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A WEB-BASED EQUIPMENT RENTAL SYSTEM FOR SUSTAINABLE FARMING

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Abstract: Agriculture is the foundation of any prosperous society. The newest revolution caused by improved technology in this sector would bring about a significant change; that is the proposed idea, which presents a platform for the farmers to rent agricultural equipment necessary for that moment to help enhance resource utilization and wastage. Some important features of this platform include multilingual access, a strong database for transactions, and a mechanism for feedback and rating driven by the user. The platform also works with predictive models for pest and disease management, weather forecasting, crop selection, and market price estimation. It further facilitates transportation assistance and loans as additional benefits. Such a great solution is at its best in addressing the underutilization of machines and promoting efficient practices for sustainable agriculture. The intuitive interfaces and innovative features also make it a one-stop solution for farmers to improve resource management and achieve sustainable solutions in the agricultural domain.

Keywords: Farming, Agriculture, Rental, Next JS, Web App, Farmer Multilingual Support, Agricultural Machinery Rental.

I. INTRODUCTION

Agriculture has always been the backbone of human society in producing food and raw materials, providing economic stability to societies worldwide. Medium- and small-scale farmers still struggle with financial constraints regarding modern agricultural machinery despite all these challenges. The high costs of acquiring and maintaining machines compel farmers to fall back on traditional implements and manual labor, which leads to underutilization, diminished productivity, and less scalability of farm machinery. Studies indicate that ownership of farm machinery leads to the underutilization of the machines, particularly for seasonal operations, to which renting remains a sustainable solution for relieving such financial burdens (Sreedevi et al., 2022) [1]. Modern technology has brought about online machinery rental systems to alleviate this situation by providing farmers access to the required machinery without significant upfront costs. Research indicates that innovative agricultural platforms combined with one Feature of smartness, AI recommendations with multilingualism, can further close accessibility and enhance farming productivity (Swarnamalya & Anbumani, 2023) [3].

To address these issues, we propose a web-based equipment rental system for sustainable farming so that access to necessary farm equipment (for example, tractors, tillers, and harvesters) remains flexible. This system eliminates the cost burden of ownership and optimizes resource use; thus, farmers will all have access to modern technology. It is powered by Next.js to provide interactive front-end capabilities, Prisma for robust database back-end implementation, and Large Language Models (LLMs) for brilliant AI-assisted multi-language support and recommendations. The multilingual Feature ensures that users from all walks of life will comfortably navigate and explore the system, thereby removing one of the largest identified use barriers in the current research (Rani & Reddy, 2019) [6]. Besides, secure payment integrations create flexibility in transactions through multi-digital payment support without the need for physical rental offices and with minimal operational bottlenecks. One of the platform's key innovations is its AI-powered recommendation engine, which analyzes user data, soil conditions, crop types, and seasonal requirements to suggest the most suitable equipment. By implementing machine learning models, this system ensures optimized resource allocation and data-driven decision-making, significantly improving farm productivity (Bandiwadekar et al., (2023) [2]. A feedback and rating system also fosters accountability among service providers, ensuring high standards

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are maintained. Future upgrades include a mobile application for increased accessibility and IoT integration for real-time monitoring of agricultural practices (Shin et al., 2023) [5]. By incorporating these advanced technologies, our platform aims to revolutionize agricultural practices, making farming more sustainable, cost-effective, and technology-driven, ultimately empowering farmers with efficient and intelligent solutions.

