

# From Informal to Intelligent Agriculture: A Digital Transformation Framework for Land Leasing

*A Scalable Digital Ecosystem for Transparent and Secure Agricultural Land Leasing in India*

<sup>1</sup>Sarvesh Kasar, <sup>2</sup>Tanmay Rathod, <sup>3</sup>Vedant pawar, <sup>4</sup>Prakhar Shukla,  
<sup>1</sup>B.tech(CSE-SY), <sup>2</sup>B.tech(CSE-SY), <sup>3</sup>B.tech(CSE-SY), <sup>4</sup>B.tech(CSE-SY),

<sup>1</sup>School of Computing,

<sup>1</sup>MIT-ADT University, Pune, India

<sup>1</sup>sarveshkasar1210@gmail.com, <sup>2</sup>rtanmay761@gmail.com <sup>3</sup>vedantggs12@gmail.com,

<sup>4</sup>prakhar.shukla6125@gmail.com,

**Abstract**—Leasing agricultural lands holds significant importance for sustaining the economic well-being of numerous smallholder farmers worldwide, especially those residing in underdeveloped regions characterized by communal property rights over land holdings. Nevertheless, the lease procedure typically lacks formality, is not documented properly, and separates itself from established agrarian systems. Informal practices lead to job security concerns, limited financial resources like loans and insurances, suboptimal resource allocation for development projects, and increased operational hazards. Although improvements in electronic record-keeping for property deeds and implementation of computerized farming techniques haven't fully reached lease agreements across all areas. The research introduces an innovative approach aimed at transforming agricultural lease agreements into formalized systems based on clear and comprehensive information sharing. This system includes electronic property documents, advisory tools for making choices about farming practices, digitally signed legal papers, and regulatory frameworks designed to make lease terms clearer, enhance agricultural yield predictions, and encourage tenants' involvement in economic aid initiatives. Utilizing supplementary information sources such as previous studies and existing reports, the investigation highlights how this reform could enhance various aspects including efficiency, societal well-being, financial stability, and governmental oversight effectiveness. A suggested plan provides an adaptable approach tailored towards environmental preservation in farming areas.

**Index Terms**—Agricultural Land Leasing, Decision Support Systems, Digital Agriculture, Digital Governance, Sustainable Agriculture, Tenant Farmers.

## INTRODUCTION

Agriculture has been a strength of food security and livelihoods of the rural people who occupy a good percentage of the world population particularly in the developing economies. The leasing system of access to land is becoming more prevalent in many agrarian societies due to land fragmentation, methods of inheritance, migration and population pressure. This has led to the emergence of tenant farming as a significant instrument to sustain agricultural production. However, despite the prevalence of the leasing of land, it continues to be practiced in massiveness on an informal and undocumented basis, which creates systemic inefficiencies and social inequities. The informal land leasing is an arrangement that would not allow the land tenants to invest in soil conservation, irrigation facilities and other advanced farming technology since they are repeatedly terrified by the prospect of eviction not to mention the absence of the legal protection. Concurrently, landowners tend to leave land unused in total disarray due to the threat of being sued or losing the ownership. All these issues predispose the rural areas to poor land use, low agricultural output, and rural development [1]. At the same time, the governments and development agencies have implemented high investments in digitalization of land records and technology-based agriculture such as establishment of electronic land registries, precision farming machinery, and advisory systems based on data. Though the efforts have brought more transparency and efficiency in the ownership of land, most of the efforts have excluded the tenant farmers who lack the documentation of their lease. As a result, the digital revolution in the agricultural sector has helped to fortify the imbalances in a non-intentional way. This paper will present the argument that land leasing needs to be part of the digital agriculture ecosystem to make sure that the agricultural development is inclusive, efficient, and sustainable [2].

## LITERATURE REVIEW

The existing literature is abundant in discussing the benefits of digital technologies in agriculture, because they include enhanced crop yields, improved resource use and management, and efficient decision-making by applying artificial intelligence and satellite images, and the Internet-of-Things (IoT) devices. Precision agriculture systems and decision-support tools have had immense promise in optimization of inputs such as water, fertilizers, and pesticides and therefore great productivity with minimum environmental effects. These benefits are not well distributed though due to structural problems of land tenure and access rights [3].

The literature of land governance has always insisted on the fact that long-term agricultural investment and sustainable land management require secure and legally established rights to property. Institutional support systems will be having formally owned or secure tenure farmers who will be putting in better farming practices. Quite the contrary, informal systems of tenancy lead to uncertainty, discourage investment and restrict financial services access [12].

