

Irrigation Systems in Different Agro-Ecological Zone of Domar Upazila, Nilphamari, Bangladesh

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Authors' contributions

This work was carried out in collaboration between both authors. Author SCS designed the study, performed the statistical analysis, wrote the protocol and managed literature searches. Author SMZH wrote the first draft of the manuscript, performed the GIS analysis and collecting data from the field. Both authors read and approved the final manuscript.

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ABSTRACT

An Agro-ecological (AEZ) zone describes its all characteristics about those phenomena which are related with agriculture such as temperature, rainfall, humidity, soil quality, soil fertility, crop pattern of a specific region. This study was done to find out irrigation distribution, crop pattern, and a relation between them. 12 AEZ units divided in a study area on the basis of topography, soil characteristics and development possibility from H. Brammer's research "Agroecological aspects on agricultural research of Bangladesh". In this study, data were collected by questionnaire survey, official documents and irrigation machine's locations data were collected by using GPS machine and Google earth. Irrigation distribution maps were created by inserting location data into XY data input on ArcGIS 10. Comparing satellite images of different time of a year from Google earth, Crop pattern map has produced. The result here shown in Domar upazila found 4242 irrigation machines including electric pump, diesel pump and deep tubewell and also found relation between irrigation systems and crop pattern. In findings, there mainly diesel pump used in AEZ unit 1, AEZ unit 5 and AEZ Unit 12 and these AEZ units are dominated by Potato, Maize, Groundnut, Chili and Tobacco

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cultivation and rest AEZ units are dominated by Boro cultivation where used deep tubewell and electric pump. This research helps to compare irrigation systems of different AEZ units and ensure the proper irrigation system. Proper distribution of irrigation systems according to AEZ units improve the agricultural production and also improve the socio-economic condition.

Keywords: Agro-ecological Zone; Irrigation System; GIS; Crop Pattern; AEZ units.

1. INTRODUCTION

Agro-ecological zones (AEZ) define by the soil composition, landform and climatic condition [1]. The Parameters of AEZs are the basic climatic and edaphic requirements of crops and also helps on the management systems under which the crops are grown [1]. There is a similar combination of constraints found on each zone and potentials for land use and serves as a focus for the targeting of recommendations designed to improve the existing land-use situation, either through increasing production or by limiting land degradation [1]. Crop-specific limitations of prevailing climate conditions, soil conditions, and terrain resources, under assumed levels of inputs and management conditions, can be identified by using AEZ matching procedures [2]. The Agro-ecological zones approach that combines land evaluation methods are with socioeconomic and multiple-criteria analysis to evaluate spatial and dynamic aspects of agriculture through GIS [3]. Agro-ecological zones (AEZs) considered as geographical areas which demonstrating the same climatic conditions that to support rained agriculture according to their ability [4]. Latitude, elevation influence AEZs, and temperature, as well as seasonality, and rainfall amounts and distribution during the growing season when it is considered as regional scale [5]. Different irrigation method is used in a different Agro-ecological zone, for example, those AEZ which contain hilly region use mainly sprinkler method and AEZs of plain land use basin method [6]. Soil, land type and climatic data were analyzed, and weekly Bangladesh Water Development Board (BWDB) well records were correlated with land types in order to determine the duration of seasonal flooding on individual land types in each Thana [7]. The objectives were to define agro-ecological units within which the potential productivity of selected important crops could be assessed [7]. On the other hand, irrigation is the method in which water is supplied to the plants at regular intervals for agriculture [8]. During inadequate rainfall, period helps to grow of crops, maintain the soil conditions of landscapes and re-vegetation of disturbed soils and also in dry areas [9]. Irrigation is also used for sewage

disposal, mining, dust suppression but it is mainly used in agricultural sector [8]. In Bangladesh, 94% of the land is used small and minor irrigation [10]. Water is being lifted through 26,704 deep tube wells, 4,69,226 shallow tube wells, 56,829 low lift pumps, 1,42,132 manual pumps, and more than 5,65,000 indigenous water lifting devices in this country according to a recent survey data [10]. But the lack of proper use of these irrigation devices and unplanned cropping activities has resulted in low irrigation coverage [10]. The irrigation efficiency is only about 30%, with proper utilization and improved management, by using the same number of irrigation devices it can be increased to 4.0 to 5.0 million hectares land from the present 3.12 million hectare [10]. There are eight major kind of crop rotation can be recognized in Bangladesh and most of these can be subdivided into one or more sub-types [7]. Environmental conditions is influenced the major crop rotations, especially land levels in relation to flooding, duration of flooding, soil moisture holding capacity and time of onset of the pre-monsoon rain [11]. To fulfill the demand of the food and other agricultural product they have to produce agricultural products 3 or 4 times in a year. Though it is a riverine country the water found in the river in rainy season and in other part of the year Rivers is almost remain dry. Maximum precipitation occurs in this country in the rainy season and rest of time of the year it was almost precipitation less except Sylhet and Chittagong region [12].

Bangladesh land is divided in 30 major AEZ Units with 88 sub-division 535 units and in this country [13], there use irrigation almost 6 months of the year. Some AEZ needs more irrigation for crop production and some AEZ needs less irrigation.

Domar upazila is under Nilphamari District and it is under Tista Meandering Floodplain Agro-ecological zone. It this upazila found 12 soil units which are considered as 12 Agro-ecological zone units. These AEZ units are identified on the basis of topography, soil characteristics and development possibility. A major portion of the upazila is covered by Boro cultivation and

second major crop of this area is potato. Beside these tobacco, maize, chili, ground nut are also cultivated. These crops are considered as major crops of Domar upazila. Other crops such as sugarcane, wheat, ginger, turmeric, garlic, onion, vegetables, mango, lichi, and banana are also cultivated in very few areas. According to a survey of Bangladesh Bureau of Statistics in 2011, 18908 acres of land were irrigated by power pump (electric and diesel) and 1838 acres were irrigated by deep tubewell and 23 acres by other machine [14]. Total irrigated lands were 20769 acres in that year [14]. Now-a-days there use only electric pump, diesel pump and deep tubewell for irrigation. This research is necessary for identify irrigation system and develop the irrigation system on the basis of crop pattern and AEZ Unit and increasing crop production.