II. LITERATURE REVIEW

The past few decades have witnessed rapid agrotechnological advancements to ameliorate the age-old issues of inefficient resource utilization, high cost, and limited access to modern machinery. Many research studies and systems have been developed to improve farming, mainly due to the importance of machinery rental services and technology solutions for agricultural management [1][2][3]. Setting up a rental system for agricultural machinery is suggested in the literature as an alternative solution to financial barriers faced by small and medium-scale farmers. Kumar et al. (2018) reported that owning agricultural machinery often leads to underutilization, especially in cases where the mechanization of farm operations is only needed during certain seasons. Rental systems now offer themselves as a viable option for farmers to afford the use of machinery without significant capital investment [1][13][14]. Systems like "Agri Brilliance" have been created for things like listing equipment, predicting crops, and machine learning for value addition [1]l.Agriculture-based e-commerce platforms are gaining the ability to provide maximum accessibility and convenience. Adeyemi and Shuaibu (2019) argue that an online platform improves the process of renting by providing a one-stop centralized web space where a user can check the availability, book, and possibly pay for equipment[2][9][12]. Studies have stressed the importance of having a user-friendly interface and other features, such as multilingual support, for better adoption, especially in rural and underserved areas[6].

Recent developments have sought innovative technologies, IoT, AI, and Machine Learning integration to improve and uplift agricultural platforms. An AI-based recommendation model in an application increases on-the-go decision-making regarding optimizing equipment matching farmers' requirements, such as crop type and soil conditions during a given season [3]. Moreover, IoT-enabled sensors further utilize resources in precision farming through smart farming [5]. The significant challenges addressed by the alternatives have their respective drawbacks. Lack of inclusivity in most systems due to language limitations and coverage constraints is another. Without secure payment options and efficient feedback mechanisms, user trust and, thus, platform reliability tend to dwindle [7]. Studies by Rani and Reddy (2019) say there is low adoption in rural areas due to non-localization and lack of intuitive designs [6].

New literature offers suggestions for further improving agricultural platforms. Hamad and Alnabhan (2018) propose an application compatible with mobile-gadget-based platforms to extend user access to those who use smartphones only [8]. Other emerging trends include whether integration with precision farm technologies and AI-based analytics, which would help provide predictive knowledge, would somehow optimize farming activities[5].

III. METHODOLOGY

The Web-Based Farm Equipment Rental System for Sustainable Agriculture enhances farm equipment rentals' scalability, efficiency, and security by overcoming previous methods' limitations. The previous systems employed Python Flask for backend development and SQL databases for structured data management, supplemented with essential frontend technologies such as HTML, CSS, JavaScript, and React. These systems, although functional, had several limitations. Flask-based design did not support server-side rendering (SSR) and static site generation (SSG) natively, leading to more client-side processing, lower page load, and poor search engine optimization (SEO). Otherwise, the previous implementation relied on standard session-based authentication, which could be hijacked and require specific security configurations. One of the most important limitations was the absence of an integrated rental calendar, where users needed to manually set rental periods, leading to double bookings and suboptimal equipment utilization.

Our solution addresses these problems by utilizing Next.js, a new React framework explicitly designed to improve performance, security, and scalability. In contrast to traditional React-based configurations that depend on client-side rendering, Next.js employs server-side rendering (SSR) and static site generation (SSG) to render page loads faster, SEO-friendly, and with reduced computational burden on the client side. This renders the user experience quicker and more efficient, particularly for rural or low-bandwidth users where connectivity can be a bottleneck.

The backend architecture relies on MongoDB with Prisma ORM instead of the conventional SQL-based databases with strict relational schema management. MongoDB is a NoSQL database, and it supports extreme flexibility, scalability,

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and efficient query execution, making it ideal for handling dynamic rental data. Prisma ORM simplifies the interaction with the database, offering efficient and structured data management with security and integrity being guaranteed.

