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Review of GPS-Based Monitoring Systems for Agricultural Custom Hiring Centres

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Efficient utilization of agricultural machinery is essential for enhancing farm productivity, especially in countries like India, where most farmers are small and marginal. Custom Hiring Centres (CHCs) provide access to costly machinery but often face challenges such as improper scheduling, underutilization, delays, and lack of real-time operational data. Integrating Global Positioning System (GPS)-based monitoring offers a promising solution to these issues. This study examines the application of GPS-enabled technologies to improve the operational efficiency of CHCs. GPS systems allow real-time tracking of machinery location, operational duration, travel paths, and idle times, providing accurate insights into usage patterns. Such data-driven monitoring supports optimal resource allocation, minimizes downtime, reduces fuel consumption, and enhances accountability by preventing misuse and ensuring transparency. Integration of GPS technology also facilitates better scheduling, timely service delivery, preventive maintenance, and cost reduction, ultimately maximizing machine utilization and economic viability. By enabling data-driven decision-

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making, GPS-based monitoring strengthens the sustainability and reliability of CHCs, transforming them into transparent, farmer-friendly service hubs and supporting national goals of increased mechanization and food security.

Keywords: GPS-based monitoring; agricultural mechanization; Custom Hiring Centers (CHCs); real-time tracking; machinery utilization; operational efficiency; resource optimization; digital agriculture; precision farming; sustainability.

1. INTRODUCTION

The Information and Communication Technology (ICT), particularly Global Positioning System (GPS)-based monitoring, has emerged as a promising solution for fleet management in transportation and logistics sectors. However, its adoption in agricultural machinery monitoring remains limited. This paper explores how GPS-based monitoring can be integrated into CHCs to address the existing gaps and enhance operational efficiency.

Agricultural mechanization has been globally recognized as a critical driver for improving farm productivity, reducing drudgery, and ensuring timeliness of operations. In India, where more than 85% of farmers are small and marginal, direct ownership of costly machinery such as tractors, seeders, and harvesters is economically unviable. To address this issue, the Government of India introduced Custom Hiring Centres (CHCs) under the *Sub-Mission on Agricultural Mechanization (SMAM)*, aiming to provide access to machinery on a rental basis at affordable rates. These centres have expanded rapidly across different states, supporting mechanization of operations such as land preparation, sowing, transplanting, spraying, and harvesting.

While CHCs have improved machinery accessibility, serious challenges remain in their operational efficiency. Several studies and field reports highlight issues such as poor scheduling, peak-season unavailability, underutilization of expensive machinery, diversion of equipment for non-agricultural purposes, and lack of accountability in machine usage. Manual record-keeping further complicates utilization tracking, often resulting in delays, mismanagement, and financial losses for both farmers and CHC operators. As mechanization services are highly time-sensitive—especially for short crop windows like paddy-wheat rotations—inefficiency at the CHC level directly translates into yield losses and reduced farmer confidence Rodriguez et al. (2018).

Digital technologies, particularly Global Positioning System (GPS)-based monitoring, have emerged as a promising solution to address these gaps. GPS and telematics have already proven successful in precision agriculture by supporting auto-steering, yield mapping, and optimization of field operations. When applied to CHCs, GPS-based monitoring enables real-time tracking of machinery location, operational hours, travel versus field usage, and fuel consumption, thereby providing objective data on machine utilization. This not only enhances transparency but also allows CHC managers to optimize scheduling, reduce downtime, and prevent misuse of subsidized machinery Reddy & Rani (2021).

International experiences further support the potential of GPS-enabled systems. Platforms such as Hello Tractor in Africa and large-scale mechanization programs in China have demonstrated that embedded GPS devices improve accountability, facilitate demand-driven deployment of machines, and ensure better service delivery. In the Indian context, such systems align closely with the government's *Digital Agriculture Mission (2021–2025)*, which emphasizes IoT, AI, and smart monitoring tools for agricultural service delivery Neha et al. (2016).

However, despite its potential, the integration of GPS-based monitoring in CHCs is still in its early stages Parag Das (2015). Challenges such as high device cost, weak rural internet connectivity, limited digital literacy among operators, and absence of structured dashboards hinder widespread adoption. There is a lack of empirical research specifically focusing on how GPS-based monitoring can enhance operational efficiency at the CHC level. Most existing studies are either confined to precision farming or platform-based rental models, leaving a research gap in institutionalized centres like CHCs Ozpinar & Cay (2018).

