

Agricultural mechanization development in Yemen (1970-2003)

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Abstract – The Yemeni farmer has been practicing manual cultivation since long periods, in a small area that meets his family's food requirements by conducting various agricultural operations using his animals for the traction. The objective of this research was to determine the present status of the adopted agricultural machinery and make a comparison of the machinery in different of Yemeni governorates. The results of the 2002 agricultural census were used for this research, as this census covered all governorates. The results showed that the distribution of cultivated area were 7.63%, 7.92%, 28.34% and 56.11% of the total area less than 0.5 ha, from 0.5 to less than 1 ha, from 1ha to less than 5 ha and 5 ha and more respectively. While the distribution of land owners were 58.42%, 14.94%, 19.59% and 7.05% of total land owners owned less than 0.5 ha, from 0.5 to less than 1 ha, from 1ha to less than 5 ha and 5 ha and more respectively. Sa'adah governorate has the most number of machinery as well as 42640 in number and the lowest number was 86 of machineries owned by Raymah. Irrigation pumps are used in the highest number, which is 211620, the threshers was the lowest number, which is 1058. Al Hudaydah was used the highest number of tractors that is 3542 and Raymah the lowest number, 30. Al Jawf was used the highest number of harvesters, which is 239 and Dhale the lowest number 18. The highest number of threshers was used in Sana'a and the lowest number was used in Taiz, which are 193 and 15 respectively. The significant number of irrigation pumps was used in Sa'dah which is 34334 and the lowest number was used in Raymah, which is 56. San'a, Sa'dah was used the highest number of sprayers that is 2181 and Al Maharah was used the lowest numbers, which is 11. Dhamar was used the highest number and Al Mahwit was used the lowest number of the other machinery which are 8470 and 5 respectively. Regarding the machineries per hectare, the results showed that Sa'adah was in the first position of all the 21 governorates with is 1.41 machineries per hectare. Dahle and Shabwah are in the second and third positions with 1.26 and 0.92 machineries respectively. Raymah was ranked at last position with 0.006686 machineries. The results analyzed from this research show that many of agricultural operations at the present time are still carried out manually or by animals. In addition agricultural machinery per hectare area still very low and was not adequate to fulfill the meaningful mechanization.

Keywords – Agricultural mechanization, Machinery in Yemen, Distribution of cultivated area.

I. INTRODUCTION

The agricultural sector is considered one of the most important sectors in the Yemeni economy, as it is considered a primary source of job opportunities for about 54% of the population. The agricultural sector contributes to about

17.5% of the Gross Domestic Production (GDP) (Statistical year book, 2010). Mechanization systems are categorized into human, animal and mechanical technologies. Based on the source of power, the technological levels of mechanization have been broadly classified as hand-tool technology, draught animal technology and mechanical

power technology (FAO, 2006). Mechanization is an operative process through which improved agricultural activities and optimum crop production can be achieved (Al Mamun, et al., 2019). According to Alam, (2000) (as cited by Al Mamun et al., 2019), the cropping intensity and production of crops have recently been increased significantly due to the adoption of mechanization tillage, irrigation, and spraying practices. According to Oliveira et al., 2007 (as cited by Mantoam et al. 2018) being adopted for most of field operations, agricultural mechanization is one of the tools that supported the increase in world food production, bringing many benefits to farmers, such as cost reduction and higher work rate of field operations. According to Raheleh et al., (2012) in developed country, the main object of mechanization utilization is decreasing expenses or labour energy, but in developing country, it is increasing production. According to Filani and Ejiko, (2018) the word mechanization is generally the use of machinery to replace human or animal labour especially in agriculture and industry. Tractors and field machinery are tools of agricultural production. This equipment increases the productivity of the producer, improve the quality of product and reduce the hazards of operations (Ampratwum et al., 2004). The level, appropriate choice and subsequent proper use of mechanized inputs into agriculture has a direct and significant effect on achievable levels of land productivity, labour productivity, the profitability of farming, the sustainability, the environmental and on the quality of life of people engaged in agriculture (Olaoye and Rotimi, 2010). Mottaleb et al., (2016) concluded that scale-appropriate agricultural mechanization can play an important role in enhancing the labour productivity of smallholder farmers. The mechanization technologies should be including new and old machines that are continuously being used by farmers (Dela, et al., 2017). According to Mehta et al., 2014 agricultural mechanization plays a key role in improving agricultural production and productivity in developing countries. Mechanization is an essential input to raise labor and land productivity and reduce drudgery (Sims and Kienzle, 2016). Sims and Kienzle (2017) indicated that smallholder farmers are the main producers of the world's food and they will have to increase production by up to 100 percent by 2050 to feed the growing population. Mandal, (2017) mentioned that small and marginal farms are one of the immense challenges for farm mechanization in the West Bengal state of India. Since the majority of farms are marginal with land holding less than one hectare, the use of high capacity equipment is not feasible. So, small agricultural machinery is gaining importance for research. As it was concluded by Dela and Malanon, (2017) to address the

constraint of small farm holdings, small machines should also be developed or promoted for individual or small group use. In addition the use of smaller machines can reduce drudgery and may be more sustainable in areas that are less productive because of limited water. Tractors are the main farm machines used by farmers in Riau Province Indonesia for tillage operations instead of human tools and drawn-animal implements (Paman et al., 2010). Singh, (2005) introduced that mechanization technologies keep changing with industrial growth of the country, and socio-economic advancement of the farmer. He added increasing land and labour productivity with dignity are the mechanization requirements of the developing countries. Mechanization technology is, therefore, location-specific and dynamic. As it is mentioned by (Oyelade and Oni, 2013) the traditional method of farming puts serious limitations on the growth of the nation's agricultural sector thus exacerbating reduced food production leading to increased food importation. Hazza'a (1993) mentioned that the agricultural machinery was entered to Yemen randomly and unorganizedly, and did not achieve the desired goals, due to the fragmentation of agricultural ownership and the small size of agricultural holdings. The number of terraces is estimated at about 40% of the total Yemeni arable land, and small size of holding, which is difficult to subject to agricultural mechanization (Hazza'a, 1996; Hazza'a, 1997; Al-Ani, 1997). In addition, all service operations and most of the smallholder cultivation operations and service are still restricted to the use of high-cost animal and human power, Williams (1980). According to Abdul Hamid (1993), the most important goals of agricultural mechanization are the speedy completion of agricultural operations, reducing production costs, increasing productivity per unit area, increasing the productivity of the agricultural worker and raising its standard of living, improving the quality of agricultural product, reduce waste and increase livestock. If mechanization does not achieve the above objectives, it becomes a burden on the farmers and the government.

