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Digital Platforms Enabling the Sharing Economy for Heavy Farm Machinery: On-Demand Rental Services, Peer-to-Peer Access Models, and Custom Hiring Frameworks in Modern Agricultural Mechanization

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Abstract
Heavy farm machinery such as tractors, combine harvesters, sprayers, and tillage implements represent substantial capital investments with typical utilization rates below 30% in smallholder systems and 50-60% in developed markets, creating significant economic inefficiencies and barriers to mechanization. Digital platforms leveraging sharing economy principles have emerged as transformative solutions to improve machinery access, optimize utilization, and reduce per-hectare mechanization costs. This review examines the architecture, mechanisms, and impacts of mobile and web-based platforms facilitating on-demand rental, peer-to-peer sharing, and custom hiring of heavy farm equipment. Key platforms including Hello Tractor, EM3 AgriServices, Tringo, MachineryLink, and regional initiatives integrate geolocation-based matching algorithms, telematics-enabled utilization tracking, integrated payment systems, and insurance mechanisms to connect machinery owners with farmers requiring services. Applications span smallholder access enhancement in Sub-Saharan Africa and South Asia, where platforms have increased mechanization rates by 15-40%, to efficiency optimization in developed markets through dynamic pricing and route optimization. Major challenges include digital literacy gaps, infrastructure constraints, trust-building in peer-to-peer transactions, and regulatory frameworks for liability and insurance. Future developments emphasize artificial intelligence-enhanced demand forecasting, integration with precision agriculture systems, blockchain-based transaction verification, and policy instruments supporting platform scalability. Digital machinery sharing platforms represent a critical pathway toward inclusive, efficient, and sustainable agricultural mechanization globally.

Keywords: Digital agriculture platforms; Sharing economy; Heavy farm machinery; On-demand rental; Custom hiring services; Agricultural mechanization

Introduction

Agricultural mechanization remains a cornerstone of productivity enhancement, yet heavy farm machinery ownership presents formidable economic barriers, particularly for smallholder farmers who constitute approximately 84% of global farm operations [1]. Capital costs for tractors range from $15,000 to $150,000 depending on horsepower and specifications, while combine harvesters exceed $200,000 for modern units [2]. These investments become economically untenable when machinery utilization rates average 200-400 hours annually in smallholder systems compared to optimal thresholds of 800-1200 hours for cost recovery [3]. Underutilization stems from seasonal demand concentration, small operational scales averaging 1-5 hectares in developing regions, and fragmented landholdings that limit continuous deployment [4].

Traditional custom hiring services, where machinery owners provide services to neighboring farms for fees, have partially addressed these constraints but suffer from information asymmetries, limited geographic reach, and transaction inefficiencies [5]. The emergence of digital platforms since 2010, paralleling sharing economy innovations in transportation and accommodation sectors, has fundamentally transformed machinery access models [6]. Mobile applications and web-based marketplaces now enable real-time matching between equipment owners and service seekers, dynamic pricing based on demand patterns, GPS-enabled tracking of machinery location and utilization, and integrated payment and insurance mechanisms [7].

This review synthesizes current knowledge on digital platforms facilitating the sharing economy for heavy farm machinery, focusing on platform architectures, operational mechanisms, regional applications, and translational impacts. The analysis emphasizes on-demand rental systems, peer-to-peer sharing models, and technology-enabled custom hiring frameworks that have demonstrated scalability in diverse agricultural contexts. By examining case studies from Sub-Saharan Africa, South Asia, North America, and Europe, this work identifies critical success factors, adoption barriers, and future pathways for digital machinery sharing platforms in global agriculture.

2. Digital Platform Models for Heavy Farm Machinery Sharing

2.1. Peer-to-Peer and Marketplace Platforms

Peer-to-peer platforms enable direct transactions between individual machinery owners and farmers requiring services, functioning as digital intermediaries that reduce search costs and facilitate trust-building through rating systems and verified profiles [8]. MachineryLink in Europe and FarmLend in North America exemplify this model, allowing farmers to list available equipment with hourly or daily rental rates, operational specifications, and availability calendars [9]. Platform algorithms match requests with available machinery based on geographic proximity, equipment type, and booking windows, with transaction fees typically ranging from 10-20% of rental value [10].

Marketplace platforms extend beyond peer-to-peer connections to aggregate both individual owners and commercial service providers, creating comprehensive equipment catalogs accessible through mobile applications [11]. Hello Tractor, operating across Nigeria, Kenya, and other Sub-Saharan African nations, has registered over 10,000 tractors and facilitated services covering more than 500,000 hectares annually [12]. The platform integrates IoT devices transmitting real-time location data, operational hours, and maintenance alerts, enabling both utilization optimization and preventive maintenance scheduling [13].