2. DATA SOURCES AND METHODS

2.1 Data Sources

Both Primary and Secondary data were used for this study. Primary data were collected from the field of the study area using GPS Machine (Germin eTrex 30) and Secondary data sources are Soil Resource Development Institute (SRDI), Engineering department of Upazila Parishad, Domar. Statistical Year Book of Bangladesh Bureau of Statistics (BBS), Google Earth 5.2.0.0 and Journals.

2.2 Data Collection Method and Analysis

A questionnaire survey has been done to collect the irrigation systems and crop pattern information. Those questionnaires had two parts. First one was about respondent information including 6 open ended question and second part was irrigation and crop related questions and there exist 7 questions. In the second part of questionnaire 2 questions were close ended and 5 questions were open ended. 6 questions were related with irrigation machine and 1 question was related with irrigation pump and crop. There was attended 1200 responder for the questionnaire survey. GPS machine and Google earth has been used to collect the absolute location of each and every irrigation machines. AEZ units are selected from soil units determined by SRDI on the basis on soil properties and topography which are identified from Hugh Brammer "Agroecological aspects on agricultural research of Bangladesh". Crop pattern map produced from those data which were collected from questionnaire and analyzing the satellite

images (04 Dec, 2013, 9 Feb 2014, 16 Apr, 2014, 29 Aug, 2014) from Google earth 5.2.0.0. crops are identified by analyzing texture and color of different images and compare with the data collected from questionnaire survey. Area has measured with measurement tool of ArcGIS 10.0. Finally, the report has created by comparing maps (AEZ Unit map, Crop Pattern map and Irrigation distribution map).

3. STUDY AREA

Domar Upazila located in between 26°02' and 26°19' north latitudes and in between 88°46' and 88°54' east longitudes [15]. It is bounded by west bengal of India on the north, Nilphamari sadar upazila on the south, Dimla and Jaldhaka upazilas on the east, Debiganj upazila on the west [15]. Total area of Domar upazila is 250.84 sq km [15]. This upazila is under in Tista Floodplain Region. North-West and Eastern part of this area mainly rough surface highland are formed by loose soil consistency. The middle part of this upazila is formed with highland and many wide and narrow beel. In Domar upazila 14418-acre High land, 44780-acre Medium land and Low land 2786 acre. In this upazila found 58506 acre Doash (Loamy) and 692 acre Bele (Sandy) soil. This upazila is under Agro-ecological zone 3 named Tista Meander Floodplain and total upazila is covered by 12 AEZ units. In this upazila total cultivated area is 55943 acre, here including permanent cropped area 761 acre, temporary cropped area 46600 acre, permanent fellow land 124 acre and others 8582 acre. Main crops of this upazila are Boro, Potato, Maize, Tobacco, Ground Nut, and Chili. Both Shallow (Electric pump and Diesel pump) and Deep tube well are used for irrigation. Total 20800 acre areas are irrigated in year 2010-11 [14]. In recent time, fellow lands are converting to cultivation area that's why day by day number of irrigation area is increasing. This study area has been chosen because this area is very well known to me that's why data are collected easily and accurately. On the other hand, a huge amount of area is used for cultivation; as a result the output of the study is more accurate. In Fig. 1 is shown the map of the study area.

4. RESULTS AND DISCUSSION

There has identified 12 AEZ units in this upazila (Fig. 2). Total area of AEZ unit 1 is 710 hectares (ha), AEZ unit 2 covers 1783 ha, AEZ unit 3 covers 1095 ha, AEZ unit 4 covers 8425 ha, AEZ unit 5 covers 2493 ha, AEZ unit 6 covers

