

1. FARM POWER AND MACHINERY

Farm mechanization technology plays a key role in improving agricultural production and considered as an essential input to agriculture. Among various inputs such as seeds, fertilizers and irrigation, productivity of farms also depends greatly on the availability and judicious use of farm power. Tractors are pivotal part of agricultural machinery industry. Farm power availability, farm mechanization and its related aspects have a crucial role to play to enhance agricultural productivity. This section containing 15 tables presents data on various Agricultural Engineering inputs and their distribution, details of tractor production, sales and related data. It also covers of export and import of various farm equipment. Selected anthropometric and strength data of Indian agricultural workers, Classification of physical work according to severity of workload for agricultural workers, distribution of farm machinery accidents is presented. Different models of tractor, different test codes for tractors, power tillers and farm machinery, various testing centres are covered in the appendix section.

Table 1.1: Agricultural Engineering Inputs in India

(Number)

Year	Tractors Sold in India and Exported	Power Tillers sold in India	Villages electrified	Cumulative Irrigation pump sets energized
2000-01	2,39,565	16,018	5,08,071	1,28,23,480
2001-02	2,14,683	13,563	5,08,863	1,31,41,378
2002-03	1,84,608	14,613	4,92,325	1,37,92,473
2003-04	2,03,601	15,665	4,95,031	1,41,15,441
2004-05	2,61,833	17,481	4,98,877	1,44,46,461
2005-06	3,02,436	22,303	4,71,360	1,48,43,804
2006-07	3,39,830	24,791	4,87,351	1,53,68,577
2007-08	3,34,555	26,135	4,87,347	1,56,74,673
2008-09	3,32,708	35,331	4,92,831	1,59,63,476
2009-10	4,22,041	43,464	4,97,950	1,61,93,521
2010-11	5,45,109	51,414	5,37,947	1,71,67,631
2011-12	6,07,658	57,232	5,57,439	1,81,78,136
2012-13	5,90,672	51,237	5,61,751	1,90,14,881
2013-14	6,96,828	53,927	5,72,466	1,91,56,212
2014-15	6,26,839	-	5,77,698	1,99,12,081
2015-16	5,71,249	-	5,86,065	2,04,34,180
2016-17	7,44,536	-	5,92,080	2,06,45,608
2017-18	7,96,873	-	5,92,829	2,14,28,411
2018-19	8,80,472	-	5,97,464	2,13,54,379
2019-20	7,81,065	-	5,97,464	-

Source: 1. Tractor and Mechanization Association, New Delhi.

2. Power Tiller Association of India, Bangalore.

3. http://www.cea.nic.in/reports/monthly/executive_rep/apr11/16.pdf.

4. www.indiastat.com/table/power/26/villageelectrification. Accessed on 24.4.2019.

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Table 1.2: Production and Sale of Tractors in India