2.2. Custom Hiring and On-Demand Service Models

Digital custom hiring platforms formalize traditional service provision arrangements through structured workflows encompassing service requests, operator dispatch, quality verification, and payment settlement [14]. EM3 AgriServices in India operates an asset-light model where the platform recruits and trains equipment operators, coordinates with machinery owners, and manages end-to-end service delivery for farmers requesting tillage, harvesting, or spraying operations [15]. This approach addresses operator skill gaps prevalent in smallholder systems while ensuring service quality through standardized protocols and customer feedback mechanisms [16].

On-demand models emphasize rapid response capabilities, with platforms guaranteeing machinery availability within 24-48 hours of requests through predictive analytics forecasting seasonal demand patterns and pre-positioning equipment in high-demand zones [17]. Tringo in the Netherlands and Belgium utilizes algorithmic demand prediction based on weather forecasts, crop calendars, and historical booking data to optimize machinery allocation across service territories [18]. The platform achieves average utilization rates exceeding 800 hours annually compared to 400-500 hours in traditional ownership models [19].

2.3. Emerging Integrated and Hybrid Approaches

Hybrid platforms combine machinery sharing with complementary agricultural services including input supply, agronomic advisory, and market linkages, creating integrated value propositions for smallholder farmers [20]. Farmart and AgroStar in India bundle tractor rental bookings with fertilizer delivery, soil testing services, and mobile-based crop management recommendations, leveraging shared logistics networks and customer relationships [21]. This integration reduces transaction costs and enhances platform stickiness through multiple farmer touchpoints across production cycles [22].

Government-supported platforms represent another emerging model, where public agencies establish digital marketplaces to facilitate subsidized machinery access or coordinate community-owned equipment pools [23]. The Custom Hiring Centers scheme in India has digitized booking and allocation systems for government-funded machinery fleets, improving transparency and reducing patronage-based access barriers [24]. Such platforms integrate subsidy management, beneficiary verification, and usage monitoring within unified digital frameworks [25].

3. Core Mechanisms and Technologies

3.1. Matching, Geolocation, and Booking Algorithms

Platform matching algorithms employ multi-criteria optimization considering geographic distance, equipment specifications, operator availability, and historical service quality ratings [26]. Geolocation services utilizing GPS coordinates enable real-time visualization of available machinery within specified radius parameters, typically 10-50 kilometers depending on rural road infrastructure quality [27]. Advanced platforms implement route optimization algorithms that sequence multiple service requests to minimize travel time and fuel consumption while maximizing daily equipment utilization [28].

Booking systems incorporate calendar interfaces displaying equipment availability, automated confirmation workflows, and reservation management with cancellation policies balancing flexibility and commitment [29]. Dynamic pricing algorithms adjust rental rates based on demand intensity, with peak season premiums of 20-40% and off-season discounts incentivizing year-round utilization [30]. Some platforms employ auction mechanisms where farmers submit service requests with proposed prices and available machinery owners bid competitively, though these require sufficient market liquidity to function efficiently [31].

3.2. Utilization Tracking, Insurance, and Trust-Building Features

Telematics integration through IoT devices attached to machinery enables continuous monitoring of operational parameters including engine hours, fuel consumption, GPS trajectories, and implement engagement status [32]. This data serves multiple functions: verifying service delivery for payment settlement, monitoring equipment health for maintenance scheduling, and providing utilization analytics informing ownership decisions [33]. Hello Tractor's BookingTractor platform transmits data at 15-minute intervals, creating comprehensive operational logs accessible to both equipment owners and service recipients [34].

Insurance mechanisms embedded within platforms address liability concerns that traditionally inhibited peer-to-peer equipment sharing [35]. Platforms partner with insurance providers to offer per-transaction coverage protecting against equipment damage, operator injury, and third-party liabilities, with premiums typically 2-5% of rental value automatically included in booking fees [36]. Some platforms establish reserve funds through transaction fees to cover minor damage claims, expediting settlements without insurance company involvement [37].

Trust-building features include verified identity systems requiring government identification documentation, dual rating mechanisms where both owners and renters evaluate counterparties, and escrow payment arrangements where platforms hold funds until service completion confirmation [38]. Reputation scores calculated from historical transaction ratings influence search result rankings and dynamic pricing, creating incentives for service quality and equipment maintenance [39].