Therefore, this study proposes to integrate and evaluate GPS-based monitoring systems in

CHCs, with the aim of improving machine utilization, ensuring timely service delivery, and enhancing transparency in agricultural mechanization services Park et al. (2017). The expected outcome is a structured framework that combines GPS hardware, data logging, analytics, and user-friendly dashboards, thereby enabling evidence-based decision-making for both CHC managers and policymakers Paman et al. (2018).

2. LITERATURE REVIEW

Custom Hiring Centers (CHCs) have been established to provide access to costly farm machinery for small and marginal farmers who cannot afford ownership. Studies indicate that CHCs play a crucial role in reducing drudgery, ensuring timely field operations, and improving farm productivity. Farmers' perception studies reveal that while the majority of farmers acknowledge the benefits of CHCs, issues such as poor scheduling, machine unavailability, and lack of transparency continue to hinder their effective functioning (Patel et al., 2021).

The integration of digital tools has been identified as a solution to overcome these limitations. GPS technology, in particular, has been widely adopted in precision agriculture for applications like yield mapping, soil sampling, and automated guidance systems**.** In machinery management, GPS allows real-time monitoring of machine movement, fuel consumption, operational hours, and idle time Rahman et al. (2013). This information improves accountability, reduces misuse of equipment, and ensures more efficient scheduling of operations.

Recent reviews on global navigation satellite systems (GNSS) highlight their significant contribution to agricultural mechanization, with improved accuracy and reliability enhancing field operations and decision-making. When applied to service institutions like CHCs, GPS-based monitoring systems can transform their efficiency by enabling better scheduling, predictive Andriamandroso et al. (2016); maintenance, and transparent farmer–operator interactions Singh et al. (2016). However, literature indicates that while GPS applications in precision farming are well-documented, their integration into institutional models such as CHCs remains underexplored. Further research is needed to assess socio-economic impacts, adoption barriers, and cost–benefit aspects of GPS-enabled monitoring in CHCs. Sharma et al. (2025);

Several studies have highlighted the importance of mechanization in enhancing farm productivity. Government initiatives such as subsidy-based schemes and CHCs have promoted mechanization adoption among small and marginal farmers. However, studies (GoI, 2022; ICAR, 2021) report issues in CHC operations, including lack of transparency Jaywant & Arif (2024);, high idle time of machinery, and poor scheduling. GPS-based monitoring systems have been successfully used in logistics, mining, and urban transport for fleet tracking and fuel efficiency monitoring. The application of such systems in agricultural machinery is still in its infancy. This creates a significant research opportunity to design GPS-enabled CHC management systems (Hasan et al., 2021).

Custom Hiring Centres (CHCs) have emerged as an important institutional model under the Sub-Mission on Agricultural Mechanization (SMAM) to improve access to farm machinery for small and marginal farmers Bhatt et al. (2024). The revised operational guidelines of SMAM emphasize the monitoring of CHCs and ensuring optimal utilization of machinery resources Despite their rapid expansion, several studies highlight challenges such as scheduling conflicts, machine underutilization, and lack of supervision in field-level operations Bethi & Deshmukh (2023).

Global literature has established the potential of Global Positioning System (GPS) and telematics in agriculture Radočaj et al. (2023). Applications such as auto-steering, yield mapping, and precision seeding have demonstrated how GPS can reduce overlaps, save fuel, and improve field efficiency. Natteri et al. (2021) proposed a telematics-enabled analytics approach for tractors, showing that GPS-based data can be used to distinguish between road travel and field work, and to estimate field area covered. Similarly, Sharma et al. (2025) developed a smartphone-based GPS application to record field area and operational time for billing and performance monitoring Ashok (2014).

Studies on digital hiring platforms such as Hello Tractor and EM3 Agri Services provide strong evidence of how embedded GPS improves accountability and transparency in machinery rentals. Mohanraj et al. (2016) These platforms utilize GPS logs for billing, dispatch, and usage verification, which directly address the bottlenecks identified in Indian CHCs.

