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# A Review Paper on Farm Mechanization, Farm Machinery Accidents and Safety

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**ABSTRACT:** India is the largest country in the South Asian region with all the problems faced by rapidly developing nations, especially in increasing mechanization. In spite of such developments, there are limited data in the literature addressing the problem of vehicle and machine injuries related to agriculture. This is an attempt to estimate the magnitude of the problem through published literature. Here is a systematic review of the literature on machine caused injuries in agriculture farms in India, conducted using different databases and hand-searching of the selected articles. There is a lack of population-based data on injuries in India and there is large heterogeneity in the published data. This is an important research agenda for the country. Immediate steps are required to curb this problem to limit the loss of life of the farmers.

**KEYWORDS:** Farm mechanization, machinery accidents, machinery safety, mechanization status.

## I.INTRODUCTION

Farm mechanization means the improved way of doing farm practices that needs least effort and resources. Farming practice has been revolutionized with tractor & tractor driven equipment (Mechanical). The estimates suggest that a 10% increase in mechanized tilling led to a 5% fall in women's farm labour use, with no accompanying increase in their non-farm sector employment (Mahajan *et al.*, 2022). After Independence, rising population, demand for food, poor rural development and pathetic Farmers' socio-economic status, have been the inherent truth about the agricultural sector of India. With the development of mechanization in agriculture, only few states have witnessed to emerge as the model state in agriculture Since Green revolution (Kumar and Kutumbale, 2019). Agriculture assumes an imperative role in the development of the Indian economy, and it additionally contributes around 15% to the nation's GDP, offering work chances to around half of its population. In spite of the fact that there have been advancements in new technologies, sustainability is the most important issue in farming. Modern farming processes and advanced machinery have solved OHS (occupational health and safety) problems of farming. But modern equipment's smoke, dust, chemicals, and fertilizers both in manual-driven farming and modern farming are major environmental issues (Satapathy and Mishra, 2022). Custom hiring services (CHS) has enabled the small and the marginal farmers to timely carry out the farm operations by providing access to the costly farm machines at subsidized rate on hiring basis. It has been advantageous in drudgery reduction, minimizing the cost of cultivation and also creating opportunities for skilled labour. Custom hiring has facilitated efficient use of resources and applied inputs. In spite of its importance and need, farm mechanization is still beyond the reach and acceptance of many farmers in India due to various constraints perceived by them (Kisku and Bisht, 2022). Agricultural workers are not afforded the same protection under Occupational Safety and Health Administration (OSHA) regulations or child labour laws as workers in other industries (U.S. Department of Labour, 1989). Because of the unique features in agriculture, creative assessment techniques and prevention strategies are needed to reduce farm related injuries and illnesses. Occupational health nurses are in a strategic position to help identify farm related illnesses and provide expertise in prevention of injuries and illnesses for workers in their companies who are also part time farmers. Farmers are independent, creative owners/operators who may choose to initiate or bypass safe work practices and engineering controls, such as machine guards, for perceived expediency.

