

Agricultural Sustainability in Haryana: Evidence from Yield Growth, Fertilizer Use, and Input Efficiency

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Abstract:

This study analyses agricultural sustainability in Haryana from 1966–67 to 2022-23 using secondary data, focusing on productivity, input use, and structural characteristics. The findings reveal a strong sustainability paradox in which wheat and rice yields increased nearly 3.27 times, while chemical fertilizer consumption rose more than 100-fold, indicating a substantial decline in Fertilizer Use Efficiency and the presence of diminishing marginal returns. Agricultural growth in Haryana has been associated with severe NPK imbalance, soil degradation, and groundwater depletion. Land fragmentation remains acute, with marginal and small farmers dominating holdings and an average operational size of 0.76 hac, leading to subsistence-driven intensification and high dependence on chemical inputs. The results indicate that Haryana's production-oriented agricultural model is ecologically fragile and requires a transition toward resource-efficient and land-size-sensitive strategies.

Keywords: Sustainability, Agriculture, Productivity, Haryana, Rice, Wheat.

1. Introduction:

Agricultural sustainability is a critical concern for Haryana, a state in India known for its significant contribution to the country's food production. As one of the leading agricultural regions, Haryana faces the dual challenge of enhancing crop yields while ensuring environmental sustainability (Ashish, 2024). This research explores the intricate dynamics of agricultural practices in the state, with a particular emphasis on yield optimization, fertilizer usage, and operational land holdings. The interplay between these factors is crucial for developing sustainable agricultural strategies that not only meet the growing food demands but also preserve the ecological balance (Singh et al., 2023). By examining the current trends and practices in Haryana's agriculture, this study aims to provide valuable insights. These insights focus on sustainable farming methods that can improve productivity without compromising the health of the land and its resources. Understanding the relationship between yield, fertilizer application, and land holding patterns will be instrumental in formulating policies and practices that promote long-term sustainability in Haryana's agricultural sector (Devi et al., 2023).

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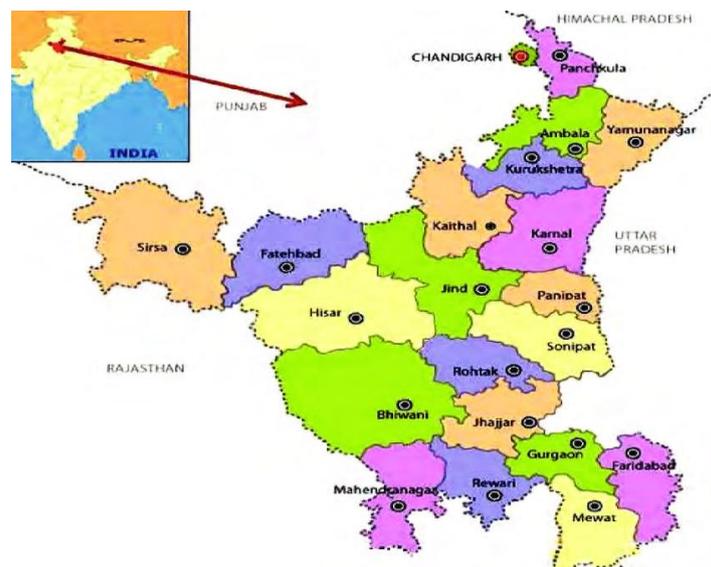
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Agriculture remains the backbone of the socio-economic fabric of Haryana. Since its inception in 1966, the state has undergone a dramatic transformation, evolving from a food-deficit region to the “Granary of India”. This transition was primarily driven by the Green Revolution, characterized by the intensive use of High-Yielding Variety seeds, expansion of canal and tube-well irrigation, and a heavy reliance on chemical fertilizers and pesticides.