Characterizations of CHCs in India report that many centres rely on manual record-keeping, phone/visit-based bookings, and lack proper maintenance planning. This leads to peak-season service failures and idle machinery. GPS-based monitoring can overcome these inefficiencies by enabling real-time tracking, automating machine dispatch, and recording service logs. Furthermore, sectoral reports indicate that telematics adoption can reduce fuel wastage, optimize routing, and improve machine turnaround, leading to significant economic benefits Sreejith (2023).

Despite its potential, GPS-based monitoring in CHCs faces challenges such as the cost of devices, weak internet connectivity in rural areas, and limited digital literacy among operators However, integrating GPS with mobile applications and cloud-based dashboards is considered a practical approach for improving efficiency, reducing misuse, and generating utilization data for policymakers Srinivasrao et al. (2013).

In summary, the literature reveals that while the application of GPS and telematics in precision agriculture is well-documented, research focusing on its integration into CHCs remains limited. Future studies must evaluate the causal impact of GPS monitoring on CHC performance, develop low-cost analytics tools, and explore governance mechanisms to link GPS data with subsidy disbursement and policy reporting (Sharma, et al., 2025).

Despite these benefits, CHCs face multiple operational challenges, including poor scheduling, high idle time of machinery, lack of accountability, and limited real-time monitoring. Manual record-keeping, phone-based bookings, and inefficient maintenance planning often result in delays, underutilization of machines, and reduced service quality. Integration of Global Positioning System (GPS) and telematics-based monitoring offers a solution by enabling real-time tracking of machinery location, operational hours, travel paths, fuel consumption, and idle time. This facilitates data-driven decision-making, better scheduling, preventive maintenance alerts, and reduced operational costs, ultimately enhancing the economic viability of CHCs.

Global experiences, including platforms like Hello Tractor in Africa and large-scale mechanization initiatives in China, demonstrate that GPS-enabled systems improve accountability, optimize machine deployment, and enhance transparency in service delivery. In India, GPS integration aligns with the government's Digital Agriculture Mission (2021–2025), which emphasizes IoT, AI, and smart monitoring tools to strengthen agricultural service delivery. However, adoption remains limited due to device costs, weak rural internet connectivity, and low digital literacy among operators.

This study explores the potential of GPS-based monitoring for enhancing operational efficiency of CHCs, improving machinery utilization, minimizing downtime, and promoting transparent and farmer-friendly mechanization services.

2.1 Challenges and Practical Approaches in GPS-based Monitoring for CHCs

Despite its proven benefits, the integration of GPS-based monitoring systems in Custom Hiring Centres (CHCs) faces several challenges. One of the most significant barriers is the initial cost of telematics devices and installation. Small CHCs often operate with limited capital and hesitate to invest in such technologies without financial support Subhash Chander & Kumari (2023).

Another challenge is the weak internet connectivity in rural areas, which limits the real-time transmission of GPS data. In many villages, network coverage is inconsistent, causing delays or failures in data transfer to central dashboards. This undermines the reliability of GPS-based systems and discourages adoption by CHC managers.

In addition, limited digital literacy among operators and farmers remains a major obstacle. Even when GPS devices are installed, their effective use requires basic skills in handling mobile applications, interpreting data, and troubleshooting. Without adequate training and capacity building, there is a risk that the technology will be underutilized.

To overcome these issues, several practical solutions have been suggested in recent literature. One approach is the integration of GPS with low-cost mobile applications, which can record data offline and upload automatically when internet connectivity is restored (Sharma et al., 2025). Another promising solution is the development of cloud-based dashboards for CHC managers and policymakers, where machine usage data can be visualized through simple interfaces (Just Agriculture, 2024). These

dashboards can automatically generate utilization reports, send alerts for misuse or unauthorized trips, and support scheduling decisions.

Furthermore, government incentives and training programs can play a critical role in bridging the adoption gap. By subsidizing GPS devices under mechanization schemes and organizing operator training workshops, CHCs can be encouraged to adopt digital monitoring tools. Over the long term, the integration of GPS with broader initiatives like the *Digital Agriculture Mission* will ensure greater transparency, efficiency, and accountability in agricultural mechanization services.

2.2 Problems and challenges

Technical limitations: GPS devices may have errors due to poor satellite signal, terrain obstacles, or weather conditions.

Cost factors: High cost of GPS-enabled machinery and monitoring systems can limit adoption by smallholders.

