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Assessing the role of climate versus farm machineries in agriculture: A case study of Rajanna Sircilla district of Telangana, India

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Abstract The purpose of this research is to assess the degree of influence of two major components of agriculture i.e., Climate and Implementation of farm machineries in agricultural sector in Rajanna Sircilla district in the Indian states of Telangana which is examined over a period of 22 years between 1998 and 2020. It mainly aims at evaluating the significance of pre-planning and thorough assessment of the physical factors that might have higher impact and may result in failure achievements of launching new schemes for the improvement in farming sector. The failure in improving the agricultural sector in spite of the efforts after implementing farm machineries in the study area is the central problem of this research which is discussed in this paper. To justify the addressed issue, the agricultural landuse, utilization, implementation of farm machineries, changes in agricultural labour force, and changes in the regional climate are compared to find out the significance of each of these factors. Multi-seasonal satellite imageries of Landsat 5TM, 7ETM and 8OLI are used to monitor the real-time agricultural landuse in each cropping season in every quinquennial interval. It was found that most of the farmers in the district were benefitted with diesel or electric pump sets, wooden or steel ploughs, power tillers or tractors and manual or electric sprayers and dusters but still the net sown area and specially the spring cropped area was continuously declining till 2015-16 which was mainly due to the shortage of water for irrigation as most of the farmlands were dependent on elevated groundwater. So, without assessing and predicting the climatic factor the implementation of farm machineries did not result effectively. But after the construction of Mid-Manair dam on the Manair river in 2018, the agricultural landuse has significantly increased.

Keywords —Climate, Farm Machineries, Agricultural Landuse, Agricultural Labor force, Cropping Intensity, Irrigation Intensity

I. INTRODUCTION

Weather and climate are natural and autonomous phenomenon which cannot be controlled by humans. Except for certain fruits, most of the food crops including agricultural, horticultural and floricultural plants are seasonal and highly sensitive to minor changes in the local weather even for a shorter time period. Dry-spell, drought, wind storms and flood are some of the notable natural calamities caused by weather and climate change and may last from days to years which have severe adverse impact on farm sector. In olden days there were no efficient technics or technology adopted by the cultivators to avoid the loss in farm production during such situations. Now a days, technology plays an important role in all of the everyday activities as it reduces time, labour and expenses. Technology helps in achieving the goals with higher success rate, minimal economic loss and environmental degradation. Technology safeguards us from unpredicted disasters and keep us informed about the future possibilities. Adoption of technology helps the farm holders and cultivators in reducing the cost of labour expenses and saving time of work. For example, mechanization in terms of tractors or power tillers with Mouldboard ploughs, Chisel ploughs, Rotary ploughs, Sub-Soilers, Soil turning ploughs, Harrowing ploughs and Tilt angle Disc ploughs including Scrapers can replace a large number of plough-pulling farm filed bullocks, agricultural labourers, Indigenous ploughs and Ards which are traditionally used. It also reduces the time of ploughing with less efforts and in better manner compared to the manual and traditional methods. Sprayers and dusters can easily and uniformly shower or distribute pesticides, herbicides and insecticides with less time and labour. Similarly, Bush Cutters, Mowers, Balers, Harvesters, Cultivators, Broadcast Spreaders, Manure Spreaders, Slurry Spreaders, Seeders, Planters, Seed Drills and Backhoes are some of the popular and proven farm machineries which

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reduce the time, labour and expenses in farming from farm field preparation till milling the crops. Application of GM crops have reduced the risk of crop damage due to extreme climatic conditions such as dry-spell, drought, aridity and flood as well as increase in production with higher efficiency. Advanced irrigation technology such as sprinklers and drippers have reduced the water being wasted because of irrigation flood (over irrigated water) or open evaporation. However, adoption or implementation of all of the above-mentioned techniques or technologies depend on detailed information about the weather conditions. Without proper understanding of the past and present weather condition or long-term climate condition, it is difficult to predict the future calamities and it may affect the year ahead agricultural action plans. This is why it is necessary to thoroughly study the regional climate at least for a period of 25 years before planning for agriculture for an agro-hydrological period. Understanding the climate condition can enable the cultivators to decide which variety of cultivar should be used for the coming year keeping in view of the predicted annual weather. Also, it facilitates the cultivators to determine the cropping pattern and technique of cultivation so that the possible calamities and agronomic loss can be avoided. In other words, it can be said that the adoption of technology and application of the techniques of agriculture fully depends on the information gathered or predicted on the local or regional weather and the long period climate. This paper insights the climate profile of the study area over a period of 40 years starting from 1980 to 2020 on decadal interval.

II. Aim and Objectives

This paper mainly aims at examining the effectiveness of the efforts initiated by the government to improve the farming sector in Rajanna Sircilla district where the climate is semiarid. It also intends to underline the risk and result of excluding the climatic factor while focusing on implementing farm machineries for the sake of sectoral development.

III. Study Area

The present study area, Rajanna-Sircilla, is a district in the Indian states of Telangana which geographically extends between 78.520785°E to 79.026729°E longitude and 18.213764°N to 18.691502°N latitude on the table land of Deccan plateau. Spatially the district occupies an area of 1897.965km² in the north central region of the state. The district is surrounded by Jagtial district in the northeast, Karimnagar in the east, Siddipet in the south, Kamareddy in the southwest and Nizamabad district in the northwest (Figure No. 1). The district has only one revenue division which consists of 13 mandals (former 9) consisting of 172 revenue villages including of 2 Urban Local Bodies (ULBs). As per the 2011 census, there were 120182 households residing in the district making a sum total of 476487 individuals out of which 236430 male and 240057 female individuals were there. The district had an average density of 251 persons per square kilometer with 1015 females per 1000 males. By 2011, 78.83% of the total population in the district were rural inhabitants against 21.17% urban population. The average household size of the district was 4 persons per family. The district had a literacy rate of 62.71% while the rate of male literacy was 73.47% and rate of female literacy was 52.17%. since the census 2021 has not conducted yet, but the projected population of the district is estimated to have 544470 individuals with 272433 males and 272037 females by the year 2021 indicating the density of population in the district might have risen to 287 persons per square kilometers with 998 as the ratio of sex. The total work participation of the district was 62.1% as per 2011 census out of which 31.8% were male and 30.4% were female. Out of the total workforce, 54.1% were main workers while only 8.1% were marginal workers. Out of the total main workers, 52.9% workers were male against 47.1% female workers. On the other hand, only 38.9% of the total marginal workers were male against 61.1% female marginal workers. Nearly 56.4% of the main workers were engaged in agricultural activities including the cultivators and agricultural laborers while 43.6% of the main workers were engaged in non-agricultural activities including household industries and other economic activities. The district has an average elevation of 472m from the mean sea level ranging from 277m lowest to 667m highest at places. The terrain gradually elevates from east to west and northwest. The Maner river which is a tributary of the river Godavari flows from southwest to east along with its main tributary the Mula vagu which flows from the northwestern hills in the district. The river nearly divides the district in two halves. Most of the western and north western hilly regions are covered by forest canopy. Nearly one-sixth of the total geographical area in the district is covered by forest while approximately 40% of the land area are used for agricultural purpose. The average min-max temperature in the district ranges between 22.5 °C to 31.9 °C while the long period average temperature is measured to be 27.1 °C for the past 40 years. Often the minimum temperature may fall to 20 °C during the winter nights while the maximum temperature may increase up to 34.23 °C during the summer days. On an average the district receives 956mm of annual rainfall which is higher than the state average. The district has received highest 2236mm of annual rainfall against the lowest 562mm of rainfall at places between the past four decades in the district.

IV. Material and Methodology

The administrative boundaries of the study area are obtained from the Survey of India (SOI) and Telangana state Remote sensing Application Center. Multi-seasonal Landsat 5, 7 & 8 Multi Spectral Imageries (MSI) are obtained from USGS ‘earthexplorer’ for the extraction of Land cover and landuse maps. The agricultural land was mapped through supervised classification in ERDAS imagine and are cross-

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verified with the Open Series Map (OSM) toposheets on 1:50000 scale obtained for the year 2005 from the SOI as well as High-resolution Google earth imageries. Climate Data are collected from multiple sources such as NCAR, CHELSA, SWAT and CHIRPS etc. at multiple spatiotemporal resolution for varied period of time. The multi-scale temperature and precipitation data in multiple data format are exported to excel tables using PanoPly software and then imported to ArcGIS user interface where the tabular data are executed in point vectors and then converted to raster tiff format. These interpolated raster data are rescaled to uniform spatiotemporal resolution and thus the climate maps are prepared. The population data was obtained from the Census Digital Library for the years 1991 to 2011. Data pertaining to the implementation of farm machineries and source-wise irrigation are obtained from the District Statistical Handbooks (DSHB) from the Directorate of Economics and Statistics (DES), Hyderabad as well as Chief Planning Officer (CPO) – Rajanna Sircilla district. The list of toposheets, satellite imageries and climate data used for this study are given at the end of the paper.