1.1 The stages of agricultural mechanization in Yemen

Agricultural mechanization in Yemen does not exceed the concept of agricultural tractor, which despite its entry into Yemen since the seventies of the last century. The degree of benefit from it is still limited to its use in plowing operations, and is rarely used to implement other operations, meaning that the tractor is not used to full capacity at an uneconomic rate, at best, it does not exceed 600 to 800 hours per year, Williams (1980). Yemeni farmers still used the municipal plow in plowing operations, which plows with a depth of 10 cm and a width of no more than 15-20 cm. The tillage

efficiency in this way was no more than 0.03 ha / hour (Williams, 1980). The cultivation and sowing operations complete with the same plow that opens the grooves and is followed by the sowing laborer (Hill, 1979). Importing agricultural tractors started in 1970 with about 20 tractors. Then the import rate increased to 2119, 5563 and 10000 tractors in 1977, 1980 and 1991 respectively (Karim, 1991). The farmer in Yemen has about 350000 mechanical horses power, with an estimated mechanization level of about 0.23 hp / ha. Hazza (1991) explained that mechanization's entry into the agricultural field in Yemen was in a period when the country was not prepared for this shift, as it lacked the scientific and technical capabilities necessary to develop clear plans and programs to implement mechanization. As well as expertise and competencies in the field of applied research aimed at selecting the most appropriate tractors agricultural machines, most of which are appropriate to the circumstances of Yemen, have led to the introduction of mechanization by random means and the resulting difficulties. The degree of mechanization in Yemen is still at its lowest levels, as the level of mechanization reached 0.22 hp / ha, which is three times less than the marginal level, which ranges between 0.5 - 0.8 hp / ha to give the land a rewarding crop (Barbara,1993). The rate of agricultural mechanization use is still at low levels, as it is 4-5 tractors per 1000 hectares (Arab Organization for Agricultural Development, 2009).

1.2 Obstacles to the development of agricultural mechanization in the Republic of Yemen

Hazza'a (1993) mentioned that obstacles mechanization are terraces, small size of holdings, lack of awareness among farmers, lack of the availability of technical cadres

specialized, the multiplicity of sources for importing machinery and tractors and their high prices, the absence of centers and automatic complexes for the rental and maintenance of machinery in all agricultural regions, poor agricultural extension activity in the field of mechanization, poor transportation network impedes a lot from the arrival of equipment and technical services to agricultural areas, weak experience and field research work in the field of mechanization in order to reach the selection of appropriate machines and equipment and the incompatibility of the imported technology in most cases with the prevailing local conditions. Alghory (2000) stated that agricultural production is lagging behind due to the dominance of the old plow that animals pull to implement most of the agricultural operations due to the expensive agricultural equipment and machinery sometimes and not suitable for the topography and nature of Yemeni lands on the other hand. The objective of this research was to determine the present status of the adopted agricultural machinery and make a comparison of the machinery in different of Yemeni governorates.

II. MATERIALS AND METHODS

The results of the 2002 agricultural census (Central Statistical Organization, 2002) were used in this research, as this census covered all governorates of the republic as it is shown in Table 1 and Table 2. The data was tabulated, classified, analyzed and graphically illustrated with respect to the objective of the research. To find out the different types of agricultural machinery available and number of machinery per unit area and comparison of governorates pattern of agricultural machinery was done by using Microsoft excel software.

Table 1 Agricultural machinery available in different governorates

Governorates	Tractors	Harvesting machine	Thresher machine	Irrigation pump	Spray motor	Others
Ibb	1159	166	35	3433	80	448
Abyan	1459	35	38	5665	42	743
Amana	1123	20	34	2189	605	126
Al Bayda	2110	00	00	12038	235	229
Taiz	1278	00	15	9255	774	1120
Al Jawf	1395	239	76	13740	372	185
Hajjah	782	00	56	3620	1266	778
Al Hudaydah	3542	186	162	21002	978	592
Hadramaut	1082	92	58	6050	394	165
Dhamar	2370	107	126	17875	514	8470
Shabwah	2267	62	35	12736	120	260
Sa'dah	1432	34	152	34334	2181	4507

Sana'a	4398	222	193	31727	1593	378
Aden	77	00	00	272	13	24
Lahij	313	00	00	9324	155	856
Ma'rib	362	30	39	7911	121	2068
Al Mahwit	94	00	00	1054	41	00
Al Maharah	98	00	00	1170	11	5
Amran	427	32	38	5999	746	92
Dahle	503	18	00	12153	1520	1486
Raymah	30	00	00	56	00	00

* Source: Central Statistical Organization, 2002.

Table 2 Distribution of the agricultural holders by categories of the total area

Governorates	Total area	Total land holders	Percentage of holders %	Distributing the holders according to the total area categories							
				< 0.5 ha		From 0.5 to < 1 ha		From 1 ha to < 5 ha		5 ha and above	
				No. of holders	area	No. of holders	area	No. of holders	area	No. of holders	area
The total of the Republic	1609485.77	1180105	100	689397	122844.40	176336	127414.93	231222	456117.81	83150	903108.63
Ibb	56444.52	175508	14.87	147659	24604.10	18040	12297.77	9510	14949.46	660	4593.20
Abyan	65071.44	28112	2.38	10024	1952.26	3868	3075.18	9033	17950.45	5187	42093.56
Amanah	9317.00	9772	0.83	6303	922.01	1195	879.83	1655	3252.50	620	4262.67
Al Bayda	74900.95	34366	2.91	9483	2784.44	8130	5945.16	12545	24718.34	4208	41508.02
Taiz	64067.44	153661	13.02	128302	15593.71	14259	9910.41	9534	16723.12	1566	21840.19
Al jawf	109245.02	28298	2.40	4553	1164.29	3997	2784.55	12263	26619.81	7486	78676.40
Hajjah	147075.60	97126	8.23	57079	10060.89	14981	10882.99	17178	35430.34	7889	90701.39
Al hodaydah	327106.52	68449	7.33	14332	3538.95	14020	11031.32	37701	81017.50	20396	231518.75
Hadramaut	54422.49	39683	3.36	24181	3753.87	5331	3820.98	7389	13675.30	2782	33172.34
Dhamar	113734.33	110641	9.38	69157	12998.22	18260	13009.04	18388	35504.70	4836	52222.38
Shabwah	58524.48	22310	1.89	5951	1458.94	4360	3278.12	8314	16745.58	3686	37041.85
Sa'dah	50726.18	48531	4.11	25637	5543.87	10838	7705.83	10630	20212.76	1426	17263.72
Sana'a	144899.52	87851	7.44	32419	7488.58	17871	13522.69	30454	61172.26	7106	62715.98

Aden	3013.33	630	0.05	176	50.51	29	23.46	212	445.87	213	2493.49
Lahij	31804.03	54910	4.65	41642	6861.86	6589	4859.76	5574	9660.95	1105	10421.46
Ma'rib	116591.97	14279	1.21	2282	589.86	1435	1017.63	4182	9204.26	6380	105780.22
Al Mahwit	27443.00	44168	3.74	28264	6348.95	9136	6353.01	6302	10868.13	466	3872.90
Al Maharah	3973.04	3426	0.29	1473	351.79	880	633.03	954	1897.62	119	10.90.61
Amran	121487.12	68572	5.81	2559	6511.04	12348	8922.22	23983	47150.39	6641	58903.47
Dahle	15089.38	36245	3.07	27325	4816.38	5759	4016.35	2948	4465.50	212	1791.15
Raymah	14493.40	35567	3.01	27556	5449.90	5010	3445.61	2833	4452.98	167	1144.91

* Source: Central Statistical Organization, 2002.

