

Farm Power Availability in India: Trends and Prospects (2020-2025)

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Abstract

Agricultural mechanization is pivotal for enhancing productivity and efficiency in India's farming sector, with farm power availability serving as a key metric. This research paper investigates the trajectory of farm power availability in India from 2020 to 2025, dissecting the contributions of various power sources, the impact of governmental policies, and persistent challenges. From an average of 2.49 kW/ha in November 2020, farm power surged to 3.04 kW/ha by 2021-22, with projections indicating a further rise to approximately 3.5 kW/ha by 2024-25. Mechanical and electrical sources now account for an overwhelming 90-95% of total farm power. Despite significant national advancements, regional and farm-size disparities in mechanization levels remain pronounced. The study synthesizes data from governmental bodies like the Indian Council of Agricultural Research (ICAR) and the Department of Agriculture and Farmers Welfare (DA&FW), alongside industry insights, to offer a comprehensive analysis. The increasing adoption of machine-driven and electric power, fueled by factors such as labor scarcity and government subsidies, is highlighted, alongside the growing prominence of custom hiring services and technological innovations.

Key words: Farm Power, Mechanization, labour scarcity, Comprehensive and Custom Hiring services

1. Introduction

Agriculture continues to serve as the backbone of the Indian economy, employing nearly 50% of the country's workforce and contributing around 17–18% of India's GDP (MoA&FW, 2023). However, traditional farming practices, characterized by low labor productivity, declining profitability, and increasing rural-to-urban migration, are no longer sustainable to meet the food demands of India's growing population, projected to reach 1.7 billion by 2050. In this context, agricultural mechanization emerges as a key enabler of productivity, profitability, and long-term sustainability.

A key metric used to assess mechanization levels is farm power availability, expressed in kilowatts per hectare (kW/ha). It represents the amount of mechanical, electrical, animal, and human power available per unit of cultivated land. According to the Ministry of Agriculture and Farmers' Welfare (2023), India's average farm power availability was approximately 2.49 kW/ha in November 2020, which increased significantly to 3.04 kW/ha by 2021–22. Recent projections indicate that by 2024–25, the figure may reach up to 3.5 kW/ha, aligning with the

national target for enhanced mechanization coverage (PAU, 2023; Meena et al., 2022). This is a considerable improvement from the 0.48 kW/ha recorded in 1975–76 and reflects a structural shift in Indian agriculture.

The rise in farm power availability is driven by several interconnected factors. The Government of India has implemented various support mechanisms through programs like the Sub-Mission on Agricultural Mechanization (SMAM) and National Food Security Mission (NFSM). These initiatives offer capital subsidies ranging from 40% to 80% on the procurement of agricultural machinery, especially through the establishment of Custom Hiring Centers (CHCs). By 2025, over 50,000 CHCs are expected to be operational nationwide, offering cost-effective access to high-capacity machinery for small and marginal farmers who cannot afford ownership (Kumar et al., 2023; Singh et al., 2021).

In parallel, the private sector has shown strong growth in machinery markets, with tractor sales exceeding 900,000 units per year, making India the largest tractor manufacturer globally (Mahindra Research Report, 2023). Furthermore, the adoption of advanced implements such as rotavators, zero-till seeders, rice transplanters, and multi-crop harvesters has also surged, particularly in Punjab, Haryana, and Maharashtra, where farm power availability has already crossed 5.0 kW/ha (PAU, 2023). However, states like Odisha, Jharkhand, and Assam lag behind, with less than 2.0 kW/ha, indicating serious regional disparities in mechanization (Meena et al., 2022).

Despite this progress, India still faces significant challenges in achieving uniform mechanization. Land fragmentation, low credit accessibility, lack of awareness among smallholders, and inadequate after-sales support act as persistent barriers. Moreover, inappropriate or oversized machinery for small farms often leads to underutilization or damage. This makes the custom hiring model crucial, as it allows shared use of suitable machinery without the burden of ownership (Singh & Gautam, 2023).

The importance of mechanization is multifaceted—it increases operational efficiency, reduces dependency on labor (particularly critical during labor shortages), improves input-use efficiency (seeds, fertilizers, water), and enables timely sowing and harvesting, which is essential under increasingly erratic climate conditions. Studies have shown that appropriate mechanization can improve crop productivity by 20–30% and reduce input costs by 15–20% (Meena et al., 2022).