V. MAPS AND OTHER DATA

Table 1 Classification of Rainfall in Rajanna Sircilla district

Rainfall Range	Classification
< 571.06	Large Deficient
571.06mm - 761.40mm	Deficient
761.41mm - 856.57mm	Below Normal
856.58mm - 1046.93mm	Normal
1046.94mm - 1142.10mm	Above Normal
1142.11mm - 1332.45mm	Excess
> 1332.46mm	Large Excess

Table 2 List of Toposheets used for spatial matching and LULC extraction

Toposheet No.	Year of Survey	Projection (Datum)	Purpose
E44G/10, 11, 12, 14, 15, 16, E44H/03	Surveyed between 1975-76, 1979-80, 2001-02 updated in 2005-06, 2007-08	Universal Transverse Mercator (WGS 1984)	Boundary matching and base map accuracy assessment

Table 3 Specification of MSI products used for Land cover-Landuse generation

DOA	Mission	Path/Row (Product) [Resolution]	Nos.
12/01/2000	Landsat-7 ETM	144/47 (C2L2SP) [30m]	1
29/02/2000			1
11/11/2000			1
03/03/2001			1
29/10/2001			1
17/01/2005	Landsat-5 TM		1
02/02/2005			1
06/03/2005			1
30/09/2005			1
27/10/2009			1
31/01/2010			1
07/03/2011			1
13/01/2015	Landsat-8 OLI		1
14/02/2015			1
18/03/2015			1
03/04/2015			1
28/10/2015			1
13/11/2015			1
11/01/2020			1
28/02/2020			1
15/03/2020			1
16/04/2020			1
25/10/2020			1
Total	**3 Missions**		**23**

Table 4 Specification of secondary source climate data used for the research

Dataset	Parameter	Resolution		Acquisition Period	Distributor
		Spatial	Temporal		
ds093.2	Min-Max Temperature	0.312°	6-hourly	1979/06/01–2011/01/01	NCAR-RDA
ds094.1		0.205°		2014/01/01–2020/06/01	
ds094.2	Mean Temperature	0.205°	Monthly	2014/01/01–2019/01/01	
ds627.1		0.703°		1979/06/01–2018/01/01	
Time Series	tmax, tmin, tmean, prec	30˜S		1979/06 – 2020/05	WSL-CHELSA
GWT-SWAT		0.33°	Daily	1979/01/01–2014/07/01	TAMU-CFSR
chirps-v2.0	Precipitation	0.05°	Monthly	1981/01 – 2020/05	CHC-UC-SANTA BARBARA

VI. RESULTS AND DISCUSSION

Climatic Scenario: On the decadal temperature maps (Figure No. 2 to 4) it can be seen that for the first three decades, the winter temperature (minimum temperature) remained apparently lower in the western, northern and southern plateaus and hilly regions than the other parts of the district while the temperature in the same region increased by 1°C/2 °C during the last decade when it increased from 22 °C to 23 °C. Between 1980 till 2010, the minimum temperature in all other parts of the district remained 23 °C which increased to 24 °C during the last decade. But in summer the scenario was observed to be quite opposite. It

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was of course, the temperature during the summer (maximum temperature) in the northern western and southern bordering hills and plateaus was apparently felt lower than the other parts of the district but it can be seen that gradually, in more places the summer time temperature has been declining. During the first decade, the temperature was 32 °C in a narrow patch stretching along the northern and western borders but by the next decade the temperature in the extreme western border decreased to 31 °C and the narrow patch with 32 °C widened for which the temperature in the complete western half and southern parts of the district decreased from 33 °C to 32 °C. The iso-thermal condition of the district in the next decade almost remained same as it was in 1980-90. But dramatically the summer time temperature in the last decade suddenly decreased by 2 °C throughout the district for which diagonally in the southwestern half of the district the temperature decreased to 31 °C while in the northeastern half of the district the temperature decreased to 32 °C. This indicates that, over the decades, the winter is gradually warming while summer is gradually becoming cooler throughout the district. The decadal mean temperature map revealed that the district is gradually cooling from west to east and the eastern half of the district is comparatively warmer than the western half and the mean temperature remains between 26 °C (in the west) to 28 °C (in the east). As discussed earlier, on an average the district receives 951.76mm of rainfall. Based on which following the rainfall classification system by IMD, the pattern of rainfall distribution in the district is classified as per the table (Table 1).

On the decadal rainfall map (Figure No. 4) which is prepared based on the above classification reveals that, during the first decade the western parts of Veernapalli, northwestern half of Rudrangi, northern half of Chendurthi, southernmost part of Gambhiraopet, East-central region of Yellareddypet and along the common boundary of Thangallapalli and Ellanthakunta mandals, received fair amount of rainfall which is excess and large excess compared to the LPA normal rainfall in the district. These places are mainly the plateau or hill ranges primarily covered by dense vegetation canopy. The foot-hill regions including the northern half of Vemulawada, Vemulawada Rural, Boinpalli mandals, western parts of Thangallapalli mandal and northeastern part of Chendurthy mandal receive above normal rainfall. In rest of the parts of the district the rainfall was almost within the normal range. But in the second decade, only the high hill regions or the table top of the plateaus in the north western parts of Rudrangi, northern border of Chendurthi, longitudinal hill forests along the border of Thangllapalli and Ellanthakunta and wester most hills of Veeranpalli mandal receive above normal or excess rainfall. In this decade the overall rainfall decreased throughout all the mandals. More than three-fourth area of Yellareddypet towards the west, nearly half of Gambhiraopet towards the central and northeast and the central region of Sircilla mandal receive below normal rainfall. In rest of the parts the district received normal rainfall. In the third decade, the overall rainfall further decreased in all the mandals and at no places excess or large excess rainfall was recorded. Those places which received excess and above normal rainfall in the previous decade, were recorded to receive just normal or above normal rainfall. The western parts of Veeranpalli, northwestern parts of Rudrangi, northern parts of Chendurthi and Vemulawada Rural, north and central parts of Boinpally, southern parts of Gambhiraopet, western half of Ellanthakunta and the eastern half of Thangallapalli mandals received normal rainfall while rest of the district received below normal rainfall. During the last decade, the overall rainfall in the district recorded to be slightly increased but except for the core forest and hill top regions, the entire district received normal rainfall. On a whole it can be said that, the district often suffers from water stress due to long period rainfall deficit but the fair amount of rainfall received by the hill-forests does not work effectively due to excessive surface runoff.

Implementation of Farm Machineries: Based on the distribution statistics obtained from the District Statistical Handbooks, by the year 1998, total 677 Tractors and Power Tillers were distributed in all the nine mandals of the district. By 2003, more 817 Tractors and Power Tillers were distributed and till 2012, no further tractors or power tillers were distributed. So, between 1998 and 2020, only 1494 Tractors and Power Tillers were distributed across the district. By the year 1998, total 11685 Sprayers, Dusters, and Power Sprayers were distributed to the farmers in the district which decreased to only 102 units by the year 2003. In this way, total 11787 units of these farm equipment were distributed in the district between 1998 and 2003 and further till 2020 no such machineries were distributed. Till 1998, there were total 33659 wooden ploughs distributed throughout the district and 13497 units by the year 2003. By the end of 2020, sum total 47156 wooden ploughs were distributed to the farmers. By 1998, there was no evidence of steel ploughs being supplied by the government. But by 2003, 7076 units of steel ploughs were distributed to the farmers in the district. By 2007 it was seen that 14706 farmers were benefitted with steel ploughs in the district. So, by the end of 2020, 21782 units of steel ploughs were distributed throughout the district. By 1998, hardly 163 diesel operated field pumps were distributed to the farmers. A total of 258 diesel operated pumps were given to farmers by the end of 2003 and no further such units were given to any farmer till the end of 2020. 25530 farmers were benefited with electric pumps till 1998 while 15550 more units were distributed by the end of 2003. Till 2020 no more pump sets were given to any farmer as per the records. Till 2003 farmers were using their limited mode of animal carts available at their locality but by 2007, 14096 units of animal carts were benefitted to the farmers. Till 2020 no further carts or motorized vehicles were distributed in the district.

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Including animal carts, tractors and power tillers, sum total 15590 farmers were benefitted. By 2007, total 3023 units of Seed Drills and Seed-cum-Fertilizer Drills were distributed to the farmers. By 2020, only 119 farmers were covered by the government who were benefitted with Sprinklers.

Scenario of Agricultural Work force: By the year 1991, the work participation rate of the district was 53.79% of which 34.83% of the total workers were directly engaged in cultivation and 29.27% of the total workers were engaged in agricultural labor work. By 2001 the percentage of cultivators decreased to 27.33% and agricultural laborers decreased to 21.32%. By 2011 the percentage of cultivators with respect to the total workers increased to 26.45%.

Pattern of Land Utilization: By the year 2001-02, nearly 16.73% of the total area was covered by forest canopy. Nearly 6.02% of the district's land surface had open pasturelands. Nearly 1.13% of the district area was covered by miscellaneous tree crops while 11.53% of lands were uncultivable barren lands. Nearly 8.87% of the district area was put non-agricultural usage which included the built-up areas and waterbodies. Only 1.77% of the surface area in the district was culturable waste. Most importantly, 30.38% of the total geographical area of the district was fallow land. Only 23.56% of area was recorded as net sown area. It was computed that nearly 37.1% of the net sown are was cropped more than once in the district. So, the cropping intensity of the district was 137.1% during this period. By the year 2005-06, no changes in the area or percentage of Forest cover, Barren & Uncultivable Lands, Land put to Non- Agri. Usage, Permanent Pasture & Grass Lands and Miscellaneous Tree Crops & Mangroves was recorded. But the culturable waste lands decreased to 1.49% while the total fallow lands in the district decreased to 13.07%. The average cropping intensity in the district decreased from 137.1% to 111.4%. By the year 2010-11 The total forest extent in the district decreased by 0.19% while 0.46% of the lands put to nonagricultural usage decreased. There was 0.55% of total decrease in the pasturelands while culturable wastelands increased by 0.82%. This year, the net sown area increased to 43.91% for which the cropping intensity increased from 111.4% to 128.9%. By the year 2014-15, the total fallow lands increased from 11.43% to 12.80% while the net sown area in the district decreased to 42.98%. This year the cropping intensity further increased to 132.8%. By the year 2020-21, the total forest cover in the district increased to 16.8% while the uncultivable barren lands decreased to 6.2% but the lands put to non-agricultural usage increased to 9.4%. The lands under miscellaneous tree crops also decreased to o.8% which was earlier 1.14% and the culturable wastelands further decreased to 1.8% from 2.21%. Fallow lands decreased by half of the previous extent and remained only 6.1%. The areal extent of net cropped area increased to 56.4% for which the intensity of cropping also increased to 163.4% during the year 2020-21 in the district.