Year	(Number)			
	Tractors number			
	Production	Domestic sale	Export	Total Sale
1970-71	20,099	33,399	-	33,399
1971-72	18,100	37,839	-	37,839
1972-73	20,802	21,802	-	21,802
1973-74	24,425	25,425	-	25,425
1974-75	31,088	31,881	-	31,881
1975-76	33,252	34,352	-	34,352
1976-77	33,146	36,066	-	36,066
1977-78	40,946	40,946	-	40,946
1978-79	54,322	54,322	-	54,322
1979-80	62,275	62,275	-	62,275
1980-81	71,024	72,012	-	72,012
1981-82	84,137	79,467	-	79,467
1982-83	63,054	63,073	-	63,073
1983-84	76,173	743,18	-	74,318
1984-85	85,005	80,317	-	80,317
1985-86	75,550	76,886	-	76,886
1986-87	80,369	80,164	-	80,164
1987-88	92,092	93,157	-	93,157
1988-89	1,09,987	1,10,323	-	1,10,323
1989-90	1,21,624	1,22,098	-	1,22,098
1990-91	1,39,233	1,39,828	-	1,39,828
1991-92	1,51,759	1,51,121	-	1,51,121
1992-93	1,47,016	1,44,337	-	1,44,337
1993-94	1,36,971	1,38,753	-	1,38,753
1994-95	1,64,029	1,64,770	-	1,64,770
1995-96	1,91,311	1,91,329	-	1,91,329
1996-97	2,21,689	2,22,684	-	2,22,684
1997-98	2,55,327	2,48,141	-	2,48,141
1998-99	2,61,609	2,62,169	-	2,62,169
1999-00	2,78,556	2,73,182	-	2,73,182
2000-01	2,35,602	2,39,565		2,39,565
2001-02	2,07,252	2,14,683	-	2,14,683
2002-03	1,56,613	1,84,608	-	1,84,608
2003-04	1,91,633	1,99,034	4,567	2,03,601
2004-05	2,49,077	2,41,757	20,076	2,61,833
2005-06	2,96,080	2,74,339	28,097	3,02,436
2006-07	3,52,368	3,06,064	33,766	3,39,830
2007-08	3,45,172	2,91,002	43,553	3,34,555
2008-09	3,43,520	2,91,566	41,142	3,32,708
2009-10	4,36,947	3,84,419	37,622	4,22,041
2010-11	5,48,397	4,82,237	62,872	5,45,109
2011-12	6,39,896	5,36,886	70,772	6,07,658
2012-13	5,78,690	5,31,891	58,781	5,90,672
2013-14	7,07,898	6,34,151	62,677	6,96,828
2014-15	6,12,994	5,51,463	75,376	6,26,839
2015-16	5,71,565	4,93,764	77,485	5,71,249
2016-17	7,77,914	6,66,185	78,351	7,44,536
2017-18	7,90,673	7,11,478	85,395	7,96,873
2018-19	7,58,929	7,88,239	92,233	8,80,472
2019-20	7,77,752	7,05,011	76,054	7,81,065

Source: Tractor and Mechanization Association New Delhi.

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Table1.3: Horse Power-Wise Tractor Production in India

						(Number)
Year	≤20 hp	21-30 hp	31-40 hp	41-50 hp	> 50 hp	Total
2000-01	1,251	54,293	1,29,654	33,169	17,235	2,35,602
2001-02	380	46,164	1,09,416	35,084	16,208	2,07,252
2002-03	216	34,626	88,090	26,902	6,779	1,56,613
2003-04	518	42,959	94,450	40,421	13,285	1,91,633
2004-05	975	48,760	1,25,993	51,893	21,456	2,49,077
2005-06	1,190	51,392	1,52,660	67,506	23,332	2,96,080
2006-07	1,537	60,014	1,70,417	91,223	29,177	3,52,368
2007-08	1,755	49,720	1,55,004	98,291	40,402	3,45,172
2008-09	2,451	49,086	1,52,558	88,596	50,829	3,43,520
2009-10	3,752	65,098	1,98,781	1,07,373	61,943	4,36,947
2010-11	4,602	69,435	2,31,488	1,55,558	87,314	5,48,397
2011-12	7,219	80,417	2,70,340	1,75,482	1,06,438	6,39,896
2012-13	18,728	35,803	2,33,697	2,11,126	79,336	5,78,690
2013-14	23,344	45,159	2,32,683	3,24,085	71,530	6,96,801
2014-15	24,521	36,752	2,01,130	2,64,962	85,629	6,12,994
2015-16	23,436	31,369	1,86,869	2,48,093	81,798	5,71,565

Source: Tractor and Mechanization Association, New Delhi.