## II.RELATED WORK

### FARM MECHANIZATION STATUS

Projected demand for tractors in India showed that total demand in India during the coming years would vary between 17,01,465 tractors in the year 1997-98 to 22,58,028 tractors in 2024-25. The gross irrigated area, demand for tractors in previous years (which explained in a way the demonstration effect) and real price were significant variables (Grover and Sharma, 2000), which positively influenced the demand for tractors in India. Indian agriculture continues to be dependent upon human and draught animal power. Animal power contributed 92 per cent of the total farm power in 1960-61 and mechanical and electrical together contributed only 8 per cent. By 1999-2000, the contribution of animal power came down to only 19 per cent and from rest of the sources such as tractors, power tillers, electric motors and diesel engines, it increased to 81 percent potential farm power available per unit cultivated land from all sources (animal and mechanical) increased from 0.32 kw/ha in 1965-66 to 115 kw/ha (net-cropped area basis) in 1997-98. Even with not much increase in cropping intensity and area under irrigation, the land productivity (for food grains only) has gone up by 144 per cent from 0.636 ton/ha in 1965-66 to 1.554 ton/ha in 1997-98 (Singh *et al.*, 2004). This was possible due to the introduction of high yielding varieties and need based farm mechanization. The tractor population in India of 41-60 hp segment has increased from 54,685 (22.8 percent of total number of tractors in a year) in 2000-01 to 91,741 (31.5 percent) in 2005-06. Usage of higher hp tractors (60 hp) has also increased from 265 tractors in 2000-01 to 2068 in 2003-04. Such steady trends in 31-40 hp and increasing trends in 41-60 hp and above 60 hp segments has observed a down fall of 21-30 hp from 54,441 tractors (22.7 per cent of total number of tractors) in 2000-01 to 50,135 (17.2 per cent of total number of tractors) in 2005-06, (Bector *et al.*, 2008). In the changing scenario, it has become more important to have projection estimates of total number of tractors, power tillers, diesel engines, electric pumps and other power-operated agricultural machinery and implements for the future years. Making use of available yearly data, the projected population of agricultural machinery and implements for future years at all-India level, (Tyagi *et al.*, 2010). The total number of tractors in Haryana were estimated to be 5,17,424 for the year 2029-30. There were two financial problems as the first infrastructural and second economical, which were majorly faced by the farmers in the purchase and use of tractors, (Chand., 2011). At Udaipur District of Rajasthan state in order to identify constraints faced by farmers in utilization of improved farm implements a sample of 120 respondents from two tehsils (Mavli & Salumber) and eight villages (Samchott, Banoda, Joyra, Mahadevkhera, Goverdhanpura, Rahami, Budgaon & Intali) were taken on the basis of proportionate random sampling. The farmers face medium level of constraints due to “Low level of education” followed by “Lack of training”. In technical constraints “Lack of demonstration on improved farm implements” and also “Poor extension service on improved farm implements” is a major communicational constraint. In case of institutional constraints “Poor banking system in rural areas” and “High initial cost of improved farm implements” and “Degraded soil structure” is major geographical constraints, which are faced by the farmers in utilization of improved farm implements. (Shekhawat *et al.*, 2021). Research done on farm mechanization in irrigated lowland Regions 1[Ilocos], 2[Cagayan Valley] and 3[Central Luzon, Philippines] by interviewing Four hundred fifty farmers on different aspects as: machine and equipment ownership; source of power and labour in farm operation; mechanization priorities; problems and constraints; demand for machinery and training skills; source of farm information; farm financing and credit information; and infrastructure accessibility. The land preparation was almost 100% done through the use of machinery, particularly the hand tractor, though the ownership of such machine's accounts only to 50%. Custom servicing has displaced manual labour on that particular farm operations. Conclusively, the cost, speed of operation, and ease or tediousness of the activity were the three major factors considered in facilitating farm mechanization, (Gavino *et al.*, 2006). The past, present and future perspective of farm mechanization in India substantiate it in four themes, namely, initiatives by the Government for farm mechanization, Impact of mechanical sources so far, Impact of chemical catalyst and the last future of farm mechanization. (Kumar *et al.*, 2019)

The earliest and most fundamental level of agricultural mechanization is human power as hand tools by human muscles, animal power to operate farm implements and machines. Mechanical power is the most powerful type of power, fuelled and supported by technology. Electricity, Hydropower, Solar energy, Wind energy, Internal combustion engines, and other agricultural energy sources are required for various farming operations, mobile or stationary processes. The use of these resources varies by country and is dependent on local circumstances, particularly their availability, (Rakhra *et al.*, 2022). Total farm power availability in Indian agriculture was 2.24 kW/ha in 2016-17. It had a share of 1.324, 0.018, 0.021, 0.460, 0.193, 0.091 and 0.130 kW/ha from tractors, power tillers, combine harvesters, diesel engines, electric motors, humans and draught animals, respectively. The overall mechanization levels for rice, wheat, maize, sorghum, pulses, oilseeds, cotton and sugarcane crops were 45, 63, 40, 26, 34, 34, 26 and 24%, respectively, (Mehta *et al.*, 2019). Farm mechanization in India with major policy changes, manufacturing companies and foreign collaborations increased farm power from 0.25 kilowatt per hectare (kW/ha) in 1951 to 2.02 kW/ha in