III. RESULT AND DISCUSSION

3.1 Distribution of land ownership

Table 3 shows the distribution of land ownership in Yemen. As shown in the table the land tenure is highly fragmented. The distribution of area were 7.63%, 7.92%, 28.34% and 56.11% of the total area less than 0.5 ha, from

0.5 to less than 1 ha, from 1ha to less than 5 ha and 5 ha and more respectively. While the distribution of land owners were 58.42%, 14.94%, 19.59% and 7.05% of total land owners owned less than 0.5 ha, from 0.5 to less than 1 ha, from 1ha to less than 5 ha and 5 ha and more respectively. This is the main problem for agricultural mechanization in Yemen.

Table 3 Distribution of land ownership

Category	Land owners	Area owned (ha)	Land owners (%)	Area owned (%)
Total	1180105	1609485.77	100.0	100.0
Less than 0.5	689397	122844.40	58.42	7.63
From 0.5 to less than ha	176336	127414.95	14.94	7.92
From 1 to less than 5	231222	456117.81	19.59	28.34
5 and more	83150	903108.63	7.05	56.11

3.2 Quantity of agricultural machinery

Many farming operation still being done manually like weeding, crop harvesting, spraying, seed broadcasting, ploughing etc. The number of tractors, harvesters, threshers, irrigation pumps, sprayers and others machines (disc plow, moldboard plow, rotary tiller, chisel plow, subsoiler, harrows, rollers, levelers, ditchers, seeders, grain drills, potato planter, trasplanters, rotary hoe, fertilizer distributer, manure spreaders, dusters, etc.) in Yemen are shown in Table 4. This farm machinery still imported from abroad countries. The results showed that the irrigation machines were used the highest number 211620 among all of the small and large machinery in Yemen. Tractors and other machinery 27298

and 22532 respectively was taken second and third position. Sprayer motors, harvesting machines and thresher machines 12662, 1244 and 1058 respectively was taken fourth, fifth and sixth position.

Table 4 Quantity of agricultural machinery

Name of machinery	Quantity (unit)
Tractor	27298
Harvesting machine	1244
Thresher machine	1058
Irrigation pump	211620
Spray motors	12662
Others	22532

3.3 Number of machinery per hectare

Machinery per unit cultivated area according to the number of machinery used in the different governorates area. Table 5 shows that Sa'adah, Sana'a, dharmar and Al Hudaydah were have the highest number of machinery, 42640, 38511, 29462 and 26462 respectively. While the lowest number 86 was used in Raymah. Amran and Shabwah were used the highest number of tractor per hectare area 0.179 and 0.135 respectively. Al Bayda, Taiz, Hajjah, Aden, Lahij, Al Mahwit, Al Maharah and Raymah were not used harvesting machines. Regarding thresher machines Al Bayda, Aden, Lagij, Al Mahwit, Al Maharah, Dahle and Raymah were not familiar with this machinery. Sa'adah was used the highest number of irrigation pumps 1.134 per/ha, Shabwah in the second place 0.756 per/ha and Al Jawf in the third place 0.453. Dahle was used the highest number per/ha of spray motors and Raymah was not used this motors. Sa'adah was

used the highest number of the other machinery 0.149 per/ha, Al Mahwit and Raymah were not familiar with these machinery. Regarding the machineries per hectare, the results showed that Sa'adah was in the first position of all the 21 governorates with is 1.41 machineries per hectare. Dahle and Shabwah are in the second and third positions with 1.26 and 0.92 machineries respectively. Raymah was ranked at last position with 0.006686 machineries. The results indicate that the difference in the use of agricultural machinery in the governorates due to the difference in area and land topography. The results analyzed from the table show that the many of agricultural operations at the present time are still carried out manually or by animals usage instead of machinery usage. In addition agricultural machinery per hectare area still very low and was not adequate to fulfill the meaningful mechanization. Therefore, agricultural machinery must be introduced into the agricultural sector to produce sustainable crops in Yemen.

Table 5 Number of different machinery per hectare

Governorates	Area (ha)	Tractors		Harvesting machine		Thresher machine		Irrigation pump		Spray motor		Others	
		No.	No. per ha	No.	No. per ha	No.	No. per ha	No.	No. per ha	No.	No. per ha	No.	No. per ha
Ibb	51512.59	1159	0.023	166	0.003	35	0.001	3433	0.067	80	0.002	448	0.009
Abyan	44480.00	1459	0.033	35	0.001	38	0.001	5665	0.127	42	0.001	743	0.017
Amana	6273.72	1123	0.179	20	0.003	34	0.005	2189	0.349	605	0.096	126	0.020
Al Bayda	33419.38	2110	0.063	00	0.000	00	0.000	12038	0.360	235	0.007	229	0.007
Taiz	53669.26	1278	0.024	00	0.000	15	0.0003	9255	0.173	774	0.014	1120	0.021
Al Jawf	30317.06	1395	0.046	239	0.008	76	0.003	13740	0.453	372	0.012	185	0.006
Hajjah	114088.20	782	0.007	00	0.000	56	0.001	3620	0.032	1266	0.011	778	0.007
Al Hudaydah	234772.79	3542	0.015	186	0.001	162	0.001	21002	0.089	978	0.004	592	0.003
Hadramut	29733.64	1082	0.036	92	0.003	58	0.002	6050	0.204	394	0.013	165	0.006
Dharmar	81445.15	2370	0.029	107	0.002	126	0.002	17875	0.219	514	0.006	8470	0.104
Shabwah	16839.35	2267	0.135	62	0.004	35	0.002	12736	0.756	120	0.007	260	0.015

Sa'dah	30266.98	1432	0.047	34	0.001	152	0.005	34334	1.134	2181	0.072	4507	0.149
Sana'a	115200.77	4398	0.038	222	0.002	193	0.002	31727	0.275	1593	0.014	378	0.003
Aden	1721.86	77	0.045	00	0.000	00	0.000	272	0.158	13	0.008	24	0.014
Lahij	21399.36	313	0.015	00	0.000	00	0.000	9324	0.436	155	0.007	856	0.040
Mar'rib	27742.69	362	0.013	30	0.001	39	0.001	7911	0.285	121	0.004	2068	0.075
Al Mahwit	50915.99	94	0.002	00	0.000	00	0.000	1054	0.021	41	0.001	00	0.000
Al Maharah	1998.94	98	0.049	00	0.000	00	0.000	1170	0.585	11	0.006	5	0.003
Amran	83268.46	427	0.005	32	0.0004	38	0.001	5999	0.072	746	0.009	92	0.001
Dahle	12429.21	503	0.041	18	0.002	00	0.000	12153	0.009	1520	0.122	1486	0.120
Raymah	12863.60	30	0.002	00	0.000	00	0.000	56	0.004	0.000	0.000	0.000	0.000

3.4 Agricultural machinery in different governorates

The availability of agricultural machinery in different governorates was unevenly in distribution. The availability of agricultural machinery in different governorates is shown graphically at figure1 to figure 21.