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Table 1.4: State-Wise Annual Sale of Tractors

State	(Number)																
	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2019-2020
Andhra Pradesh	17,520	12,203	11,263	10,626	16,615	22,448	35,613	43,758	38,417	34,730	35,173	53,175	63,275	74,920	37,028	30,243	18,335
Assam	540	571	499	493	385	771	1,120	1,296	1,588	3,583	2,430	2,057	2,099	2,408	3,557	5,669	8,513
Bihar	17,344	14,028	13,115	12,235	14,636	9,946	11,824	13,104	17,572	29,050	26,621	25,987	28,260	30,187	36,090	35,402	43,246
Chhatisgarh	-	4,939	7,129	6,570	8,790	10,192	-	-	-	-	11,134	9,254	9,221	12,139	20,011	16,861	8,674
Gujarat	11,546	13,700	8,434	10,086	17,078	23,100	29,651	25,255	20,179	24,323	44,099	41,958	30,765	44,163	46,411	39,792	55,411
Haryana	16,560	13,697	11,504	11,688	12,408	14,709	20,385	23,627	22,573	28,671	28,403	31,533	23,741	30,599	30,626	22,685	38,705
Himachal Pradesh	395	577	652	521	512	758	1,117	891	907	1,201	1,404	1,398	1,255	1,530	1,519	1,354	2,367
Jharkhand	-	2,349	2,961	2,897	3,643	5,676	-	-	-	-	6,524	6,697	6,756	8,349	8,169	8,118	0
Jammu & Kashmir	850	1,071	1,271	1,506	1,135	1,296	1,178	1,328	1,115	1,608	2,128	2,618	3,577	3,794	2,601	2,324	3,659
Karnataka	11,261	8,984	6,512	8,595	15,560	25,316	22,455	17,230	13,835	23,849	27,244	29,162	34,861	40,437	33,758	32,804	40,301
Kerala	669	348	135	148	125	765	1848	493	374	582	671	631	570	385	268	332	747
Madhya Pradesh	21,901	29,818	24,344	29,568	33,733	23,828	19,378	18,242	24,306	33,342	48,435	50,597	70,822	87,831	63,744	48,375	61,870
Maharashtra	14,420	8,586	48,67	7,112	11,545	17,173	26,070	29,815	25,610	34,186	40,951	56,664	43,245	46,669	49,839	42,125	87,621
Odisha	4,970	2,622	3,076	2,933	4,957	6,683	7,214	4,993	5,099	7,909	12,861	13,277	15,831	24,277	10,878	12,668	25,184
Punjab	20,879	19,626	15,484	13,906	11,715	12,052	16,201	18,062	20,027	28,608	24,122	26,040	27,900	35,290	2,6074	17,829	15,897
Rajasthan	14,692	16,228	109,14	18,241	23,830	27,949	34,583	29,456	25,763	31,822	53,604	57,191	44,221	65,405	64,565	61,193	21,399
Tamil Nadu	9,931	6,053	4,896	6,487	12,470	18,294	21,880	16,894	14,609	15,768	20,638	26,298	-	-	-	14,667	68,563
Telangana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13,153	22,436
Uttarakhand	-	1,345	2,861	2,479	1,869	2,321	-	-	-	-	3,893	5,377	4,600	4,969	2,205	2,769	2,394
Uttar Pradesh	65,253	48,165	39,724	38,842	46,326	44,307	48,184	39,682	51,513	73,686	76,981	82,613	84,559	95,653	92,219	71,527	1,20,664
West Bengal	3,385	2,510	2,169	2,001	3,085	4,337	5,595	5,354	6,096	9,186	13,045	12,187	12,752	13,756	12,751	12,934	20,624
Others	7,449	7,263	12,798	12,100	1,340	2,418	1,768	1,522	1,983	2,315	1,876	2,172	876	1,220	1,078	945	737
Total	2,39,565	2,14,683	1,84,608	1,99,034	2,41,757	2,74,339	3,06,064	2,91,002	2,91,566	3,84,419	48,22,37	5,36,886	5,31,891	6,34,151	5,51,463	4,93,764	7,05,011

Source: Tractor and Mechanization Association, New Delhi.

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Table 1.5: State-Wise Tractor Availability per 1000 Ha Area, Power Availability from Tractors and Food Grain Productivity.

