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Assessment of Residential Water Demand and Groundwater Supply using ArcGis Tools in Mardan City, Khyber Pakhtunkhwa, Pakistan

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ABSTRACT

Mardan city is facing the problem of portable water supply. Majority of the households do not have access to public water supply. The main focus of this research is to assess present residential water demand and ground water supply in the study area. To achieve this objective, baseline data was collected from Municipal Committee Mardan (MCM) and Public Health Engineering Department (PHED) Mardan. The ancillary data was collected from census reports Bureau of Statistics, etc. The results showed that the present water supply in each sampled union council is less than that of water demand. The gap between ground water supply and demand is widening due to population growth and urbanization. There is urgent need to enhance ground water supply to meet increasing water demand in the study area.

Keywords: *Water supply, water demand, Arc GIS, Portable water*

INTRODUCTION

Water is vital to human existence. Access to potable water supply is a basic human right [1]. It is significant to recognize that every individual on earth must have access to water [2]. About 1.1 billion people who are 17% of the total world population do not have access to portable water resources [3]. Out of this 1.1 billion people, 22% people live in South Asia, 30% in Sub- Sahara Africa and 39% in East Asia and the Pacific [4]. With the passage of time, these numbers will further increase due to rapid population growth. However, this situation will be more critical in South Asia, Africa and Middle East [5].

Rapid population growth, urbanization and climate change related uncertainties are the major causes of water scarcity around the globe [6]. Since 2007, urban population has exceeded rural population due economic migration [7]. A vertical growth of societies was observed in the form of multi-storied buildings to accommodate increasing population on a limited area [8]. This also resulted in the physical characteristics of the household such as number of rooms, built of area and garden area. These changes in household physical characteristics have a direct effect on the household water consumption [9].

The commercial, industrial and residential water demands are assessed by water management authorities [10]. However, more emphasis is given to residential water demand

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because it not only consumed more than 50% of the total municipal water but also required better consistency and quality as compared to other sectors [12].

In Pakistan, the population growth and per capita water availability has a direct relationship [13]. In 1951, the per capita water availability was 5650 cubic meter and the population was 33.7 million. This availability of water was reduced to 2800 cubic meter as the population reached to 65 million in 1972 [14]. By the year 1992, Pakistan has entered to water stress country [15]. The per capita availability would decrease to 800 cubic meter by the year 2020 at the present rate of population growth [16]. Therefore, the proper understanding and management of water demand is outmost necessary to meet the needs of human for social and economic development in the future [17].

The demand of residential water is continuously increasing in the Mardan City because of rapid population growth and pace of urbanization. The rapid population growth exerts pressure on existing water supply infrastructure. As a result, water supply infrastructure is deteriorating making supply of water challenging and costly. Therefore, the main objective of this research paper is to assess residential water demand and ground water supply management in the study area.

METHODOLOGY

Study area description:

Mardan City is located from 34° 05' N to 34° 32' N latitude and 72° 3' E to 72°14' E longitude (Figure 1). It is about 60 km east of Peshawar, capital city of Khyber Pakhtunkhwa, Province of Pakistan. It is bounded on the Northeast by Buner, Northwest by Malakand, on the East by Swabi, on the West by Charsadda and on the South by Nowshera District respectively. District Mardan has extreme continental climate i.e., hot in summer and cool in winter. In summer, monsoon precipitation occurs from June to September in which August is the rainiest month, which has recorded 128.85 mm of rainfall [18]. In winters, precipitation occurs from December to March because of winter depression.