Satellite Imagery Driven Agricultural Landuse: During 2000, the total area of the arable lands in the district was 1123.6 km² which was 59.2% of the geographical area of the district out of which 244.9 km² of lands were culturable wastelands and 878.7 km² of lands were actual agricultural lands which accounted to 46.3% of the total area. During the year 2000 spring cropped area was more than the autumn cropped area in the district which were measured 58116ha and 59393ha and the difference was 1277ha. The area under cropped more than once in the year was measured 33130ha. It means 57% of the autumn cropped area which was 55.8% of the spring cropped area was cropped more than once a year. The total cropped area was 84379ha of lands out of which 68.9% of croplands were autumn cropped and 70.4% was spring cropped. In the year 2005, the total cropped area suddenly increased to 105718ha of lands out of which 94.3% of the area was autumn cropped but only 16.5% of the land was spring cropped. This year the area under crops sown more than once a year decreased to only 11.5%. In the year 2010 the total cropped area again decreased to 88788ha and also the total area under spring crops decreased compared to the total autumn cropped area which was 6177ha of lands. Nearly 66.3% of the total cropped area was cropped in autumn season and 59.3% of the total cropped area was cropped in spring season. However, the area cropped more than once in this year was shared from 38.7% of the autumn cropped lands and the same was 43.2% of the total spring cropped lands. By the year 2015, Further the total cropped area decreased to 66727ha. Nearly 43.9% of the total cropped area was cropped during the autumn season while it was 74.0% for spring crops. The area cropped more than once in the year was 24.2% of the total spring cropped area. By the year 2020, the total cropped area suddenly increased to 115490ha out of which 76.6% of the area was autumn cropped while 60% was spring cropped. The area cropped more than once in that year increased to 42227ha. The data discussed above are depicted in the tables (Table 5 to 20) and maps (Figure 1 to 10) at the end of this paper which are collected from the mentioned sources of the section IV of this paper.

VII. SUMMARY

Climate plays a pivotal role in agriculture as agriculture is highly sensitive to minor changes in the weather condition compared to the natural vegetation. Extreme temperature causes more soil evaporation and restricts the plant growth. Soil heat may damage the plant roots and may result in complete crop destruction. Added to which scanty rainfall may result in moisture deficiency and hence the plants may die. Scarce rainfall results in dry spell in short run and drought in long run which is absolutely unsuitable for agriculture. But fluctuation in temperature and rainfall are natural weather phenomenon which can't be controlled by humans. Hence, in course of time to mitigate the issue, several alternatives have been adopted by the producers. Adoption of new technologies and application of advanced

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techniques in agriculture also dependent on climate variations. Such as, early awareness about the upcoming weather condition by observing the past scenarios through Remote Sensing technology and simulating the obtained data using GIS technique to predict the future scenario with precise accuracy can help the cultivators for early preparedness to fight with the expected disaster. Modern techniques of water harvesting and advanced irrigation technology can help in mitigating the water crisis as well as fight with dry spell or drought. Also, using genetically modified climate resilient cultivars can save the farmers from unexpected crop destruction due to natural calamities or extreme weather phenomenon. However, adoption or implementation of all of the above-mentioned techniques or technologies depend on detailed information about the weather conditions. Without proper understanding of the past and present weather condition or long-term climate condition, it is difficult to predict the future calamities and it may affect the year ahead agricultural action plans. This is why it is necessary to thoroughly study the regional climate at least for a period of 25 years before planning for agriculture for an agro-hydrological period. Understanding the climate condition can enable the cultivators to decide which variety of cultivar should be used for the coming year keeping in view of the predicted annual weather. Also, it facilitates the cultivators to determine the cropping pattern and technique of cultivation so that the possible calamities and agronomic loss can be avoided. In other words, it can be said that the adoption of technology and application of the techniques of agriculture fully depends on the information gathered or predicted on the local or regional weather and the long period climate.

VIII. Conclusion and Recommendations

Till 2000, the farmers of the district were following traditional methods of farming but in course of time, gradually the farm machineries were introduced to the farmers which started from diesel pump sets to electric pump sets, wooden plough to steel ploughs, tractors or power tillers, nonelectric to electric sprayers as well as dusters. Even though the pump sets were facilitated to the farm workers there was no significant improvement in the agricultural water supply system was observed in the district. Maximum dependency on ground water resulted in depletion of the water table which was lacking of recharge due to decreased rainfall. Hence, out of five quinquennial years of observations, in three years the area under spring crops was less than the area under autumn crops. Also, the area under the crops sown more than once a year was declining till 2015 but increased after the Mid Manair Dam was constructed and irrigation was possible. Only during 2015 the spring cropped area in all the mandals was more than the autumn cropped area in the district. It is due to the increase in annual rainfall between 2010 and 2020 which led the farmers to draw water from the ground and irrigate to the farm fields. Also, it was noticed that after 2003, the distribution of the basic farm machineries stopped and in 2007 only some cultivators, Seed Drills and Fertilizer Drills were introduced to the farmers. When the farm machineries were introduced, distributed or facilitated to the farmers, the net sown area was decreasing along with the number of farmers was also declining in the district. After the construction of the Mid Manair dam also not much improvement in the farm practices was observed. Because by 2020 also the total area under Spring crops was 19204ha less than the total area of autumn cropped area. Since the newly constructed dam is benefitting the surrounding agricultural lands, it should ceaselessly irrigate all the agricultural fields in the district which are even farther from the dam location. Advanced irrigation technology must be introduced to the farmers such as surface and subsurface drip irrigation, Dry pipe sprinkler systems, Deluge, Upright Sprinkler, Impact sprinklers, Wet pipe systems, Fixed Spray and Rotary systems can reduce the risk of excessive evapotranspiration, as well as uniform supply of water to the plants as the region has semiarid climate. To prevent the soil erosion due to the structural and denudational land form in the district, advanced soil conservation techniques and technology must be introduced and trained to the farmers. Since the surface runoff is more in the western and northern parts of the district due to the elevated terrain, it is recommended to practice soil conservation as well as rain water harvesting in bell-shaped sumps or ponds to avoid open evaporation as well as sustainable use of water in the farm fields. As per the information provided by the Commissionerate of Agriculture, the precision farming is not yet introduced to the farmers in the district which is an essential step that should have already taken till date. Hence it is recommended that the application of remote sensing technology for precision farming can improve the agricultural sector of the district.

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Table 5 Implement of Farm Machineries in Rajanna Sircilla district till 1998

Mandal	Tractors & Power Tillers	(Power) Sprayers, Dusters	Ploughs (Wooden)	Steel Plough	Diesel Pump sets	Electric Pump sets
Boinpally	50	2239	2651	0	40	2389
Chandurthy	61	1049	5356	0	0	2768
Ellanthakunta	96	1633	4713	0	2	3154
Gambhiraopet	63	234	2891	0	2	2066
Konaraopet	55	1872	4004	0	0	3236
Mustabad	81	444	3370	0	1	2909
Sircilla	97	1169	4397	0	0	3688
Vemulawada	79	2080	3188	0	90	2394
Yellareddipet	95	965	3089	0	28	2926
Total	**677**	**11685**	**33659**	**0**	**163**	**25530**

Source: District Statistical Handbook, 2001-02 Karimnagar, DES – Hyderabad

Table 6 Implement of Farm Machineries in Rajanna Sircilla district till 2003

Mandal	Tractors & Power Tillers	(Power) Sprayers, Dusters	Ploughs (Wooden)	Steel Plough	Pump sets		Sugarcane Crusher Worked by	
					Diesel	Electric	Power	Bullocks
Boinpally	54	0	1910	804	0	2499	0	5
Chandurthy	37	12	1469	1133	0	3449	3	5
Ellanthakunta	28	0	1370	1250	0	1615	0	0
Gambhiraopet	69	0	874	380	15	480	0	0
Konaraopet	12	6	2215	973	4	2264	0	12
Mustabad	72	0	845	346	18	1800	0	0
Sircilla	93	0	932	460	0	1021	0	0
Vemulawada	57	4	2028	1535	49	1034	0	22
Yellareddipet	395	80	1854	195	9	1388	0	23
Total	**817**	**102**	**13497**	**7076**	**95**	**15550**	**3**	**67**

Source: District Statistical Handbook, 2005-06 Karimnagar, DES – Hyderabad

Table 7 Implement of Farm Machineries in Rajanna Sircilla district till 2007

Mandal	Tractors & Power Tillers	(Power) Sprayers, Dusters	Ploughs		Pump sets		Animal Cart	Sugarcane Crushers	Cultivators	Seed (cum-Fertilizer) Drills
			Wooden	Steel	Diesel	Electric				
Boinpalle	54	0	1910	1591	0	2499	1665	5	371	760
Chandurthy	37	12	1469	1049	0	3449	1509	8	1175	754
Ellanthakunta	28	0	1370	2834	0	1615	634	0	2273	1

 DOI : 10.35291/2454-9150.2024.0074

Gambhiraopet	69	0	874	1036	15	480	1264	0	1002	30
Konaraopeta	12	6	2215	799	4	2264	1576	12	1890	110
Mustabad	72	0	845	815	18	1800	898	0	1256	8
Sircilla	93	0	932	2560	0	1021	2300	0	2232	449
Vemulawada	57	4	2028	1399	49	1034	1643	22	1252	53
Yellareddipet	395	80	1854	2623	9	1388	2607	23	2590	855
Total	**817**	**102**	**13497**	**14706**	**95**	**15550**	**14096**	**70**	**14041**	**3020**

Source: District Statistical Handbook 2010-11 Karimnagar, DES – Hyderabad

Table 8 Implement of Farm Machineries in Rajanna Sircilla district till 2012

Mandal	Tractors & Power Tillers	(Power) Sprayers, Dusters	Ploughs		Pump sets		Animal Cart	Sugarcane Crushers	Cultivators	Seed (cum-Fertilizer) Drills
			Wooden	Steel	Diesel	Electric				
Boinpalle	54	0	1910	1591	0	2499	1665	5	371	760
Chandurthy	37	12	1469	1049	0	3449	1509	8	1175	754
Ellanthakunta	28	0	1370	2834	0	1615	634	0	2273	1
Gambhiraopet	69	0	874	1036	15	480	1264	0	1002	30
Konaraopeta	12	6	2215	799	4	2264	1576	12	1890	110
Mustabad	72	0	845	815	18	1800	898	0	1256	8
Sircilla	93	0	932	2560	0	1021	2300	0	2232	449
Vemulawada	57	4	2028	1399	49	1034	1643	22	1252	53
Yellareddipet	395	80	1854	2623	9	1388	2607	23	2590	855
Total	**817**	**102**	**13497**	**14706**	**95**	**15550**	**14096**	**70**	**14041**	**3020**