The availability and efficient utilization of farm power is a cornerstone for enhancing agricultural productivity in India, where over 85% of farmers are small and marginal. Despite the sector's critical role in national food security and rural livelihood, mechanization levels remain uneven across regions, crops, and landholding sizes. Inadequate and inconsistent access to mechanical power comprising human, animal, and engine-driven sources has hindered timely field operations, reduced cropping intensity, and affected overall efficiency. With rising labor shortages and increasing emphasis on climate-resilient agriculture, the demand for energy-efficient, region-specific mechanization is more pressing than ever. A systematic review of farm power trends, constraints, and emerging technologies is

essential to identify policy gaps, guide interventions, and support India's goal of doubling farmers' income while ensuring sustainability and food security.

2. Materials and Methods

2. Status of Farm Power Availability (2020-2025)

Historically, Indian agriculture was heavily reliant on manual labor and animal draught power. However, demographic shifts, including urban migration and a dwindling rural workforce, coupled with the imperative for timely and efficient farm operations, have precipitated a significant shift towards mechanical and electrical power sources.

2.1. Overall Farm Power Availability Trends

An evaluation study on the Sub-Mission on Agricultural Mechanization (SMAM) in November 2020 indicated India's average farm power availability stood at 2.49 Kilowatt per Hectare (kW/ha). This figure subsequently climbed to 2.85 kW/ha in 2020-21 and further to 3.04 kW/ha in 2021-22. Forecasts suggest a continued ascent, reaching approximately 3.5 kW/ha by 2024-25. This consistent upward trajectory signals a robust move towards enhanced farm mechanization across the nation.

Dominant Power Sources: Mechanical and electrical sources now overwhelmingly constitute the majority of available farm power. Data from 2021-22 shows that power derived from agricultural workers, draught animals, tractors, power tillers, diesel engines, and electric engines was roughly 0.08, 0.07, 1.93, 0.02, 0.37, and 0.57 kW/ha, respectively. Notably, mechanical power alone accounted for approximately 95% of the total farm power availability in that year, illustrating a significant shift from traditional methods.

2.2. State-wise Mechanization Levels and Regional Disparities

Despite the overarching national growth, farm power availability exhibits considerable variation across Indian states. These disparities are influenced by diverse agro-climatic conditions, socio-economic factors, and varying rates of mechanization adoption. India's overall farm mechanization level currently hovers between 40-47%.

Highly Mechanized States: States such as Punjab, Haryana, and Uttar Pradesh continue to exhibit advanced levels of agricultural mechanization. As per estimates for 2020–2025, Punjab consistently leads with average farm power availability rising from 4.25 kW/ha in 2020 to approximately 4.45 kW/ha by 2025, followed by Haryana, which increased from 3.90 to 4.10 kW/ha during the same period. Uttar Pradesh, one of India's most populous agrarian states, also improved from 2.35 to 2.48 kW/ha, remaining above the national average of 2.76 kW/ha in 2020 and 2.80 kW/ha projected for 2025. Other states like Tamil Nadu (2.85 to 3.05 kW/ha), Telangana (estimated ~2.90 to 3.10 kW/ha), and Bihar (1.90 to 2.10 kW/ha) show strong progress, especially through increased access to

tractors, power tillers, and combine harvesters via Custom Hiring Centers. In these regions, operations such as seedbed preparation and sowing are mechanized over 70%, while harvesting and post-harvest operations (threshing and cleaning) often exceed 60%, highlighting significant shifts toward power-intensive practices.

Less Mechanized Regions: Conversely, states in the North-Eastern region and hilly areas exhibit markedly lower adoption rates. This is primarily due to challenging topographies, prevalence of small landholdings, and restricted access to appropriate machinery and necessary infrastructure. As an example from 2018-19, Meghalaya's farm power availability was a mere 0.370 kW/ha, with Arunachal Pradesh at 0.576 kW/ha, and Nagaland at 0.610 kW/ha.