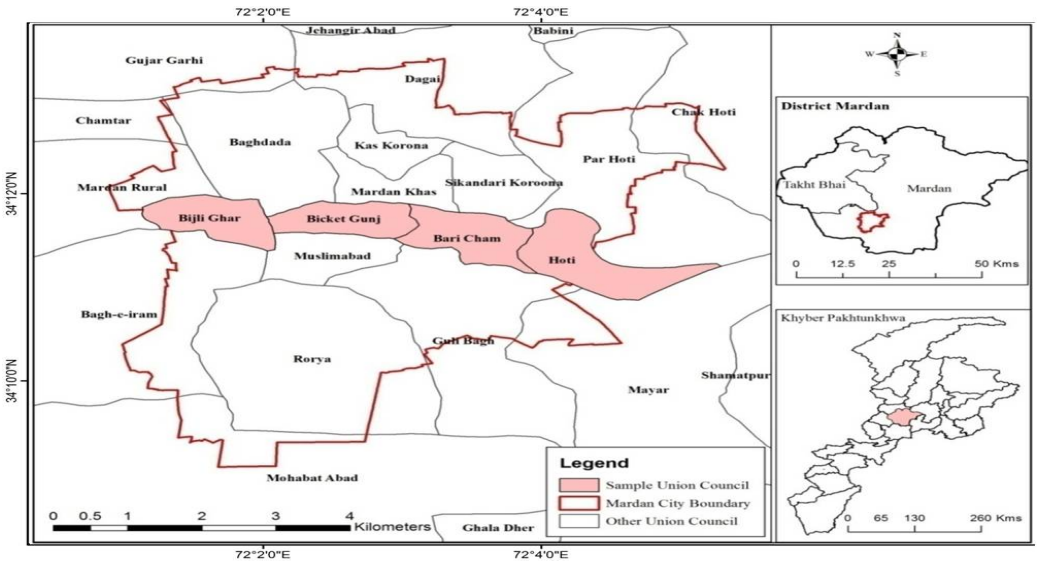

Figure 1: Location map of the study area, which is taken from Local Government and Rural Development Department, District Mardan

Existing source of water supply

Tube wells are the main ground water source of residential water supply in the study area. There are fourteen tube wells in the study area. Among these, two tube wells are in union council Bejlighar, four in union council Baricham, two tube wells in union council Bicket Gunj and six tube wells in union council Hoti respectively. These tube wells are operated once or twice a day to fill the overhead tanks. These tanks are connected with water supply pipelines. The widths of these pipelines vary in size from 2 to 8 inches as shown in figure 2.

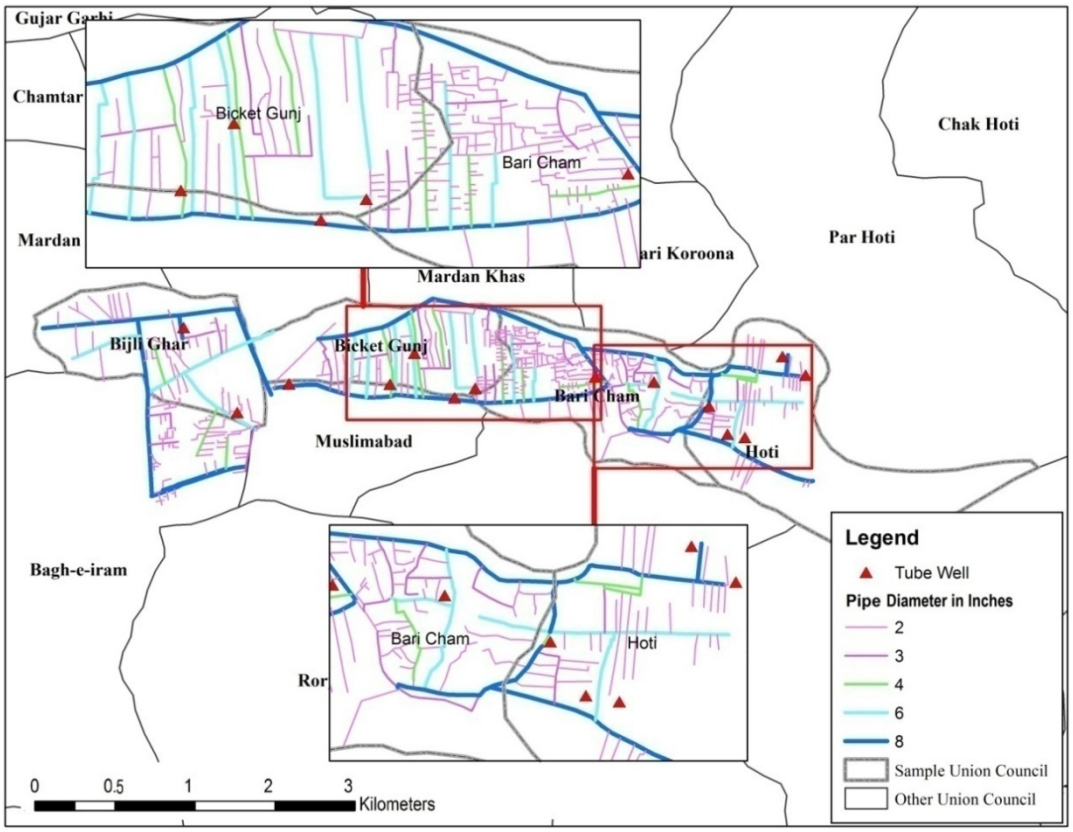

Figure 2: Density of Water Supply Pipelines and Tube Wells in the Study Area for which the source PHED Mardan (2015 has been used.