3.3. Payment, Financing, and Operational Integration

Integrated payment systems supporting mobile money, digital wallets, and bank transfers reduce transaction friction and enable cashless operations critical in contexts with limited banking infrastructure [40]. Platforms in Sub-Saharan Africa integrate with M-Pesa, MTN Mobile Money, and other regional mobile payment networks, while Indian platforms connect to UPI and Paytm ecosystems. Automated invoicing, payment splitting between platform fees and equipment owner revenues, and transparent transaction histories enhance financial management for both individual owners and commercial operators.

Financing partnerships enable equipment acquisition by prospective service providers through platform-facilitated credit arrangements. Hello Tractor collaborates with financial institutions to offer tractor financing where projected platform rental revenues serve as collateral and repayment occurs automatically through revenue-sharing agreements. This approach transforms platform participation from merely accessing existing equipment to enabling new machinery investments specifically for sharing economy deployment.

Operational integration with farm management information systems, weather services, and input suppliers creates data ecosystems enhancing platform value propositions. Machinery booking data combined with soil maps and crop calendars enable precision timing of tillage and planting operations, while integration with harvest forecasting systems allows combine harvester pre-booking during optimal maturity windows.

4. Regional Applications and Case Studies

4.1. Developing Regions: Sub-Saharan Africa and South Asia

Sub-Saharan Africa faces acute mechanization deficits with tractor densities averaging 13 units per 100 square kilometers of arable land compared to 200 in South Asia and 500 in Europe. Digital platforms have emerged as critical mechanization accelerators, with Hello Tractor documenting 40% increases in smallholder mechanization access in operational regions of Nigeria, Kenya, and Senegal. The platform's IoT-enabled tractor sharing model addresses trust barriers through transparent hour-metering and enables pay-per-hectare pricing rather than hourly rates, aligning costs with farmer revenue potential.

In South Asia, particularly India, platform adoption has been driven by fragmented landholdings averaging 1.08 hectares and seasonal demand concentration for key operations including wheat harvesting and rice transplanting. EM3 AgriServices operates across 15 Indian states, coordinating over 25,000 equipment units and serving 300,000+ farmers annually. The platform's standardized pricing, quality guarantees, and timely service delivery have reduced custom hiring costs by 15-25% while improving operational timeliness critical for crop establishment and harvest quality.

Case studies from Bangladesh demonstrate platforms facilitating mechanized rice transplanting, a labor-intensive operation where mechanization adoption has lagged despite proven efficiency gains. Digital booking systems coordinating mechanical transplanter availability with nursery readiness and field preparation timing have increased transplanter utilization from 80 hours to 450 hours annually, dramatically improving ownership economics and service affordability.

4.2. Developed Markets: North America and Europe

In developed agricultural systems, digital machinery sharing addresses different imperatives including optimizing high-value equipment utilization, accessing specialized machinery with limited individual deployment needs, and reducing capital intensity amid economic pressures. European platforms like Tringo facilitate sharing of precision agriculture equipment including variable-rate sprayers, GPS-guided planters, and sensor-equipped harvesters where purchase costs exceed €100,000 but annual individual farm requirements justify only 100-200 operational hours.

North American platforms emphasize neighbor-to-neighbor sharing among mid-sized farms (200-800 hectares) seeking to reduce machinery ownership costs while maintaining operational flexibility. FarmLend and MachineryLink report equipment categories including grain carts, tillage implements, and harvest equipment as most frequently shared, with average rental transactions generating 25-35% returns on equipment investment value annually for owners. Platform data indicates that shared machinery achieves 60-80% higher annual utilization compared to single-owner deployment, translating to 30-40% reductions in per-hectare mechanization costs for renters.

Collaborative consumption models in Europe extend beyond rental to include cooperative ownership structures digitally coordinated through platforms. Multiple farmers jointly purchase equipment with platform-managed booking systems ensuring equitable access and transparent cost allocation based on actual usage tracked through telematics. This hybrid approach combines ownership stability with sharing economy efficiency principles.

5. Challenges and Future Perspectives

5.1. Adoption Barriers, Digital Divide, and Infrastructure Constraints

Digital literacy remains a fundamental barrier, particularly in developing regions where smallholder farmers may lack smartphone access or digital navigation skills]. Platform interfaces requiring text input, calendar management, and payment authorization present usability challenges for farmers with limited formal education. Voice-based interfaces, simplified visual workflows, and agent-assisted booking models have emerged as adaptive strategies, though these increase operational complexity and transaction costs.

