosion under high rainfall conditions, and provide supplementary income without encroaching on prime agricultural land. Adoption of such multifunctional crops not only stabilizes fields ecologically but also functions as a risk-buffer against seasonal crop failures.

#### **Soil Health Monitoring and Advisory Support**

Periodic soil testing and site-specific nutrient management advisories are essential for addressing nutrient imbalances, optimizing fertilizer use, and improving overall soil fertility. Regular monitoring allows farmers to make informed decisions regarding crop selection, input application, and rotational planning, thereby sustaining soil productivity and ensuring long-term farm viability.

### Policy and Institutional Support

Sustained adoption of crop rotation and diversified cropping systems requires robust policy and institutional backing. Policymakers should incorporate these practices into agricultural development programs and incentive structures, particularly in high-rainfall, sugarcane-dominated regions. Supportive interventions can include financial incentives, technical guidance, market facilitation for rotational crops, and integration of soil health programs, all of which contribute to the ecological sustainability and livelihood security of farmers in Ajara Taluka.

### Discussion

The present study provides a detailed field-based understanding of cropping systems in Ajara Taluka, a high-rainfall region where sugarcane dominates across farm categories. The findings indicate that cropping decisions are influenced not only by agro-climatic suitability but also by market assurance, institutional support, and landholding constraints. While sugarcane cultivation enhances income stability, its continuous cultivation under monocropping or narrow crop sequences contributes to emerging concerns related to soil fertility decline and long-term sustainability, consistent with earlier findings on intensive cropping systems (Singh & Sharma, 2019; Kumar *et al.*, 2022) [20, 10].

The widespread adoption of sugarcane reflects the role of assured procurement through cooperative institutions, a trend also observed in other parts of Maharashtra (Patil & Deshmukh, 2017) [16]. However, the study highlights that small and medium farmers are more vulnerable to the negative impacts of repetitive cropping due to limited land and reduced scope for diversification. Their dependence on sugarcane-paddy systems increases pressure on soil nutrients and biological processes, supporting evidence from previous studies on monocropping-induced soil degradation (Lal, 2015; Meena *et al.*, 2020) [11, 12]. Paddy cultivation during the Kharif season remains essential for household food security under high rainfall conditions. However, repeated paddy-sugarcane sequences contribute to soil compaction, nutrient imbalance, and declining fertilizer efficiency. Farmers' perceptions of reduced productivity and increased pest incidence align with documented impacts of continuous cropping on soil health and system resilience (Jat *et al.*, 2021; Sharma *et al.*, 2023) [9, 19].

Crop rotation practices observed in the study area reflect farmers' adaptive strategies to manage risk and maintain productivity. While small and medium farmers attempt limited diversification through plot division, these efforts remain insufficient to offset the long-term effects of continuous sugarcane cultivation. In contrast, larger farmers exhibit greater flexibility in crop sequencing, enabling better nutrient management and risk distribution.

A distinctive feature of the study area is the integration of cashew as a border and perennial crop. Beyond its economic contribution, cashew plays an important ecological role in reducing soil erosion, improving soil structure, and enhancing organic matter through leaf litter. This multifunctional role is consistent with agroforestry-based approaches to soil conservation and sustainable land management (Nair, 2012) [14].

The findings underscore the importance of crop rotation as a practical strategy for restoring soil fertility and improving system resilience. Incorporating legumes and low-input crops within sugarcane-based systems can enhance nutrient cycling, improve soil biological activity, and reduce pest and disease pressure (Thapa *et al.*, 2021) [22]. Such strategies are particularly relevant in high-rainfall regions where nutrient leaching and soil

degradation are persistent challenges.

Overall, the study suggests that while sugarcane-based systems contribute to rural income stability, their long-term sustainability depends on the integration of crop rotation, diversification, and perennial components. Strengthening extension services and promoting context-specific soil management practices are essential for balancing productivity with ecological sustainability.

### Limitations of the Study

While the present study provides detailed field-based insights into cropping systems in Ajara Taluka, certain limitations should be acknowledged. The geographical focus on a single taluka restricts the wider generalization of findings to other regions with differing agro-climatic and institutional conditions. The use of purposive and community-assisted sampling, although effective in capturing responses across farm categories, may not fully represent all segments of the farming population.

The study largely relies on farmer-reported information and field observations, which may be subject to recall bias and individual perceptions, particularly in assessing soil fertility changes and pest incidence. In addition, the absence of laboratory-based soil analysis limits the ability to empirically validate soil health conditions, making such conclusions indicative in nature.

Further, the cross-sectional design of the study captures conditions at a specific point in time and does not account for long-term variations in cropping patterns or soil dynamics. The analysis is primarily descriptive, and the lack of advanced statistical or detailed economic assessment restricts deeper examination of relationships between variables and profitability aspects of different cropping systems.

### Conclusion

The study, based on extensive field observations across 95 villages of Ajara Taluka, highlights the central role of sugarcane in shaping local cropping systems and rural livelihoods. Supported by favourable agro-climatic conditions and institutional market structures, sugarcane serves as the primary source of farm income, while paddy cultivation remains critical for household food security.

However, the dominance of sugarcane-paddy monocropping, particularly among small and medium farmers, has led to concerns related to declining soil fertility, nutrient imbalance, and increased vulnerability to pests and climatic variability. The findings clearly indicate that continuous cultivation without adequate crop rotation adversely affects long-term soil health and system resilience.

Although crop rotation practices exist, their effectiveness is constrained by land limitations, labour availability, and economic dependence on sugarcane. The integration of cashew as a border crop emerges as an important adaptive strategy, contributing to soil conservation, organic matter improvement, and supplementary income.

The study concludes that sustainable agricultural development in Ajara Taluka requires a balanced approach that maintains the economic advantages of sugarcane cultivation while addressing ecological challenges through crop rotation, diversification, and soil-friendly practices. Promoting legume-based rotations, strengthening extension support, and encouraging site-specific interventions will be critical for enhancing long-term sustainability and resilience of farming systems.

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### Conflict of interest

The author reports no conflict of interest related to this study.

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