Population Growth and Distribution

Total population of district Mardan was 357 thousand in 1951. It reached to 481 thousand in 1961, 697, 881 and 1460 thousands in 1972, 1981 and 1998 respectively [19]. It is evident that the population of district Mardan has increased since 1951. For this study, union council polygon layer with attributes of population figures of 2009 were used to calculate population density layer. The analysis shows that except union council Hoti, all other sampled union councils have higher population density followed by adjacent union councils as evident from figure 3.

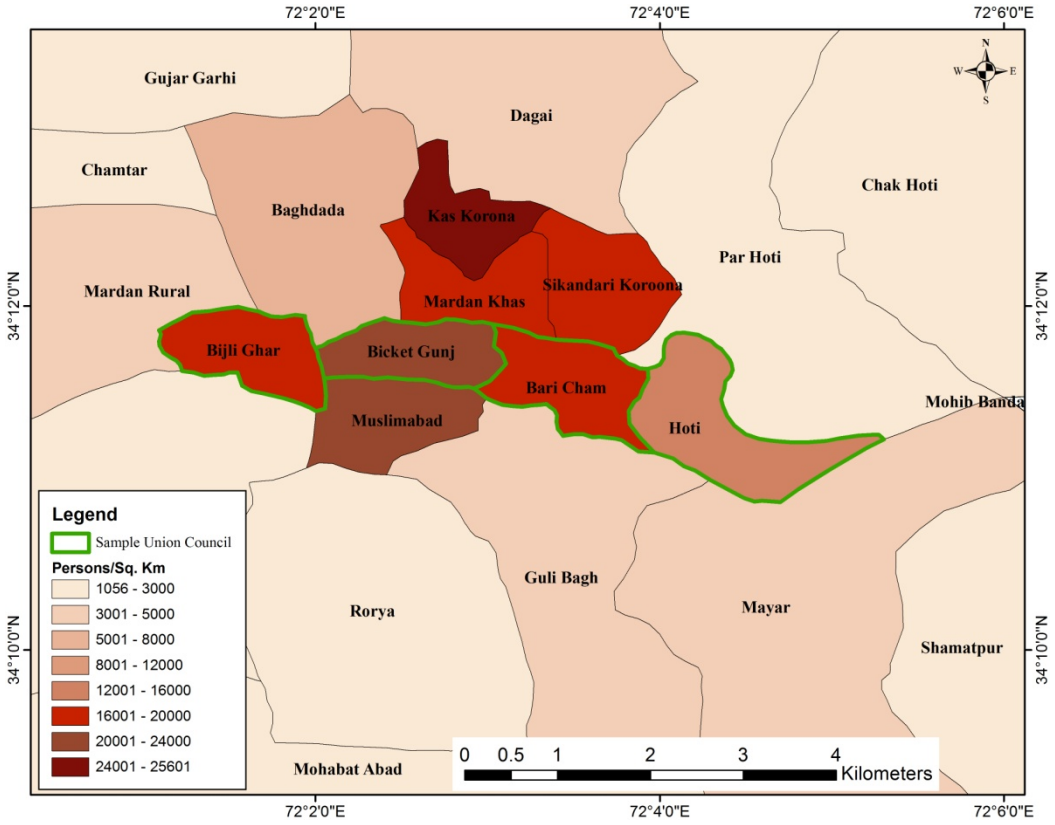

Figure 3: Population Density of the Study Area, taken from District Population Welfare Office Mardan (2009)

DISCUSSION AND ANALYSIS

The baseline data, such as maps of water supply pipelines and location of tube wells was collected from Public Health Engineering Department (PHED) Mardan and the data regarding water supply from each tube, type of machinery, number of connections, operational hours of each tube wells were collected from Municipal Committee Mardan (MCM). Map of the study area was obtained from Local Government and Rural Department (LG &RDD) Mardan. This map was later on modified in Arc GIS. The population statistics were taken from District Census Report of the study area. However, for this study, the population data of 2009 was obtained from population welfare department Mardan.