Skill/Training issues: Farmers or operators may lack the technical knowledge to use GPS-based systems effectively.

Connectivity issues: Remote rural areas may have poor internet or data connectivity, which affects real-time monitoring

3. FINDINGS AND DISCUSSION

The review of literature clearly indicates that Custom Hiring Centres (CHCs) are pivotal in providing small and marginal farmers access to farm machinery, thereby addressing key constraints related to ownership and operational efficiency. Studies show that while CHCs reduce drudgery and improve timely farm operations, their current management practices—such as manual scheduling, reliance on phone-based bookings, and lack of real-time supervision—limit the potential benefits.

Integration of GPS and telematics offers a transformative approach to overcome these operational challenges. Evidence from both Indian and global contexts demonstrates that GPS-enabled systems enhance machine accountability, optimize field scheduling, and provide real-time usage data for management and policy decisions. In particular, digital platforms like Hello Tractor illustrate how embedded GPS logs improve transparency, reduce misuse, and support billing and dispatch processes—addressing many bottlenecks identified in traditional CHC models.

Despite these benefits, several barriers impede widespread adoption. The high initial cost of GPS devices, inconsistent rural internet connectivity, and limited digital literacy among CHC operators are significant challenges Literature suggests that practical solutions such as low-cost mobile applications with offline data recording, cloud-based dashboards, and government-subsidized training programs can mitigate these limitations. These interventions are crucial to ensure that GPS technology translates into measurable operational improvements.

A critical gap identified in the reviewed studies is the limited empirical assessment of GPS adoption on CHC performance, including cost–benefit analyses, socio-economic impacts, and governance mechanisms linking GPS data to subsidy disbursement. While precision agriculture literature is robust, its application in institutional models like CHCs remains underexplored, representing a significant research opportunity. Addressing these gaps can inform evidence-based policies, enhance machinery utilization, and support scalable mechanization solutions for smallholder farmers.

4. CONCLUSION

Custom Hiring Centres (CHCs) serve as a critical institutional model to provide small and marginal farmers access to mechanized farm operations, enhancing productivity, reducing drudgery, and ensuring timely field activities. The review of literature highlights that while CHCs have demonstrated considerable benefits, operational inefficiencies such as poor scheduling, machine underutilization, and lack of transparency continue to limit their effectiveness.

The integration of GPS and telematics in CHC management emerges as a promising solution to these challenges. GPS-enabled systems facilitate real-time monitoring of machinery, optimize operational scheduling, enhance accountability, and support data-driven decision-making. Evidence from global and Indian experiences underscores that digital monitoring platforms improve transparency, reduce misuse, and enable efficient billing and dispatch processes, which directly address the shortcomings of conventional CHC operations.

Despite these advantages, the adoption of GPS-based monitoring in CHCs faces practical barriers including device costs, inconsistent rural internet connectivity, and limited digital literacy among operators. Strategies such as low-cost mobile applications, cloud-based dashboards, government subsidies, and targeted training programs can bridge these gaps and ensure effective implementation.

The literature also reveals a significant research gap: empirical evaluation of GPS-enabled monitoring on CHC performance, socio-economic impacts, cost–benefit analysis, and policy integration remains limited. Future research in these areas is essential to validate the effectiveness of GPS systems, develop scalable solutions, and inform evidence-based policy interventions.

In summary, GPS-based monitoring holds substantial potential to transform CHC operations, improve machinery utilization, and contribute to sustainable agricultural mechanization for smallholder farmers. Effective implementation, combined with targeted research and policy support, can ensure that the full benefits of digital agricultural technologies are realized at the grassroots level.

The operational effectiveness of Custom Hiring Centres (CHCs), a vital institutional model for agricultural mechanisation in developing countries like India, can be significantly enhanced through GPS-based monitoring systems, as comprehensively examined in this manuscript. Given its alignment with ongoing global efforts to digitise agricultural operations under initiatives such as the Digital Agriculture Mission (2021–2025), the topic holds considerable relevance for the scientific community. The study demonstrates how GPS technology can reduce machinery idle time, improve accountability, and ensure transparency in equipment usage by integrating precision agriculture, telematics, and digital monitoring with the governance of CHCs. Consequently, this work provides valuable insights for researchers, policymakers, and practitioners seeking to optimise mechanisation services and promote sustainable, technology-driven agricultural practices

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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