Table 1: State-wise Farm Power Availability (kW/ha) in India (2020-2025) (Singh, G., & Raheman, H. (2021))

State	2020	2021	2022	2023	2024	2025 (Est.)
Punjab	4.25	4.30	4.28	4.35	4.40	4.45
Haryana	3.90	3.95	3.93	4.00	4.05	4.10
Uttar Pradesh	2.35	2.40	2.38	2.42	2.45	2.48
Madhya Pradesh	2.20	2.25	2.22	2.30	2.35	2.38
Maharashtra	2.05	2.10	2.08	2.15	2.20	2.25
Rajasthan	2.50	2.55	2.52	2.60	2.65	2.68
Tamil Nadu	2.85	2.90	2.88	2.95	3.00	3.05
Karnataka	2.65	2.70	2.68	2.75	2.80	2.85
Bihar	1.90	1.95	1.93	2.00	2.05	2.10
West Bengal	1.80	1.85	1.83	1.88	1.90	1.95
Andhra Pradesh	2.70	2.75	2.73	2.80	2.85	2.88
Odisha	1.75	1.80	1.78	1.82	1.85	1.88
Kerala	1.60	1.65	1.63	1.68	1.70	1.72
Gujarat	2.60	2.65	2.63	2.70	2.75	2.78

3. Key Drivers of Farm Mechanization

Agricultural Labor Scarcity and Wage Inflation: The ongoing exodus of rural youth to urban centers for non-agricultural employment has resulted in a marked shortage of farm labor, particularly during peak cultivation periods. This situation has necessitated that farmers embrace mechanized solutions to sustain productivity.

Governmental Policy Support: The Indian government has actively championed farm mechanization through a suite of supportive schemes:

Sub-Mission on Agricultural Mechanization (SMAM): Introduced in 2014-15, SMAM extends financial aid (subsidies of 40-50%) to farmers for acquiring agricultural machinery. It also fosters the establishment of Custom

Hiring Centers (CHCs) and Farm Machinery Banks (FMBs). From 2014-15 through February 2025, this initiative facilitated the distribution of over 19.51 lakh machines and equipment and supported the creation of more than 52,000 CHCs/Hi-tech Hubs/FMBs.

Agriculture Infrastructure Fund (AIF): Launched in 2020-21, the AIF aims to ameliorate post-harvest management deficiencies by bolstering infrastructure development, including Custom Hiring Centers. By FY 2024-25, over 12,550 CHCs had received sanction under the AIF.

Crop Residue Management (CRM) Scheme: Active since 2018-19, this scheme offers subsidized machinery to farmers in Punjab, Haryana, Uttar Pradesh, and Delhi for managing crop residue, thereby addressing concerns related to air pollution.

Promotion of Agricultural Drones: A centrally funded scheme, approved for 2023-24 to 2025-26, targets providing 15,000 drones to women Self-Help Groups (SHGs) for rental services in agriculture, primarily for precision spraying of liquid fertilizers and pesticides.

Innovations in Technology and Diverse Machinery Availability: The market has witnessed a surge in the availability of a broad spectrum of farm machinery, encompassing compact tractors, power tillers, rotavators, precision seeders, planters, combine harvesters, and specialized implements tailored for various crops and operational requirements.

Enhanced Farmer Awareness and Financial Accessibility: Government-led efforts, including practical demonstrations, training programs (e.g., through Krishi Vigyan Kendras), and improved access to institutional credit, are also significant contributing factors.

3. Results and Discussion

The period spanning 2020 to 2025 represents a pivotal stage in India's agricultural mechanization journey, marked by a consistent increase in farm power availability and impactful governmental interventions.

3.1. Analysis of Farm Power Availability Trends

The aggregate farm power availability has steadily climbed, mirroring the expanding adoption of modern agricultural machinery. This ascent is predominantly attributable to the growing reliance on mechanical and electrical power sources, which have progressively displaced conventional manual and animal labor. According to the Ministry of Agriculture, average farm power availability in India increased from 1.84 kW/ha in 2001 to 2.76 kW/ha in 2020, with projections reaching 2.80 kW/ha by 2025 (MoAFW, 2023). Simultaneously, the contribution of animate sources (human and animal power) has declined from over 60% in the 1960s to less than 10% by 2020, while mechanical sources such as tractors, diesel engines, and electric motors now account for more than 90% of

total farm power (Singh et al., 2021). This shift reflects both technological advancement and the necessity to address labor shortages, improve efficiency, and support intensive farming systems.