Recent studies have explored the use of the new technologies such as blockchain to ensure that land records and digital contracting is implemented to enhance transparency and trust. Despite their technical attractiveness, a majority of these plans is small scale oriented in terms of technological feasibility and pays no attention to social-political concerns, local power relations, and regulatory constraints. Researchers indicate that technology and policy change, institutional partnership, and involvement of the end-users are the three elements that should be integrated to effectively digitalize agriculture. The present paper builds upon this perspective and proposes a holistic solution that would involve the idea of digital leasing of land into bigger systems of agriculture and governance [5].

## PROBLEM STATEMENT

Renting farmers have an agricultural agreement that is not documented in any formal way; their activities do not have well-defined legal frameworks and technologies to support the modern agricultural practice. Absence of a fixed linkage amid land registry and agricultural productivity insights and governmental backing mechanisms results in untrustworthy property rights, ineffective utilization of farmland assets, extra susceptibility during harvests, and rejection of financial aid in the form of loans, farmland insurance, and state-provided programs to smallholder farmers [6, 7].

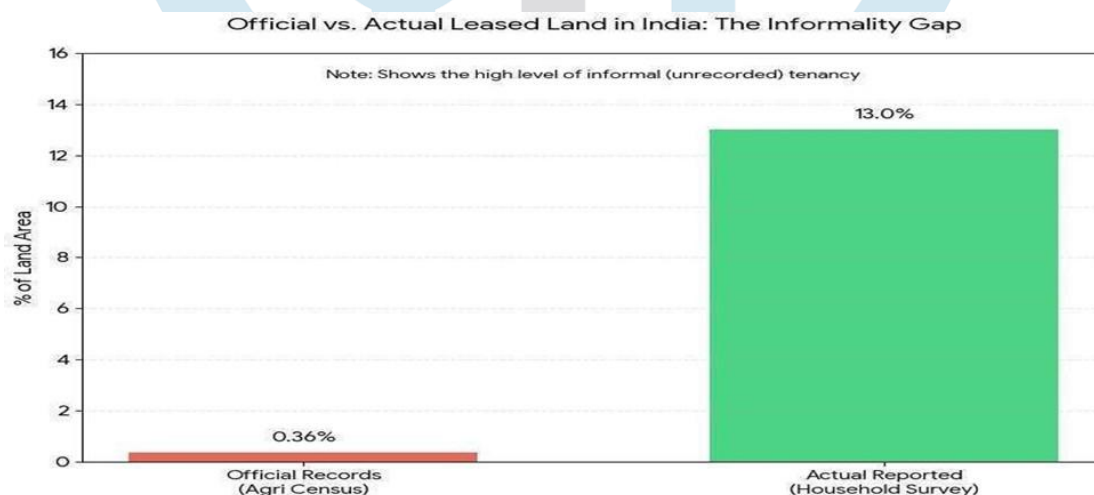


Figure 1. Official vs. Actual leased land in India: The informality gap

## RESEARCH GAP

Despite the significant progress in electronic registration of land ownership and promotion of digital tools in agriculture, the existing activities are not much concerned with agricultural land leasing formalization. Current literature and the policy frameworks address land records, farm advisory systems and financial inclusion as independent field without providing a comprehensive strategy that would intertwine lease documentation and decision support tools and institutional access [8]. There is a lack of detailed digital frameworks that can transform informal occupancy of land into a formal, scaled and integrative framework that facilitates the realities of the technology and governance in the modern world [9].

## OBJECTIVES

The primary objective of the research is to develop and introduce a smart digital platform that will transform the informal land leasing in the agricultural sector to a transparent institutionally acceptable and structured one. The study is aimed at converting the digital land leasing into the part of smart agriculture because it will allow registering the right to use land in a verifiable manner

without changing the systems of land ownership. This is a direct answer to the lock out of tenant farmers in the past to formal agricultural ecosystems.

The need to integrate land leasing information and crop suitability information by taking advantage of soil properties, climatic property and seasonal property are some of the objectives. Through this, the study will help to improve the accuracy of decisions that will be made regarding the choice of crops and land exploitation and minimize risks of production. Such integration causes the agricultural recommendations to be translated into the actual land access, other than the imaginary ownership records.

The other key objective is to ensure that the institutions become more accommodative to the tenant farmers by coming up with a structured and machine readable information on lease that can be utilized by the banks, insurance companies and government agencies. The paper will also demonstrate how the concept of formalizing the digital leases as an eligibility facilitator can be used to the advantage of financial inclusions, crop insurance services, and individuals in the agricultural welfare programs.