Source: District Statistical Handbook 2014-15 Karimnagar, DES – Hyderabad

Table 9 Total and Agricultural Workers in Rajanna Sircilla district

Sl. No.	Mandal Name	TP	TW	TMW	TC	TAgL	TNAgW	TMrgW
1	**Boinpalli**	34780	19369	19119	6649	7181	5289	250
2	**Chendurthi**	29386	16458	15878	6421	5300	4157	580
3	**Gambhiraopet**	41934	22618	22082	8801	5720	7561	536
4	**Illanthakunta**	43549	24698	24180	9231	9842	5107	518
5	**Konaraopet**	37895	21685	21521	8025	7848	5648	164
6	**Mustabad**	41492	22219	21556	10756	6449	5555	663
7	**Rudrangi**	12704	7471	7042	3019	2014	2009	429
8	**Sircilla**	59758	27336	26463	2399	2103	21961	873
9	**Thangallapalli**	39057	22079	21028	8722	6164	6142	1051
10	**Veernapalli**	11335	6163	5985	2391	3009	585	178
11	**Vemulawada**	34334	16211	16031	3949	4597	7485	180
12	**Vemulawada (R)**	28039	15956	15647	6352	4942	4353	309
13	**Yellareddypet**	39288	21698	21167	8259	6233	6675	531
14	**Total**	**453551**	**243961**	**237699**	**84974**	**71402**	**82527**	**6262**

Source: DCHB – 1991

Table 10 Total and Agricultural Workers in Rajanna Sircilla district

Sl. No.	Mandal Name	TP	TW	TMW	TC	TAgL	TNAgW	TMrgW
1	**Boinpalli**	37564	20932	19662	6816	6896	5950	1270
2	**Chendurthi**	31568	17877	16870	6066	4612	6192	1007
3	**Gambhiraopet**	44186	23949	21625	7729	4451	9445	2324
4	**Illanthakunta**	46297	25900	21425	9344	6093	5988	4475
5	**Konaraopet**	41381	23571	20924	8148	6173	6603	2647
6	**Mustabad**	44349	24100	21245	6890	5863	8492	2855
7	**Rudrangi**	13492	7893	6968	2571	2263	2134	925
8	**Sircilla**	78497	38114	35474	1634	2027	31813	2640
9	**Thangallapalli**	43871	24526	22453	7935	5345	9173	2073
10	**Veernapalli**	12121	7121	5441	2981	1696	764	1680
11	**Vemulawada**	44273	20800	18615	2890	4003	11722	2185
12	**Vemulawada (R)**	29148	16473	14621	4735	4652	5234	1852

 DOI : 10.35291/2454-9150.2024.0074

13	**Yellareddypet**	44310	24001	21476	7202	4617	9657	2525
14	**Total**	**511057**	**275257**	**246799**	**74941**	**58691**	**113167**	**28458**

Source: DCHB – 2001

Table 11 Total and Agricultural Workers in Rajanna Sircilla district

Sl. No.	Mandal Name	TP	TW	TMW	TC	TAgL	TNAgW	TMrgW
1	Boinpalli	39240	22721	20041	7073	8227	4741	2680
2	Chendurthi	33587	19051	14672	4903	5392	4377	4379
3	Gambhiraopet	46878	24884	21514	4604	8373	8537	3370
4	Illanthakunta	48379	26909	23186	8271	10356	4559	3723
5	Konaraopet	40857	22845	18466	5826	7044	5596	4379
6	Mustabad	44217	24079	18894	4910	5910	8074	5185
7	Rudrangi	16095	8993	7697	1998	3177	2522	1296
8	Sircilla	99637	51446	45487	1863	3288	40336	5959
9	Thangallapalli	50675	27469	24285	6491	8234	9560	3184
10	Veernapalli	13363	7500	6189	3152	2293	744	1311
11	Vemulawada	50158	24599	21167	2984	5388	12795	3432
12	Vemulawada (R)	30317	17066	13903	5071	4841	3991	3163
13	Yellareddypet	46270	25573	22340	6824	7656	7860	3233
14	Total	**559673**	**303135**	**257841**	**63970**	**80179**	**113692**	**45294**

Source: DCHB – 2011

Table 12 WPR and percentage of Agricultural Workers in Rajanna Sircilla district (1991)

Mandal Name	TW wrt TP	TMW wrt TW	TC wrt TW	TC wrt MW	TAgL wrt TW	TAgL wrt MW
Boinpalli	55.69	98.71	34.33	34.78	37.07	37.56
Chendurthi	56.01	96.48	39.01	40.44	32.20	33.38
Gambhiraopet	53.94	97.63	38.91	39.86	25.29	25.90
Illanthakunta	56.71	97.90	37.38	38.18	39.85	40.70
Konaraopet	57.22	99.24	37.01	37.29	36.19	36.47
Mustabad	53.55	97.02	48.41	49.90	29.02	29.92
Rudrangi	58.81	94.26	40.41	42.87	26.96	28.60
Sircilla	45.74	96.81	8.78	9.07	7.69	7.95
Thangallapalli	56.53	95.24	39.50	41.48	27.92	29.31
Veernapalli	54.37	97.11	38.80	39.95	48.82	50.28
Vemulawada	47.22	98.89	24.36	24.63	28.36	28.68
Vemulawada Rural	56.91	98.06	39.81	40.60	30.97	31.58
Yellareddypet	55.23	97.55	38.06	39.02	28.73	29.45
Total	**53.79**	**97.43**	**34.83**	**35.75**	**29.27**	**30.04**

Table 13 WPR and percentage of Agricultural Workers in Rajanna Sircilla district (2001)

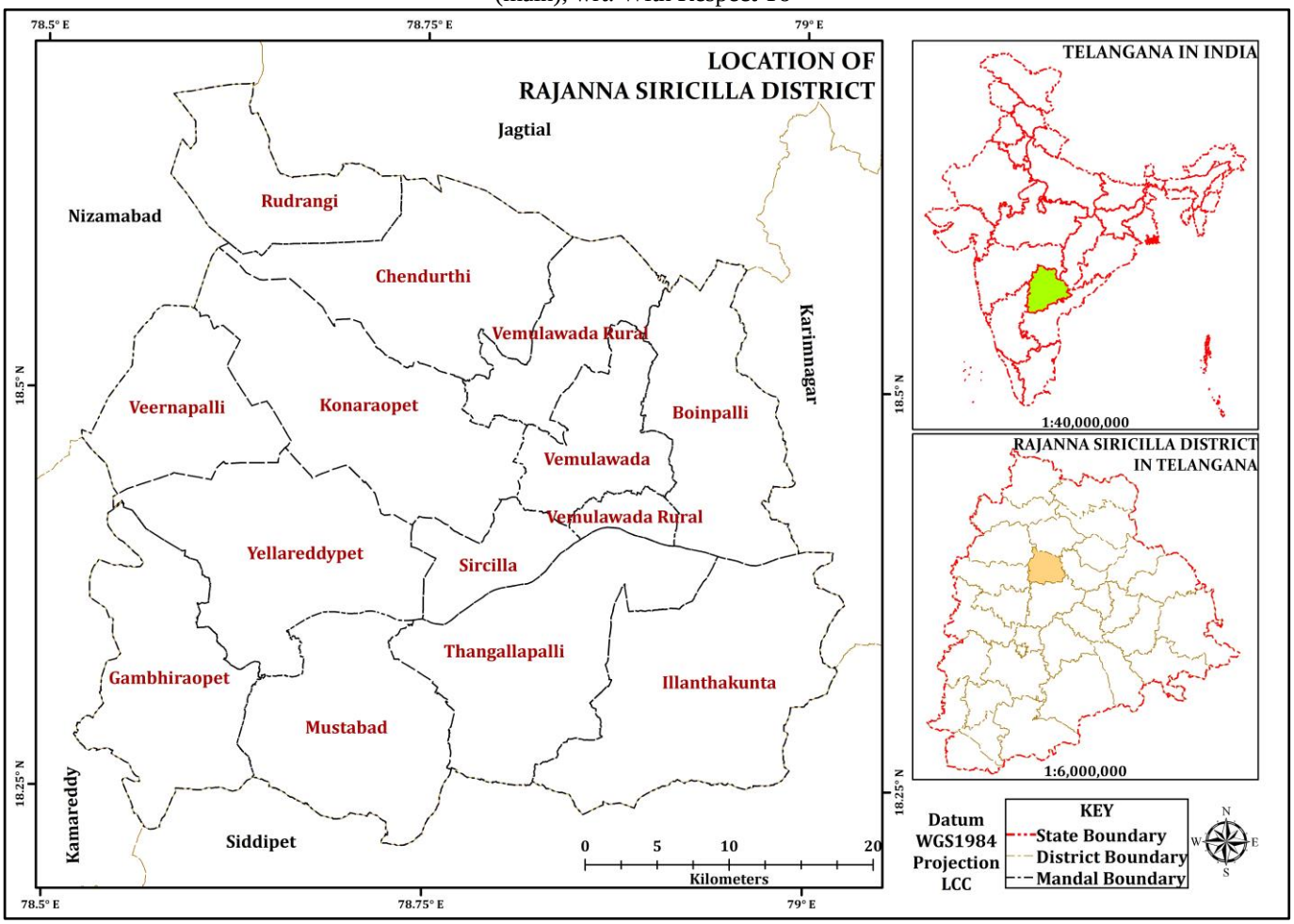
Mandal Name	TW wrt TP	TMW wrt TW	TC wrt TW	TC wrt MW	TAgL wrt TW	TAgL wrt MW
Boinpalli	55.72	93.93	32.56	34.67	32.94	35.07
Chendurthi	56.63	94.37	33.93	35.96	25.80	27.34
Gambhiraopet	54.20	90.30	32.27	35.74	18.59	20.58
Illanthakunta	55.94	82.72	36.08	43.61	23.53	28.44
Konaraopet	56.96	88.77	34.57	38.94	26.19	29.50
Mustabad	54.34	88.15	28.59	32.43	24.33	27.60
Rudrangi	58.50	88.28	32.57	36.90	28.67	32.48
Sircilla	48.55	93.07	4.29	4.61	5.32	5.71
Thangallapalli	55.90	91.55	32.35	35.34	21.79	23.81
Veernapalli	58.75	76.41	41.86	54.79	23.82	31.17
Vemulawada	46.98	89.50	13.89	15.53	19.25	21.50
Vemulawada Rural	56.52	88.76	28.74	32.38	28.24	31.82
Yellareddypet	54.17	89.48	30.01	33.54	19.24	21.50
Total	**53.86**	**89.66**	**27.23**	**30.37**	**21.32**	**23.78**