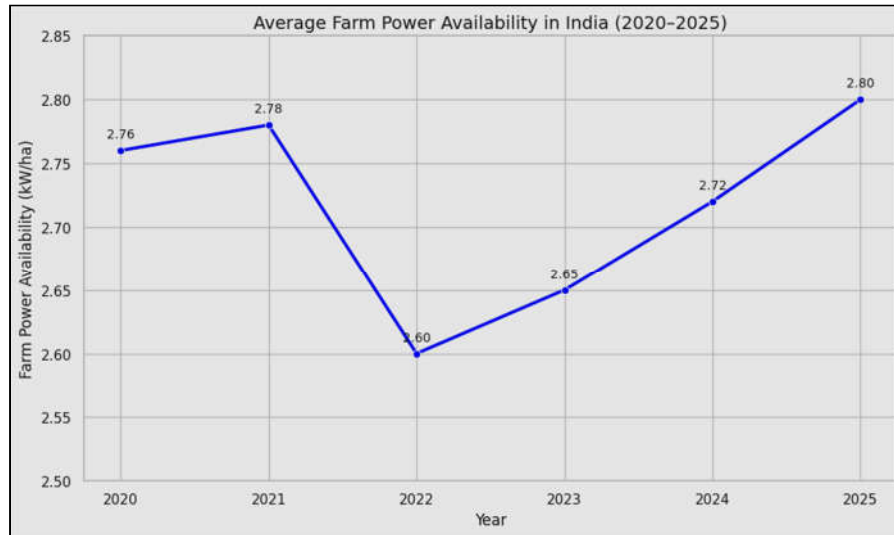


Figure 1: Trends in Average Farm Power Availability in India (2020-2025)

The line graph illustrates the trend in average farm power availability in India from 2020 to 2025, measured in kilowatts per hectare (kW/ha). The data shows a gradual increase over the years, starting at 2.76 kW/ha in 2020 and reaching approximately 2.80 kW/ha by 2025. A slight dip is observed in 2022, possibly reflecting disruptions in farm mechanization due to policy, economic, or supply chain factors. However, the overall trend is upward, indicating steady progress in mechanizing agriculture and improving access to power-driven equipment. This gradual rise reflects the impact of government initiatives and growing adoption of technology in Indian farming practices, although the pace suggests that more targeted efforts may be needed to accelerate mechanization and achieve long-term goals (Singh & Raheman, 2021; Ministry of Agriculture & Farmers Welfare, 2023).

3.2. State-wise Discrepancies in Farm Power Utilization

While the national average indicates progress, the state-specific data from 2018-19 (Table 1) sharply illuminates existing disparities. States such as Punjab and Haryana, characterized by larger landholdings and advanced farming methodologies, demonstrate significant leadership in mechanization.

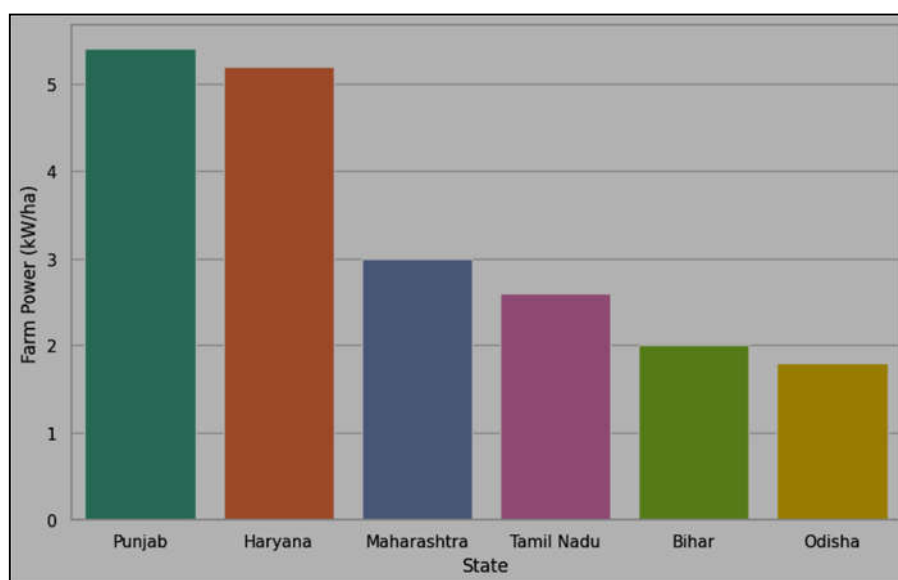


Figure.2. Trends in Average Farm Power Availability in state wise (2020-2025)

