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Research Article

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

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ABSTRACT

The leasing of agricultural land is very crucial in sustaining the smallholder farmers and rural economies, and it is more so in developing regions where land is sub-divided into small parcels and land access is limited. Even though it is noteworthy, agricultural land leasing is largely informal, being founded on oral or unregistered contracts that are not legally binding and are not registered in institutions. This informality puts the tenant farmers in a position of being insecure, inaccessible to credit, insurance and government welfare systems and this discourages long-term investments in land productivity. Even though governments in the world have come far in terms of digitalizing land ownership records and improving the concept of digital agriculture, lease agreements remain largely beyond the digital ecosystems.

The paper will provide an elaborate blueprint of digital transformation that will enable to transform the informal leasing of agricultural lands to an intelligent, structured, and transparent system. It is a framework that integrates the digital lease records, crops and decision support advisory systems, institutional integration systems to improve agricultural planning, financial inclusion, and governance. The paper has determined the role of digital land leasing to enhance the use of resources, reduce transaction costs, enhance the security of tenants, and sustainable development of agricultural resources based on secondary data, policy reports, and available literature. The proposed solution is a policy-consistent and scalable solution that can empower the rural livelihoods and improve the effectiveness of the agricultural governance.

Keywords: *Digital Agriculture, Agricultural Land Leasing, Tenant Farmers, Decision Support Systems, Digital Governance, Sustainable Agriculture*

1. 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 into 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 agricultural development is inclusive, efficient, and sustainable [2].

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, most 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 [4].

3. Problem Statement

Renting farmers has 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 [5][6].

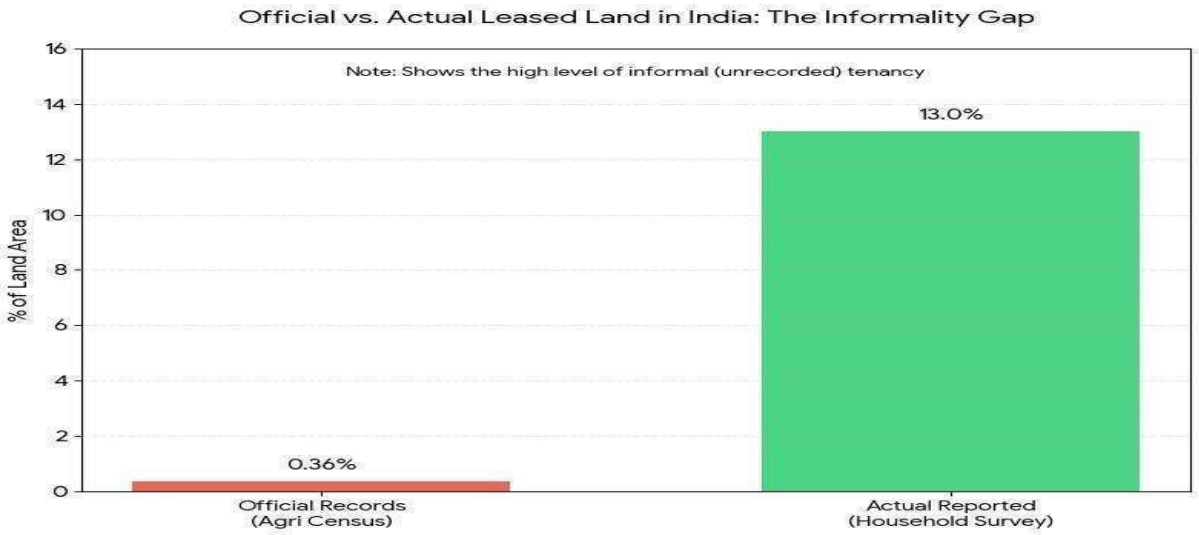

Figure 1: Official vs. Actual leased land in India: The informality gap

4. 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 [7]. 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 [8].