Haryana’s agricultural profile is characterized by its small land area of 4.42 million hectares, yet it remains a pioneer in food crop production, significantly contributing to the national economy (Panwar & Dimri, 2018). The state has recorded a remarkable 15.9 percent contribution to the Gross State Value Added from agriculture in 2025 which highlighting its vital role in economic growth (Gupta, 2025). Even after rapid industrialization, agriculture remains the backbone of Haryana’s economy making a substantial contribution to the state’s economic development (Mafi et al., 2024). However, this agricultural transformation, while achieving self-sufficiency in food production, has also led to a range of environmental challenges. Intensive farming practices associated with the Green Revolution have contributed to soil degradation, declining organic matter, and contamination of water resources due to excessive use of chemical inputs (Singh, 2000). Furthermore, the growth in agricultural productivity across the state has been uneven, with regional disparities shaped by socio-economic, physiographical, and institutional factors (Ghosh, 2013). The adverse effects of intensive cultivation and indiscriminate fertilizer use have led to land and water degradation and declining environmental quality, posing serious threats to agricultural sustainability and national food security (Kumar et al., 2022; Goyal et al., 2024). These challenges highlight the urgent need for a comprehensive assessment of agricultural sustainability and the adoption of environmentally sound farming practices in Haryana.

Figure 1: Map of Haryana.



Source: Internet open source

Agriculture sustainability must be measured through three dimensions economic, environmental, and social (Bathaei & Štreimikienė, 2023). Analysis through these dimensions give an idea regarding sustainability of agriculture. Economic sustainability reflects the ability

of the agricultural system to maintain stable and adequate productivity and farm income, which in this study is assessed using the average yield¹ of major crops. Environmental sustainability focuses on the conservation of natural resources and the ecological impacts of farming practices. Accordingly, fertilizer consumption has been used as an indicator to evaluate environmental pressure on agricultural land. Social sustainability relates to equity, livelihood security, and the structure of farming communities, and is examined through operational landholding size based on 2015-16 data. An integrated assessment of these three dimensions provides a comprehensive understanding of agricultural sustainability, as imbalances among them can undermine long-term agricultural development.

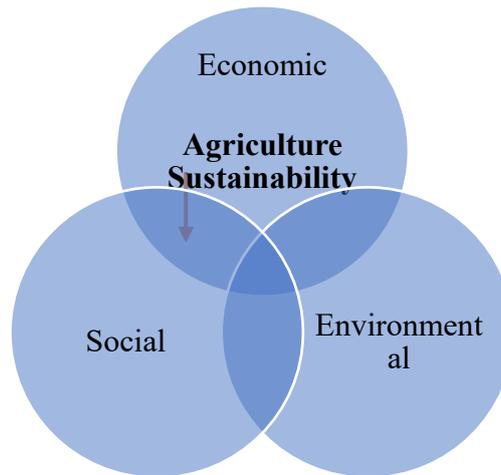


Figure 2: *Three dimensions of Agriculture Sustainability.*

1.1 Research Problem:

Despite the continuous increase in the Index of Agricultural Production, growing evidence of diminishing marginal returns on agricultural inputs has emerged. The relationship between fertilizer consumption and crop yield is no longer linear which indicating a gradual decline in the soil's inherent productivity. This trend highlights serious concerns regarding the long-term sustainability of agricultural productivity in Haryana, particularly in the context of ongoing pressure on natural resources.

1.2 Objectives of the Study:

This paper aims to analyze the trajectory of agricultural sustainability in Haryana from 1966 to 2023 using secondary data. The specific objectives are:

1. To examine the long-term trends in the yield of major food crops (Rice, Wheat).
2. To analyze the growth in chemical fertilizer consumption and its correlation with yield.
3. To assess the implications of land-holding patterns on the sustainability of the farming model.

1.3 Significance of The Study:

By using longitudinal data from the Statistical Abstract of Haryana, this study provides a clear

¹ Average yield refers to production per unit area.

picture of the efficiency gap in modern farming. The findings will be crucial for policymakers to advocate for a shift from “Production-Centric” agriculture to “Resource-Efficient” or “Sustainable” agriculture.