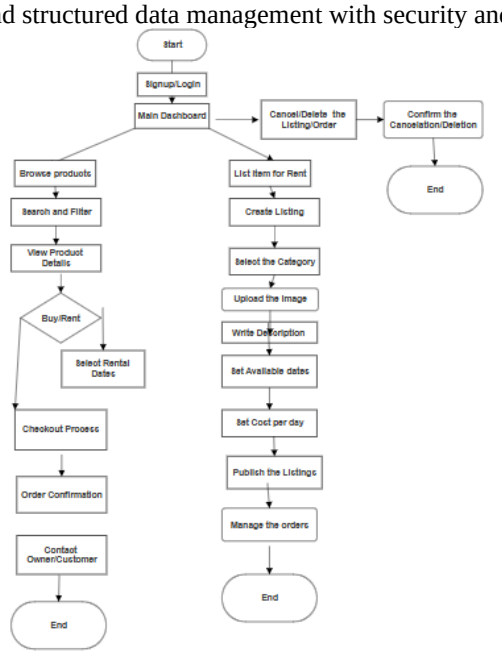

Fig 1: Flowchart

One of the most significant enhancements in our system is the use of secure authentication mechanisms. Instead of relying on session-based logins, where sessions are tracked constantly from the server side, we implement Google-based and cookie-based authentication. Google authentication allows users to securely log in using their existing Google credentials without the need for manual account creation and without compromising security. Cookie-based authentication maintains user sessions alive without exposing sensitive login credentials, offering a secure and trouble-free authentication experience.

One of the major drawbacks of previous methods was the lack of an automated schedule system, which caused rental conflicts and inefficient equipment distribution. Our approach offers a Rental Calendar through which users can select rental dates dynamically and prevent double bookings in real time. The system checks for availability automatically before confirming a booking, giving users an efficient, conflict-free rental process. For deployment and hosting, we utilize Vercel, which ensures scalability, performance, and continuous integration. Vercel's automated deployment and build pipelines facilitate seamless updates compared to traditional hosting methods that use manual server configurations and maintenance. By hosting on Vercel, we ensure that the platform is responsive, highly available, and capable of handling large-scale user interactions efficiently. One of our solution's most important design decisions is the exclusion of online payment gateways. Considering the high illiteracy rate among farmers and the challenges of digital payment adoption in rural areas, we opted to keep the rental process offline for payment handling. This decision reduces complexity, increases accessibility, and allows easy adoption without introducing barriers to financial transactions and digital literacy. With the addition of Next.js, Mongo DB with Prisma ORM, Google-based and cookie-based authentication, and a dynamic Rental Calendar, our solution overcomes the inefficiencies of previous systems. It provides a more secure, scalable, and user-centric solution. Combining optimized performance, enhanced authentication methods, and automated rental scheduling best suits our solution for sustainable and efficient agricultural equipment rentals. Future advancements may include mobile applications and IoT-based machinery tracking, enhancing further accessibility and operational efficiency in agriculture.

IV. RESULTS AND DISCUSSIONS

A. Deployment

The Agricultural Machinery Rental Platform is deployed on Vercel, a strong and user-friendly cloud hosting platform for modern web applications. Vercel ensures smooth compatibility with frameworks like Next.js, which was used in this project so that the platform would deliver fast, reliable, and scalable performance. The deployment process starts with preparing the application code developed using Next.js for the front end and Prisma for managing the database. The code repository was hosted on GitHub to facilitate version control and collaborative development.

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Fig 2: landing page of the web app

The deployment was done by linking the GitHub repository to Vercel. This enabled an automated and continuous deployment process where every code update in the repository is immediately built and deployed. Environment variables such as database credentials and API keys were configured through Vercel's secure environment settings to ensure the platform ran securely. These configurations ensured seamless integration with Prisma for database operations and Google OAuth for user authentication. Once deployed, Vercel's in-built optimization tools improved content delivery, ensuring the platform runs efficiently even under heavy traffic. Vercel's analytics tools allow real-time monitoring and swift resolution of issues, ensuring the platform remains responsive and reliable for all users. This approach deploys our project most effectively and extends its services so that accessibility and efficiency within the agricultural sector are increased.

B. Multilingual Support

The Agricultural Machinery Rental Platform integrates multilingual support as a core feature to address the various linguistic requirements of farmers across different regions. The functionality allows users to interact with the platform in their preferred language, thus enhancing accessibility and inclusivity. Language barriers are a common issue, especially in rural and agricultural communities, and addressing them was a critical consideration during the development process.