The maps of water supply pipelines, location of tube wells, overhead tanks were collected from PHED Mardan. First, these maps were scanned and were saved as jpeg files. Then these maps were geo-referenced and digitized in ArcGIS software. To find the total water demand for each sampled union council, the population figures were multiplied by 20 because MCM has taken 20 gallons as a standard of water supply for each individual in the study area. For this purpose, the population figures of 2009 were obtained from Social Welfare Department Mardan. The values of water supply per acre per day of each sampled union council were obtained from MCM. To assess water budget, the following formula was used:

Water Budget = Water Demand – Water Supply

These values were then plotted on the study area map to show spatial distribution of water budget by using Arc GIS software.

Assessment of Residential Water Budget

Assessment of residential water budget is determined by subtracting water supply values from water demand values. The water demand values were obtained from census figures multiplied by standard of water supply fixed by water supply agency in the study area.

Union Council-Wise Per Acre Water Supply

The actual water supply in union council Bicket Gung is 75,000 gallons per day. The total area of union council is 153 acres. The per acre water supply in union council Bicket Gung is 490 gallons per day. The total public water supply in union council Hoti is 200,000 gallons per day and the total area is 538 acres, so per acre water supply is 372 gallons per acre per day. While the total water supply in union council Bari Cham is 170,000 gallons per day and its total area is 116 acres, so the total water supply per acre is 1,465 gallons per day. Similarly, the total water supply in union council Bejlighar is 170,000 gallons per day and its total area is 119 acres, so its total supply is 119 gallons per acre as shown in **figure 4**.

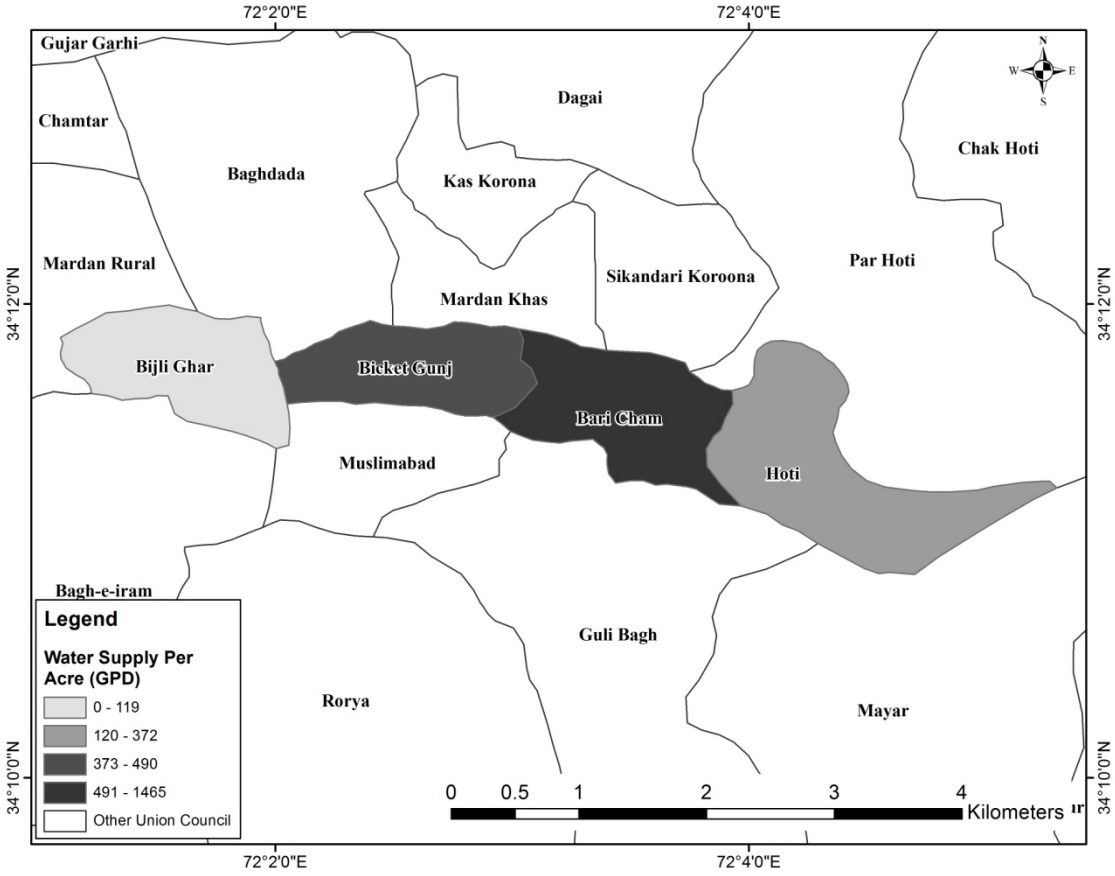

Figure 4: Union Council-Wise per Acre Water Supply, taken from MC Mardan (2015)