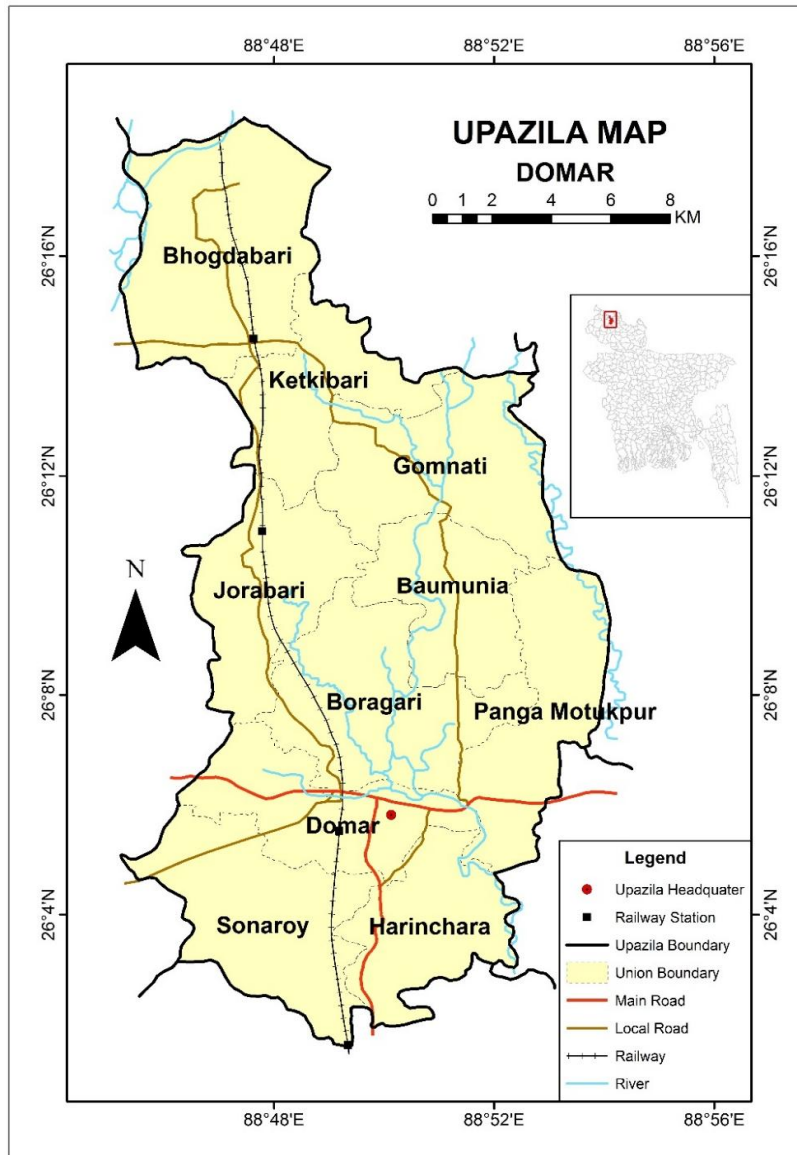


Fig. 1. Study area

1682 ha, AEZ unit 7 covers 1032 ha. AEZ unit 8 covers 1350 ha, AEZ unit 9 covers 2930 ha, AEZ unit 10 covers 140 ha, AEZ unit 11 covers 345 ha and AEZ unit 12 covers 36 ha of this upazila. Main crops of this upazila are Boro, Potato, Maize, Ground nut, Tobacco, Chili (Fig. 4). A large number area is cultivated by Boro, and second major crop is Potato. There are found total 4242 irrigation machines, wherefore 61 deep tubewells and 4179 shallow tubewells are counted. There are found 831 shallow diesel pumps and 3348 shallow electric water pumps of total shallow pumps. Here found 110 irrigation machines is in AEZ unit 1, 310 irrigation

machines are found in AEZ unit 2, 209 irrigation machines are found in AEZ Unit 3, 1841 irrigation machines are found in AEZ unit 4, 430 in AEZ unit 5, 309 in AEZ unit 6, 203 in AEZ unit 7, 242 in AEZ unit 8, 490 in AEZ unit 9, 23 found in AEZ unit 10, 71 in AEZ unit 11 and 4 is found in AEZ unit 12 that shown in Table 1.

Shallow water machines are two types, one is diesel pump which run with the diesel and second one is electric pump run with the electricity. No manual irrigation machines are found in the study area.

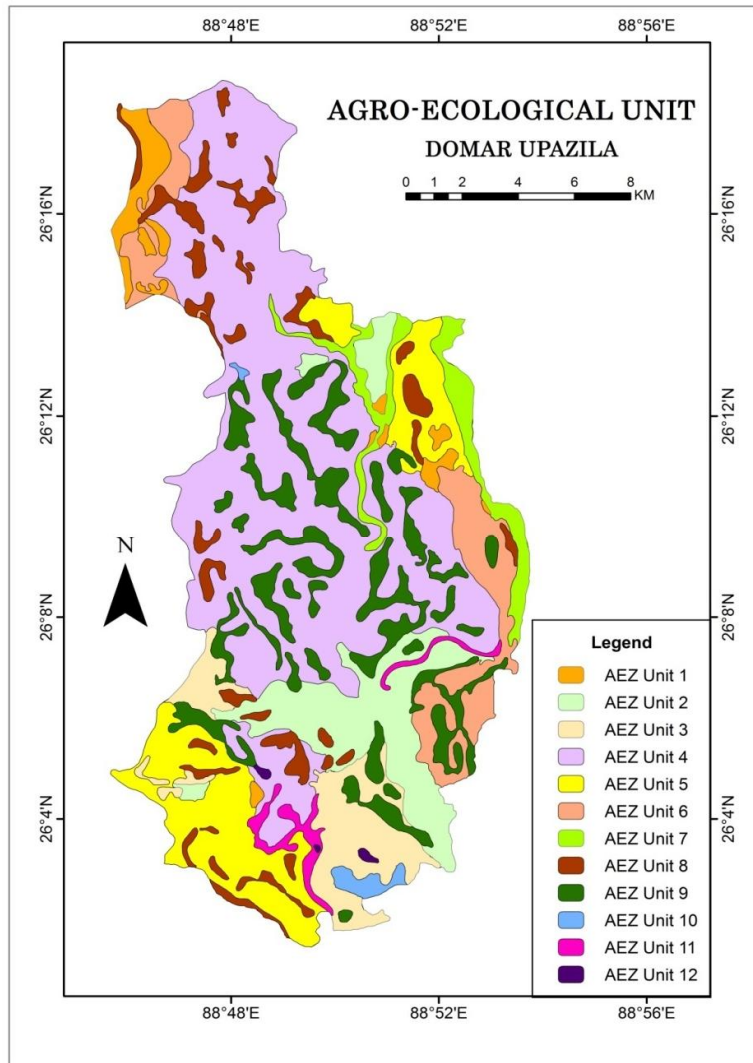


Fig. 2. AEZ units of Domar Upazila

Table 1. Distribution of irrigation machine in different AEZ units

AEZ units	Deep tube well	Shallow tube well		Total
		Diesel	Electric	
AEZ Unit 1	1	85	24	110
AEZ Unit 2	18	84	208	310
AEZ Unit 3	6	29	174	209
AEZ Unit 4	26	277	1538	1841
AEZ Unit 5	1	85	344	430
AEZ Unit 6	2	111	196	309
AEZ Unit 7	0	56	147	203
AEZ Unit 8	3	57	182	242
AEZ Unit 9	5	36	449	490
AEZ Unit 10	1	0	22	23
AEZ Unit 11	0	8	63	71
AEZ Unit 12	0	2	2	4
Total	63	830	3349	4242