Table 14 WPR and percentage of Agricultural Workers in Rajanna Sircilla district (2011)

 DOI : 10.35291/2454-9150.2024.0074

Mandal Name	TW wrt TP	TMW wrt TW	TC wrt TW	TC wrt MW	TAgL wrt TW	TAgL wrt MW
Boinpalli	57.90	88.20	31.13	35.29	36.21	41.05
Chendurthi	56.72	77.01	25.74	33.42	28.30	36.75
Gambhiraopet	53.08	86.46	18.50	21.40	33.65	38.92
Illanthakunta	55.62	86.16	30.74	35.67	38.49	44.66
Konaraopet	55.91	80.83	25.50	31.55	30.83	38.15
Mustabad	54.46	78.47	20.39	25.99	24.54	31.28
Rudrangi	55.87	85.59	22.22	25.96	35.33	41.28
Sircilla	51.63	88.42	3.62	4.10	6.39	7.23
Thangallapalli	54.21	88.41	23.63	26.73	29.98	33.91
Veernapalli	56.13	82.52	42.03	50.93	30.57	37.05
Vemulawada	49.04	86.05	12.13	14.10	21.90	25.45
Vemulawada Rural	56.29	81.47	29.71	36.47	28.37	34.82
Yellareddypet	55.27	87.36	26.68	30.55	29.94	34.27
Total	**54.16**	**85.06**	**21.10**	**24.81**	**26.45**	**31.10**

Abbreviations: WPR: Work Participation Rate (Percentage of Total Workers with respect to the Total Population), TP: Total Population, TW: Total Workers, TMW: Total Main Workers, TC: Total Cultivators (main), TAgL: Total Agricultural Laborer (main), wrt: With Respect To



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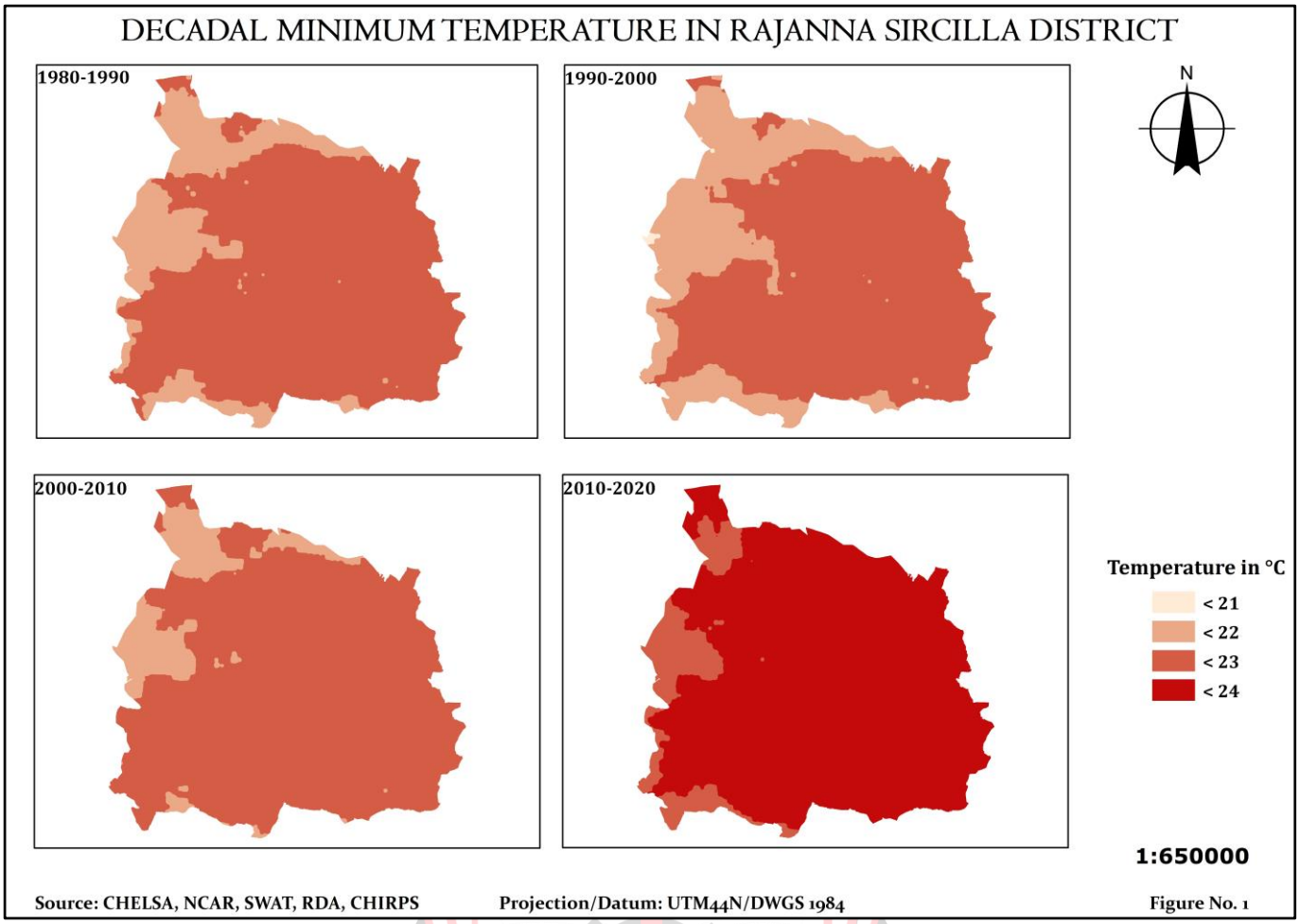