State	Tractor density per 1000 ha area	Power availability from tractors, (kW/ha)	Food grain productivity,(t/ha)	Power per unit production,(kW/t)
Andhra Pradesh	48	1.17	1.32	0.89
Assam	14	0.28	1.72	0.16
Bihar	54	1.34	2.10	0.64
Gujarat	44	1.07	1.96	0.55
Haryana	96	2.52	3.88	0.65
Himachal Pradesh	30	0.72	2.80	0.26
Jammu and Kashmir	40	0.92	2.03	0.45
Karnataka	32	0.73	1.64	0.45
Kerala	4	0.12	2.7	0.45
Madhya Pradesh	28	0.71	1.41	0.50
Maharashtra	28	0.64	1.15	0.56
Odisha	25	0.58	1.30	0.45
Punjab	79	2.29	4.34	0.53
Rajasthan	34	0.78	1.32	0.59
Tamil Nadu	46	1.29	2.69	0.48
Uttar Pradesh	58	1.55	2.50	0.62
West Bengal	23	0.51	2.68	0.19

Source:Senthilkumar T., Chandel, N.S, Mehta, C.R., B.S.Gholap (2017). Trends of Tractorozationin Indian Agriculture.Agricultural Mechanization in Asia, Africa and Latin America (AMA), 48(2), 50-59.

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Table 1.6: Mechanization Levels for Major Crops in India (2019-20)

Crop	Seed bed preparation	Sowing/ planting/ transplanting	Weeding and interculture & plant protection	Harvesting and threshing	Crop wise average
Rice	80	30	30	60	50
Wheat	85	65	50	75	69
Maize	70	40	40	30	45
Sorghum and millets	60	30	20	20	33
Pulses	65	40	25	35	41
Oilseed	65	40	20	25	38
Cotton	70	35	35	0	35
Sugarcane	65	20	30	15	33
Overall	70	38	31	32	45

Source:Mehta, C.R., Chandel, N.S., Jena P C, Anamika Jha (2019). Indian Agriculture Counting on Farm Mechanization. Agricultural Mechanization in Asia, Africa and Latin America (AMA), 50(1), 84-89.

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Table 1.7: Farm Power Availability from Different Sources in India

Year	Farm power, (kW/ha)						Total power, (kW/ha)
	Agriculture workers	Draught animals	Tractors	Power tillers	Diesel engines	Electric motors	
1971-72	0.045	0.133	0.020	0.001	0.053	0.041	0.293
1975-76	0.048	0.135	0.040	0.001	0.078	0.056	0.358
1981-82	0.051	0.128	0.090	0.002	0.112	0.084	0.467
1985-86	0.057	0.129	0.140	0.002	0.139	0.111	0.578
1991-92	0.065	0.126	0.230	0.003	0.177	0.159	0.760
1995-96	0.071	0.124	0.320	0.004	0.203	0.196	0.918
2001-02	0.079	0.122	0.480	0.006	0.238	0.250	1.175
2005-06	0.087	0.120	0.700	0.009	0.273	0.311	1.500
2011-12	0.100	0.119	0.804	0.014	0.295	0.366	1.698
2015-16*	0.087	0.110	1.050	0.016	0.330	0.541	2.134
2019-20*	0.080	0.130	1.400	0.021	0.352	0.560	2.543

* Calculated

Source:Mehta, C.R., Chandel, N.S., Senthikumar T, (2014). Status, Challenges and Strategies for Farm Mechanization in India..Agricultural Mechanization in Asia, Africa and Latin America (AMA), 45(4), 43-50.

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Table 1.8: Cropping Intensity and Power Availability on Indian Farms

Year	Cropping intensity, (%)	Productivity, (t/ha)	Power available, (kW/ha)	Power per unit production, (kW/t)	Net sown area per tractor, (ha)
1975-76	120	0.94	0.36	0.38	487
1985-86	127	1.18	0.58	0.49	174
1995-96	131	1.50	0.92	0.61	84
2005-06	132	1.65	1.50	0.91	47
2010-11	141	1.92	1.68	0.88	31
2015-16*	141	2.02	2.13	1.05	24
2019-20*	141	2.29	2.54	1.11	18

*Calculated

Source: Mehta, C.R., Chandel, N.S., Senthilkumar T, (2014). Status, Challenges and Strategies for Farm Mechanization in India. *Agricultural Mechanization in Asia, Africa and Latin America (AMA)*, 45(4), 43-50.