2. Methodology:

This research employs a quantitative and analytical framework to evaluate the sustainability of agriculture in Haryana across three core dimensions: economic, environmental, and social. The study relies on longitudinal secondary data spanning from 1966-67 to 2022-23 which primarily sourced from the Statistical Abstract of Haryana. Economic sustainability is assessed through the average yield of Wheat and Rice, which represent the state’s major food crops. Environmental pressure is measured via chemical fertilizer consumption trends, while social sustainability is analyzed using 2015-16 operational landholding data categorized into marginal/small, medium, and large groups. The analytical approach includes trend-line analysis to track productivity growth over time, the Pearson correlation coefficient (r) to examine the relationship between fertilizer inputs and yields. A critical evaluation of Fertilizer Use Efficiency (FUE) based on the Law of Diminishing Marginal Returns to identify long-term ecological and economic vulnerabilities.

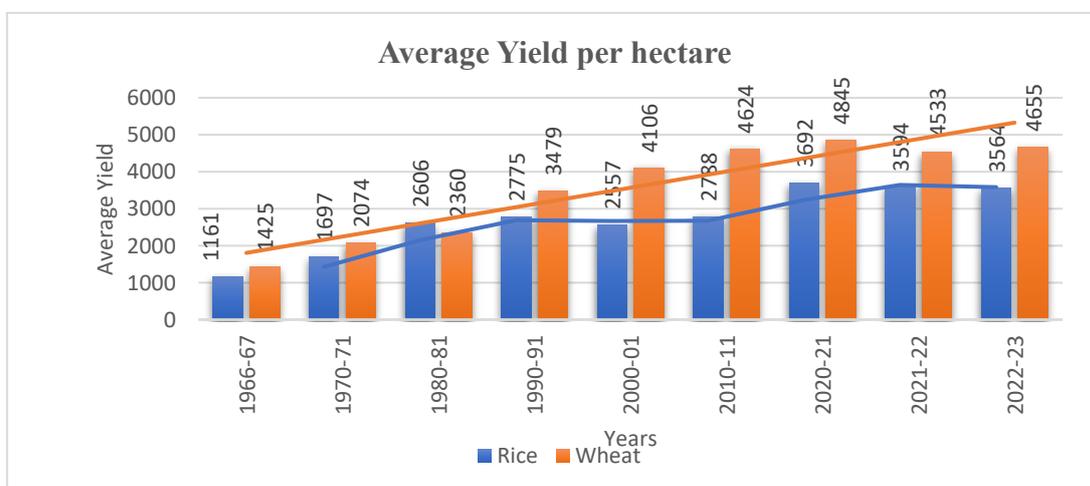
3. Result:

This section presents the results of the study focusing on trends in crop yield and fertilizer use, and the relationship between fertilizer application and crop productivity in Haryana from 1966-67 to 2022-23. The analysis is limited to wheat and rice, as these are the most important staple food crops and play a critical role in food security and agricultural sustainability.

3.1 Trend in Average Productivity per Hectare of Wheat and Rice

The trend line of average Productivity per hectare for wheat and rice indicates a generally increasing pattern over the study period in figure 3. Both crops show improvements in productivity, reflecting advancements in agricultural practices, improved seed varieties, irrigation facilities, and better farm management techniques.

Figure 3: Average Yield per Hectare.