3.4.1 Ibb governorate

Figure1 shows that the irrigation pumps were the maximum and threshers were the minimum. The results showed that 3433 farmers used the irrigation pump and only 35 used threshers. The tractors were in the second place; 1159 farmers used the tractor. The usage of tractors per cultivated area was 0.023 per/ha. Harvesters, threshers, sprayers and other machinery were found to be 166, 35, 80 and 80 respectively.

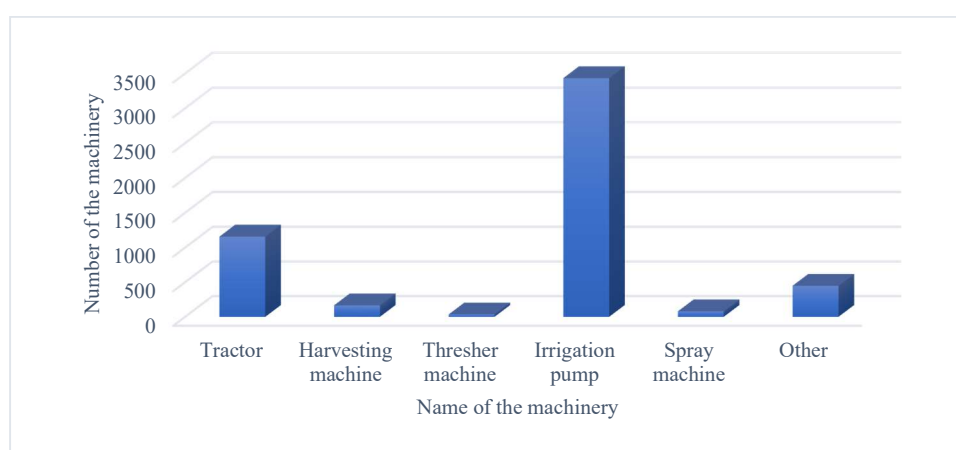


Figure 1 Number of machinery in Ibb governorate

3.4.2 Abyan governorate

Irrigation pumps were the maximum and harvesters the minimum as shown in table 2. The results showed that 5665

farmers used the irrigation pump and 35 farmers used threshers. The tractors in the second place, 1459 farmers used tractor. Threshers, sprayers and other machinery were 35, 38, 42 and 743 respectively.

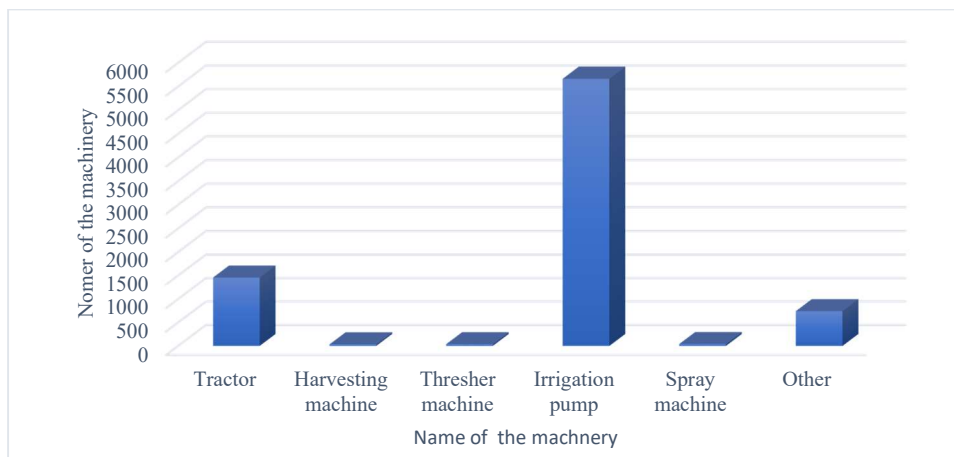


Figure 2 Number of machinery in Abyan governorate

3.4.3 Amanah governorate

The number of machineries were 1123, 20, 34, 2189, 605 and 126 tractors, harvesters, threshers, irrigation pumps, sprayers and others respectively as shown in table 3. The

results showed that irrigation pumps were the maximum and harvesters were the minimum. The number tractors per hectare area were found to be 0.033 and irrigation pumps 0.349 per hectare.

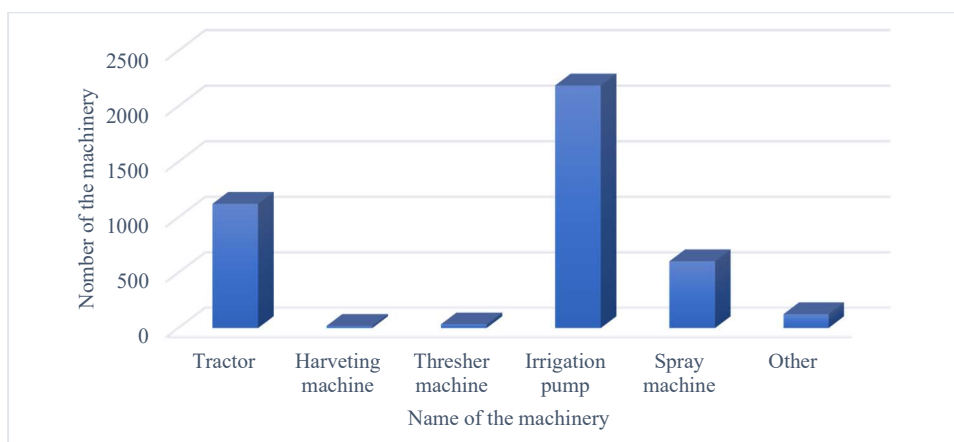


Figure 3 Number of machinery in Amanah governorate

3.4.4 Al Bayda governorate

Al Bayda governorate was not familiar with harvesters and threshers. 12038, 2110, 235 and 229 farmers used

irrigation pumps, tractors, sprayers and others machines respectively. Irrigation pumps were in first place and tractors in the second place.

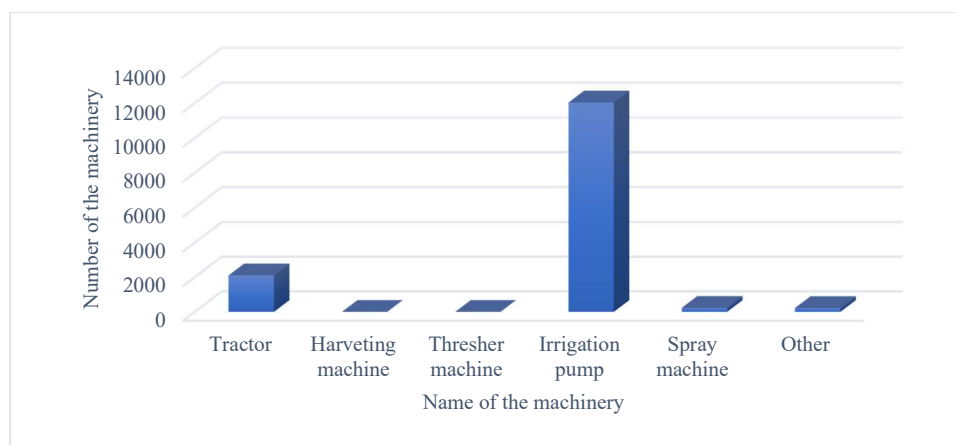


Figure 4 Number of machinery in Al Bayda governorate

3.4.5 Taiz governorate

Figure 5 shows that among the entire machineries irrigation pump were the maximum and threshers the minimum. Harvesters were not used in Taiz. 9255, 1278, 774,

15 and 1120 farmers used irrigation pumps, tractors, sprayers, threshers and others machines. The number tractors per hectare area were found to be 0.024 and irrigation pumps 0.173 per hectare.