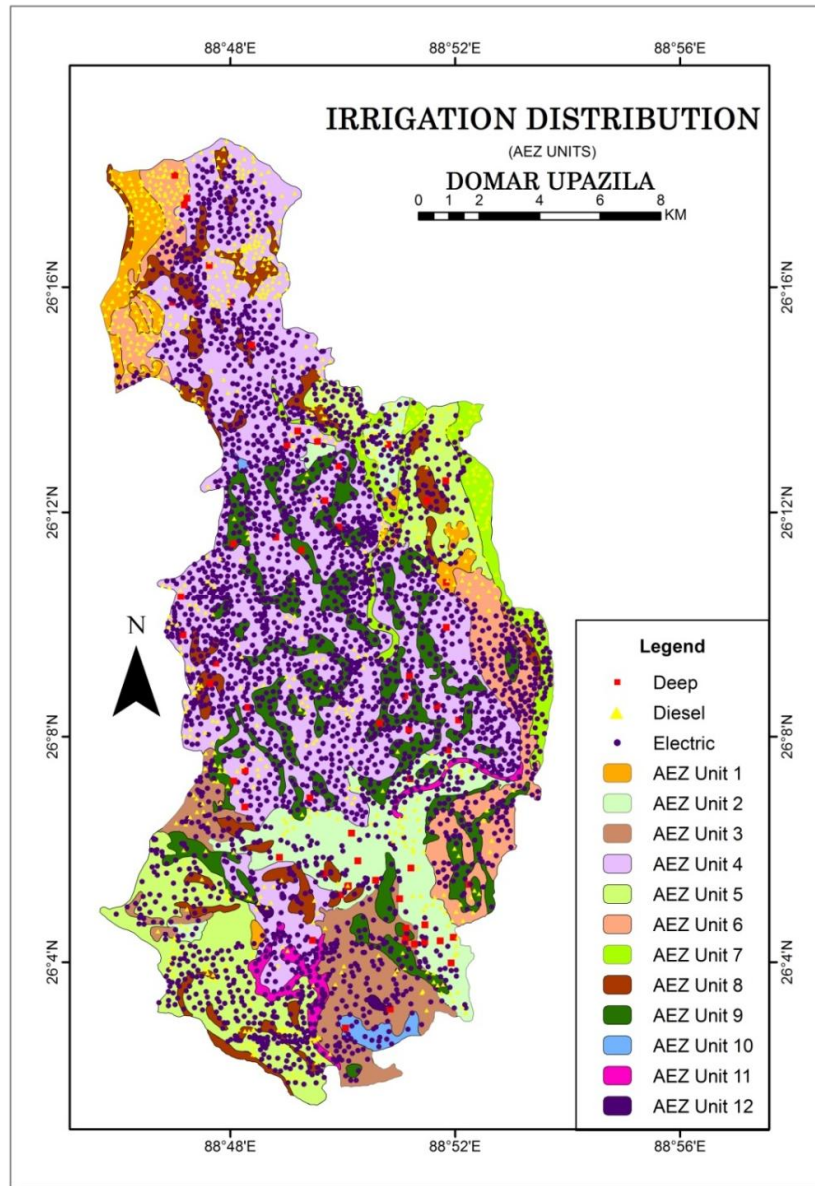


Fig. 3. Irrigation machines distribution of Domar Upazila

In Fig. 5 has shown the major crops of the study area. Those are Boro, Potato, Maize, Ground nut, Tobacco, Chili. A large number of electric pump are used in Boro production. Diesel pumps are used mainly for potato, maize, ground nut, chili, tobacco production. A large amount of area is covered by Boro in AEZ units 2, 3, 4, 6, 7, 8, 9 and 10. Here also found electric pump in a large number (Fig. 3). Deep tube well found in those areas of AEZ units where Boro cultivation is dominant (Fig. 5). Those AEZ units where Boro cultivation is dominant, they are comparatively low land than AEZ units 1,5 and 12. Those lands

cover a large area at the same height and soil humidity rate is high. These types of land are suitable for Boro cultivation. During Boro cultivation needs lots of water supply. Electric pump and deep tubewell can supply more water than diesel pump. On the other hand, cost is also a fact. Electricity is cheaper than diesel. That's why electric pump and deep tubewell is used for Boro cultivation. AEZ units 1, 5 and 12 found a large amount of area cultivated by Potato and for irrigation for potato land use diesel pump. These AEZ units are highland comparatively than other AEZ units and they cover a small area at a time.

They have low humidity. Potato, wheat, ground nut, maize, chili and tobacco these types of crops are suitable for those types of land. They need fewer water supplies (one or two times per month). As they cover small area and less irrigation, so diesel pump is suitable for those crops.

In Fig. 6 shown that most of the part of AEZ unit 1 is dominant by diesel pump (77%) where 21%

area is covered by electric pump and only 2% area is covered by deep tubewell of this unit. In the case of AEZ unit 2 there is 11% is covered by deep tubewell, 25% by diesel pump and 64% area is covered by electric pump. In AEZ unit 3, 89% area is irrigated by electric pump, 5% by deep tubewell and only 6% by diesel pump. A major portion (81%) of AEZ unit 4 is irrigated by electric pump and 16% by diesel pump and rest 3% by deep tubewell.