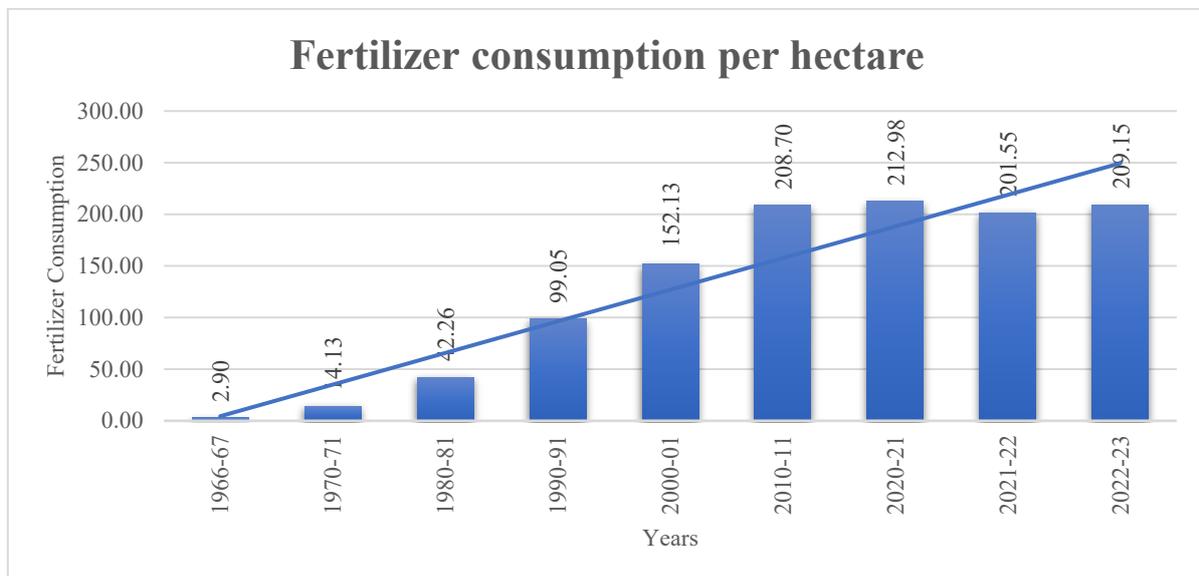
Source: Author’s Calculations (Statistical Abstract of Haryana 2023-24).

Wheat and rice were selected for analysis because they are the most widely cultivated and consumed cereal crops, forming the backbone of national food security. These crops contribute significantly to caloric intake, farmer income, and overall agricultural output. Any change in their yield has direct implications for food availability and economic stability. An analysis of yield trends reveals a sustained increase in cereal productivity over time. Wheat shows the most robust growth, with average yields rising from 1,425 kg/ha in 1966-67 to 4,655 kg/ha in 2022-23, as indicated by the trendline analysis. Rice has followed a similar upward trajectory, increasing from 1,161 kg/ha to 3,564 kg/ha during the same period. However, its trendline reflects a gradual deceleration or plateauing in the decades following the initial Green Revolution phase. Although both crops demonstrate upward trends, variations in growth rates are observed, which may be attributed to differences in crop response to inputs, climatic conditions, and cultivation practices. Overall, the trend suggests a positive development in cereal crop productivity.

3.2 Trend in Fertilizer Consumption

The trend line of fertilizer use shows a consistent increase over time, indicating a growing reliance on chemical fertilizers to enhance agricultural production. This rise reflects efforts to meet the increasing food demand driven by population growth and limited availability of arable land.

Figure 4: *Fertilizer Consumption per Hectare.*



Source: Author's Calculations (Statistical Abstract of Haryana 2023-24).

The graph illustrates periods of gradual increase as well as phases of relatively rapid growth in fertilizer application. These fluctuations may be associated with changes in agricultural policies, fertilizer subsidies, technological adoption, and farmer awareness. Fertilizer use has seen a dramatic increase over the years which is 2.90 tonnes in 1966-67 and 209.15 tonnes in 2022-23, as shown in Figure 4. The increasing trend suggests that fertilizer input has become an essential component of modern farming systems. However, the trend also highlights the

importance of balanced and efficient fertilizer use, as excessive application may lead to environmental degradation and diminishing returns in crop yield.

3.3 Relationship Between Fertilizer Use and Crop Yield (Wheat and Rice)

The relationship between fertilizer uses and the yield of wheat and rice shows a positive association, indicating that increased fertilizer application contributes to higher crop yields. As fertilizer use increases, the average yield per hectare of both wheat and rice also tends to rise. This relationship suggests that fertilizers play a crucial role in supplying essential nutrients required for crop growth and productivity. However, the strength of the relationship varies between wheat and rice, reflecting differences in nutrient requirements, soil conditions, and crop physiology. While fertilizer use significantly influences yield, the results also indicate that fertilizer alone does not fully determine productivity. Other factors such as rainfall, irrigation, soil quality, and farming practices also affect yield outcomes. Therefore, sustainable yield improvement requires an integrated approach combining efficient fertilizer use with other agronomic practices.