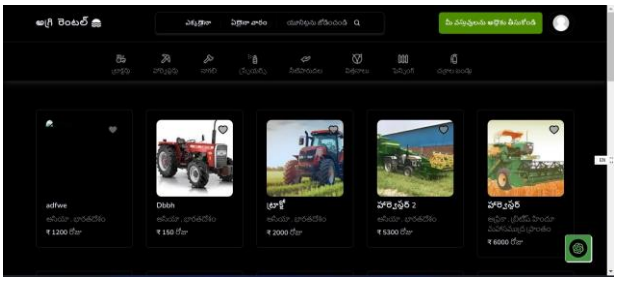

Fig 3: Multilingual Support – Telugu

A multilingual system was introduced, using modern localization techniques, tools, and frameworks compatible with Next.js. The user interface is dynamic based on the selected language, ensuring all content, labels, and navigation elements are correctly translated. The platform currently supports various languages and is open to users with different linguistic backgrounds. Additional regional languages are planned for future iterations, taking into consideration user feedback and usage data from the platform.

The introduction of multilingual support has significantly enhanced user interaction. With this, farmers can easily surf equipment, inspect specifications, and make bookings without struggling with language understanding. This Feature is an effortless experience and helps bridge the gap between technology and the community that has otherwise been traditionally underrepresented. The functionality of multiple languages ensures that our solution is not just a technological solution but a platform that empowers farmers regardless of their preferred languages.

C. Authentication and Security

The Web-Based Equipment Rental System for Sustainable Farming ensures user security and data protection by implementing robust authentication methods. The system has two secure login options: email-based authentication and Google OAuth integration. These methods ensure that only verified users can access the platform, safeguarding sensitive information and preventing unauthorized access.

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The email-based login system allows users to create accounts and log in securely using their email credentials. For added convenience and security, the integration of Google OAuth allows users to authenticate via their Google accounts. This simplifies the login process and leverages Google's advanced security measures, including two-factor authentication and real-time protection against malicious activity.

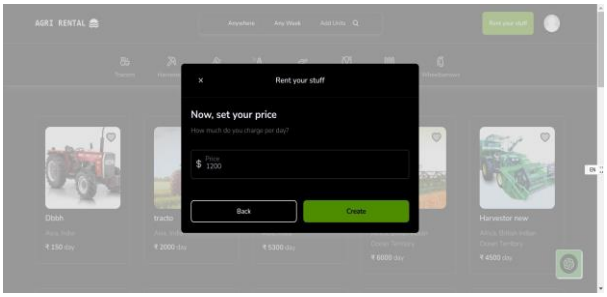

Fig 4: Decision on Price

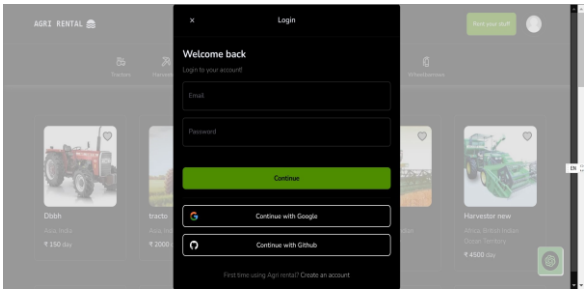

Fig 5: Google Authentication

The platform's implementation process ensures that all authentication processes follow industry standards. User credentials are encrypted and kept safe from data breaches or unauthorized access. This strong authentication framework gives users confidence and complies with data protection regulations. Providing safe and user-friendly login options for farmers and equipment providers ensures a seamless and safe experience for them.