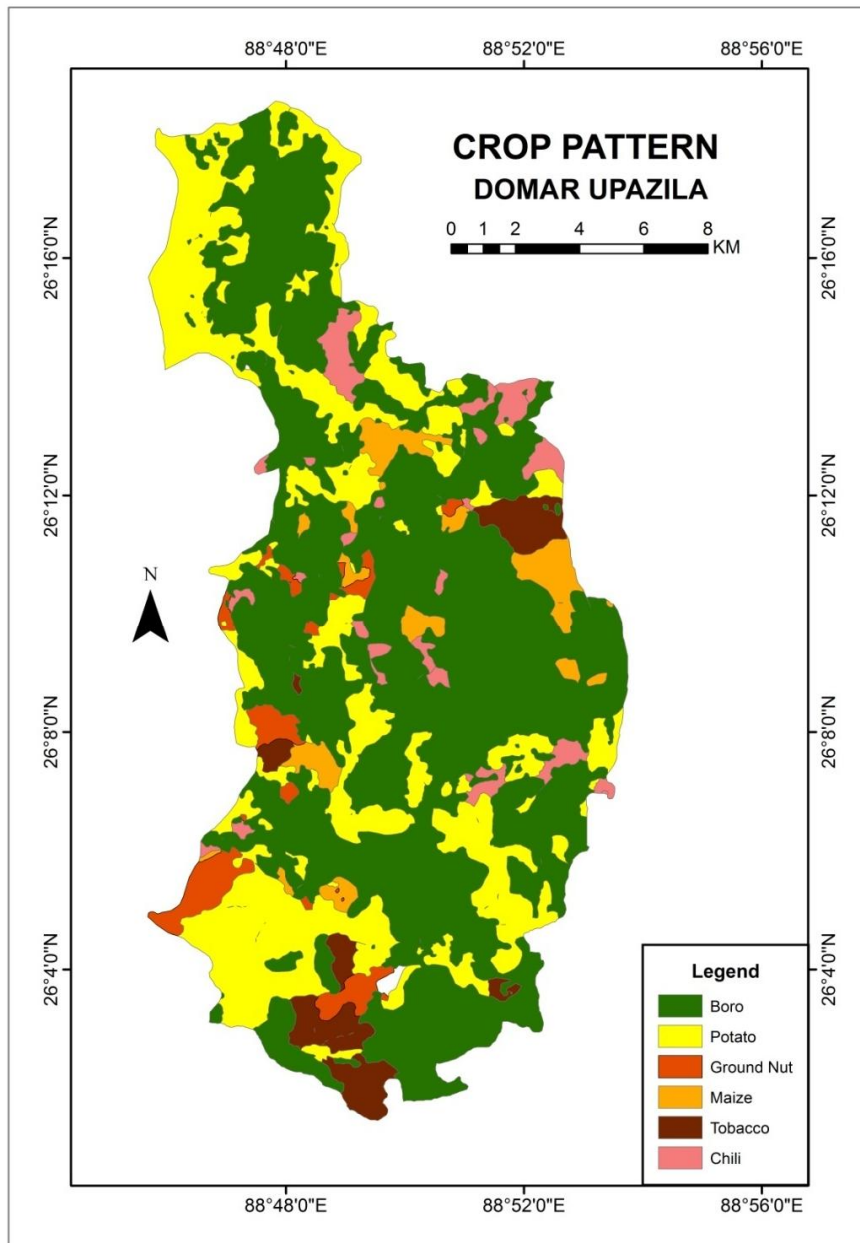


Fig. 4. Crop pattern of Domar Upazila

Half of the AEZ unit 5 is covered by deep tubewell and 44% by electric pump and 6% by diesel pump. In AEZ unit 6 only 1% area is irrigated by deep tubewell, 63% by electric pump and rest 36% irrigated by diesel pump. 65% area of AEZ Unit 7 is covered by Electric pump, 34% by diesel pump and 1% by deep tubewell. On the other hand, deep tubewell cover 2% and diesel pump 21% and electric pump cover 77% in AEZ

Unit 8. In AEZ unit 9, 2% area is irrigated by deep tubewell. 94% by electric pump and only 4% by diesel pump. No diesel pump is found in AEZ unit 10. This is area 5% is covered by deep tubewell and 95% is covered by electric pump. In AEZ unit 11, 95% area is covered by electric pump and 5% area is covered by diesel pump and in AEZ unit 12, 4% area is covered by deep tubewell, 68% by electric pump and rest