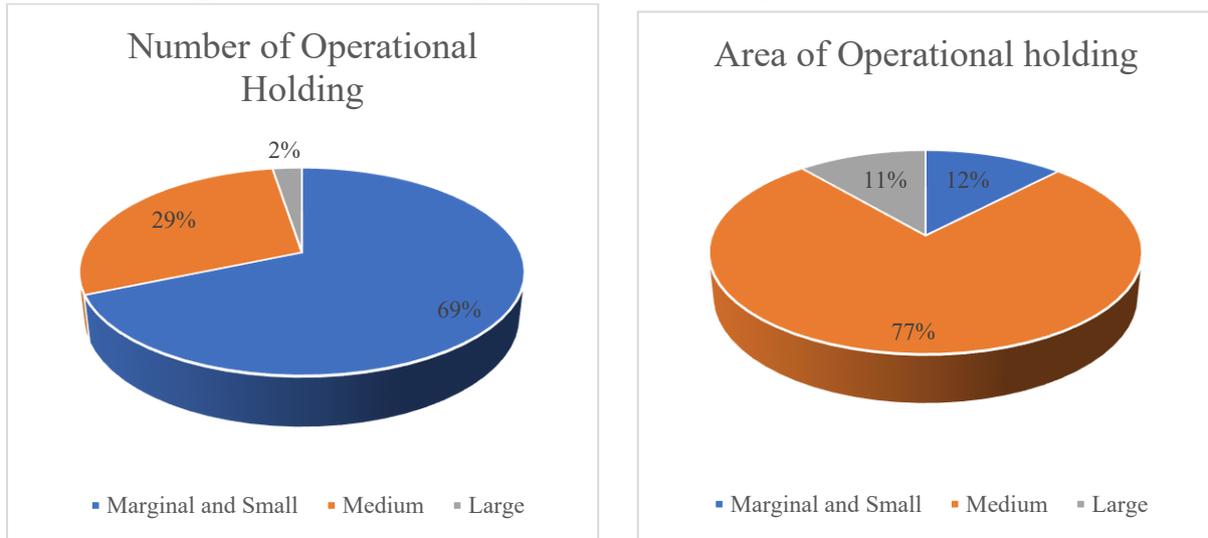
The Pearson correlation coefficient (r) between fertilizer consumption and average yield of rice is **0.83**, indicating a strong positive relationship between the two variables. This high positive value suggests that increases in fertilizer use are closely associated with increases in rice yield per hectare. The result implies that fertilizer application plays a significant role in enhancing rice productivity by supplying essential nutrients required for plant growth and grain formation. The Pearson correlation coefficient for wheat is $r = 0.99$, shows a positive relationship, indicating that higher fertilizer use is generally associated with increased wheat yield. Although the strength of the relationship may differ slightly from that of rice, the positive correlation confirms that fertilizer input is an important factor influencing wheat productivity.

These findings demonstrate that fertilizer consumption has a substantial impact on the yields of both major cereal crops. However, the correlation does not imply causation, and yield performance is also influenced by other factors such as climatic conditions, irrigation availability, soil fertility, and crop management practices. Therefore, while fertilizer use contributes significantly to yield improvement, sustainable increases in wheat and rice production require a balanced and integrated agricultural approach.

3.4 Analysis of Structural Dimension: Operational Holdings

The structural dimension of agriculture serves as the foundational framework for sustainability because it dictates the distribution and utilization of land as the primary resource. A critical component of this dimension is the pattern of operational holdings, which refers to the actual land area used wholly or partly for agricultural production by a single unit (Ardakani et al., 2020). The size and distribution of these holdings are decisive factors in determining a farmer's capacity for investment, mechanization, and the implementation of long-term ecological conservation measures (Ren et al., 2019). In a landscape characterized by extreme disparity, the viability of sustainable practices often hinges on whether a holding provides sufficient scale for economic and environmental efficiency.