2017. Furthermore, the contribution of mechanized sources to farm power increased from some 3 percent in 1951 to 88 percent in 2013-14, replacing human and draught power. In addition, the production of tractors increased significantly from a meager 880 units in 1951 to about 900,000 units in 2019. This has transformed India from being a net importer of tractors through the 1960s and 1970s to being an exporter of tractors, exporting some 92,000 units in 2019. In terms of inclusiveness, although larger farms are more mechanized, the Input Census data (2011-12) reveals that even in the category of small and marginal holdings (less than 2 ha), an average of roughly 44 percent of farmers use farm machinery (e.g., tractors, diesel engine pump sets, electric pump sets and power tillers), (Gulati and Juneja, 2020). At present, Farm power availability from tractors has grown from 0.007 kW/ha in 1960-61 to 1.03 kW/ha in 2013-14 and it is further estimated to reach 3.74 kW/ha by 2032-33. According to the World Bank estimates, half of the total Indian population would be in urban areas by 2050. It is further estimated that the percentage of farm workers of total workforce would reduce to 49.9% in 2033 and 25.7% in 2050 from 54.6% in 2011. The share of agricultural workers in total power availability in 1960-61 was about 16.3%, which is going to reduce to 2.3% in 2032-33. (Tiwari *et al.*, 2019). FAO-IFPRI study, focused on the tractors, the universal power sources for all other driven implements and equipment in agriculture, with significant potential to replace animal draught power and human power, including children's muscle power. Tractor the first type of machine-powered equipment in use at lower levels of agricultural development, the context where most child labour is found. Mechanization is mostly assumed to reduce child labour, as it is expected to be labour saving in general. The use of tractors and other machinery could increase children's engagement in farm activities. The tractor allows farmers to cultivate larger areas, or if it leads to shifting chores of work from hired labour to family workers, e.g., for weeding edges of farmland not reachable by machinery. The new FAO-IFPRI study provides a rigorous quantitative assessment for seven developing countries in Asia (India, Nepal and Vietnam) and sub-Saharan Africa (Ethiopia, Ghana, Nigeria and Tanzania) based on comparable farm household survey data, (Takeshima and Los, 2022). One study was conducted in two districts – Bhiwani and Kaithal, covering two blocks of each district and two villages from each block with random sample techniques with 200 respondents. Constraints faced in adoption of agricultural mechanization for in-situ management of crop residue were lack of self-confidence (17.0% and 21.0%) and lack of time (28.0% and 32.0%) was social constraint whereas poor guidance from panchayat (9.0 and 7.0%), were lack of proper marketing (25.0 and 21.0%) and lack of awareness about application process (21.0% and 14.0%) were communicational, financial and technical constraints reported in Bhiwani and Kaithal district, (Kaushik and Sabharwal, 2022).

### III.SAFETY IN FARM MACHINERY

The goal of developing awareness in youth of the hazards found on the farm is in agreement with one of the goals expressed in the Rural Ontario Safety Kit (Farm Safety Association Incorporated, 1980). The goal into the areas of positive attitude development, behaviour modification, problem solving, and emergency preparedness determined by this study the objectives for a farm safety awareness program as teaching farm awareness, machine handling skills, machinery safety etc., (Steffen, 1990). Eight districts from different agro-climatic zones in the state of Madhya Pradesh (central India) to collect information on agricultural injuries that occurred during a five-year period (1995-1999) revealed that out of 76 incidents, 7 (9.2%) were fatal and 69 (90.8%) non-fatal. The overall incidence rate was 1.25/1000 workers/year. Among the fatal incidents, tractors and snakebites contributed 42.9% each, while fall/drowning in farm wells were the cause of the remaining fatal incidents. Out of the total incidents, 59 (77.6%) were due to farm machinery, 9 (11.8%) were due to hand tools, and 8 (10.6%) were due to other sources like snakes, wells, agricultural chemicals, etc. Source-wise classification revealed that tractor-related incidents were most common (46.0%), followed by threshers (14.5%), sickles (10.5%), electric motors and pump sets (7.9%), snakes (5.3%), chaff cutters and wells (4.0% each), grain mills (2.6%), and pickaxe, self-propelled machines, sprayers, and agricultural chemicals (1.3% each). The incidence rate/ 1000 machines/year was highest for self-propelled machines (50.00), followed by tractors (25.83), grain mills (17.39), threshers (9.40), chaff cutters (1.91), electric motors and pump sets (1.27), sprayers (0.45), sickles (0.16), and pickaxes (0.09). The total number of victims who sustained fatal or non-fatal injuries was 82, of which 79.3% were farmers and 20.7% were agricultural laborers. Males constituted 92.7% of the victims, while 7.3% of the victims were female. The highest number of victims was in the age group of 30-44 years (45.1%), followed by 15-29 years (32.9%), above 45 years (17.1%), and below 14 years (4.9%). Information on 1,911 incidents reported in ten leading newspapers published during the five-year period (1995-1999) from different regions of the state was also collected. Based on the incidence rates calculated from the village survey data and the number of injuries-prone agricultural machines in the state of Madhya Pradesh, it was estimated that in the year 2000, there would have been about 17,480 agricultural incidents in the state, causing the death of about 2,050 workers and injuries to 16,770 workers, which included amputations of limbs, burns, cuts, etc. The total monetary loss due to these injuries was estimated as about US \$27 million/year. (Tiwari *et al.*, 2002). Operational reasons and their specific procedures,

sometimes clients ask manufacturers for safeguarding solutions that are appropriate for them or refuse the safeguarding solutions that are proposed. In addition to safeguards bypass and constraints imposed by the client identifies problems and needs, namely: 1) inherently safe design measures; 2) managing risks during the building phases of the machinery's life cycle besides production and maintenance; 3) ensuring the applicable standards are used and updated; 4) designing and validating safety-related control systems and; 5) making clients more conscious of the importance of safety of machinery, (Gauthier *et al.*, 2021).

