Full Length Research Paper

Investigating biophysics and bioclimate effect on the health of tourists in Yazd Province using tourism climate index (TCI)

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The ever growing challenges of life in the recent centuries, the spread of different physical and mental diseases, and inactivity due to the development of technology made human to think about taking step for decreasing these problems using natural graces. One of these graces is travel to regions which have proper environmental conditions, especially good climatic conditions in the whole or part of the year. For this purpose, Yazd province, due to having high tourism potential, has been selected for evaluation in this regard. Using tourism climate index (TCI) bioclimate index, this research has proceeded to evaluate climate comfort condition of Yazd province. For this purpose, 30-year (1976 to 2005) mean of the data from temperature, humidity, wind speed, rainfall, and sunlight hour of 5 cities of Yazd province, extracted from the site of national meteorology organization, have been used. Studying TCI index for different months and cities of the province, it has been found that the best climatic condition with regard to physical health for tourists is in the months of Oct. or Nov. with TCI coefficient of 87, and the worst month with TCI index mean of 51 is evaluated for July. In this province, the best seasons are respectively introduced as fall, spring, winter and summer, and considering all days of year, the most ideal bioclimate conditions with the emphasis on tourists' health is seen in Anar region, the south west of the province, however, Yazd city is ranked as the most unfavorable city among the cities of the province.

Keywords: Environmental health, climate comfort, TCI index, tourism, Yazd province.

INTRODUCTION

Today the people's health is not just limited to healthy food and water, health with regard to access to rare medicines and tablets, health centers and hospitals, etc. The ever growing challenges of life in the recent centuries, the spread of different physical and mental diseases, and inactivity due to the development of technology made human to think about taking step for decreasing these problems using natural graces. One of these graces is travelling to regions which have proper environmental conditions, specially good climatic conditions.

In our age, tourism is one of the new areas in humanities studies and it is considered by countries in different directions (Farzin, 2005). The interest in tourist is due to its economic significance in one hand and its social, cultural and economic effects on the other hand (Farzin, 2005).

Based on the estimation of Tourism World Organization, the income of this industry would reach $800,000,000,000 in 2010. In the coming decade, the tourism industry would be placed at the top of world's profitable industries table. This industry with the income as much as $500,000,000,000 in 1998 has super passed automobile and computer industry, and it is anticipated that by 2020, it overcomes oil, which is the only high-income industry. In this industry, the number of tourists would reach to about 1,000,000,000 persons in 2010 and to the border of 1,600,000,000 persons (Ranjbar, 2009) in 2020. Considering the significance of tourism industry,

Table 1. TCI Sub-indexes and their point.

Sub-index	Climate variable	Point in TCI
CID	mean maximum temperature and mean minimum relative humidity	40
CIA	Mean temperature and mean relative humidity	10
R	Total precipitation	20
S	Sunny hours	20
CID	Mean wind speed	10

Source: Freitas et al. (2004), and Roshan et al. (2009).

besides political, social and cultural factors, natural environmental factors also play significant role in tourism development and also tourist attraction. In fact, a tourist uses a geographical space, this space has a physical and natural structure including natural and biological factors (climate, geology, topography, animal and plant community), and also some factors which have been caused by human activity (Martin, 2005; Olofintoye and Adeyemo, 2011; El Shafie et al., 2011), therefore, tourism and environment (both in human and natural dimensions) are mutually linked to each other. Environment forms so many attractions (Papeli et al., 2004).

Tourism is notoriously associated with climate and it has a main role on tourism demand (Scott et al., 2004; Jacqueline et al., 2004, 2005; Joao et al., 2007; Roshan et al., 2010a). Climate could be a local index for region attraction; it also affects periodical activities, structures, functions and tourists' comfort (Shakoor et al., 2008; Roshan et al., 2010a, 2010b, 2011; Borna, 2011).

Most tourists spend their holidays by resting in sunny weather, a pleasant weather not a hot one (Martin, 2005). Climate is not just a temperature and physical factor, but an aesthetic factor which affects the form of environmental and plant community (Jacqueline et al., 2004). As an effective factor, climate is significant due to its neural and mental effects on tourists, it is effective in choosing destination for spending holidays (Freitas et al., 2008). An appropriate climate could bring about tourist's positive responses, and tourists also make their travel plan based on the climatic conditions of destination (Ranjbar, 2009).

According to Clawson1, the ideal climate for spending holidays and outing is somewhere which has no rain, is being ever pleasantly warm, but not hot, has a cloudless mild sunny sky, not being too humid, has a light breeze etc (Martin, 2005). In general, climate is significant in tourism for some reasons. First, in some cases, the climate itself is considered as an attraction, like places with warm winters which is favored by those people living in cold regions. Second, the diversity of climate in a region or country provides the expansion of tourism industry and the possibility of tourism activities in different seasons of year. In other words, any climate has its own peculiar tourism activity, and if a country has different climates, it has the potentiality for tourist attraction in most seasons of year (Roshan et al., 2009).

Therefore, tourism is under the influence of comfort and climate conditions, and the purpose of present research is to introduce appropriate period with regard to climate-comfort and tourists' health in Yazd province. Rather than the mentioned matter, the significance of the study also lies in the fact that this province is one of the old and historical provinces of the country and has so many natural and historical tourism attractions for tourists. Therefore, considering the abovementioned cases, it is essential to conduct the research in the area of the relationship between human's health and his living environment.

MATERIALS AND METHODS

In this research, library and statistical methods, and also special bioclimate model have been applied. Therefore, at first climate data of the studies region, including: the parameters of temperature, humidity, wind speed, rainfall and sunlight hour for a 30-year period (1976 to 2005) for 5 meteorology stations of Yazd, Tabas, Robat Posht-e Badam, Bafgh and Anaar in Yazd province were extracted from the site of national meteorology organization, then 30-year mean of these data has been used for calculating Tourism-climate index (TCI). Having calculated TCI for different months of year and for each station, TCI zoning map index of Yazd province was prepared, and finally appropriate month with regard to comfort on tourists' physical health and inappropriate months with regard to climate on tourist physical health were analyzed and evaluated.