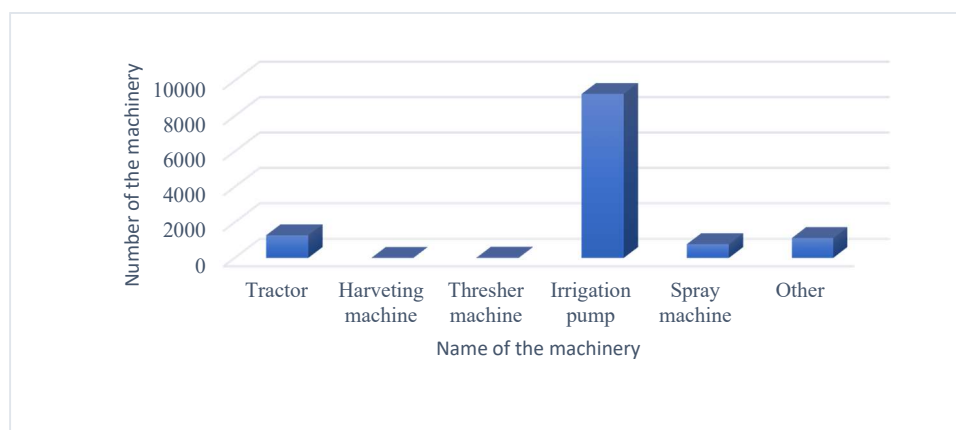


Figure 5 Number of machinery in Taiz governorate

3.4.6 Al Jawf governorate

Irrigation pumps were the maximum and threshers the minimum. In addition all other types of machinery are used as shown in figure 6. The results showed that farmers used

13740, 1395, 372, 239, 76 and 185 irrigation pumps, tractors, sprayers, harvesters, threshers and others machinery respectively. The number tractors per hectare area were found to be 0.046 and irrigation pumps 0.453 per hectare.

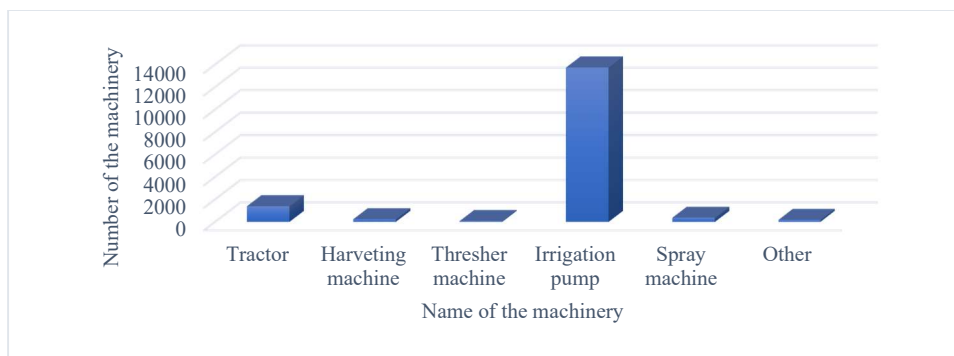


Figure 6 Number of machinery in Al Jawf governorate

3.4.7 Hajjah governorate

In Hajjah governorate, mostly used irrigation pumps and sprayer are in leading position. Tractors are in the third position after sprayer. The other machineries were in the

fourth position. Figure 7 shows that the least used machinery were the threshers. Harvesters were not used in this governorate. The number tractors per hectare area were found to be 0.007 and irrigation pumps 0.032 per hectare.

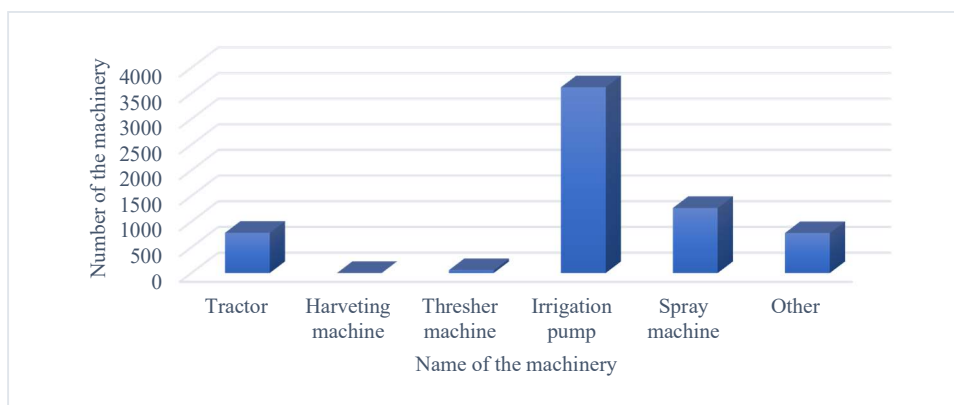


Figure 7 Number of machinery in Hajaah governorate

3.4.8 Al Hudaydah governorate

The large numbers of irrigation pumps were used (21002 pumps). In the second position became tractors (3542

tractors). In addition all other types of machinery are presented as shown in Figure 8. The number tractors per hectare area were found to be 0.015 and irrigation pumps 0.089 per hectare.

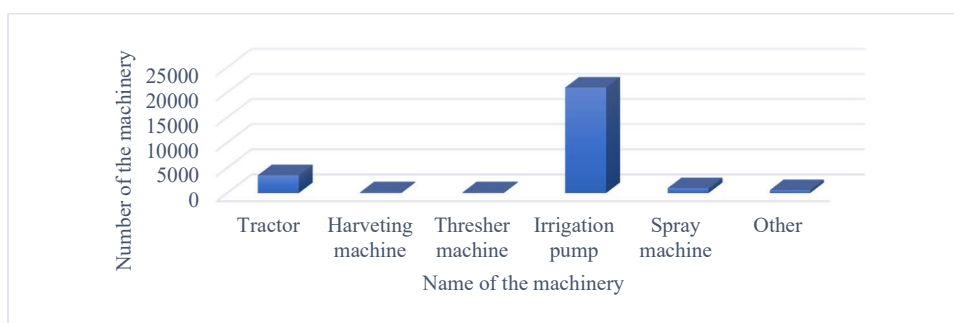


Figure 8 Number of machinery in Al Hudaydah governorate

3.4.9 Hadramaut governorate

As indicated in Figure 9 the maximum irrigation pumps were used among all the machineries. The tractors were in

second position. Sprayers were in the third position. Harvesters, threshers and others machinery were used in minimum range. The number tractors per hectare area were found to be 0.036 and irrigation pumps 0.204 per hectare.