While the farm mechanization is more in northern India, the accidents were more in the villages in southern India. On average of the four regions, the tractor incidents (overturning, falling from the tractor, etc.) were highest (27.7%), followed by thresher (14.6%), sprayer/duster (12.2%), sugarcane crusher (8.1%) and chaff cutter (7.8%) accidents. Most of the fatal accidents resulted from the powered machinery, with the annual fatality rate estimated as 22 per 100,000 farmers. The hand tools related injuries (8% of the total accidents) were non-fatal in nature. In spite of the enactment of legislation, the shortcomings in production and monitoring of the machinery in field use may be responsible for the high rate of accidents (e.g., 42 thresher accidents/1,000 mechanical threshers/year in southern India), (Nag and Nag, 2004). Two groups of 50 experienced tractor-driving farmers and 50 non-driving farmers were selected from 2 villages, 50 km from Delhi. All participants were interviewed for details of work routine and noise exposures. Self-reported hearing problems were similar (4 cases each) in both the groups of 50 farmers. The noise levels observed on tractors in different operations were in the range of 90 - 110 dB. Tractor noise levels exceeded the recommended safe limits of OSHA and NIOSH prescribed standards, (Kumar *et al.*, 2005). Two safety practices as risk factors for injury: (1) the presence of safety devices on machinery and (2) low levels of routine machinery maintenance. Limited presence of safety devices on machinery during farm operations was associated with higher risks for injury (RR 1.94; 95% CI 1.13-3.33;  $P_{\text{trend}} = 0.02$ ). Lower routine maintenance scores were associated with significantly reduced risks for injury (RR 0.54; 95% CI 0.29-0.98;  $P_{\text{trend}} = 0.05$ ). The injury prevention programs require continued focus on the use of safety devices on machinery and maintenance itself is a risk factor or that more modern equipment that requires less maintenance places the operator at lower risk, (Narsimhan *et al.*, 2010). A total of 106 agricultural injuries were reported during the survey conducted in Etawah district of Uttar Pradesh in India during a five-year period (1996–2000). Out of 106 injuries, 9% were fatal and 91% non-fatal. The agricultural injuries incidence rate was 0.8/1000 workers/year. Out of total injuries 57 were farm machinery related, 43 were due to hand tools and six were due to other sources like animal bites, slip and fall in the field. Males constituted 79% of the victims, while 21% of the victims were female. The highest number of victims was in the age group of 30–44 years (36) followed by 15–29 years (31), above 44 years (23) and below 15 years (16). Based on the injury incidence rate, it was estimated that in the year 2000, there would have been 580 agricultural injuries in the Etawah district, causing 46 deaths and 534 injuries to farm workers. The monetary loss due to agricultural injuries in Etawah district of UP for the year 2000 was estimated to be US \$ 730,000. This is a substantial economic burden, therefore, interventions and injury prevention training need to be given due attention to reduce injuries on Indian farms, (Patel *et al.*, 2010). About 36.2% fatalities were caused by farm machinery that involves tractors. The IIR per year of farm machinery, hand tools and injuries due to other sources were 3.2 per 1000 machines, 0.7 per 1000 tools and 77 per 100000 workers, respectively. Correlation between number of injury-prone agricultural machines and number of farm machinery injuries is  $r=0.80$  (number of injuries increases with increase in number of machines). The  $\chi^2=72.53$ ;  $p<0.01$  of number of hand tools and number of farm hand tools-related injuries, those are statistically significant. Exposures to agricultural machinery during farming operations can result in injuries confounding that may be fatal or non-fatal, (Khadatkar *et al.*, 2022).

#### IV.ACCIDENTS IN AGRICULTURE

Preventing incidents means recognizing hazards and avoiding them, or at least, taking appropriate precautions if they must be encountered. Fallings are also some causes of accidents from tractor.