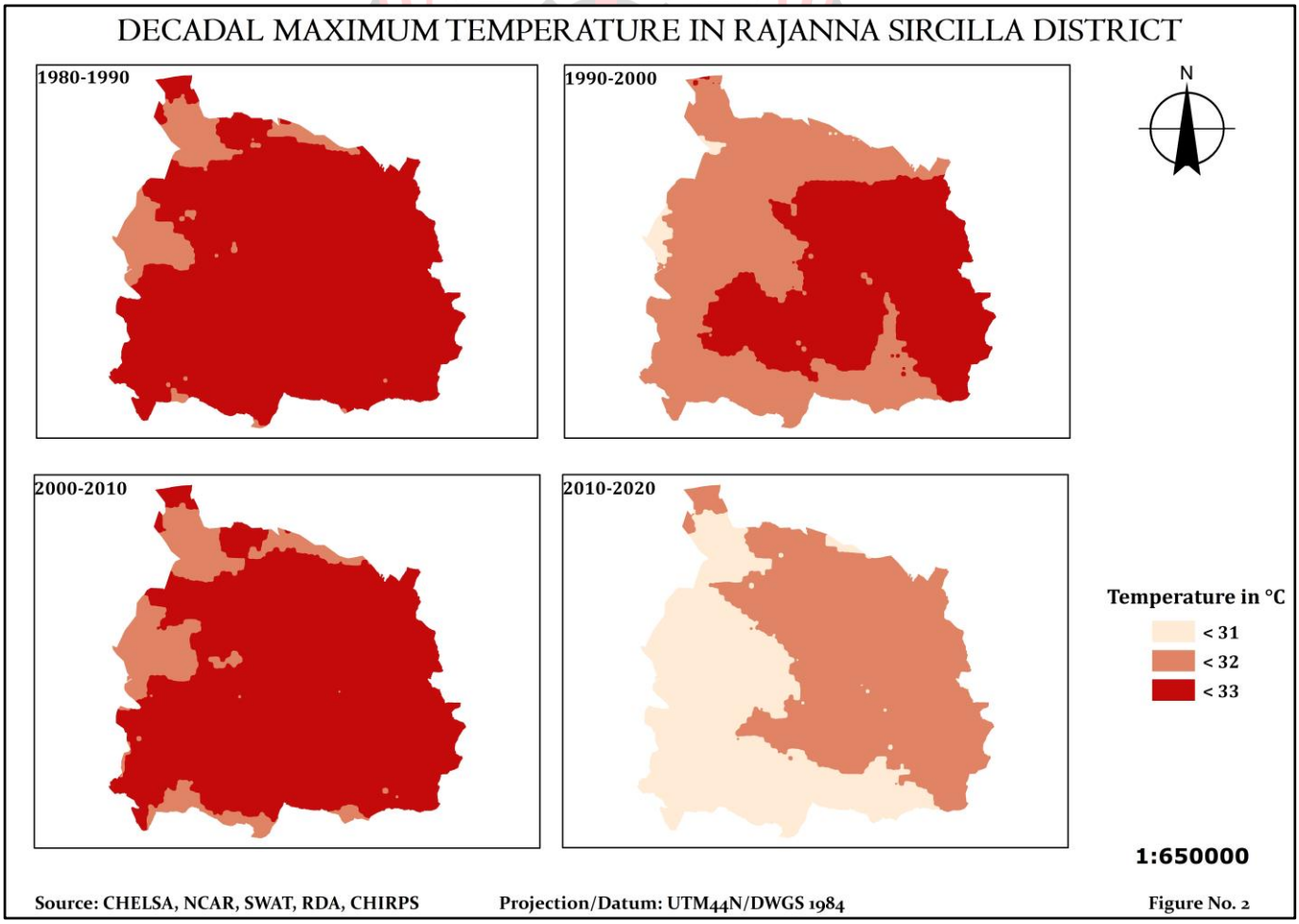

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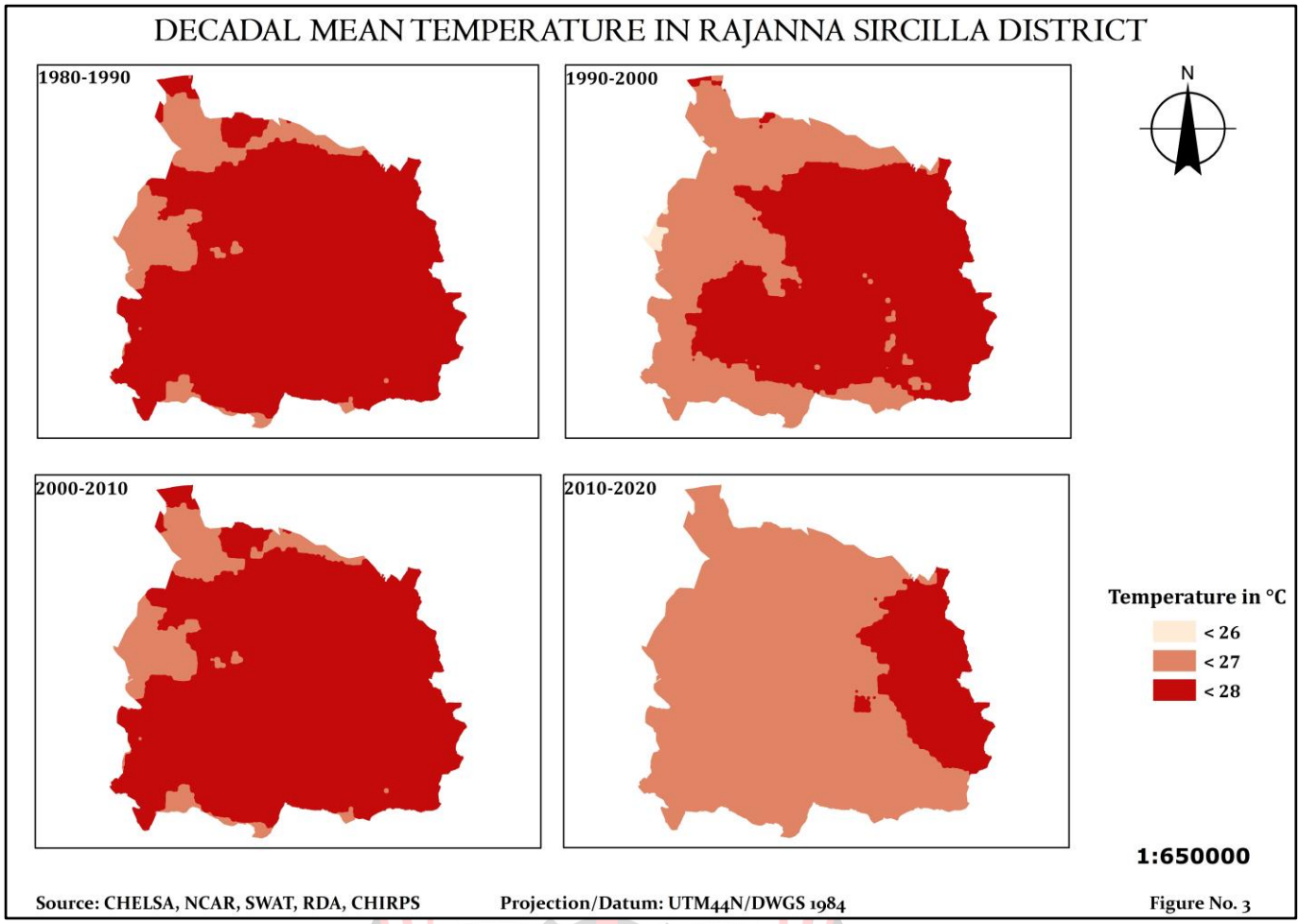

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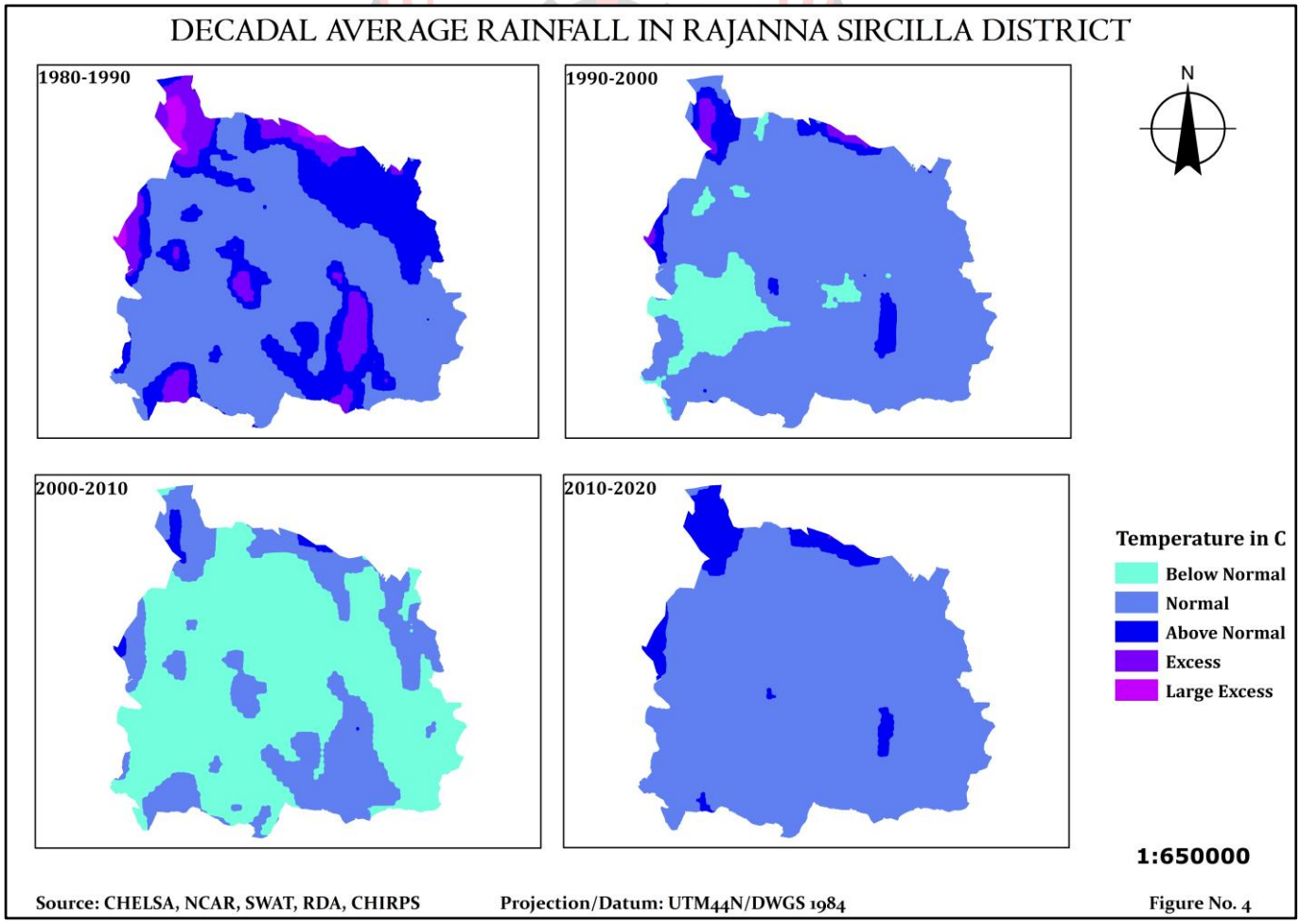

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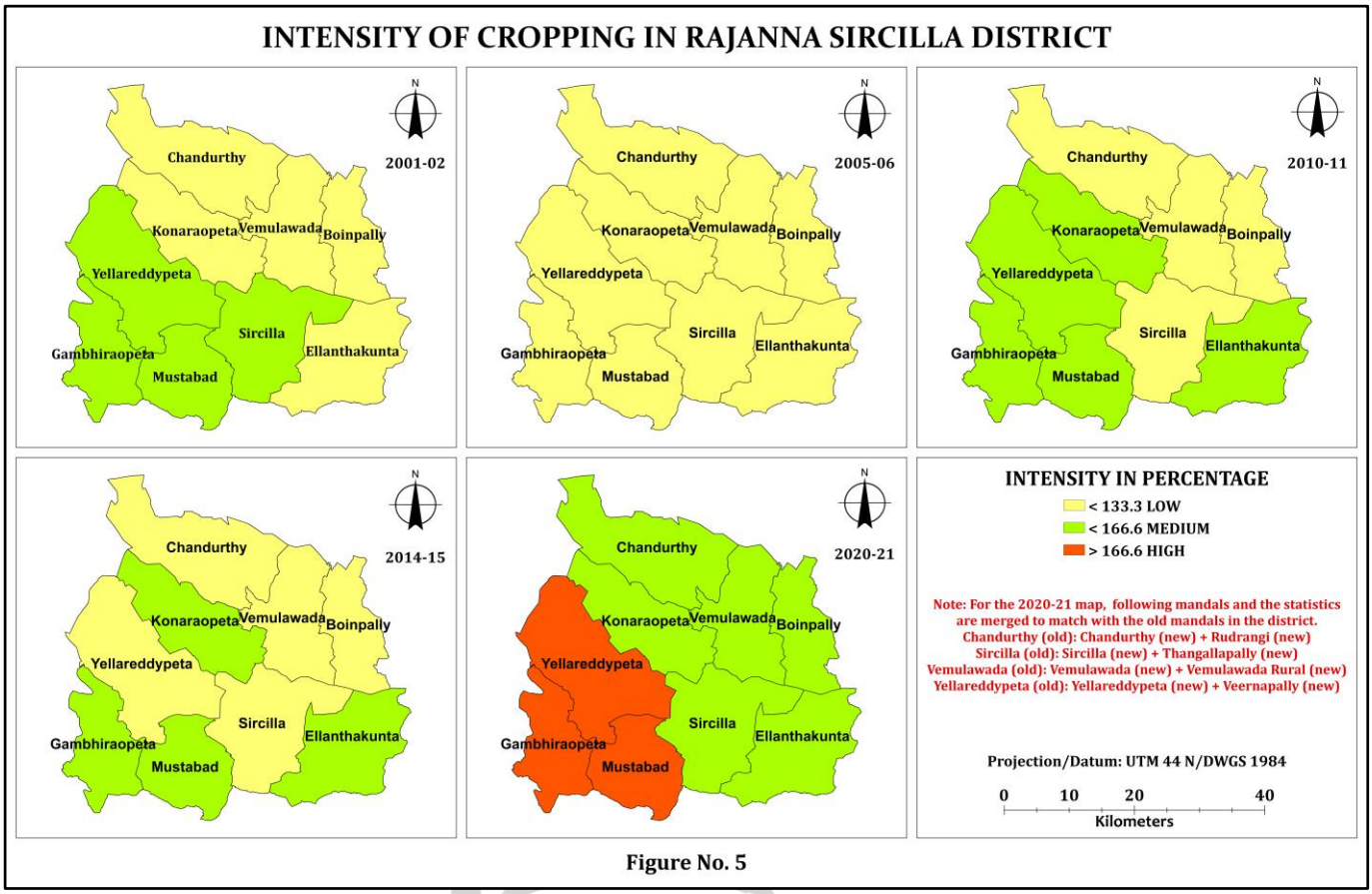