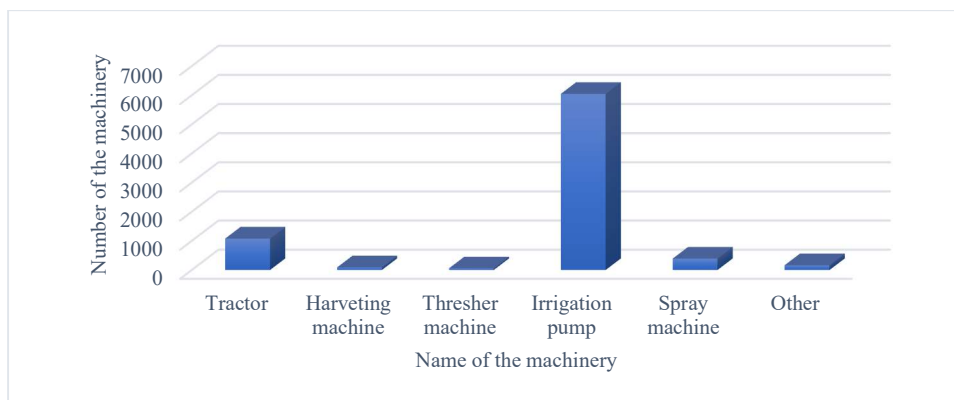


Figure 9 Number of machinery in Hadramaut governorate

3.4.10 Dhamar governorate

Irrigation pumps were the maximum and threshers the minimum. In addition all other types of machinery are used as shown in figure 10. The results showed that farmers used

17875, 2370, 514, 167, 126 and 8470 irrigation pumps, tractors, sprayers, harvesters, threshers and others machinery respectively. The number tractors per hectare area were found to be 0.029 and irrigation pumps 0.219 per hectare.

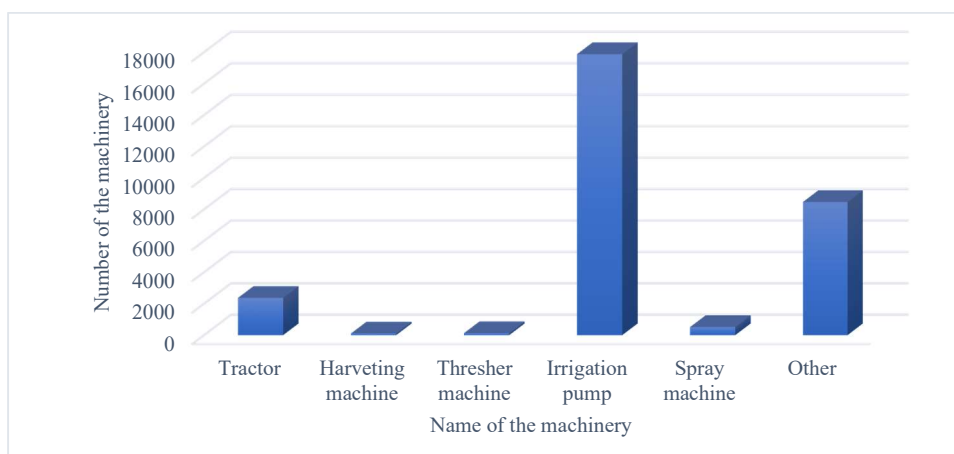


Figure 10 Number of machinery in Dhamar governorate

3.4.11 Shabwah governorate

Figure 11 shows that the irrigation pumps were the maximum and threshers were the minimum. The results showed that 12736 farmers used the irrigation pump and only

35 used threshers. The tractors were in the second place; 2267 farmers used the tractor. The usage of tractors per cultivated area was 0.135 per/ha. Harvesters, threshers, sprayers and other machinery were found to be 62, 35, 120 and 260 respectively.

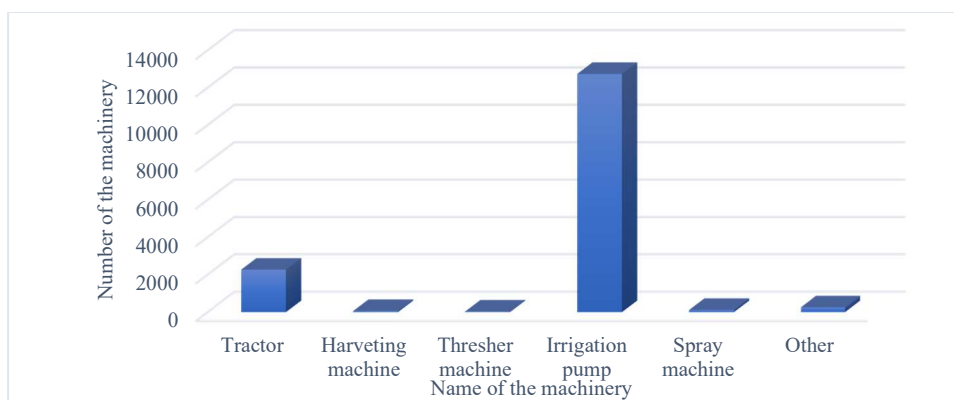


Figure 11 Number of machinery in Shabwah governorate

3.4.12 Sa'dah governorate

The number of machineries were 1432, 34, 152, 34334, 2181 and 4507 tractors, harvesters, threshers, irrigation pumps, sprayers and others respectively as shown in table 3.

The results showed that irrigation pumps were the maximum and harvesters were the minimum. The number tractors per hectare area were found to be 0.047 and irrigation pumps 1.134 per hectare.

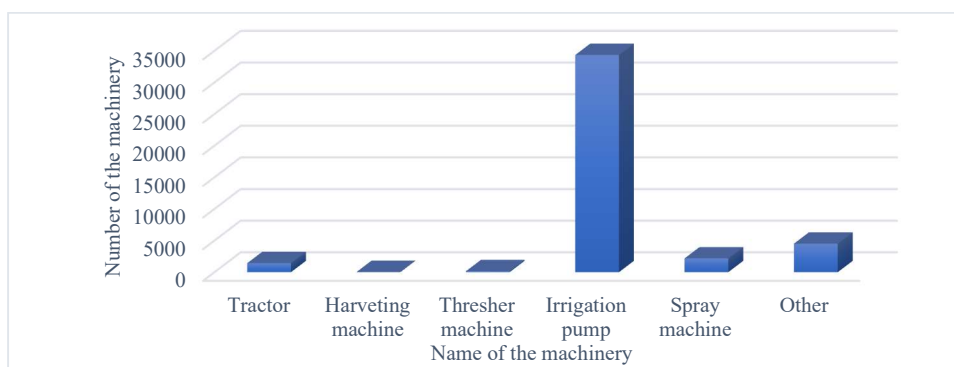


Figure 12 Number of machinery in Sa'dah governorate

3.4.13 Sana'a governorate

The number of machineries were 4398, 222, 193, 31727, 1593 and 378 tractors, harvesters, threshers, irrigation pumps, sprayers and others respectively as shown in figure 13. The

results showed that irrigation pumps were the maximum and threshers were the minimum. The number tractors per hectare area were found to be 0.038 and irrigation pumps 0.275 per hectare.