The research will also attempt to make sure that the generalizability and the applicability of the proposed framework to other agrarian environments is achieved. This will entail the testing of its compatibility with its current digital land records systems, compatibility with its policies and compatibility with future technology such as artificial intelligence, satellite-based monitoring, and predictive analytics. Lastly, the study will be seeking to offer a policy that is consistent and replicable model of smart agricultural land governance [1].

## METHODOLOGY

The research study presented in the paper is qualitative and conceptual research study, which integrates system design concepts and a comprehensive study of the secondary data sources. The way the analytic survey of the government policy documents, land governance arrangements, scholarly articles and reports on the international development processes and issues are conducted is the identification of patterns, challenges as well as opportunities associated with land leasing and digital agriculture. The proposed framework is elaborated on the premises of the synthesis of the findings of the literature on land governance, literature on digital transformation, and socio-technical adoption theories [10]. The viability analysis and the possible outcomes are analysed to the case studies and the evidence of the technology adoption that was reported [7, 11].

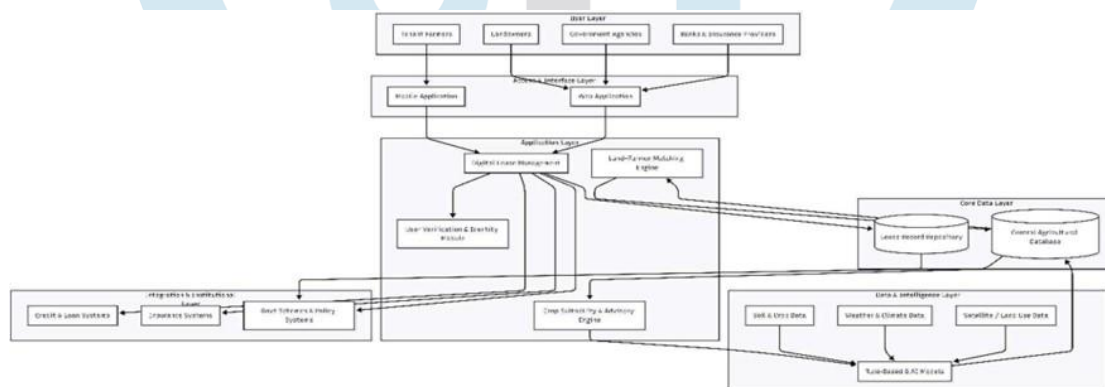


Figure 2. System Architecture

## EXPERIMENTAL SETUP/DATA COLLECTION

The research design of the study article is based on the conceptual and framework-based research design which is supported by the secondary data sources and system modelling tools. The research presupposes design-based validation as not all the features of the implementation are implemented yet, and it can be used to determine the possibility, relevance and potential effect. The model is experimented using real agricultural data, policy documents and provided case studies of digital agriculture to model the realistic deployment environment.

The government reports on agriculture, release of data by other bodies such as Food and Agricultural Organization (FAO), World Bank and the national agricultural agencies are the secondary data collection methods. Such kind of data sets will provide information on the trends of land use, tenancy rates, institutional access to credit and crop productivity trends. The aspect of crop suitability in the framework is backed by the soil and climatic data that are received in the agro-meteorological repositories that can be accessed by the public [1].

The traditional informal clusters of leasing and digitally empowered agribusiness platforms are opposed to put the framework in context of the realities of the operation conditions. The proposed system is evaluated with the help of such key indicators as the state of lease documentation, the rate of institutional access, the efficiency of land use, and the accuracy of the advisory and estimate the transformative potential of the proposed system. These indicators have been selected based on the factors of relevance with the sustainability of agriculture, economic inclusion, and effective governance.

Mapping of data flow among the users and application services, intelligence layers and institutional integrations performed with system level simulations are also done. This renders it interoperable in which intermodule verification of scalability and information integrity can be confirmed. Though the proposed study will not assume the live field experimentation, the design of the experiment will ensure that the proposed framework is based on the current empirical realities and constructed in line with the modern technological and policy reality [2].

## RESULTS

Judging by the results, the process of land leasing the agricultural land by using digital documentation and institutionalizing it can provide significant advantages in the availability of the institutional support processes to the tenant farmers. It is proved that use of decision-support systems may result in the increase of the yield at least by 25-26 percent, and the increase in the better use of land and farm inputs. Another aspect that is revealed in the proposed structure is the fact that one can minimize the transaction costs, enhance the visibility of the leasing contracts, and display the government schemes in a concentrated way. More data transparency also promotes evidence-based policymaking and a stronger governance presence [1, 13].