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Table 1.9: Major Export Destinations for Indian Farm Equipment Industry

Sl. No.	Name of the country	% share
1	USA	45.50
2	Argentina	20.00
3	Sri Lanka	9.50
4	Myanmar	9.00
5	Thailand	6.30
6	Bangladesh	4.80
7	Others	4.80

Source:Mechanization: Key to higher productivity to double farmers' income, FICCI 2017, Sectoral Paper on Farm Mechanization-NABARD, Dec 2018, Industry reports and PwC analysis.

Table 1.10: Major Countries from where India Imports Farm Equipment

Sl. No.	Name of the country	% share
1	China	74.00
2	Italy	10.00
3	Japan	5.00
4	Thailand	4.00
5	USA	3.00
6	Taiwan	1.00
7	Others	3.00

Source:Mechanization: Key to higher productivity to double farmers' income, FICCI 2017, Sectoral Paper on Farm mechanization-NABARD, Dec 2018, Industry reports and PwC analysis.

Table 1.11: Import and Export of Agricultural Machinery (USD million)

Sl. No.	Year	Import	Export
1	2014	53	73
2	2015	47	84
3	2016	42	86
4	2017	43	88

Source:Mechanization: Key to higher productivity to double farmers' income, FICCI 2017, Sectoral Paper on Farm mechanization-NABARD, Dec 2018, Industry reports and PwC analysis.

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Table 1.12: Tractor Manufacturers in India

Sl. No.	Name of the Manufacturer
1	Action Construction Equipment Ltd Dudhola Link Road, Vill. Dudhola, Distt. Palwal -121102, Haryana, India 91-129-2306111, marketing@ace-cranes.com
2	Captain Tractors Pvt Ltd Padavia Road, Veraval (Shapar), Taluka : KotdaSangani, Dist. Rajkot 360025, Gujarat India 91-2827-252547, 91-2827-253916-17, data@captaintractors.in
3	CNH Industrial (India) Pvt. Ltd. Plot No.-03 Udyog Kendra, Greater Noida- 201306, Distt, Gautam Nagar, Uttar Pradesh, India http://www.cnhindustrial.com/
4	Escorts Ltd 15/5 Mathura Road, Faridabad – 121 003, India 91-129 – 2250222, http://www.escortsgroup.com/
5	Force Motors Ltd Mumbai-Pune Road, Akurdi, Pune, Maharashtra– 411035, India Tel. : 91- 20 27476381 http://www.forcemotors.com/home/index
6	Gromax Agri Equipment Ltd Near Vishwamitri Railway Over bridge, Vishwamitri, Vadodara - 390011, Gujarat, India 91-265-7118400, trakstar@gromaxagri.com , http://trakstartractor.com/
7	Indo Farm Equipment Limited Export Promotion Industrial Park, Phase-II, Baddi, Baddi, Himachal Pradesh 173205, India 91-78329-25001, Email : mail@indofarm.in , www.indofarm.in
8	International Tractors Ltd Vill. ChakGurjran, P.O. Piplanwala Jalandhar road, Hoshiarpur, Punjab, 146022, India 91-1882 522 220 , sonalika@sonalika.com
9	John Deere India Pvt. Ltd. Tower 14, Cybercity, Magarpatta City, Hadapsar, Pune – 411013, India 91-20-66425000, http://www.deere.co.in/en
10	Mahindra & Mahindra Ltd. Samta Nagar Rd, Kandivali, Singh Agri Estate, Kandivali East, Mumbai, Maharashtra 400101, India 91-22 2490 5906, tractorcure@mahindra.com
11	Preet Tractors Pvt Ltd PO Box No. 29, Nabha - Patiala Road, Nabha, Distt. Patiala, Punjab, India. 91- 1765 220 400, info@preet.co
12	Same Deutz-Fahr India Pvt. Ltd. 72 M SIPCOT Industrial Complex Ranipet - Vellore - 632403 Tamil Nadu, India 91- 4172 247163, http://www.samedeutz-fahr.com/en/
13	Tractors and Farm Equipment Limited 77, Nungambakkam High Road Nungambakkam, Chennai - 600 034, India 91- 44 6691 9000, corporate@tafe.com
14	VST Tillers Tractors Ltd Plot No- 1, Dyavasandra Indl. Layout, Whitefield Road, Mahadevapura Post, Bengaluru-560048, Karnataka, India 91 - 80 – 67141111, www.vsttractors.com , tollfree@vsttractors.com

Source: Tractor and Mechanization Association, New Delhi.