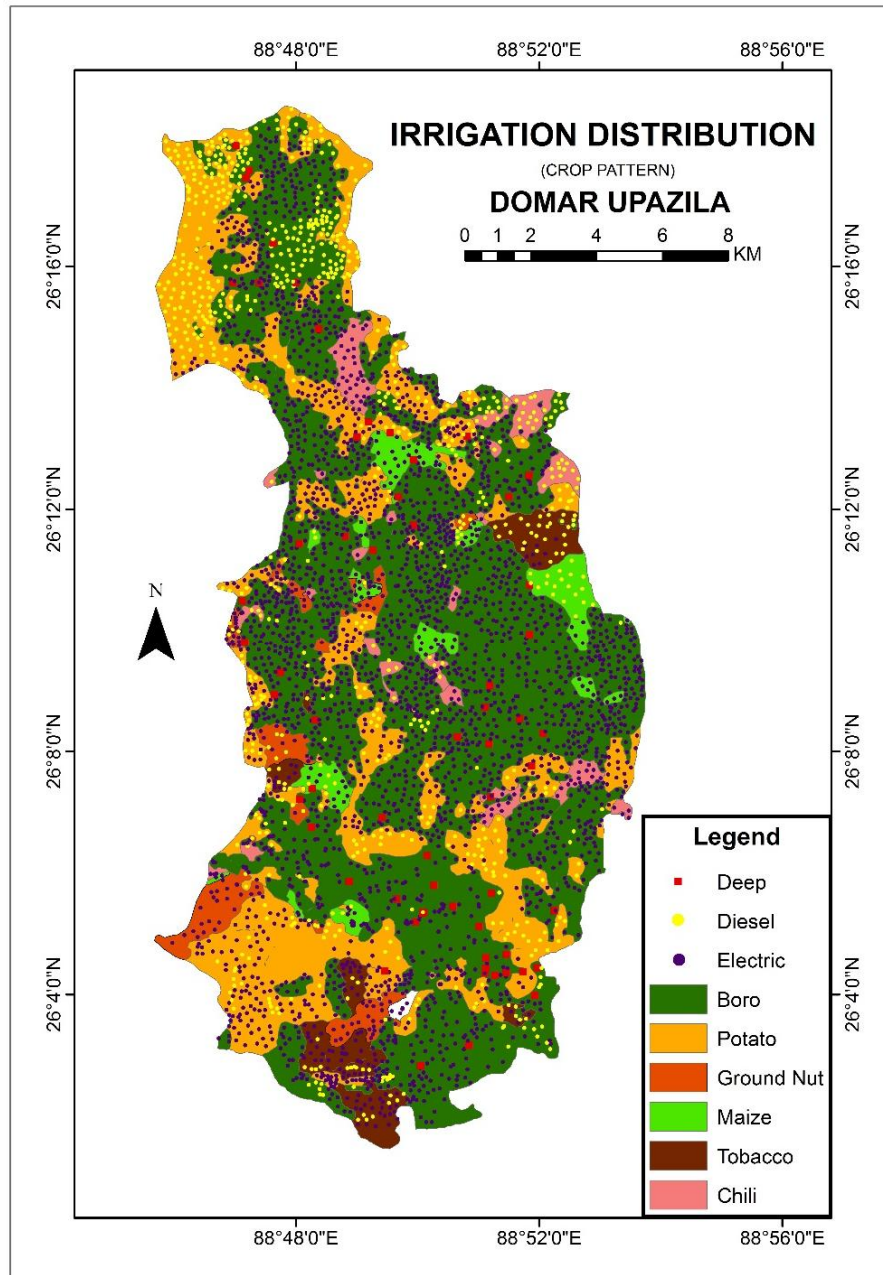


Fig. 5. Irrigation machines distribution according to crop pattern

28% by diesel pump. A large portion area of every AEZ units except AEZ unit 1 is covered by electric pump of this upazila. In all AEZ units there found very few amounts use of deep tubewell and large portion use of electric pump because in this upazila there are many divide of land due to roads, houses, villages. Deep tubewell needs a large area to irrigate but there are found very few large cultivation land at a time which suitable for deep tubewell. On the other hand, deep tubewell is a very costly and electric pump very cheaper than deep tubewell. Electric pump is easy to use than deep tubewell. For that reason, electric pumps are used in a large number on this upazila. Diesel pumps are used in those areas of an AEZ unit where electricity is not available and other crops such as potato, ground nut, tobacco, maize, and chili are cultivated.

In the Fig. 7 is shown the irrigation distribution of domar upazila according to crop pattern of different AEZ unit of this upazila. Here, in AEZ unit 1 of this upazila, 15.8% Boro cultivation area is irrigated by deep tubewell, 34.8% cultivation area is irrigated by diesel pump and rest 49.3% area is irrigated by electric pump. 95.9% by diesel pump and 4.1% by electric pump is

irrigated ground nut cultivation area. Like this maize cultivation area (51.58% by diesel pump and 48.42% by electric pump), potato cultivation area (89.93% by diesel pump and 10.34% by electric pump) and tobacco cultivation area (65.55% by diesel pump and 34.45% by electric pump) are irrigated. In this unit chili is cultivated by electric pump. In AEZ unit 2 boro cultivation area (13.84% by deep tubewell, 7.14% by diesel pump and 79.02% by electric pump), chili cultivation area (19.3% by diesel pump and 80.7% by electric pump), maize cultivation area (36.73% by diesel pump and 63.27% by electric pump), potato cultivation area (44.86% by diesel pump and 55.14% electric pump), tobacco cultivation area (20.54% by diesel pump and 79.46% by electric pump) are irrigated. In AEZ unit 3 boro cultivation area (16.6% by deep tubewell, 4.9% by diesel pump and 78.5% by electric pump), chili cultivation area (2.98% by diesel pump and 97.02% by electric pump), ground nut cultivation area (7.63% pump and 82.91% electric pump), tobacco cultivation area (39.01% by diesel pump and 60.99% by electric pump) are irrigated. Deep tubewell is covered 3.30%, diesel pump is covered 7.30%, and electric pump is covered 89.40% for boro cultivation. Diesel pump cover