Infrastructure deficits including unreliable internet connectivity in rural areas, limited mobile payment infrastructure, and poor road networks constraining equipment mobility fundamentally limit platform scalability. Hello Tractor reports that 35% of potential service areas in Sub-Saharan Africa lack sufficient cellular connectivity for real-time telematics data transmission, necessitating offline operational modes with periodic data synchronization.

Equipment standardization challenges arise from diverse machinery brands, attachment compatibility issues, and varying maintenance states affecting service quality consistency. Unlike ride-sharing platforms where vehicle standardization is relatively high, farm machinery encompasses thousands of equipment configurations requiring detailed specification matching and operator training verification.

5.2. Regulatory, Trust, and Scalability Challenges

Regulatory frameworks for liability allocation in equipment damage, operator injury, and crop damage from improper operations remain underdeveloped in most jurisdictions. Ambiguities regarding whether platforms function as intermediaries or service providers affect legal responsibilities and insurance requirements. Progressive regulatory models treating platforms as technology facilitators while requiring mandatory insurance coverage and dispute resolution mechanisms offer promising approaches, though implementation remains limited.

Trust deficits between equipment owners and renters, particularly in peer-to-peer models, require sustained reputation-building through consistent platform performance and effective dispute resolution. Platforms report that 15-20% of initial transactions involve conflicts regarding equipment condition, service quality, or payment settlement, necessitating robust customer support infrastructure. Graduated trust mechanisms where new users access limited equipment categories or transact through platform-verified operators before gaining peer-to-peer access have proven effective.

Scalability challenges include achieving market liquidity where sufficient equipment density ensures reasonable response times while maintaining adequate utilization for owners to justify platform participation. Network effects require critical mass on both supply and demand sides, with platforms typically requiring 50-100 equipment units per operational district to achieve viable liquidity. Capital requirements for achieving this scale, combined with limited venture capital availability for agricultural technology in developing markets, constrain expansion rates.

5.3. Future Directions and Integration Opportunities

Artificial intelligence applications for demand forecasting, dynamic routing optimization, and predictive maintenance represent significant enhancement opportunities. Machine learning models analyzing historical booking patterns, weather forecasts, and crop calendars can predict service requirements 7-14 days in advance, enabling proactive equipment positioning and operator scheduling. Computer vision systems analyzing field imagery to assess crop maturity and recommend optimal harvest timing integrated with harvester booking could further improve operational precision.

Sustainability linkages including carbon footprint tracking from machinery operations, incentive mechanisms for fuel-efficient equipment, and integration with conservation agriculture service markets offer environmental value additions. Platforms documenting reduced equipment manufacturing through improved utilization and facilitating transition to electric or alternative-fuel machinery could access climate finance and carbon credit mechanisms.

Policy integration opportunities include coordination with agricultural subsidy programs, quality certification schemes, and financial inclusion initiatives. Digital platforms providing verifiable service delivery records could enable performance-based subsidy disbursement, while transaction data might inform credit scoring for farmers lacking traditional collateral. Public-private partnerships where governments provide capital subsidies for equipment acquisition conditional on platform-based sharing arrangements could accelerate mechanization while ensuring broad accessibility.

6. Figures

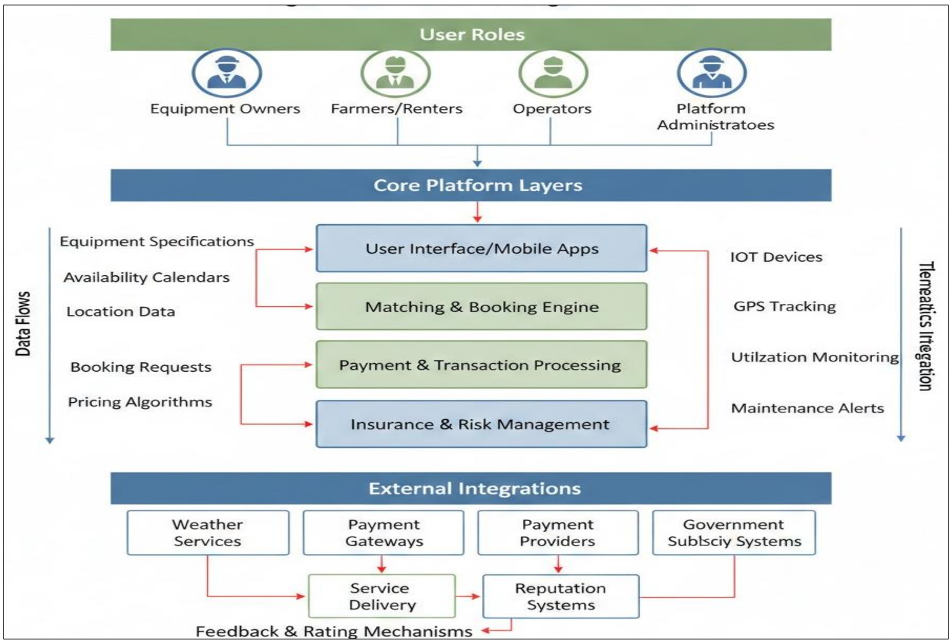

Fig 1: Architecture of digital platforms for sharing economy of heavy farm machinery