D. Listing and Posting of Equipment

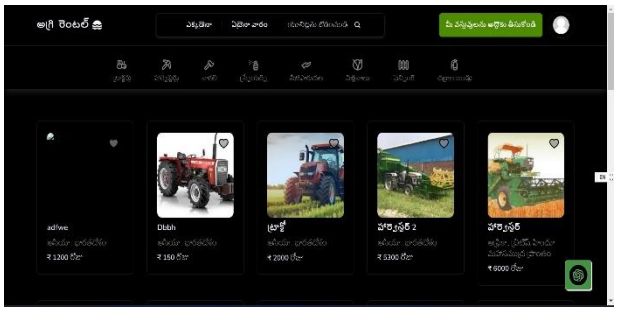

Fig 6: Dashboard

The Web-Based Equipment Rental System for Sustainable Farming has a streamlined feature for equipment providers to list their machinery on the platform. This process allows owners to efficiently share details about their equipment, making it accessible to farmers who require rentals. The intuitive interface ensures users can easily upload listings without technical difficulties, promoting broader participation and resource sharing.

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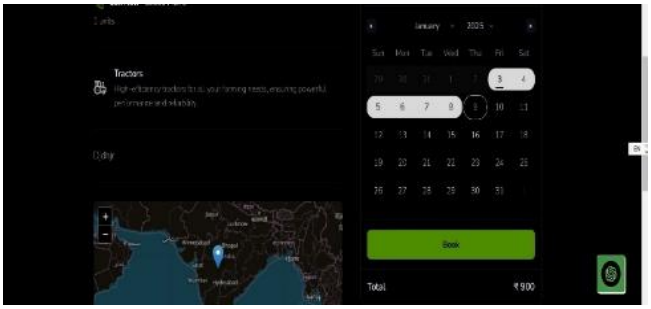

Fig 7: Rental Item View

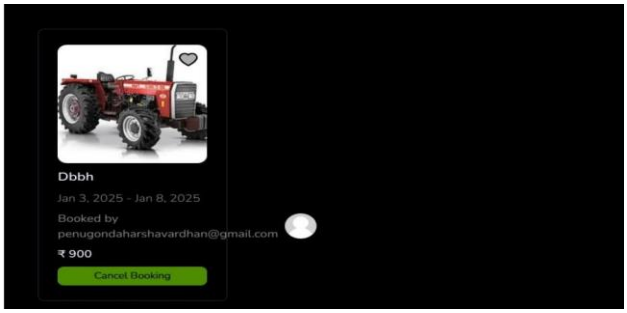

Fig 8: Rental Date Selection

Providers post equipment by filling out a simple form that contains fields for basic information like the name of the equipment, description, rental cost, deposit amount, and availability. Users can also upload images of their equipment to make their listings more visible and attractive. Once the listing is submitted, it appears on the platform's marketplace, where farmers can browse and make informed rental decisions.

The Feature of equipment posting has been thoughtfully developed so that simplicity is not lost, but functionality prevails. With the front end through Next.js, this interface is highly responsive and user-friendly. With Prisma, the backend can be securely operated, thereby safely storing all data related to equipment, ensuring timely updation, which is beneficial in a collaborative ecosystem that will bring efficient usage of resources along with the association between equipment providers and farmers for successful farming solutions that are sustainable and accessible.

V. CONCLUSION

The Web-Based Agricultural Equipment Rental System for Sustainable Farming presents an innovative solution to farmers' challenges in accessing modern agricultural machinery. It allows for intuitive, scalable, and secure equipment renting to implement sustainable farming practices without heavy investment in machinery.

The system provides users with a user-friendly and readily accessible experience by integrating advanced technologies into the system technologies, ranging from multilingual support to real-time bookings, secure gateways for paying, and various mechanisms for offering feedback. Moreover, the layered architecture of such a platform is designed with modern frameworks in mind, particularly Next.js and Prisma. The system will continue to scale efficiently to accommodate this growth in high-security performance standards.

It will also play a vital role in promoting sustainable agriculture by making eco-friendly and resource-efficient farm equipment available for its farmers, mainly in remote or resource-constrained locations. Future updates, such as mobile applications and IoT integration, will further enhance the system's promotion of sustainable agricultural practices. The Web-Based Agricultural Equipment Rental System for Sustainable Farming empowers farmers to embrace modern farming technologies while contributing to agricultural practices' long-term sustainability, helping both farmers and the environment.

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