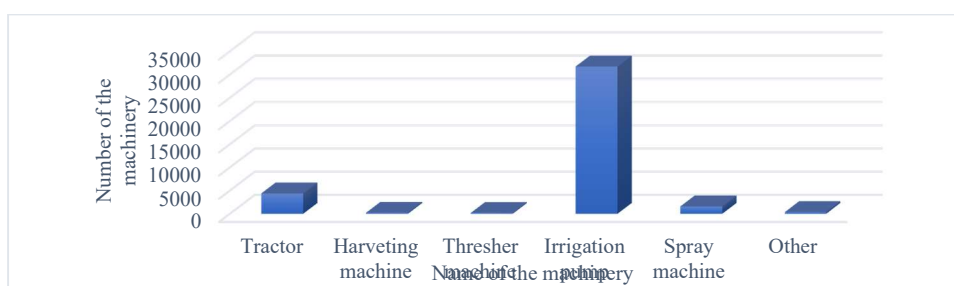


Figure 13 Number of machinery in Sana'a governorate

3.4.14 Aden governorate

In Aden governorate, mostly used irrigation pumps and tractors are in leading position. The other machineries were

in the third position. The sprayers were in the fourth position Figure14. Harvesters and threshers were not used in this governorate. The number tractors per hectare area were found to be 0.045 and irrigation pumps 0.158 per hectare.

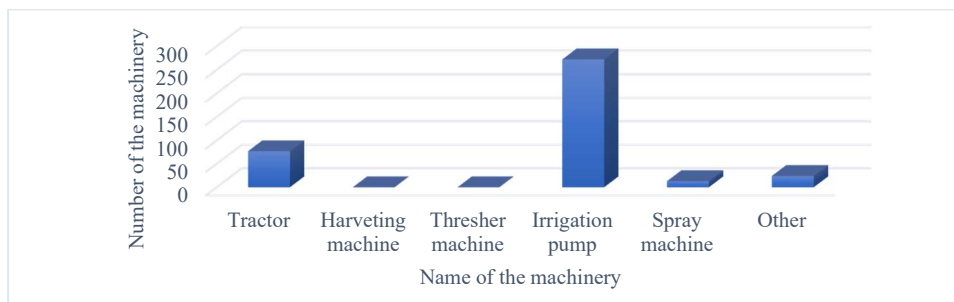


Figure 14 Number of machinery in Aden governorate

3.4.15 Lahij governorate

Figure 15 shows that the irrigation pumps were used at significant level while other machines and sprayers were used

at less number. Harvester and threshers were not used. The number tractors per hectare area were found to be 0.015 and irrigation pumps 0.436 per hectare

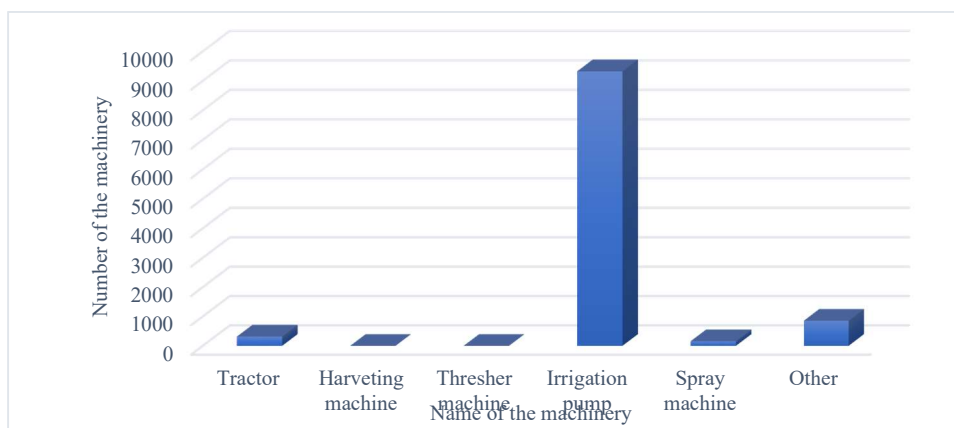


Figure 15 Number of machinery in Lahij governorate

3.4.16 Ma'rib governorate

As indicated in Figure 16 the maximum irrigation pumps were used among all the machineries. The other machines were in second position. Tractors were in the third position. Harvesters, threshers and sprayers machinery were used in minimum range. The number tractors per hectare area were found to be 0.013 and irrigation pumps 0.285 per hectare.

3.4.17 Al Mahwit governorate

In Al Mahwit governorate, mostly used irrigation pumps and tractors are in leading position. Sprayers are in the third position after tractors. The other machineries were in the fourth position. Figure 17 shows that the least used machinery were the threshers. Harvesters, threshers and other machines were not used in this governorate. The number tractors per hectare area were found to be 0.002 and irrigation pumps 0.021 per hectare.

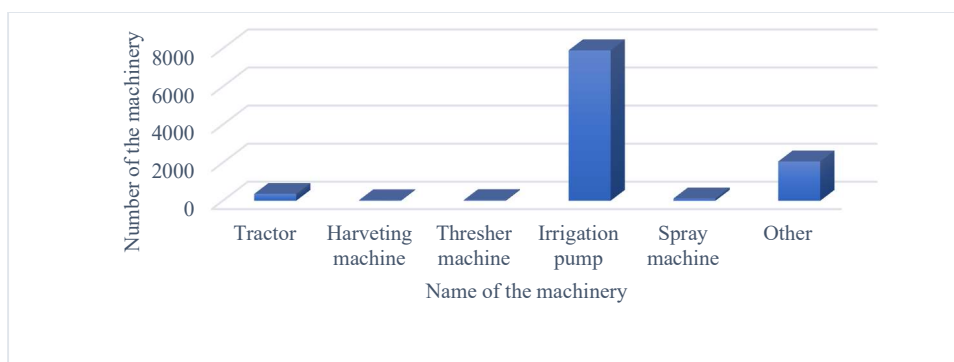


Figure 16 Number of machinery in Ma'rib governorate

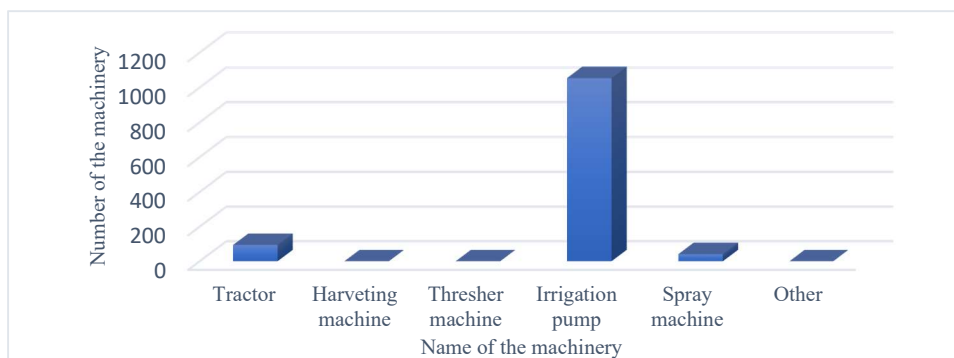


Figure 17 Number of machinery in Al Mahwit governorate

3.4.18 Al Maharah governorate

As shown in Figure 18 irrigation pumps were the maximum and threshers the minimum. The other machines were used at a less number. Harvesters and threshers were not

used. The results show that farmers used 1170, 98, 11 and 5 irrigation pumps, tractors, sprayers and other machines respectively. The number tractors per hectare area were found to be 0.049 and irrigation pumps 0.585 per hectare.