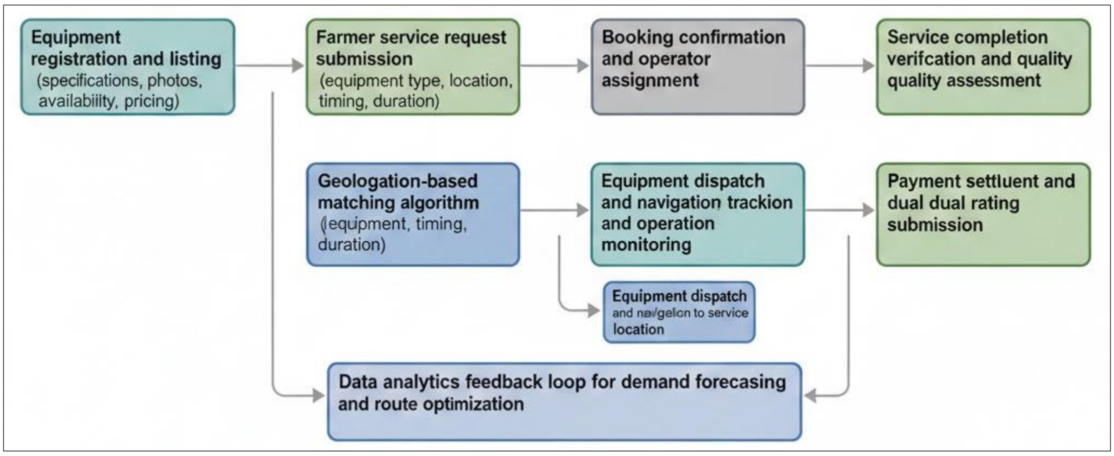

Fig 2: Key components and workflow in on-demand heavy farm machinery rental platforms

7. Table

Table 1: Major digital platforms and marketplaces for heavy farm machinery sharing/rental

Platform Name	Primary Region	Key Features	Machinery Types	Business Model
Hello Tractor	Sub-Saharan Africa (Nigeria, Kenya, Senegal, etc.)	IoT-enabled tracking, pay-per-hectare pricing, operator dispatch	Tractors, implements	Commission-based marketplace + telematics subscription
EM3 AgriServices	India (15+ states)	Standardized pricing, quality guarantees, operator training	Tractors, harvesters, transplanters, sprayers	Asset-light custom hiring coordination
Tringo	Netherlands, Belgium	AI demand forecasting, route optimization, cooperative integration	Precision equipment, harvesters, specialized implements	Rental marketplace + cooperative management tools
MachineryLink	Europe (multi-country)	Peer-to-peer rental, verified user profiles, equipment insurance	Tractors, tillage, harvest equipment	Commission-based P2P platform
FarmLend	North America	Neighbor-to-neighbor sharing, calendar management, dynamic pricing	Grain carts, planters, sprayers, combines	Transaction fee-based rental marketplace
JioKrishi (Reliance)	India	Integrated input supply, advisory bundling, subsidy linkage	Tractors, implements	Hybrid marketplace + value-added services
Trringo (Mahindra)	India	Manufacturer-backed equipment pool, service guarantees	Mahindra tractors and implements	Owned equipment rental + franchisee network
AgriShare	East Africa	Community equipment pools, shared ownership coordination	Tractors, processing equipment	Cooperative management + revenue sharing

Table 2: Core technologies and features integrated in sharing economy platforms for farm machinery