TCI structure

This index is obtained from 7 climatic parameters including mean maximum temperature, mean temperature, mean minimum relative humidity, mean relative humidity, total precipitation, mean sunny hours and mean wind speed. All the above parameters are used in this index as monthly mean. TCI index includes 5 sub-indexes, obtained from the abovementioned climatic parameters (Table 1).

Daytime comfort index (CID) and daily comfort index (CIA) are considered as comfort indexes in TCI and they are obtained from psychrometric chart, in which ASHRA thermal comfort standard has been drawn. Based on ASHRA definition, thermal comfort is a mental condition that expresses satisfaction with the environment. It means that in the conditions of thermal comfort, one never prefers warmer or colder conditions (Freites et al., 2004; Ebrahimi, 2005; Jacqueline et al., 2005; Janbaz et al., 2011).

TCI is obtained from the following formula:

Relation (1): $TCI = 2[(4 \times CID) + CIA + (2 \times P) + (2 \times S) + W]$

Table 2. Qualitative values of TCI.

Descriptive rank	TCI point
Ideal	90 - 100
Excellent	80 - 89
Very good	70 - 79
Good	60 - 69
Acceptable	50 - 59
Insignificant - marginal	40 - 49
Inappropriate	30 - 39
Very inappropriate	20 - 29
Extremely inappropriate	10 - 19
Impossible	-30 - 9

Source: Freitas et al. (2004), Jacqueline et al. (2004) and Roshan et al. (2009).

All sub-indexes used in TCI, allocate a spectrum from rank 5 (favorable) to -3 (extremely unfavorable) to themselves. Rank 5 is considered as the most favorable rank in TCI formula.

Finally, having calculated TCI for all months of year, values obtained from this index include a range from (-30) to (100), that point (100) is the ideal condition for tourism and (-30) is considered as impossible condition for tourism. Therefore, TCI is divided into 10 qualitative indexes as presented in Table 2.

Finally, the source of tourism climate for reach zone is divided into 6 annual distributions. In fact, these six distributions vary during a year from a favorable climate for tourism (TCI ≥80) for each month of the year and a poor climate for tourism (TCI≤40) throughout the year (Scott and McBoyle, 2001).

RESEARCH FINDINGS

Having analyzed TCI values for different months in Yazd province, the following results have been extracted:

Having calculated TCI index in April, it has been found that two counties of Robat Posht-e Badam and Anaar with output factor of 90 have the most ideal bioclimate conditions in Yazd province, while Yazd city, with output factor of 74, has the lowest comfort condition in this month (Figure 1).

In May, again two counties of Robat, Posht-e Badam and Anaar with output factor of 90 are classified in the category of ideal regions, while Yazd, as the most unfavorable station with the factor of (41) is dropped to insignificant or marginal class (Figure 2).

In the last month of spring, TCI index has been declined for all counties, so the best bioclimate condition is seen in Robat County with the factor of 74, and Yazd with the factor of 41 is still introduced as the most in appropriate city (Figure 3).

Evaluating TCI values, calculated for the first month of summer, based on Figure 4, it is observed that Yazd, Tabas and Bafgh stations are in the most inappropriate bioclimate conditions, and just Anaar county, in the southwest of the province, with the factor of 67, is in the good threshold (Figure 4).

In the analysis of two months of August and September,

being in insignificant – marginal range, Yazd county still lacks favorable bioclimate conditions, which is surely due to its scorching sunshine, high temperature and lack of humidity in these months of the year for the studied region, while Anaar county with the factor of 67 for the month of August, and being located in the good range has more appropriate conditions than other counties, however, this condition has been changed for the month of September and Posht-e Badam county with the factor of 90 is introduced as the most ideal county for the concerning month (Figures 5 and 6).

Having calculated TCI index for the month of October, it has been specified that the southwest of the province, specially Yazd and Anaar have the lowest comfort conditions, however, based on the map guide section it is determined that output values of TCI for the whole province have the greater values than other months (Figure 7). Analyzing general mean of TCI index for the month of November, the Figure 8 has been extracted, so that after October and April, this month is ranked the third in Yazd province with regard to climate comfort index. In this month, Bafgh County, with output factor of 91, is introduced as the most ideal month and regions as Robat and Anaar are put in the category of unfavorable climate conditions (Figure 8).

In the analysis of December, it is observed that after several periods, Yazd station, which was introduced as the worst month, has more appropriate conditions than other counties in this month with the factor of 74. In this month most regions of the province are placed in the acceptable range (Figure 9).

However, in the analysis of January, which is the first month of Christian year and also winter season, it is observed that TCI index has had more decline in winter than fall. It could be due to dry and cold weather of the province which is also influenced by local conditions of the region.

In this time of the year, the interesting point is that Yazd city is again placed in the good range with output factor of 68 after several months of being introduced as unfavorable city with regard to bioclimate factors. In this month, TCI mean for the whole province is 61, that Bafgh with the factor of 52 is placed in the most unfavorable condition (Figure 10).

Once again as we approach spring, TCI values for the whole province are added, in a way that February with the factor of 69 is ended to March with the factor of 81. Although in the month of February, Bafgh County with the factor of 79 is placed in the highest climate comfort, in the month of March, it is Yazd that is placed as excellent by getting factor of 89. In these two months, the atmospheric humidity has been almost increased which itself has caused the decrease of weather coldness and dryness (Figures 11 and 12).