Data on farm power sources and agricultural machines available in the panchayats in Himachal Pradesh revealed that bullock rearing has decreased on account of their high cost of maintenance and limited requirements round the year and tillage is mainly done by power tillers on custom hiring for its convenience and easy portability. Majority of the studied victims (28.97%) were in the age group of more than 60 years followed by 23.87 percentage in age group of 41-50 years. The reported incidents with respect to accidents/injuries from machines total 78 cases out of which 29.49 per cent injuries were from power tiller and 24.30 per cent from sickle/saw/spade and 19.23 per cent from thresher respectively. Rest of the accidents/ injuries were from other sources. The Abbreviated Injury Scale (AIS) of accidents highlighted that 42.06 per cent cases were serious but not life threatening, 28.97% were of moderate scale and 15.48%

injuries were life threatening with probability of survival. 8.33% cases were critical with survival probability, (Gupta *et al.*, 2022). Evaluation of risk estimates of agricultural incidents occurring during 2012–2013 in Madhya Pradesh, India. The study was carried out in 360 villages in 9 districts of Madhya Pradesh namely Datia, Shivpuri, Balaghat, Barwani, Indore, Jhabua, Narshigpur, Satna, and Bhopal. A total of 92 793 agricultural workers participated in a survey of agricultural incidents. Of 21 agricultural incidents, 14% were fatal and 86% non-fatal in nature. The agricultural incident rates were 0.23/1000 agricultural workers per year and 0.2/1000 agricultural machines per year. The annual monetary loss due to deaths in agricultural incidents in Madhya Pradesh was estimated to be Rs. 16935.4 lakhs, (Khadatkar and Kot, 2022). “Centers for Disease Control and Prevention” (CDC, 2013) says agriculture is one of the three most dangerous occupations in terms of work-related injuries and diseases. This can be achieved in the agricultural sector, with special attention to health and safety issues in this sector (Jugmohan, 2013). The agricultural workers have to work in hazardous conditions like exposure to sunlight, dust, dirt etc. while performing different activities like weeding, harvesting, threshing, de-husking, cleaning and packaging of crops. Many of them were not aware about the harmful effect created by strong UV light of the Sun and other microorganisms mixed with soil and also dust particles, (Satapathy *et al.*, 2022). Analysis of data on monetary compensation and estimating the rate of injuries related to agricultural activities in the state of Punjab revealed that during the four consecutive years (2012–2015) an overall 5888 hazards cases related to agricultural activities were reported from the state, out of which 1993 (33.85%) were fatal and 3895 (66.15%) were non-fatal injuries. Among the fatal cases, the leading causes reported were due to electric motors (34.47%), poisoning through snake bites (21.48%), poisoning through pesticide applications with sprayers (19.62%) and crushed under/falling from the tractors and related equipment (13.50%). The annual fatality rate of the state of Punjab was estimated as 14.14 per 100 000 agricultural workers, while the overall injury incidence rate was observed as 39.57 per 100 000 agricultural workers, (Lohan *et al.*, 2022). Evolution of safety advances in wireless and smart farming applications for agriculture with a focus on safety designs, fail - safe system engineering and wireless network infrastructures such as Bluetooth, GSM, Wi - Fi 802.11 and 802.15 like ZigBee, Lo - Ra technologies and even unmanned aerial vehicles (UAV). conclusions have been drawn about limits and perspectives of sensing systems for obstacle avoidance like lasers, image processing, Bluetooth low - energy, RFID passive systems and Artificial Intelligence (AI), (Cecchini, 2022). An IoT based agricultural accidents monitoring system developed to know the cause and analysis of accidents also to estimate losses due to agricultural accidents. It has capability to feed and upload data along with live photographs from the spot of accident and from the place of investigation. The system consists of a mobile app and a server-based software. Android Studio and Adobe Dreamweaver were used for development of android apps for creating, publishing, and managing websites and mobile content while MySQL, J2EE technology were used to develop web applications, CVS is a version control system used for Source Configuration Management (SCM). The system can generate reports as per the access authentication. The analysis includes accidents type and nature, total number, farm machinery related, hand-tools related and other accidents. Apart from research organizations this system can revolutionize safety in agriculture through manufacturers, policy makers, insurance companies for implementation of more safety features, safety standards on the equipment, creating awareness whereby bringing down accidents to the minimum level for a safe tomorrow in the field of agriculture, (Babu *et al.*, 2022).

## V.CONCLUSION

The mechanization gap between the expected level of knowledge and status of implements found that lack of awareness resulted in low status in respect of implements and its importance. Standardization and quality marking centers of farm equipment should be established in potential areas of the state, (Dhruw, 2022). Farm mechanization, accidents in farm operations and safety needs to be studied because it will give us the idea and scope of the future. The level of mechanization to be achieved, the futuristic developments and safety measures to be considered while manufacturing the machineries and to prevent the accidents the knowledge of the scenarios should be known hence the study and reviewing the mechanization level, farm machinery accidents and safety is needed.

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