Technology/Feature Category	Specific Technologies	Primary Functions	Implementation Challenges
Geolocation and Mapping	GPS/GNSS, Google Maps API, OpenStreetMap	Equipment location tracking, farmer-equipment matching, route optimization, service area visualization	Connectivity in remote areas, map accuracy in rural zones
Telematics and IoT	CAN bus readers, cellular-enabled IoT devices, LoRaWAN sensors	Operational hour tracking, fuel monitoring, implement engagement detection, maintenance alerts	Device cost, cellular coverage, power supply management
Mobile/Web Interface	Android/iOS native apps, progressive web apps, responsive design	Service booking, equipment browsing, availability checking, payment processing	Digital literacy barriers, multi-language support, offline functionality
Matching Algorithms	Multi-criteria optimization, constraint satisfaction, auction mechanisms	Equipment-farmer pairing based on proximity, specifications, availability, pricing	Market liquidity requirements, computational complexity at scale
Payment Integration	Mobile money APIs (M-Pesa, UPI), digital wallets, escrow systems	Automated payment processing, transaction splitting, refund management	Payment gateway fees, fraud prevention, reconciliation
Insurance and Risk Management	Per-transaction insurance, damage assessment tools, claims processing	Liability coverage, equipment damage protection, dispute resolution	Premium affordability, claims verification, regulatory compliance
Rating and Reputation	Dual-rating systems, weighted scoring, feedback analytics	Trust-building, quality incentives, fraud deterrence	Rating manipulation, bias management, cold-start problems for new users
Data Analytics	Predictive modeling, demand forecasting, utilization analytics	Seasonal demand prediction, pricing optimization, equipment positioning	Data privacy concerns, analytical expertise requirements, model accuracy

Table 3: Regional applications and impacts of digital machinery sharing platforms

Region/Country	Platform Examples	Primary Applications	Documented Impacts	Key Success Factors
Nigeria	Hello Tractor, Tractor4Hire	Smallholder tractor access for land preparation, planting	40% increase in mechanization access, 500,000+ hectares serviced annually	Mobile payment integration, IoT tracking, operator training
Kenya	Hello Tractor, Twiga Foods	Tractor services, integrated input delivery	35% reduction in land preparation costs, improved timeliness	Payment flexibility, trust mechanisms, rural connectivity
India (North)	EM3, Trringo, JioKrishi	Wheat harvesting, rice transplanting, custom hiring coordination	15-25% cost reduction, 300,000+ farmers served, 450-hour utilization rates	Standardized pricing, quality assurance, dense equipment networks
India (South)	Trringo, Gold Farm	Paddy harvesting, precision spraying	30% improvement in harvest timeliness, reduced post-harvest losses	Manufacturer backing, franchisee networks, seasonal financing
Bangladesh	iDE's machinery service centers	Mechanical rice transplanting, tillage	80-hour to 450-hour utilization improvement, labor cost savings	Subsidy coordination, cooperative structures, centralized maintenance
Netherlands/Belgium	Tringo	Precision equipment sharing, cooperative management	60-80% utilization improvement, €30,000-50,000 annual cost savings per farm	Advanced infrastructure, cooperative culture, regulatory support
United States	FarmLend, MachineryLink	Specialized equipment rental, neighbor sharing	30-40% reduction in mechanization costs for renters, 25-35% ROI for equipment owners	High equipment standardization, insurance integration, rural broadband
East Africa (Multi-country)	AgriShare, One Acre Fund	Community equipment pools, smallholder mechanization	Increased mechanization adoption in cooperative member farms	NGO support, community trust, group lending mechanisms

Table 4: Advantages, limitations, and scalability challenges of digital platforms in the farm machinery sharing economy

Dimension	Advantages	Limitations	Scalability Challenges
Economic	50-100% utilization improvement; 15-40% cost reduction for renters; 25-35% equipment owner ROI; reduced capital requirements	Transaction fees (10-20%); initial platform access costs; insurance premiums add 2-5% to rental costs	Achieving market liquidity; balancing supply/demand across seasons; pricing optimization in low-income markets
Operational	Real-time equipment tracking; automated booking and payment; quality verification through ratings; data-driven maintenance scheduling	Dependence on cellular connectivity; equipment standardization difficulties; operator skill variability; service quality consistency	Multi-region expansion logistics; equipment diversity management; operator recruitment and training at scale
Technological	IoT integration enables precise utilization tracking; mobile payment reduces transaction friction; algorithms optimize matching and routing	Digital literacy barriers; smartphone/internet access gaps; telematics device costs; platform complexity for low-literacy users	Infrastructure deficits in rural areas; technology adaptation costs; continuous platform development requirements
Social/Trust	Rating systems build reputation; verified profiles reduce fraud; transparent pricing eliminates negotiation friction; insurance mechanisms protect transactions	Trust deficits in peer-to-peer models; cold-start problems for new users; rating manipulation risks; dispute resolution complexity	Building trust across diverse user bases; managing cross-regional reputation portability; conflict resolution at scale
Environmental	Reduced equipment manufacturing through improved utilization; potential for emission tracking and optimization; facilitates transition to cleaner technologies	Limited current focus on sustainability metrics; potential for increased travel emissions from equipment mobility	Integration with carbon accounting systems; incentive mechanisms for efficient equipment; policy linkages for green machinery
Regulatory	Digital records facilitate subsidy verification; transparent transactions enable credit scoring; platform data supports policy development	Ambiguous liability frameworks; insurance regulatory gaps; cross-border operation complexity; data privacy concerns	Developing supportive regulatory frameworks; navigating diverse jurisdictions; compliance costs; intellectual property for algorithms
Market Access	Enables smallholder access to previously unaffordable machinery; reduces geographic barriers; facilitates specialized equipment access	Requires critical mass (50-100 units per district); seasonal demand concentration limits year-round viability; limited equipment diversity in nascent markets	Geographic expansion requires local partnerships; market education and user onboarding; competition from informal custom hiring