Conclusion
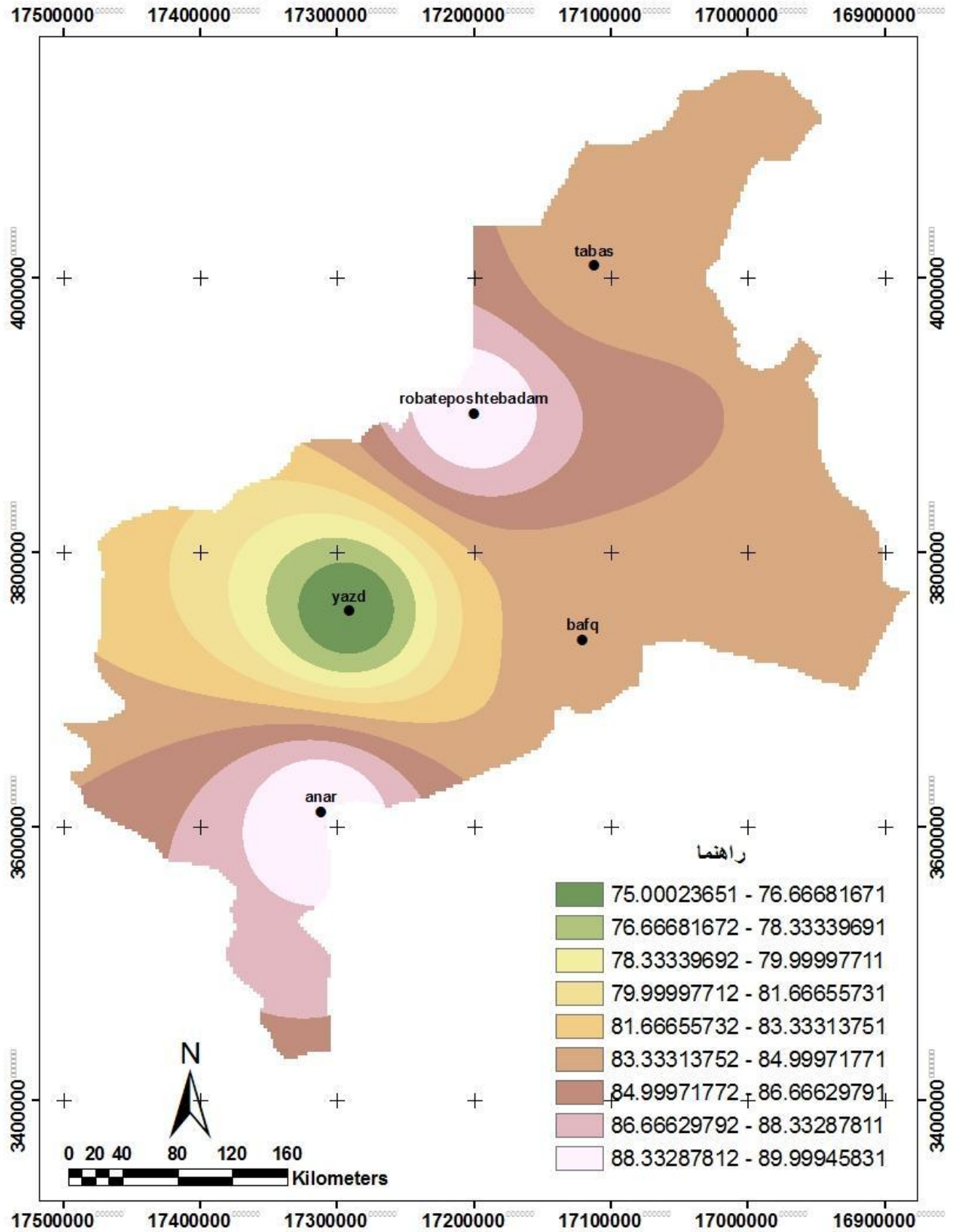
Having analyzed 30-year (1976 to 2005) mean of the