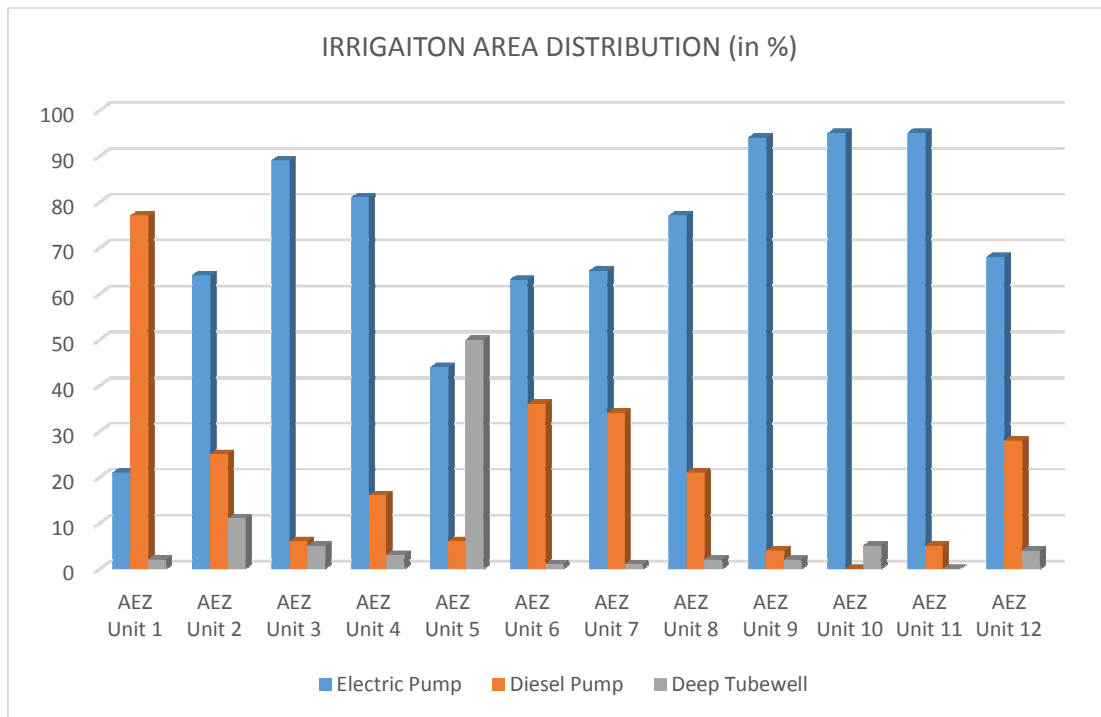


Fig. 6. Irrigation area covered by deep tubewell, electric pump and diesel machine of different AEZ units of Domar Upazila

Source: Field Survey, 2016

12.43% land by diesel pump and 92.37% by electric pump), potato cultivation area (17.09% by diesel and electric pump covered 87.57% land for chili cultivation. Like this for ground nut cultivation by diesel pump and 81.17% land by electric pump, for potato cultivation 27.97% land by diesel pump and 72.03% land by electric pump, for tobacco cultivation 12.24% land by diesel pump, 87.76% land by electric pump, for maize cultivation 18.83% land by diesel pump, 94.88% land by electric pump are irrigated in AEZ unit 4. Deep tubewell is covered 1.55%, diesel pump is covered 6.42%, and electric pump is covered 92.03% for boro cultivation. Diesel pump cover 53.84% and electric pump covered 46.16% land for chili cultivation. Like this for ground nut cultivation 7.2% land by diesel pump, 92.8% land by electric pump, for maize cultivation 70.70% land by diesel pump and 29.3% land by electric pump, for potato cultivation 6.26% land cultivated by diesel pump and 93.73% land by electric pump, for tobacco cultivation 28.70% land cultivated by diesel pump, 81.30% land cultivated by electric pump are irrigated in AEZ unit 5. Deep tubewell is covered 0.94%, diesel pump covered 1.33%, and electric pump covered 85.84% for boro cultivation. Diesel pump covered 0% land and electric pump covered 100% land for Chili cultivation. Like this for maize cultivation 54.48% land covered by diesel pump and 45.52% land covered by electric pump, for potato cultivation 63.47% land covered by diesel pump and 36.53% land covered by electric pump, for tobacco cultivation 0% land by diesel pump, 100% land by electric pump are irrigated in AEZ unit 6. Deep tubewells are covered 0.88%, diesel pumps are covered 15.97%, and electric pumps are covered 83.14% for boro cultivation. Diesel pump cover 66.97% land and electric pump covered 33.03% land for chili cultivation. Like this for maize cultivation 57.43% land by diesel pump and 42.75% land by electric pump, for potato cultivation 46.17% land by diesel pump and 53.83% land by electric pump, for tobacco cultivation 90.3% land by diesel pump, 9.97% land by electric pump are irrigated in AEZ unit 7. Deep tubewell is covered 3.8%, diesel pump is covered 13.1%, and electric pump is covered 83.1% for boro cultivation. Diesel pump cover 4.68% land and electric pump covered 95.32% land for chili cultivation. Like this for ground nut cultivation use only diesel pump here, for maize cultivation 4.6% land by diesel pump and 95.4% land by electric pump, for potato cultivation 43.79% land by diesel pump and 56.21% land by

electric pump, for tobacco cultivation 23.93% land by diesel pump, 76.07% land by electric pump are irrigated in AEZ unit 8. In unit 9, deep tubewell is covered 3.33%, diesel pump is covered 1.29%, and electric pump is covered 95.38% for boro cultivation. Diesel pump cover 13.74% land and electric pump covered 86.26% land for chili cultivation. Like this for ground nut cultivation 15.18% by diesel pump and 84.82% by electric pump, for maize cultivation 8.31% land by diesel pump and 91.69% land by electric pump, for potato cultivation 20.36% land by diesel pump and 79.64% land by electric pump, for tobacco cultivation 19.69% land by diesel pump, 80.31% land by electric pump are irrigated in this unit. In AEZ unit 10, only cultivated boro and 4.6% of areas are irrigated by deep tubewell and 95.4% areas are irrigated by electric pump. Whole boro and chili areas are irrigated by electric pump. 6.5% of ground nut areas are irrigated by diesel pump where rest 93.5% is irrigated by electric pump. 3.77% of potato land is irrigated by diesel pump and 96.23% of potato area is irrigated by electric pump. 21% area is irrigated by diesel pump and 88.79% area is irrigated by electric pump of tobacco area in AEZ unit 11. In AEZ unit 12, 5.2% of Boro area is irrigated by deep tubewell where rest 94.8% is irrigated by electric pump. 58.77% of ground nut land is irrigated by diesel pump and 41.23% of potato area is irrigated by electric pump. Like this 52.03% area is irrigated by diesel pump and 47.97% area is irrigated by electric pump of tobacco area. There found use of electric pump, land of cultivation area is large and comparatively low land and diesel pump use where cultivation lands area is small and comparatively high. Irrigation by deep tubewell is available in large cultivation area and lands are comparatively low. Boro cultivation is available where lands are comparatively low and potato, ground nut, maize, chili; tobacco cultivation is available where lands are comparatively high. For that reason, AEZ unit 1, AEZ unit 5 and AEZ unit 12 found a large number use of diesel pump and rest AEZ units found a large number of electric pump. Cultivation area irrigated by deep tubewell found in all AEZ units except AEZ unit 11. Because all these AEZ units has some large low land area at a time for cultivation. On the other hand GIS helps to identify the location of irrigation pumps and crop pattern. Those data are merged and compared with the AEZ data, that's why it is possible to identify the irrigation pattern and crop patterns according to AEZs.