8. Conclusion

Digital platforms leveraging sharing economy principles have fundamentally transformed heavy farm machinery access, transitioning from ownership-centric models to utilization-optimized service ecosystems. Through integrated technologies including geolocation-based matching, telematics-enabled tracking, mobile payment systems, and reputation mechanisms, platforms have demonstrated capacity to increase machinery utilization rates by 50-100%, reduce per-hectare mechanization costs by 15-40%, and enhance smallholder access to critical agricultural services. Regional applications spanning mechanization acceleration in Sub-Saharan Africa and South Asia to efficiency optimization in developed markets validate platform versatility across diverse agricultural contexts. However, persistent challenges including digital literacy gaps, infrastructure constraints, regulatory ambiguities, and trust-building requirements demand continued innovation in platform design, supportive policy frameworks, and adaptive business models. Future trajectories emphasizing artificial intelligence integration, sustainability linkages, and public-private coordination position digital machinery sharing platforms as essential instruments for achieving inclusive, efficient, and environmentally responsible agricultural mechanization globally.

9. References

1. Lowder SK, Skoet J, Raney T. The number, size, and distribution of farms, smallholder farms, and family farms worldwide. World Dev. 2016;87:16-29.
2. Takeshima H, Adhikari RP, Shivakoti S, *et al.* Heterogeneous returns to chemical fertilizer at the intensive margins: Insights from Nepal. Food Policy. 2016;69:97-109.
3. Singh G. Estimation of a mechanization index and its impact on production and economic factors—a case study in India. Biosyst Eng. 2006;93(1):99-106.
4. Diao X, Cossar F, Houssou N, Kolavalli S. Mechanization in Ghana: Emerging demand, and the search for alternative supply models. Food Policy. 2014;48:168-181.
5. Mrema GC, Baker D, Kahan D. Agricultural mechanization in sub-Saharan Africa: time for a new look. Rome: Food and Agriculture Organization; 2008.
6. Balafoutis A, Beck B, Fountas S, *et al.* Precision agriculture technologies positively contributing to GHG emissions mitigation, farm productivity and economics. Sustainability. 2017;9(8):1339.
7. Trendov NM, Varas S, Zeng M. Digital technologies in agriculture and rural areas. Rome: Food and Agriculture Organization; 2019.
8. Schor JB, Fitzmaurice CJ. Collaborating and connecting: the emergence of the sharing economy. In: Reisch LA, Thøgersen J, editors. Handbook of research on sustainable consumption. Cheltenham: Edward Elgar Publishing; 2015. p. 410-425.
9. Costanigro M, McCluskey JJ, Mittelhammer RC. Segmenting the wine market based on price: hedonic regression when different prices mean different products. J Agric Econ. 2007;58(3):454-466.
10. Sundararajan A. The sharing economy: the end of employment and the rise of crowd-based capitalism. Cambridge: MIT Press; 2016.
11. Aker JC, Ghosh I, Burrell J. The promise (and pitfalls) of ICT for agriculture initiatives. Agric Econ. 2016;47(S1):35-48.