Figure 5: *Distribution of Operational Holdings and Area (2015-16).*



Source: Author's Calculations (Statistical Abstract of Haryana 2023-24).

The charts illustrate a highly fragmented land structure, where Marginal & Small farmers constitute the majority of holdings but operate on limited land area, hindering the adoption of sustainable agricultural practices. The structural dimension of agricultural sustainability, analyzed through operational holdings for 2015-16 which reveals a highly fragmented and skewed land distribution. For a detailed analysis, the total operational holdings were categorized into three groups: Marginal and Small (up to 2.0 hectares), Medium (2.0 to 10.0 hectares), and Large (10.0 hectares and above). The data highlights that the agricultural sector is heavily dominated by the Marginal and Small category, accounting for 1,116,333 holdings with an average size of only 0.76 hectares. This sub-hectare average poses a severe challenge to sustainability as it limits the adoption of modern, resource-efficient technologies. In contrast, the medium category manages a significant portion of land with an average of 11.39 hectares, providing better economic viability. The Large category, while numerically small (41,385 units), operates on extensive areas with an average size of 19.03 hectares. From a sustainability perspective, this disparity indicates that while medium and large farmers have the spatial capacity for sustainable investments, the vast majority (Marginal and Small) are forced into 'subsistence-driven intensification'. This leads to a higher reliance on chemical fertilizers to maximize output from limited land, ultimately threatening long-term soil health and agricultural stability.

4. Discussion:

The empirical results presented in the previous section necessitate a deeper critical analysis to understand the sustainability trajectory of the region's agriculture. The findings collectively indicate that agricultural growth has been driven primarily by improvements in productivity rather than the expansion of cultivated land, as reflected in the upward trend of wheat and rice yields. This productivity-led growth pattern, however, warrants closer examination of the inputs supporting it. While a statistical correlation exists between rising fertilizer application and increased crop productivity, a deeper analysis of the provided data reveals a significant threat to long-term sustainability. This phenomenon is best explained through the Law of

Diminishing Marginal Returns, where the growth in inputs has vastly outpaced the growth in output. Specifically, between 1966-67 and 2022-23, the yield of wheat increased by approximately 3.27 times (from 1,425 kg/ha to 4,655 kg/ha). Whereas fertilizer consumption per hectare² skyrocketed by over 100 times, jumping from 2.90 tonnes to 209.15 tonnes, as shown in figure 4. Such a disproportionate increase clearly signals structural inefficiencies in input use. This massive disparity indicates a sharp decline in Fertilizer Use Efficiency. A single unit of fertilizer today produces far less grain than it did five decades ago, suggesting that the soil's natural fertility is exhausted and yields are being "forced" through excessive chemical intervention (Conant et al., 2013).

Beyond declining efficiency, the nature of fertilizer use itself further intensifies environmental stress. Furthermore, the ecological impact is compounded by a severe NPK imbalance within the state's fertilizer consumption profile (Sharma et al., 2023). According to the 2022-23 per hectare data, the consumption is heavily skewed toward Nitrogen (N), which accounts for 160.43 units per hectare, while Potassium (K) stays at a mere 3.73 units per hectare. This skewed ratio aimed primarily at maintaining the rapid growth of wheat and rice which leads to soil acidification, nutrient mining, and increased risk of nitrate leaching into the groundwater. Consequently, what appears to be a positive correlation in productivity is actually a sign of increasing ecological and economic vulnerability for Haryana's farmers, as the system now requires more chemicals for smaller marginal gains in yield (Panwar & Dimri, 2018). The trend illustrates that while fertilizer application per hectare has reached extreme levels, the lack of a balanced nutrient approach further threatens the long-term health of the soil.