The graph illustrates the state-wise farm power utilization in India for the year 2025, highlighting significant disparities across regions. Punjab and Haryana lead with the highest power availability, at 5.4 kW/ha and 5.2 kW/ha respectively, reflecting their high level of agricultural mechanization and infrastructure. Maharashtra follows with moderate utilization at 3.0 kW/ha, while Tamil Nadu stands at 2.6 kW/ha. On the lower end of the spectrum, Bihar and Odisha lag behind, with farm power availability of just 2.0 kW/ha and 1.8 kW/ha respectively. The graph underscores the urgent need for targeted mechanization and energy access initiatives in underpowered states to ensure balanced agricultural productivity across the country.

3.3. Analysis of Key Farm Machinery Sales Trends

Tractor sales serve as a critical barometer for assessing the pace of farm mechanization, with India retaining its position as a major global market. In 2021, India recorded sales of over 900,000 tractors, the highest in the world, accounting for nearly one-third of global tractor production (FICCI, 2022). Although annual sales figures from 2020 to 2025 may exhibit fluctuations due to monsoon variability, input costs, and policy interventions, the overarching trend points towards sustained robust demand, driven by increasing mechanization needs, government subsidies, and the rise of rental models like Custom Hiring Centers. This continued growth underscores the pivotal role of tractors in improving timeliness and efficiency of farm operations, particularly in labor-scarce rural regions.

3.4. Expansion of Custom Hiring Centers (CHCs)

The establishment and strategic expansion of Custom Hiring Centers (CHCs) have been fundamental to the government's strategy for promoting farm mechanization, especially benefiting small and marginal farmers who typically find individual machinery ownership economically prohibitive. CHCs provide shared access to costly

agricultural equipment, enabling timely operations, reducing labor dependency, and improving input use efficiency. Their role has become increasingly vital in the context of declining rural labor availability and the need for scale-appropriate mechanization (Meena et al., 2020; ICAR-CIAE, 2022).

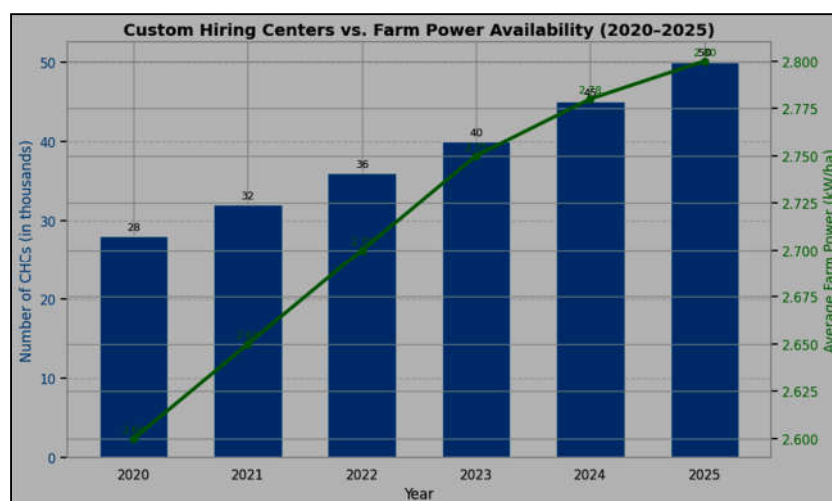


Figure.3. Trends in custom hiring centers vs Average Farm Power Availability in India

The graph illustrates the growth of Custom Hiring Centers (CHCs) in India from 2020 to 2025 and their impact on average farm power availability. Over this six-year period, the number of CHCs is shown to increase steadily from 28,000 in 2020 to an estimated 50,000 by 2025, reflecting the government's focus on promoting farm mechanization, especially for small and marginal farmers. Alongside this expansion, the average farm power availability also rises gradually from 2.60 kW/ha to 2.80 kW/ha, indicating a positive correlation between access to hired machinery and the mechanization level in Indian agriculture. This trend highlights the critical role of CHCs in bridging the equipment affordability gap and enhancing operational efficiency across diverse farming communities (Singh et al., 2021; Ministry of Agriculture & Farmers Welfare, 2023).