Union Council-Wise Per Acre Water Demand

The population density in union council Bicket Gung is 125.39 persons per acre. MCM has taken 20 gallons per day as a standard of water supply per capita in the study area. So, to find out water demand per acre in union council Bicket Gung, the population density per acre was multiplied by 20 and the result was 2,508 gallons per acre. Similarly, this water demand was 760 gallons, 3,680 gallons and 660 gallons per day in union council Hoti, Bari Cham and Bejlighar respectively as shown in **figure 5**.

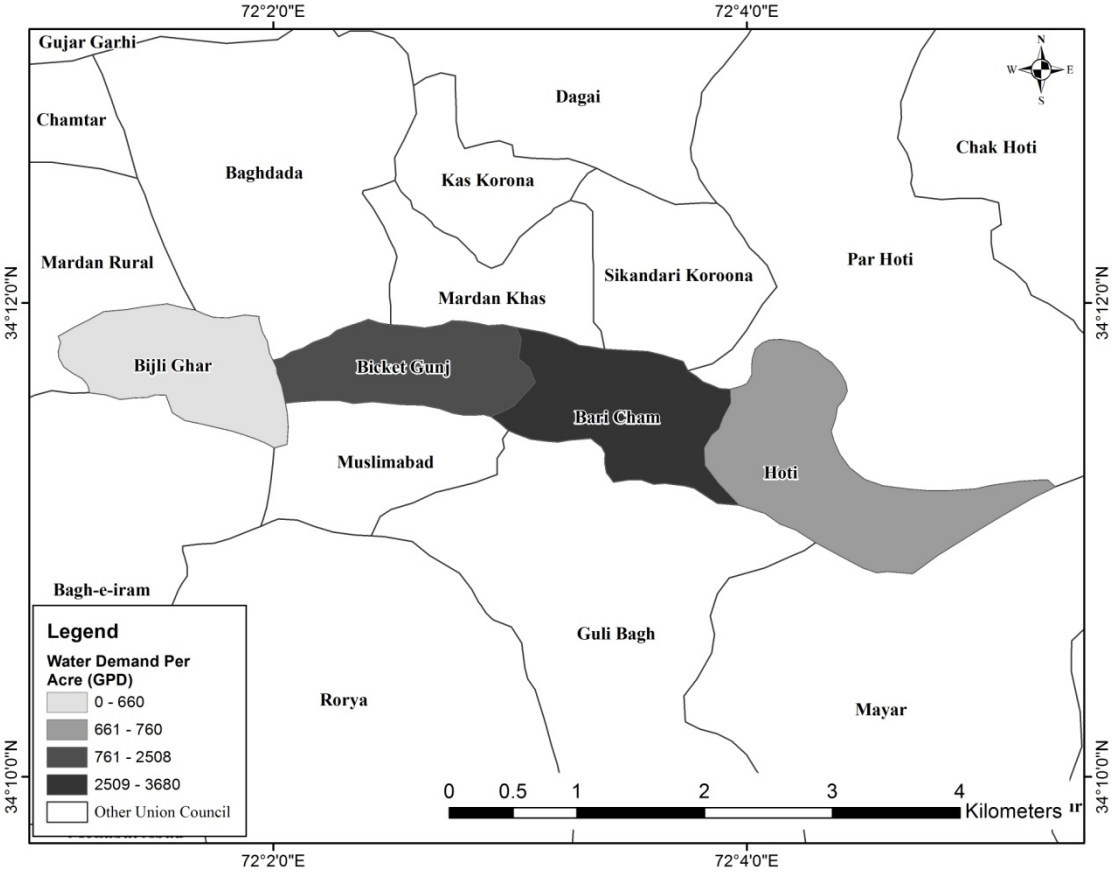

Figure 5: Union Council-Wise per Acre Water Demand, taken from MC Mardan (2015)

Water Budget Analysis Per Acre (Gallons per Day)

The present water demand per acre in union council Bejlighar is 660 gallons per day and actual water supply is 119 gallons per day. Similarly, this water demand is 2,508 gallons per day in union council Bicket Gung and its water supply 372 gallons per acre day while these figures are 3,680 gallons and 1,465 gallons per day per acre for union council Bari Cham and 760 and 372 gallons per acre per day for union council Hoti respectively. It is evident from above figures that water demands exceed more than 60% of the water supply in each sampled union council in the study area. This gap is widening with the passage of time because of rapid population growth and pace of urbanization. There is urgent need to improve the existing water supply to narrow down the gap between water supply and demand in the study area.