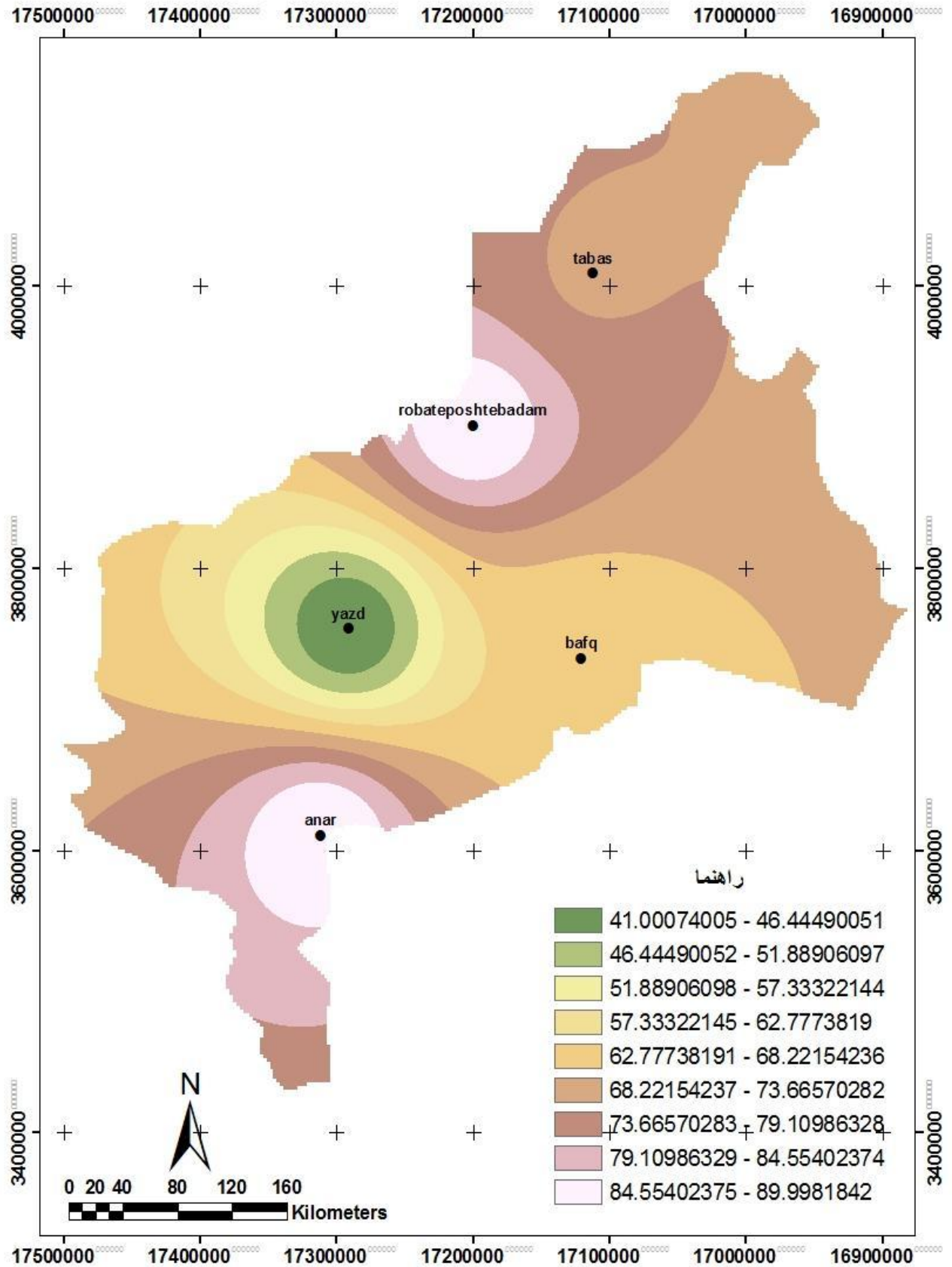
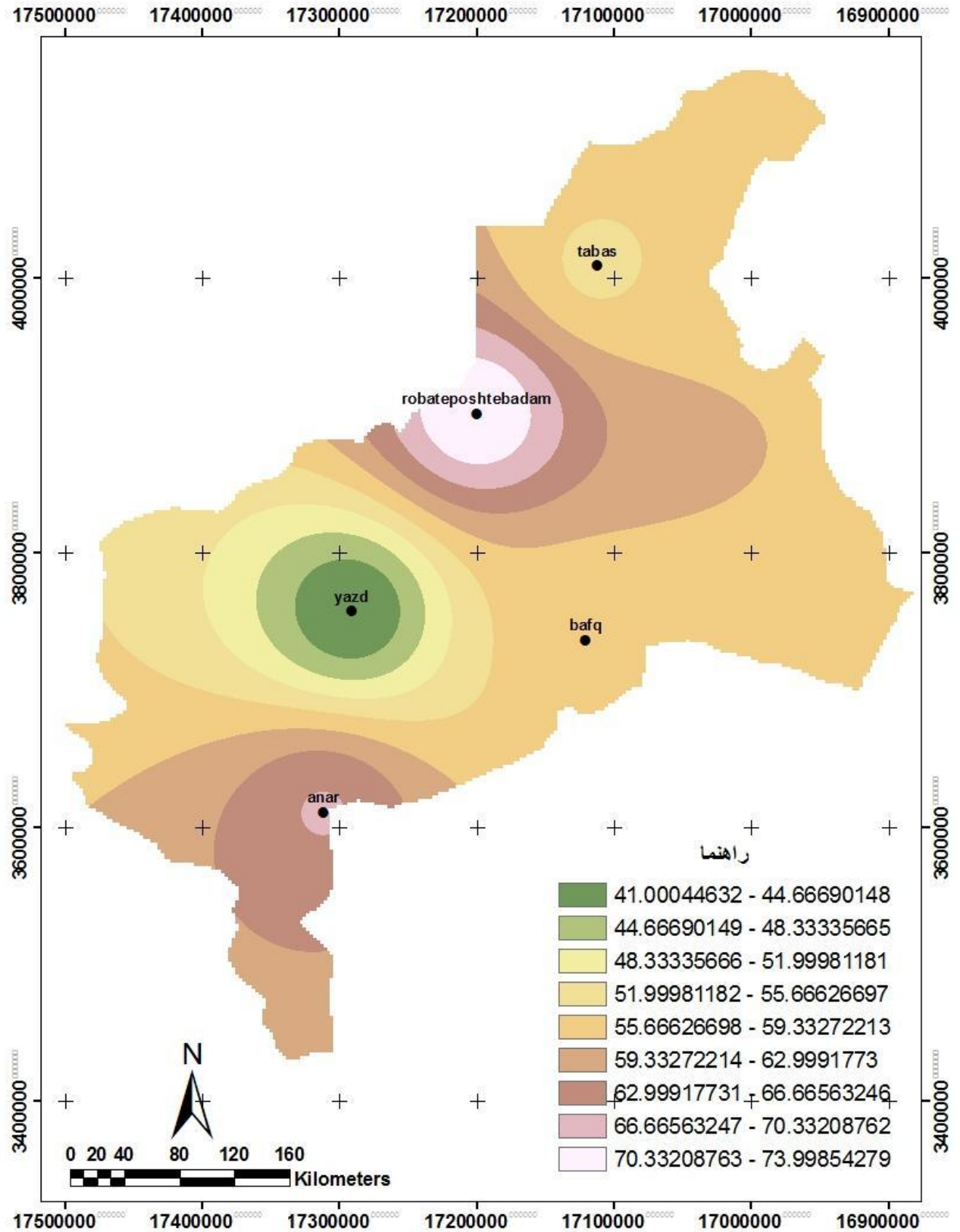**Figure 1.** TCI zoning for April.