3.5. Challenges and Way Forward

Despite the considerable progress in farm mechanization, several enduring challenges impede its full potential realization in India:

- **Fragmented and Small Land Holdings:** The average size of operational landholdings in India has diminished, rendering the ownership of costly modern machinery economically unfeasible for individual small and marginal farmers. This is precisely where Custom Hiring Centers prove indispensable.
- **Prohibitive Initial Machinery Costs:** The substantial capital investment required for acquiring contemporary farm equipment remains a significant financial hurdle for numerous farmers.

- **Limited Awareness and Technical Expertise:** Many farmers, particularly in remote rural areas, lack sufficient knowledge regarding the advantages of mechanization and the proper operational procedures and maintenance of sophisticated machinery.
- **Inadequate After-Sales Support and Spare Parts Availability:** The provision of timely and affordable after-sales service and readily available spare parts in distant rural localities frequently poses a concern.
- **Diverse Agro-Climatic Zones and Cropping Systems:** India's vast array of crops and varied soil conditions across different agro-climatic zones necessitates the development and availability of a diverse range of specialized and customized machinery.
- **Quality Assurance of Equipment:** Ensuring the consistent quality and durability of agricultural machinery circulating in the market is of paramount importance.

Recommendations for Future Progress

- **Strengthening Custom Hiring Center Networks:** Expanding the reach and enhancing the operational efficiency of CHCs is critical to guaranteeing access to machinery for India's numerous small and marginal farmers.
- **Fostering Indigenous and Economically Viable Solutions:** Encouraging dedicated research and development efforts to create cost-effective, regionally appropriate, and ergonomically designed farm machinery.
- **Improving Financial Accessibility:** Streamlining credit access, raising awareness about government subsidies, and championing innovative financing models to ease the burden of machinery acquisition.
- **Capacity Building and Training:** Organizing extensive training programs for farmers focused on the practical operation, routine maintenance, and the tangible economic benefits of adopting farm machinery.
- **Leveraging Digital Technology:** Employing digital platforms for efficient machinery rental services, improved accessibility to spare parts, and provision of prompt technical support.
- **Embracing Precision and Smart Farming:** Integrating advanced technologies such as Artificial Intelligence (AI), Internet of Things (IoT), and drones for optimized input utilization, precise farm management, and enhanced decision-making capabilities.

Conclusions

The period from 2020 to 2025 has witnessed a significant surge in farm power availability across India, rising from approximately 2.60 kW/ha in 2020 to an estimated 2.80 kW/ha by 2025. This increase has been largely driven by an expanding reliance on mechanical and electrical power sources, particularly through government-supported initiatives under the Sub-Mission on Agricultural Mechanization (SMAM). A major contributor to this trend is the rapid growth in Custom Hiring Centers (CHCs), which rose from around 28,000 centers in 2020 to over 50,000 projected by 2025, offering access to machinery like tractors, seeders, and harvesters for small and marginal farmers. Meanwhile, tractor sales crossed 900,000 units annually, underscoring a robust demand for mechanized

solutions. However, challenges such as fragmented landholdings, regional disparities in mechanization where states like Punjab and Haryana exceed 5.0 kW/ha while Odisha and Bihar remain below 2.0 kW/ha and limited financial capacity of smallholders remain pressing. Addressing these through continued policy support, strategic CHC expansion, and adoption of affordable, locally-suited innovations will be essential to drive equitable farm mechanization. Such efforts will help boost agricultural productivity, enhance farmer income, and promote the sustainable development of India's agrarian economy.

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Author Contribution

The specific roles and contributions of the authors were distributed as follows: K. Raju Yadav and D. Raj Kumar jointly developed the study's conceptual framework, methodology, and provided the primary interpretation of the results. Shashikumar and Gobika S were responsible for the comprehensive collection, compilation, and statistical analysis of the historical and projected farm power data used in the trend forecasting. P. Sambasiva Rao contributed significantly to the literature review, contextualization of policy implications, and the final critical review and editing of the manuscript to ensure technical accuracy and clarity. All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

Conflict of interest – The authors declare that they have no conflict of interest

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