5. Objectives

The primary objective of the research is to develop and introduce a smart digital platform that will transform informal land leasing in the agricultural sector to a transparent institutionally acceptable and structured one. The study aims 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 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 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].

6. 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.[9] The viability analysis and the possible outcomes are analysed to the case studies and the evidence of the technology adoption that was reported [10][11].

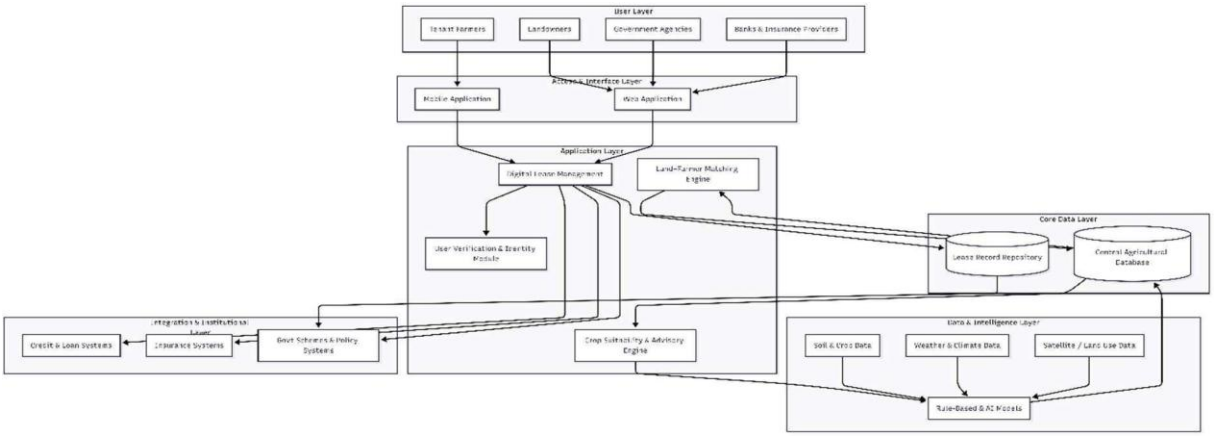

Figure 2: System Architecture

7. 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 Agriculture Organization (FAO), World Bank and the national agricultural agencies are the secondary data collection methods. Such 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 putting 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 to the sustainability of agriculture, economic inclusion, and effective governance. Mapping 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 inter-module 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].

8. Results Analysis and Discussion

Judging by the results, the process of land leasing 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]