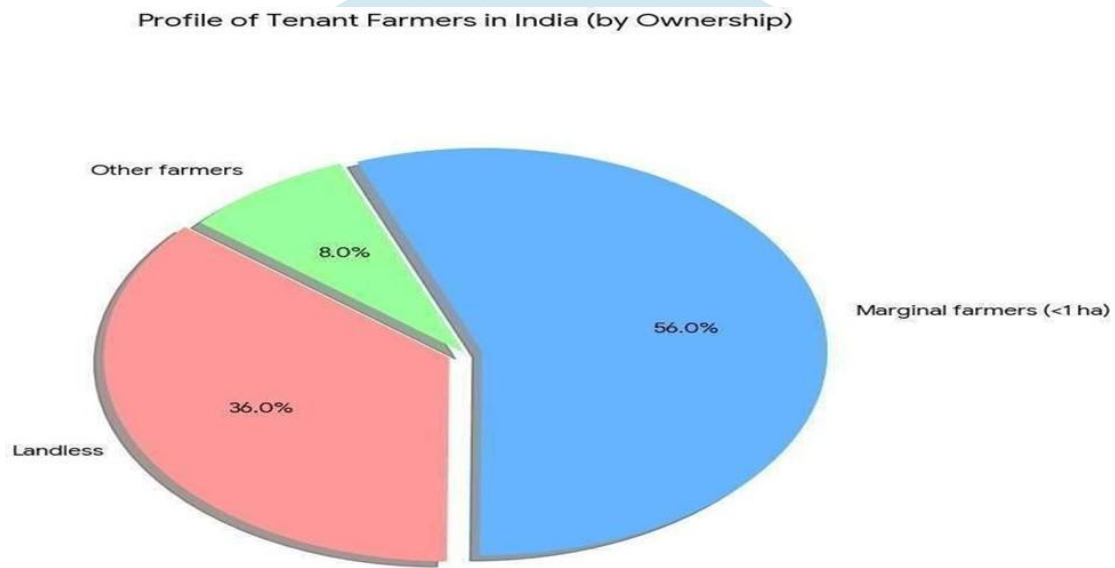


Figure 3. Profile of Tenant Farmers in India (by Ownership)

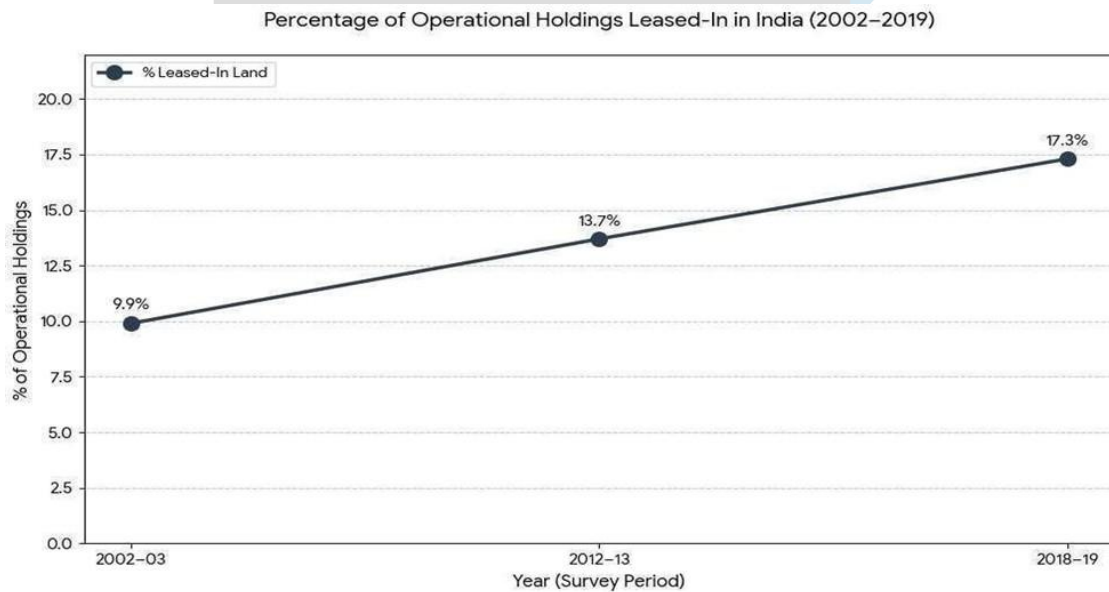


Figure 4. Percentage of Operational Holdings Leased in India (2002-2019)

## ANALYSIS AND DISCUSSION

The findings reveal the importance of the digital lease formalization to resolve the loopholes between the tenant farmers and the landowners and between the institutions. The framework also deals with various challenges of agricultural risk and inefficiency by the incorporation of lease records and advisory and financial systems. The sustainable adoption will need the institutional recognition and coordination of policies as indicated in the discussion as well as the technological solutions are not enough. The suggested solution demonstrates the way a socio-technical system can be implemented to enhance trust, minimize conflicts, and ensure inclusive agricultural development at the same time [3].