Figure 2. TCI zoning for May.
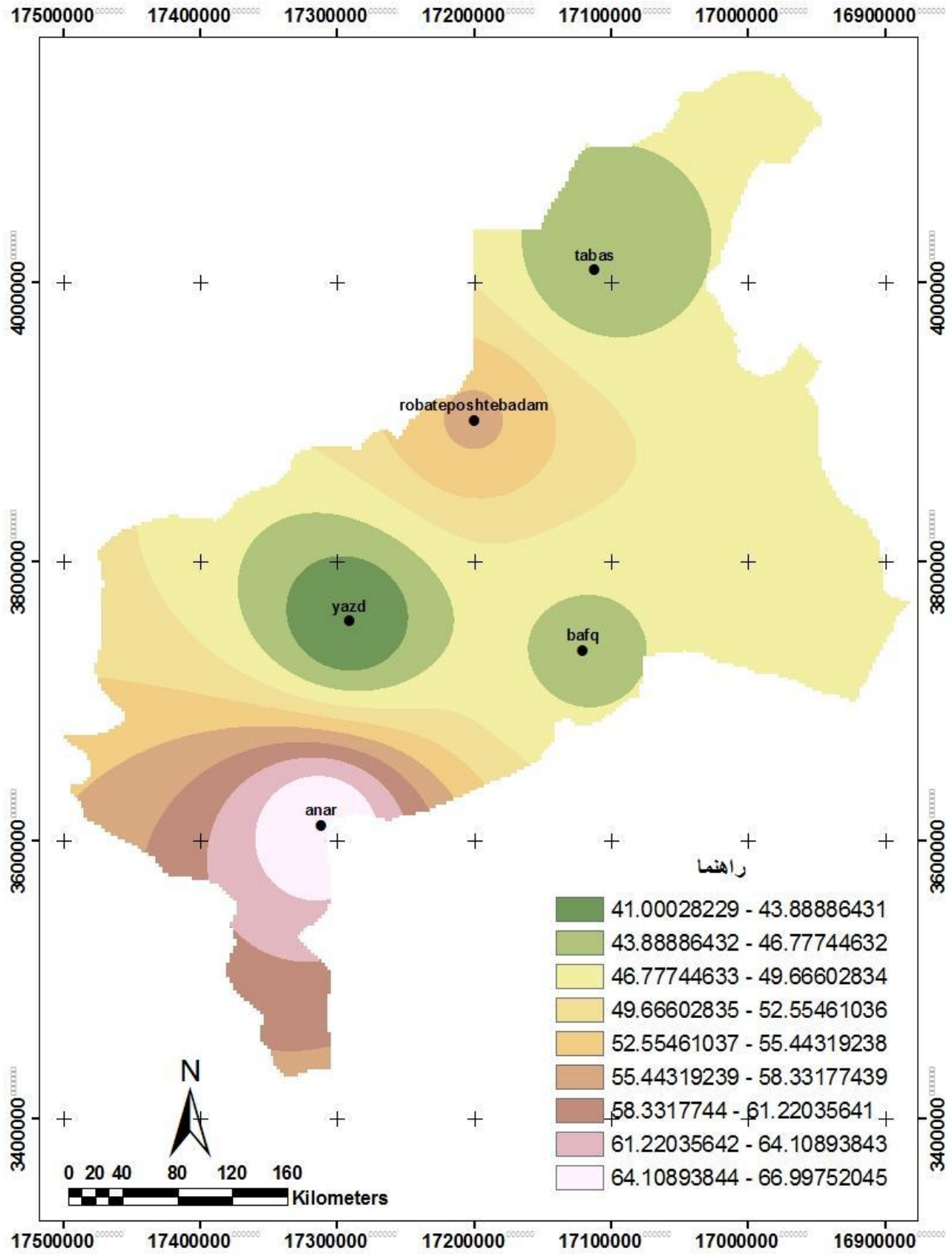
Figure 3. TCI zoning for June.
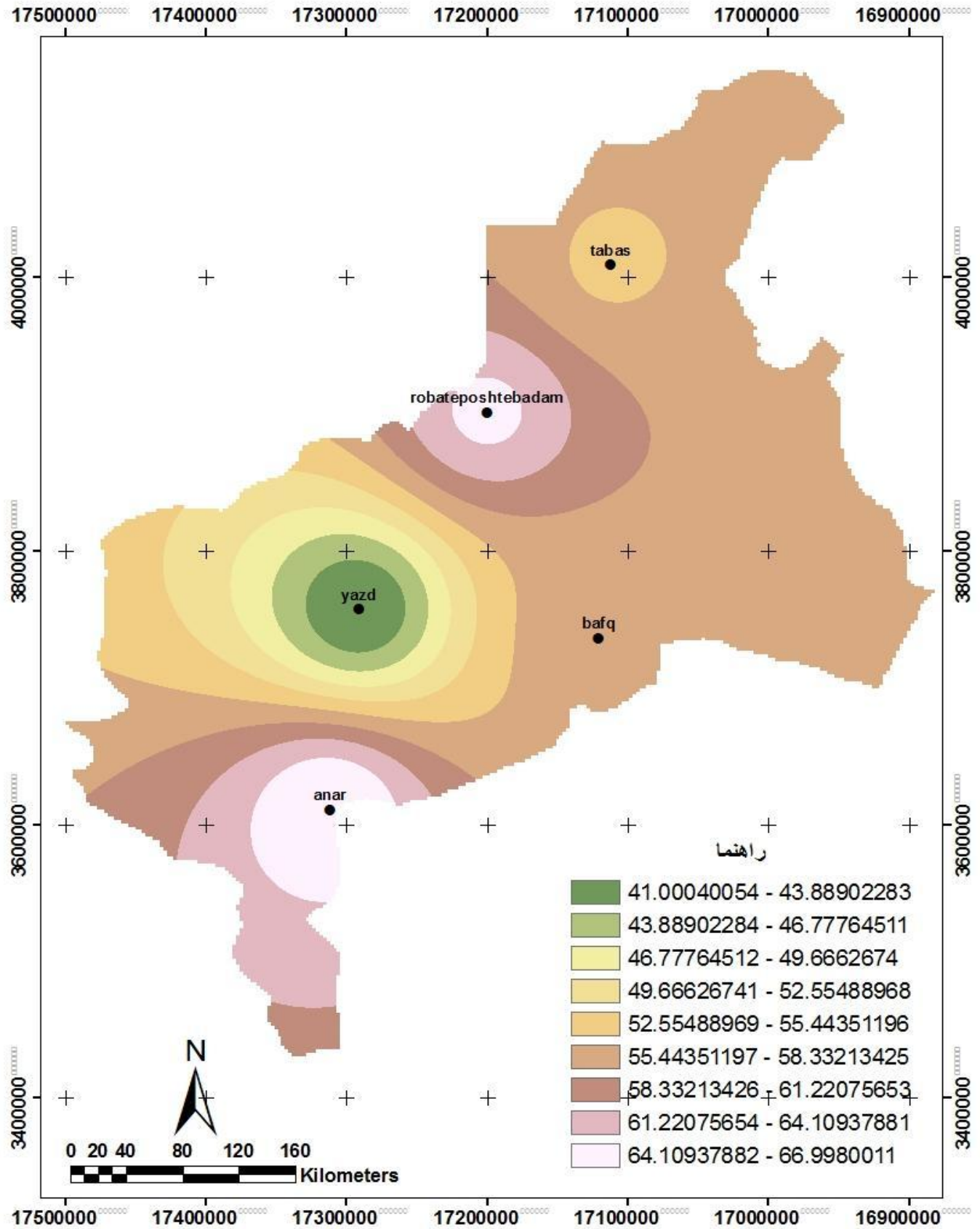