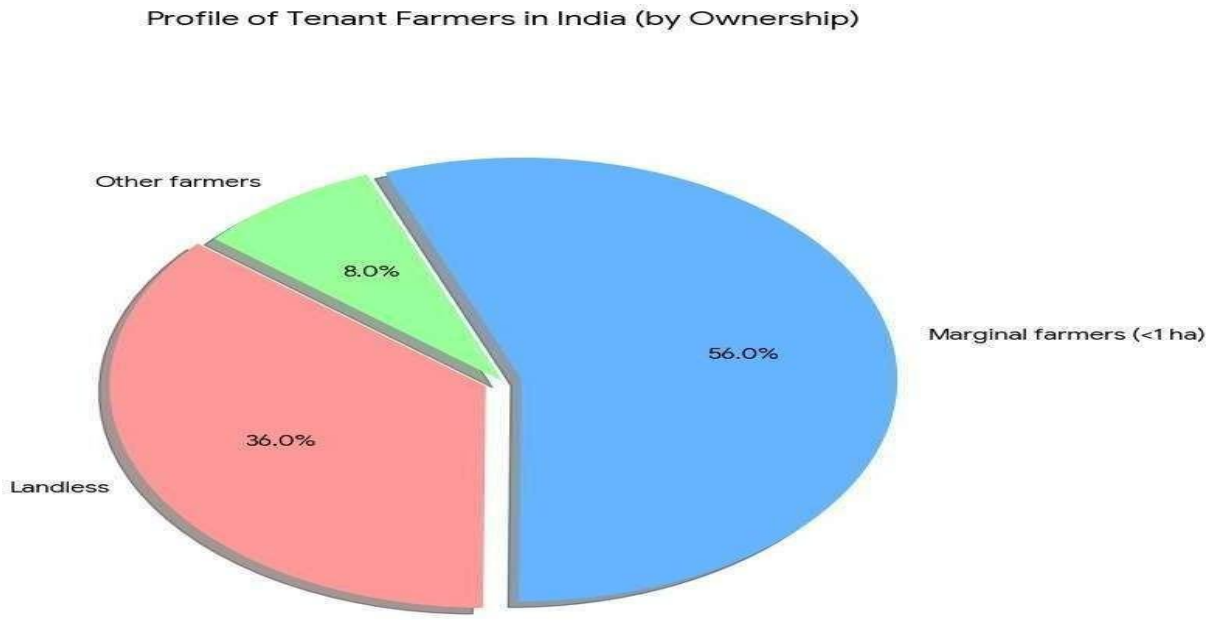

Figure 3: Profile of Tenant Farmers in India (by Ownership)

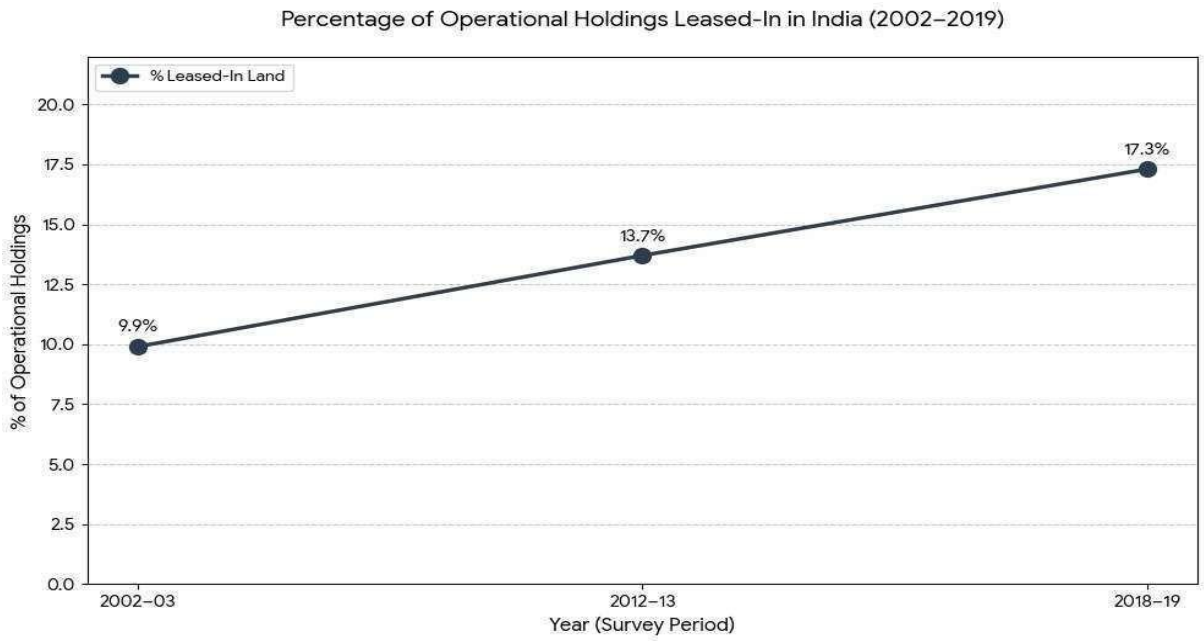

Figure 4: Percentage of Operational Holdings Leased in India (2002-2019)

The findings reveal the importance of 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]

9. Conclusion and Future Scope

This paper presents a revolutionary suggestion of how 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 behavioral information reduces the probability of scaling and studying the long-term results. Empirical research of the model in the future should be conducted to show that the proposed model is improved.

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.

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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Conflict of Interest

None.

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