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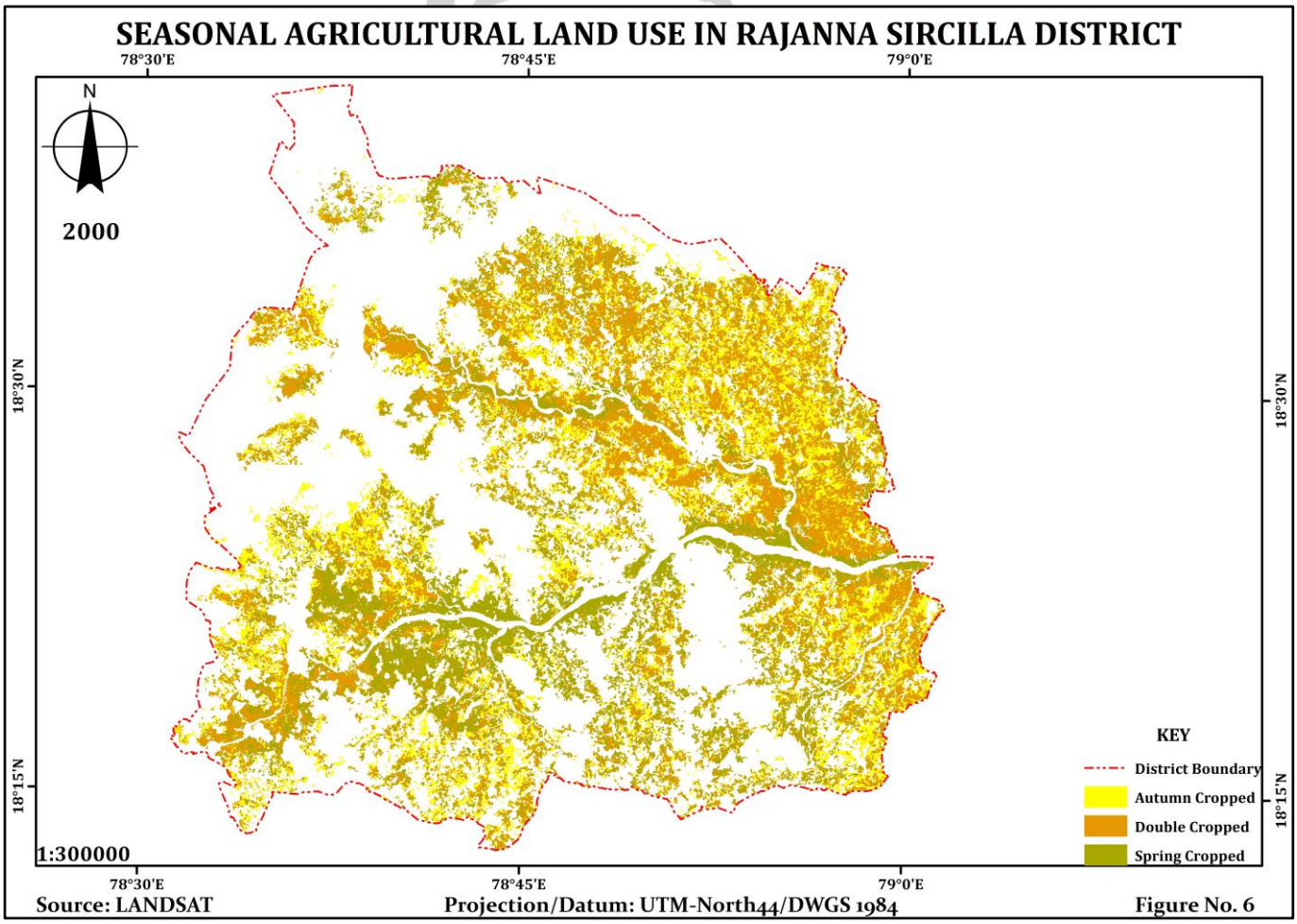

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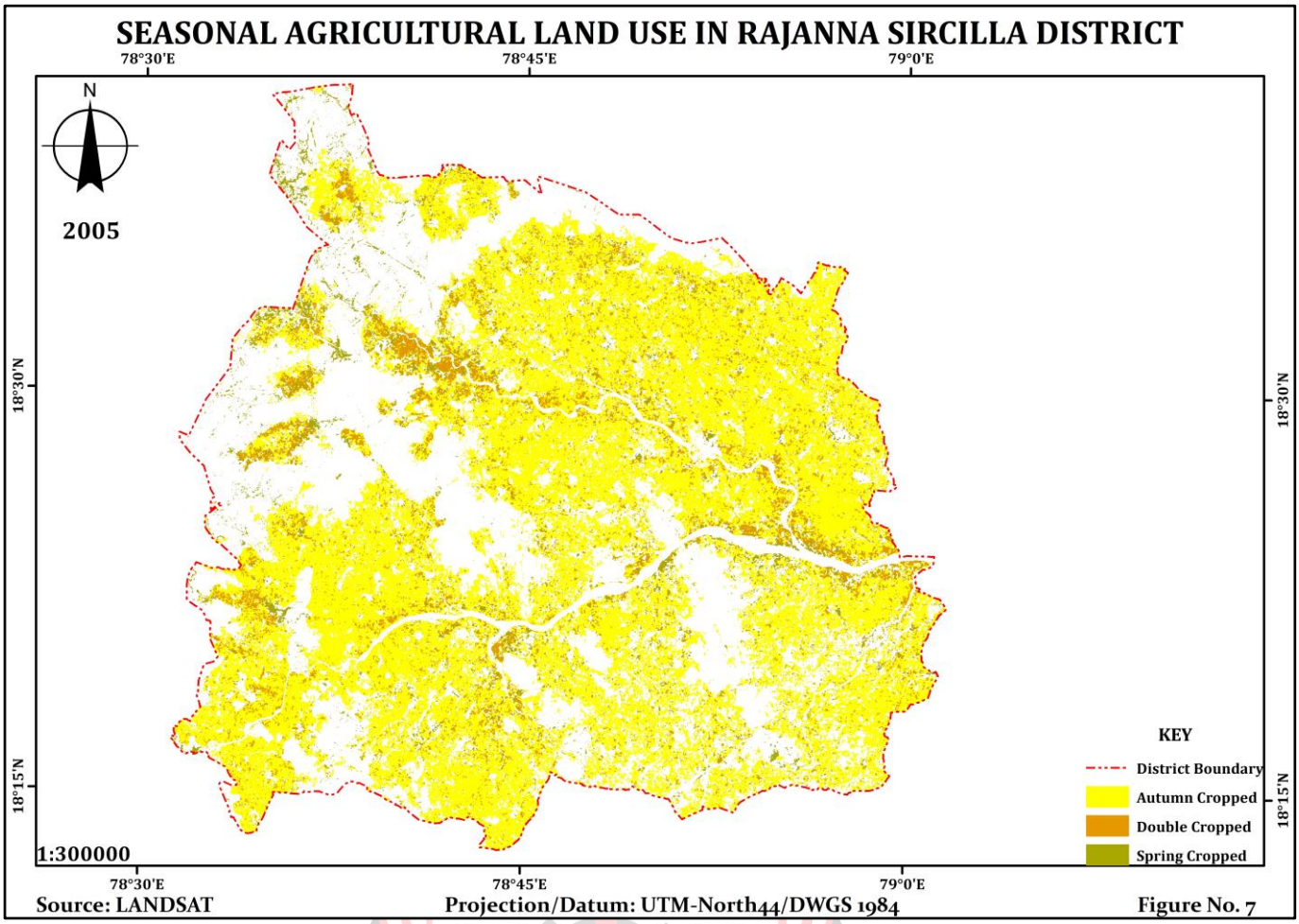