These environmental outcomes cannot be understood in isolation from the region's landholding structure. The findings indicate that agricultural sustainability in the study area is shaped by a complex interaction between land structure, input intensity, and productivity outcomes. The dominance of fragmented landholdings has emerged as a critical structural constraint, particularly for marginal and small farmers, who operate under severe spatial limitations (Sharma & Malik, 2021). The long-term growth in yield and fertilizer usage must be viewed against the backdrop of shrinking operational holdings, which complicates the path to sustainable agriculture. This structural pressure has encouraged a pattern of input-intensive cultivation, wherein chemical fertilizers are increasingly used to compensate for limited land availability rather than to enhance inherent soil productivity (Hossain & Singh, 2000). When examined together, fragmented landholdings and rising input use form a mutually reinforcing cycle of dependency. The long-term rise in fertilizer consumption, when viewed alongside this fragmented land structure, suggests a negative sustainability linkage in which declining land size intensifies chemical dependency.

While this strategy has contributed to improved economic performance in terms of rising crop yields, it simultaneously raises concerns regarding environmental sustainability. Productivity gains achieved under such conditions are increasingly reliant on external inputs rather than resource efficiency, indicating a shift toward chemically driven output growth (Shrestha & Subedi, 2019). In contrast, medium and large landholders possess greater capacity to adopt

² Fertilizer per hectare = Total fertilizer/ Total cropped area.

resource-conserving technologies and balanced input use, highlighting an emerging sustainability divide within the agricultural system. Consequently, the coexistence of rising productivity and environmental stress reflects a sustainability paradox, where economic gains are being realized at the cost of ecological stability. This imbalance underscores the need for land-size-sensitive sustainability interventions that reduce input dependency while maintaining productivity, particularly for marginal and small farmers.

5. Conclusion:

The study concludes that while Haryana has successfully transitioned into the “Granary of India” since 1966, its current agricultural model faces a significant sustainability paradox. Economic gains, evidenced by a robust increase in Wheat and Rice yields and a 15.9 percent contribution to the GSVA, are being undermined by deteriorating environmental and structural factors. The massive surge in chemical fertilizer consumption which increasing over 100 times compared to a mere 3.27 times increase in wheat yield, highlights a sharp decline in Fertilizer Use Efficiency and the onset of diminishing marginal returns. Furthermore, the heavy skew toward Nitrogen-based fertilizers and the highly fragmented land structure, where marginal and small farmers dominate 1,116,333 holdings, create a cycle of “subsistence-driven intensification” that threatens long-term soil health and ecological stability. For true agricultural sustainability, policy interventions must move beyond just increasing yields. There is an urgent need to support marginal farmers through cooperative farming or better resource-use efficiency to break the cycle of high chemical dependency on small plots. Without addressing the structural limitations of land size, the environmental dimension will continue to be compromised for economic survival.

6. Limitation of the Study:

A primary limitation of this research is its reliance on the 2015-16 Agricultural Census for analyzing operational landholding patterns. This is due to the fact that the Government has not yet released the updated official data for the subsequent periods, which limits the assessment of the most recent structural changes in Haryana’s land distribution up to 2023.

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References:

- Ardakani, Z., Bartolini, F., & Brunori, G. (2020). New Evaluation of Small Farms: Implication for an Analysis of Food Security. *Agriculture*, 10(3), 74. <https://doi.org/10.3390/AGRICULTURE10030074>
- Devi, J., Kumar., Dr. S., & Kumar, D. S. (2023). Role of geo informatics in achieving sustainable agriculture and it’s scenario in Haryana: An overview. *International Journal of Communication and Information Technology*, 4(1), 26–28. <https://doi.org/10.33545/2707661x.2023.v4.i1a.56>
- Ashish, A. (2024). Comparative Insights into the Changing Patterns of Cropping Intensity in Haryana. *International Journal of English, Literature and Social Science*, 9(6), 094–102. <https://doi.org/10.22161/ijels.96.18>