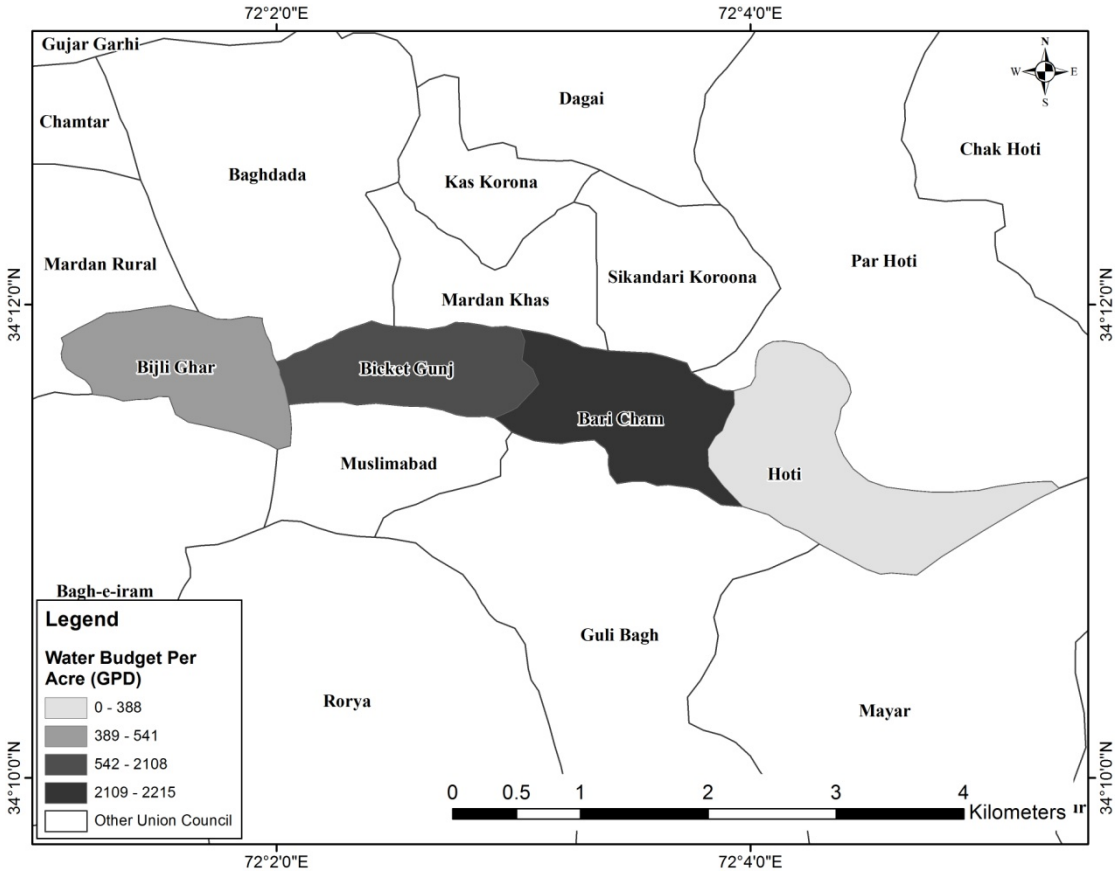

Figure 6: Water Budget Analyses per Acre (Gallons per Day) which is taken from MC Mardan (2015).

CONCLUSION AND RECOMMENDATIONS

In Mardan city, total water supply is dependent on ground water. Water is mainly supplied through tube wells. There are fourteen tube wells in four sampled union councils. Union council wise, water supply and demand budget analysis concludes that all the sampled union councils were short of water supply. Similarly, the present tube wells and water supply infrastructure is not capable of meeting the present water demand in the study area. There is an urgent need to allocate budget to upgrade present water supply infrastructure, to install new tube wells and employ skilled labor force for the maintenance of water supply pipelines and tube wells.

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