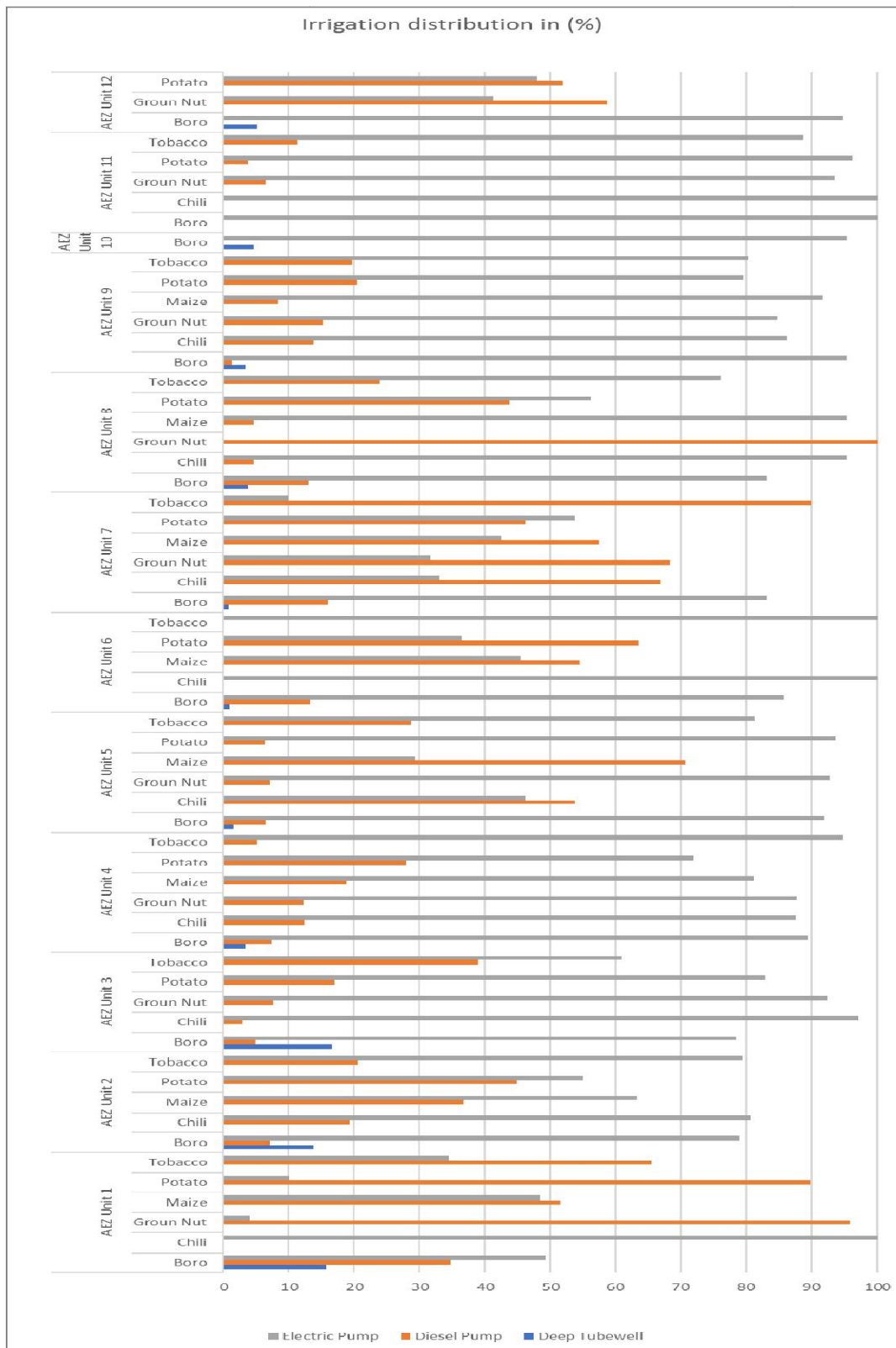


Fig. 7. Irrigation machines distribution (%) according to crop pattern and AEZ unit

5. CONCLUSION

All AEZ areas are irrigated by ground water with the help of deep tubewell, diesel pump and electric pump for all crops which are cultivated here. But the location of irrigation machines is not well distributed. It is important to maintain a sequence for pump location to irrigate the area equally. By proper distribution of the irrigation machine may need less time to irrigate the same land that is irrigated by haphazardly distributed. This study can be applied to identify the distribution of irrigation system of an area. This research will help to select suitable irrigation system of a definite crop according to AEZ units. In future, for further research related to this study a researcher will get help from this study to identified crop pattern distribution, irrigation machines distribution, relation with AEZ units, crop pattern and irrigation system and application of GIS.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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