Figure 4. TCI zoning for July.
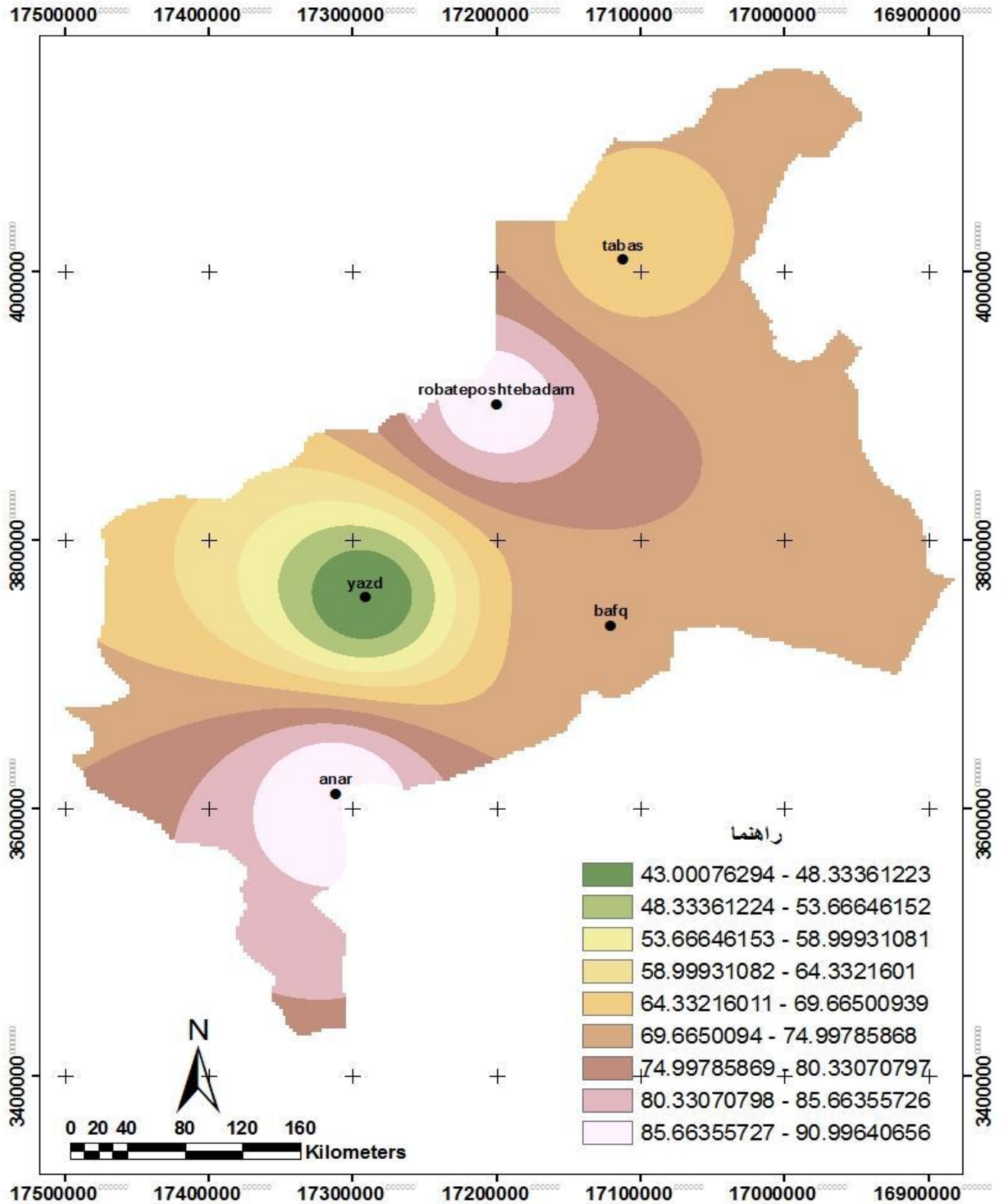
Figure 5. TCI zoning for August.