- Bathaei, A., & Streimikiene, D. (2023). A Systematic Review of Agricultural Sustainability Indicators. *Agriculture*, 13(2), 241–241. <https://doi.org/10.3390/agriculture13020241>
- Conant, R. T., Conant, R. T., Berdanier, A. B., & Grace, P. (2013). Patterns and trends in nitrogen use and nitrogen recovery efficiency in world agriculture. *Global Biogeochemical Cycles*, 27(2), 558–566. <https://doi.org/10.1002/GBC.20053>
- Ghosh, M. (2013). *Growth and Regional Divergence in Agriculture*. 63–81. https://doi.org/10.1007/978-81-322-0981-2_5
- Goyal, S. S., Dave, R., Kumar, R., & Bhatia, U. (2024). Indian interstate trade exacerbates nutrient pollution in food production hubs. *Communications Earth & Environment*, 5(1), 9.
- Gupta, D. (2025). Understanding the Growth Trajectory in Haryana’s Agriculture: A Sectoral Analysis. *Asian Journal of Economics, Business and Accounting*, 25(9), 349–363. <https://doi.org/10.9734/ajeba/2025/v25i91977>
- Hossain, M., & Singh, V. (2000). Fertilizer use in Asian agriculture: implications for sustaining food security and the environment. *Nutrient Cycling in Agroecosystems*, 57(2), 155–169. <https://doi.org/10.1023/A:1009865819925>
- Kumar, S., Shivani, Dey, A., Kumar, U., Kumar, R., Mondal, S., Kumar, A., & Manibhushan. (2022). Location-specific integrated farming system models for resource recycling and livelihood security for smallholders. *Frontiers in Agronomy*, 4, 938331. <https://doi.org/10.3389/fagro.2022.938331>
- Mafi, Malik, D. P., Rimpi, & Choudhary, N. (2024). Structural Changes in Haryana Agriculture. *Asian Journal of Agricultural Extension, Economics and Sociology*, 42(10), 130–137. <https://doi.org/10.9734/ajaees/2024/v42i102568>
- Panwar, S., & Dimri, A. K. (2018). Trend analysis of production and productivity of major crops and its sustainability: A case study of Haryana. *Indian Journal of Agricultural Research*, 52(5), 571–575. <https://doi.org/10.18805/IJARE.A-5019>
- Ren, C., Liu, S., Grinsven, H. van, Reis, S., Jin, S., Liu, H., Gu, B., & Gu, B. (2019). The impact of farm size on agricultural sustainability. *Journal of Cleaner Production*, 220, 357–367. <https://doi.org/10.1016/J.JCLEPRO.2019.02.151>
- Sharma, H. K., & Malik, S. (2021). Land Distribution Structure, Marginalisation of Holdings and Dimensions of Viability Crisis in Indian Agriculture: A State Level Analysis. *Indian Journal of Agricultural Economics*, 76(2), 207–224. <https://doi.org/10.63040/25827510.2021.02.001>
- Sharma, N., Pannu, R. S., Malik, D. P., Kumari, N., & Sain, V. (2023). Growth and Instability of Fertilizer Consumption in Haryana, India. *Journal of Agriculture and Ecology Research International*, 24(3), 1–6. <https://doi.org/10.9734/jaeri/2023/v24i3526>

- Shrestha, J., & Subedi, S. (2019). Improving crop productivity through sustainable intensification. *South Asian Research Journal of Agriculture and Fisheries*, 1(1), 8–11. <https://doi.org/10.36346/SARJAF.2019.V01I01.002>
- Singh, D., Sharma, O. P., Kushwah, N., Chauhan, A. P. S., & JAIN, M. L. (2023). Agronomic Considerations for Sustainable Intensification of Crop Production. *Plant Science Archives*, 8(2), 7–9. <https://doi.org/10.51470/psa.2023.8.2.07>
- Singh, R. B. (2000). Environmental consequences of agricultural development: A case study from the Green Revolution state of Haryana, India. *Agriculture, Ecosystems & Environment*, 82(1–3), 97–103.