12. Adu-Baffour F, Daum T, Birner R. Can small farms benefit from big companies' initiatives to promote mechanization in Africa? A case study from Zambia. Food Policy. 2019;84:133-145.
13. Wolfert S, Ge L, Verdouw C, Bogaardt MJ. Big data in smart farming–a review. Agric Syst. 2017;153:69-80.
14. Daum T, Birner R. Agricultural mechanization in Africa: Myths, realities and an emerging research agenda. Global Food Secur. 2020;26:100393.
15. Hermans F, Klerkx L, Roep D. Structural conditions for collaboration and learning in innovation networks: using an innovation system performance lens to analyse agricultural knowledge systems. J Agric Educ Ext. 2015;21(1):35-54.
16. Van Loon J, Woltering L, Krupnik TJ, *et al*. Scaling agricultural mechanization services in smallholder farming systems: Case studies from sub-Saharan Africa, South Asia, and Latin America. Agric Syst. 2020;180:102792.
17. Fielke S, Taylor B, Jakku E. Digitalisation of agricultural knowledge and advice networks: A state-of-the-art review. Agric Syst. 2020;180:102763.
18. Klerkx L, Jakku E, Labarthe P. A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda. NJAS-Wageningen J Life Sci. 2019;90-91:100315.
19. Michels M, Bonke V, Musshoff O. Understanding the adoption of smartphone apps in crop protection. Precis Agric. 2020;21(6):1209-1226.
20. Birner R, Daum T, Pray C. Who drives the digital revolution in agriculture? A review of supply-side trends, players and challenges. Appl Econ Perspect Policy. 2021;43(4):1260-1285.
21. Fabregas R, Kremer M, Schilbach F. Realizing the potential of digital development: The case of agricultural advice. Science. 2019;366(6471):eaay3038.
22. Accenture Development Partnerships. Digitally enabled agricultural extension. London: USAID; 2017.
23. Zhou Y, Zhang X, Tian X, *et al*. Agricultural mechanization and land productivity in China. Int J Sustain Dev World Ecol. 2020;27(6):530-542.
24. Kienzle J, Ashburner JE, Sims BG. Mechanization for rural development: A review of patterns and progress from around the world. Rome: Food and Agriculture Organization; 2013.
25. Pingali P. Agricultural mechanization: adoption patterns and economic impact. In: Evenson R, Pingali P, editors. Handbook of agricultural economics. Vol 3. Amsterdam: Elsevier; 2007. p. 2779-2805.
26. Atzori L, Iera A, Morabito G. The internet of things: A survey. Comput Netw. 2010;54(15):2787-2805.
27. Vecchio Y, Agnusdei GP, Miglietta PP, Capitanio F. Adoption of precision farming tools: The case of Italian farmers. Int J Environ Res Public Health. 2020;17(3):869.
28. Sørensen CG, Fountas S, Nash E, *et al*. Conceptual model of a future farm management information system. Comput Electron Agric. 2010;72(1):37-47.
29. Kutter T, Tiemann S, Siebert R, Fountas S. The role of communication and co-operation in the adoption of precision farming. Precis Agric. 2011;12(1):2-17.
30. Pathak HS, Brown P, Best T. A systematic literature review of the factors affecting the precision agriculture adoption process. Precis Agric. 2019;20(6):1292-1316.
31. Fountas S, Carli G, Sørensen CG, *et al*. Farm management information systems: Current situation and future perspectives. Comput Electron Agric. 2015;115:40-50.
32. Kaloxylos A, Eigenmann R, Teye F, *et al*. Farm management systems and the Future Internet era. Comput Electron Agric. 2012;89:130-144.
33. Pierpaoli E, Carli G, Pignatti E, Canavari M. Drivers of precision agriculture technologies adoption: A literature review. Procedia Technol. 2013;8:61-69.
34. Kamilaris A, Kartakoullis A, Prenafeta-Boldú FX. A review on the practice of big data analysis in agriculture. Comput Electron Agric. 2017;143:23-37.
35. Rose DC, Sutherland WJ, Parker C, *et al*. Integrated farm management for sustainable agriculture: Lessons for knowledge exchange and policy. Land Use Policy. 2016;81:834-842.
36. Finger R, Swinton SM, El Benni N, Walter A. Precision farming at the nexus of agricultural production and the environment. Annu Rev Resour Econ. 2019;11:313-335.
37. Beluhova-Uzunova R, Shishkova M, Ivanov B. Agricultural machinery sharing as a tool for sustainable agriculture. Bulg J Agric Sci. 2020;26(4):779-784.
38. Caffaro F, Cavallo E. The effects of individual variables, farming system characteristics and perceived barriers on actual use of smart farming technologies. Agric Syst. 2019;183:102874.
39. Barnes AP, Soto I, Eory V, *et al*. Exploring the adoption of precision agricultural technologies: A cross regional study of EU farmers. Land Use Policy. 2019;80:163-174.
40. Aker JC, Mbiti IM. Mobile phones and economic development in Africa. J Econ Perspect. 2010;24(3):207-232.