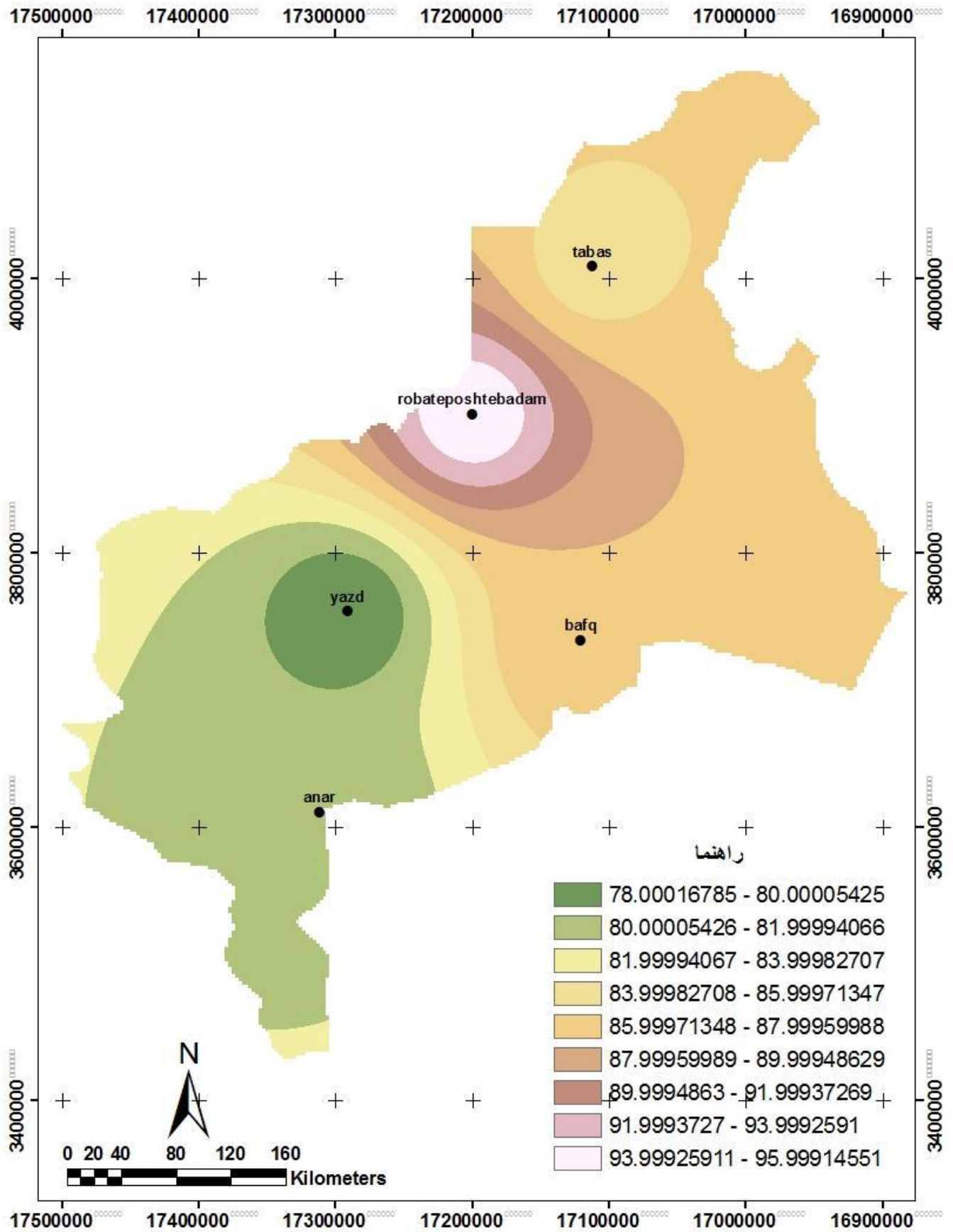
Figure 6. TCI zoning for September.
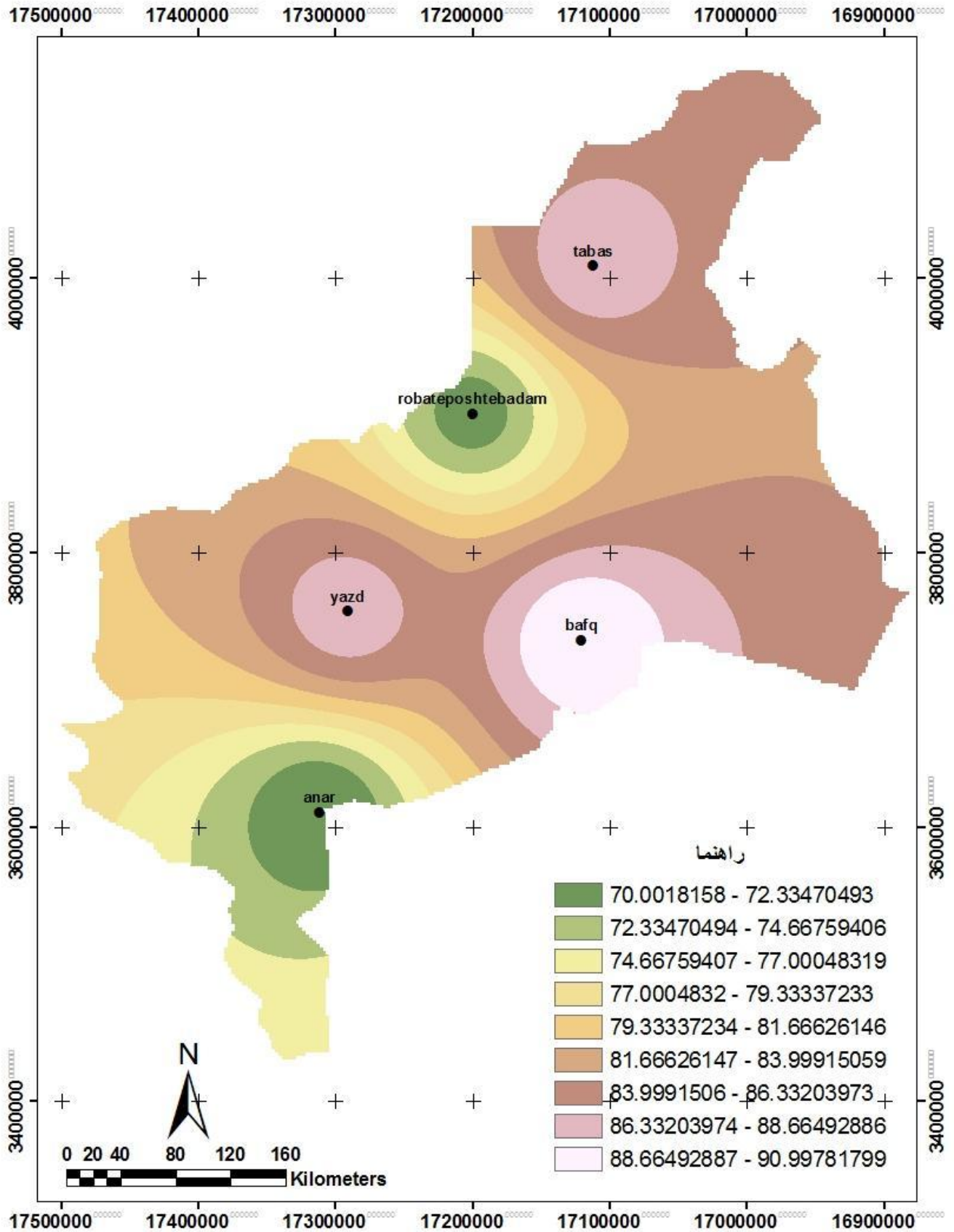
Figure 7. TCI zoning for October.