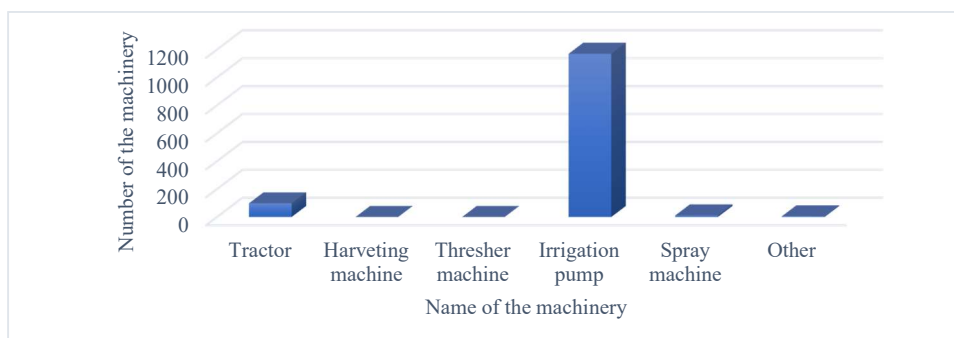


Figure 18 Number of machinery in Al Maharah governorate

3.4.19 Amran governorate

Figure 19 shows that the irrigation pumps were used at significant level. Sprayers, tractors and the other machines

were at the second, third and fourth position. Harvester and threshers were used at less number. The number tractors per hectare area were found to be 0.017 and irrigation pumps 0.072 per hectare.

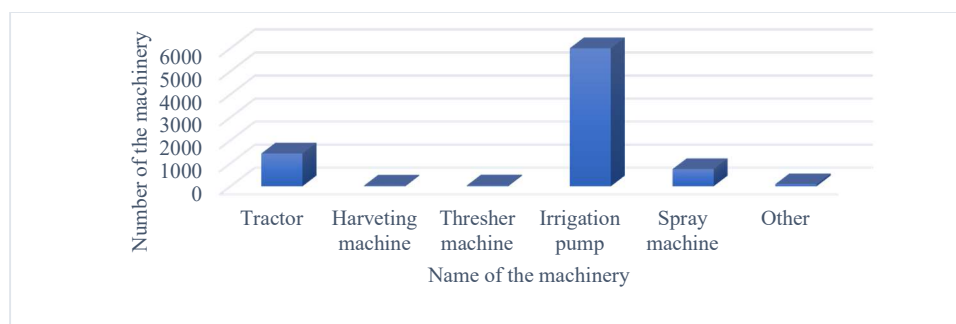


Figure 19 Number of machinery in Amran governorate

3.4.20 Dhale governorate

Figure 20 shows that the irrigation pumps were used at significant level. Sprayers, other machines and tractors were

at the second, third and fourth position. While harvesters were used at less number. Threshers were not used. The number tractors per hectare area were found to be 0.041 and irrigation pumps 0.978 per hectare.

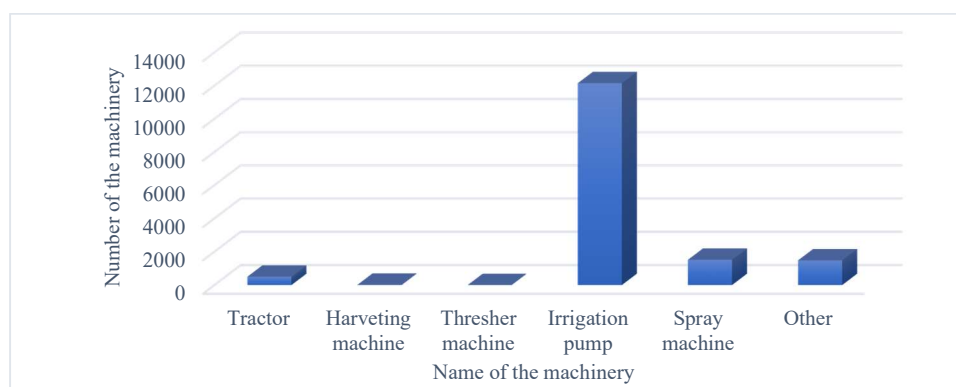


Figure 20 Number of machinery in Dhale governorate

3.4.21 Raymah governorate

In Raymah only the tractors and irrigation pumps were used as shown in figure 21. This is due to topography of

governorate. The number tractors per hectare area were found to be 0.002 and irrigation pumps 0.004 per hectare.

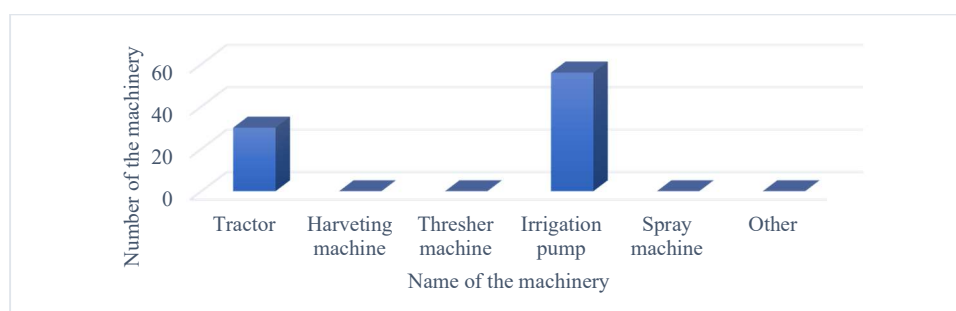


Figure 21 Number of machinery in Raymah governorate

IV. CONCLUSION

The results indicate that the difference in the use of agricultural machinery in the governorates due to the

difference in area and land topography. The results analyzed show that the many of agricultural operations at the present time are still carried out manually or by animals instead of

machinery. In addition agricultural machinery per hectare area still very low and was not adequate to fulfill the meaningful mechanization. The small size of the holdings do not allow the farmer to own the appropriate machinery, which may become a burden on him in the event that he is unable to operate them for a long period to cover their expenses. The horsepower of the tractors, the full specifications of the agricultural machinery, the country of origin and the date of entry into service of the tractors and agricultural machinery are not indicated agricultural census. Therefore, the following recommendations may be taken:

1. The upcoming agricultural census forms must contain data showing the horse power of tractors and the full specifications of agricultural machinery.
2. Providing small-sized agricultural machinery and equipment suitable for use in lands and terraces where large agricultural machinery cannot be used.
3. Activating and supporting research field experiments in the field of agricultural mechanization with the aim of reaching the selection of appropriate tractors and agricultural machines.
4. There is a need to develop a policy of mechanization for the development of mechanization in each governorate.
5. An evaluation research is required for the period 2003 to date.

ACKNOWLEDGMENT

The results of the 2002 agricultural census were used for this research, as this census covered all governorates.

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