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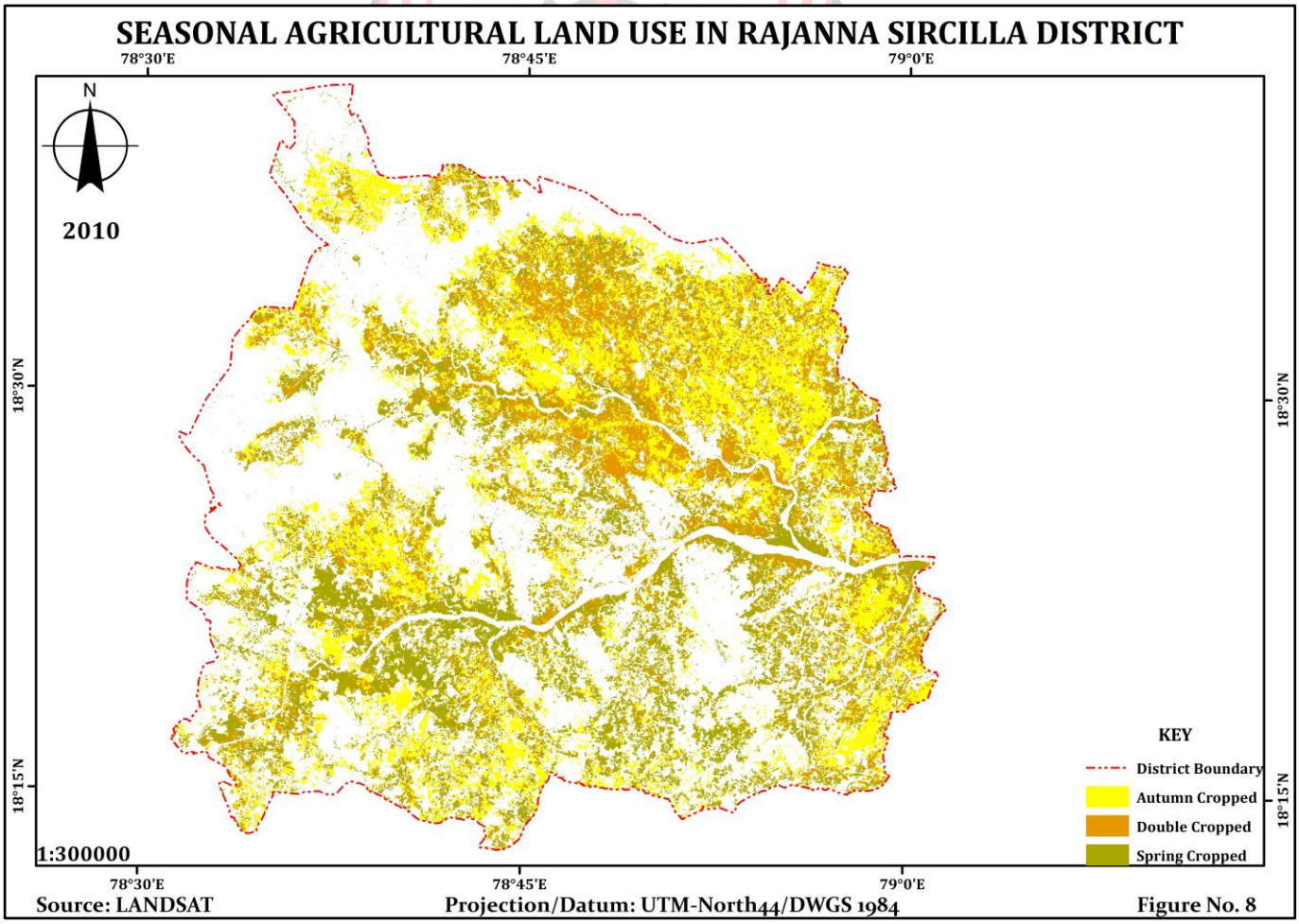

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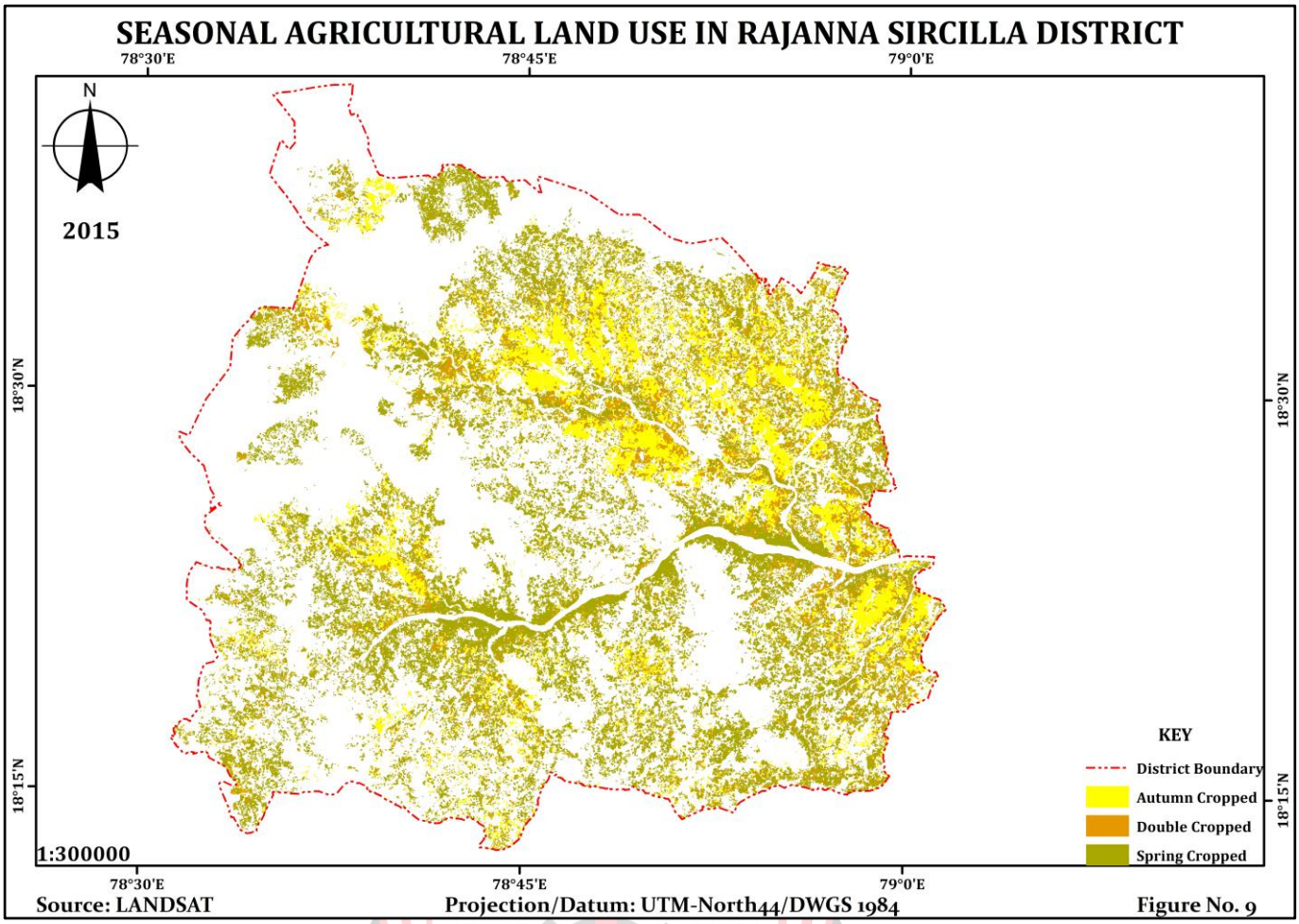

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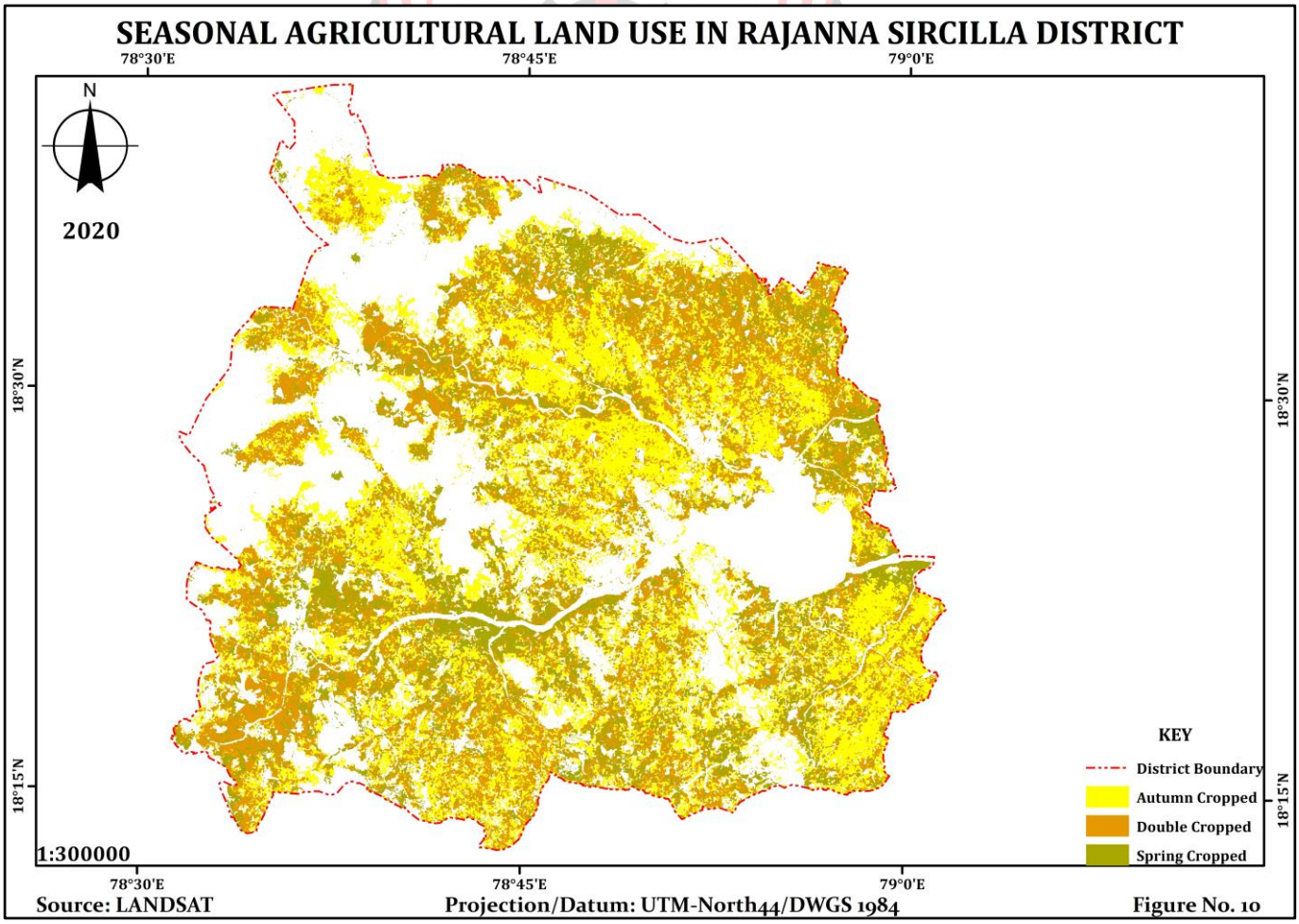

Figure No. 10

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