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Table 1.13: Selected Anthropometric and Strength Data of Indian Agricultural Workers (2019)

Parameters	Unit	Male (N =8970)			Female (N =5648)		
		Mean	Percentile values		Mean	Percentile values	
			5 th	95 th		5 th	95 th
Anthropometric data							
Weight	kg	55.1	42.0	71.5	47.8	35.0	65.0
Stature	cm	1636	1523	1756	1521	1420	1634
Eye height	cm	1525	1410	1646	1408	1310	1521
Acromial height	cm	1364	1255	1477	1265	1173	1370
Elbow height	cm	1029	941	1121	963	890	1045
Iliocrystale height	cm	954	861	1050	900	820	984
Metacarpal III height	cm	692	620	770	653	587	729
Grip diameter (inside)	cm	48	39	58	45	35	57
Popliteal height sitting	cm	418	369	470	393	341	447
Buttock-popliteal length	cm	443	382	502	427	365	487
Hip breadth sitting	cm	314	257	372	309	250	371
Strength data		Male (N=5,570)			Female(N=3,945)		
Hand grip strength (Right)	N	347	206	510	220	118	353
Push strength (both hands) standing	N	220	133	323	143	84	230
Pull strength (both hands) standing	N	218	140	320	159	101	240
Leg strength (Right) sitting	N	317	155	516	304	160	486
Torque strength both hands (standing)	N	56	31	95	41	25	62

Source: Gite, L.P., Agrawal, K.N., Mehta, C.R., Potdar, R.R., Narwariya, B.S. (2019). Hand Book of Ergonomical Design of Agricultural Tools, Equipment and Work Places. Jain Brothers, New Delhi (ISBN-10: 8194413710, ISBN-13: 978-8194413714), 218 p.

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Table1.14: Classification of Physical Work According to Severity of Workload for Agricultural Workers

Category	Heart rate, (beats/min)			Energy expenditure rate, (kJ/min)			
	Christensen (1964)	Astrand and Rodahl (1977)	Nag et al. (1980)	Christensen (1964)	Astrand and Rodahl (1977)	Grandjean (1982)	Nag et al. (1980)
Sedentary	60 – 70	-	< 90	5 – 6	-	-	4.6 – 7.3
Light	75 – 100	< 90	90 – 100	10 – 21	<10	<12	7.8 – 12.1
Moderate	100 – 125	90 – 110	100 – 125	21 – 31	10-20	12 – 19	12.5 – 24.6
Heavy	125 – 150	110 – 130	125 – 150	31 – 42	20-30	19 – 23	25.1 – 36.7
Very Heavy	150 –175	130 – 150	150 – 175	42 – 52	30-42	> 23	37.4 – 44.3
Extremely Heavy	> 175	> 150	-	52 – 84	> 42	-	-

Source: Data book for agricultural machinery design.2004. Technical Book CIAE/2004/1.CIAE,Bhopal.pp611.

Table1.15: Source-wise Distribution of Farm Machinery Accidents

Sl. No.	Source	% of total farm machinery accidents
1	Tractor & tractor operated implements	31.0
2	Animal drawn equipment	22.0
3	Threshers (including winnowers)	14.0
4	Electric motors/pump sets	12.0
5	Chaff cutters (manual + power operated)	9.0
6	Power tillers	6.0
7	Sprayers (manual + power sprayers)	4.0
9	Other equipment	2.0
	Total	100.0

Source:<https://aicrp.icar.gov.in/esa/survey-of-accidents-in-indian-agriculture>.Assessed on 05.05.2021.