## CONCLUSION

This paper presents a revolutionary suggestion of how the agricultural land leasing should be modernized and digitalized. The informality, insecurity, and exclusion issues that have always prevailed in tenant farming will be solved by the proposed model that will integrate the electronic documentation of lease, decision-support systems as well as alignment of regulations. The framework provides a flexible and universal framework that can be used by policy makers and practitioners to reform their land leasing systems, enhance agricultural productivity and help in the fair distribution of resources. Finally, the informal to intelligent land leasing will enhance better life of the rural folks and help in maintaining the agricultural development.

The research is rather theoretical and is based on the secondary sources of information instead of the primary field-based research. Consequently this has not been proved empirically through pilot implementation and adoption by the users. Lack of real-time behavioural information reduces the probability of scaling and studying the long-term results. Empirical research of the model in the future should be used to show that the proposed model is improved.

## LIMITATIONS OF THE STUDY

This research is very theoretical, and the data used are compiled by other sources rather than the primary data collection methods. Lack of initial field research and early adoption will not allow us to measure the uptake trend of users and assess the long-term effectiveness. In the future, these results will have to be developed through empirical verification.

## FUTURE SCOPE/RECOMMENDATIONS

The second step in the study should be pilot projects of digital land leasing sites that will create empirical data regarding adoption and use and impacts. Advanced analytics and machine learning along with customized advisory systems may also be integrated to assist in the enhancement of decision-making. The policymakers are urged to acknowledge the application of the digital lease records in the legislations, and the financial institutions are urged to amend the lending and insuring plans to suit the digitally recorded tenancy plans.

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## References

## References

- [1] Food and Agriculture Organization of the United Nations, "Digital Agriculture and Rural Transformation," FAO, Rome, Italy, 2022.
- [2] World Bank, "Digital Agriculture: Opportunities and Challenges," World Bank Group, Washington, DC, USA, 2021.
- [3] Government of India, Ministry of Rural Development, "Digital India Land Records Modernization Programme (DILRMP): Status Report," New Delhi, India, 2024.
- [4] Government of India, Ministry of Agriculture and Farmers Welfare, "India Digital Ecosystem of Agriculture (IDEA) Framework," New Delhi, India, 2023.
- [5] National Institution for Transforming India, "AI for Agriculture in India," NITI Aayog, New Delhi, India, 2022.
- [6] R. K. Singh, A. Kumar, and S. Sharma, "Applications of Artificial Intelligence in Precision Agriculture: A Review," *Computers and Electronics in Agriculture*, vol. 189, pp. 106-118, 2021.
- [7] S. Wolfert, L. Ge, C. Verdouw, and M.-J. Bogaardt, "Big Data in Smart Farming - A Review," *Agricultural Systems*, vol. 153, pp. 69-80, 2017.
- [8] K. Deininger, H. Selod, and A. Burns, "The Land Governance Assessment Framework," World Bank Publications, Washington, DC, USA, 2012.
- [9] United Nations Development Programme, "Inclusive Digital Transformation for Sustainable Development," UNDP, New York, USA, 2021.
- [10] J. Lowder, J. Scoet, and T. Raney, "The Number, Size, and Distribution of Farms, Smallholder Farms, and Family Farms Worldwide," *World Development*, vol. 87, pp. 16-29, 2016.
- [11] S. Limkar, S. Hunashimarad, P. Chinchmalatpure, A. Baj, and R. Patil, "Potential of Robust Face Recognition from Real-Time CCTV Video Stream for Biometric Attendance Using Convolutional Neural Network," in *Intelligent Data Engineering and Analytics: Frontiers in Intelligent Computing: Theory and Applications (FICTA 2020)*, vol. 2, Singapore: Springer, 2020, pp. 11-20.

- [12] S. Limkar, S. Kulkarni, P. Chinchmalatpure, D. Sharma, M. Desai, S. Angadi, and P. Jadhav, "Classification and Prediction of Rice Crop Diseases Using CNN and PNN," in *Intelligent Data Engineering and Analytics: Frontiers in Intelligent Computing: Theory and Applications (FICTA 2020)*, vol. 2, Singapore: Springer, 2020, pp. 31-40.
- [13] R. Pawar, et al., "Crop Advancement with Machine Learning," in *2023 7th International Conference on Computing, Communication, Control and Automation (ICCUBEA)*, Pune, India, 2023, pp. 1-6.