Figure 8. TCI zoning for November.
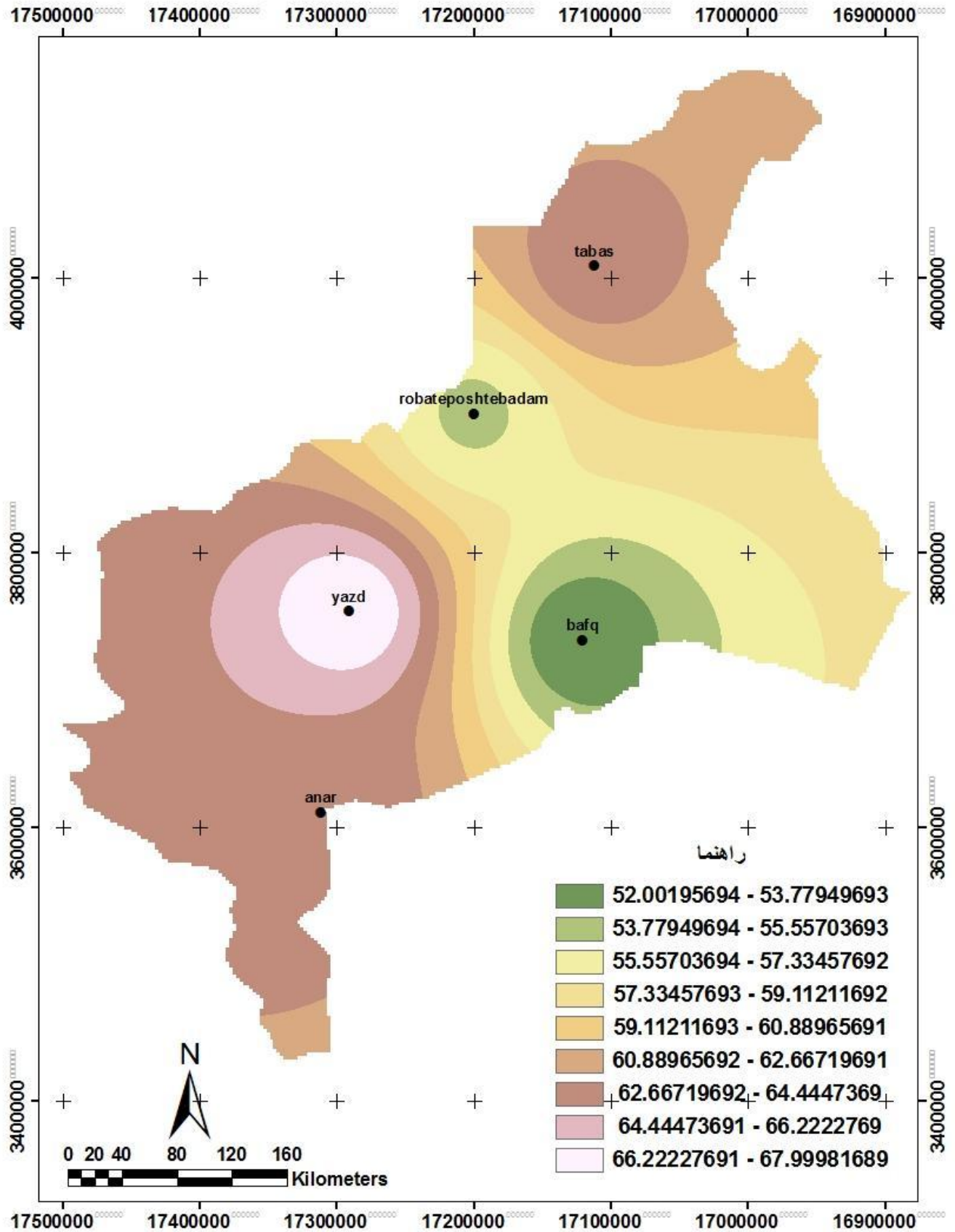
Figure 9. TCI zoning for December.

Figure 10. TCI zoning for January.

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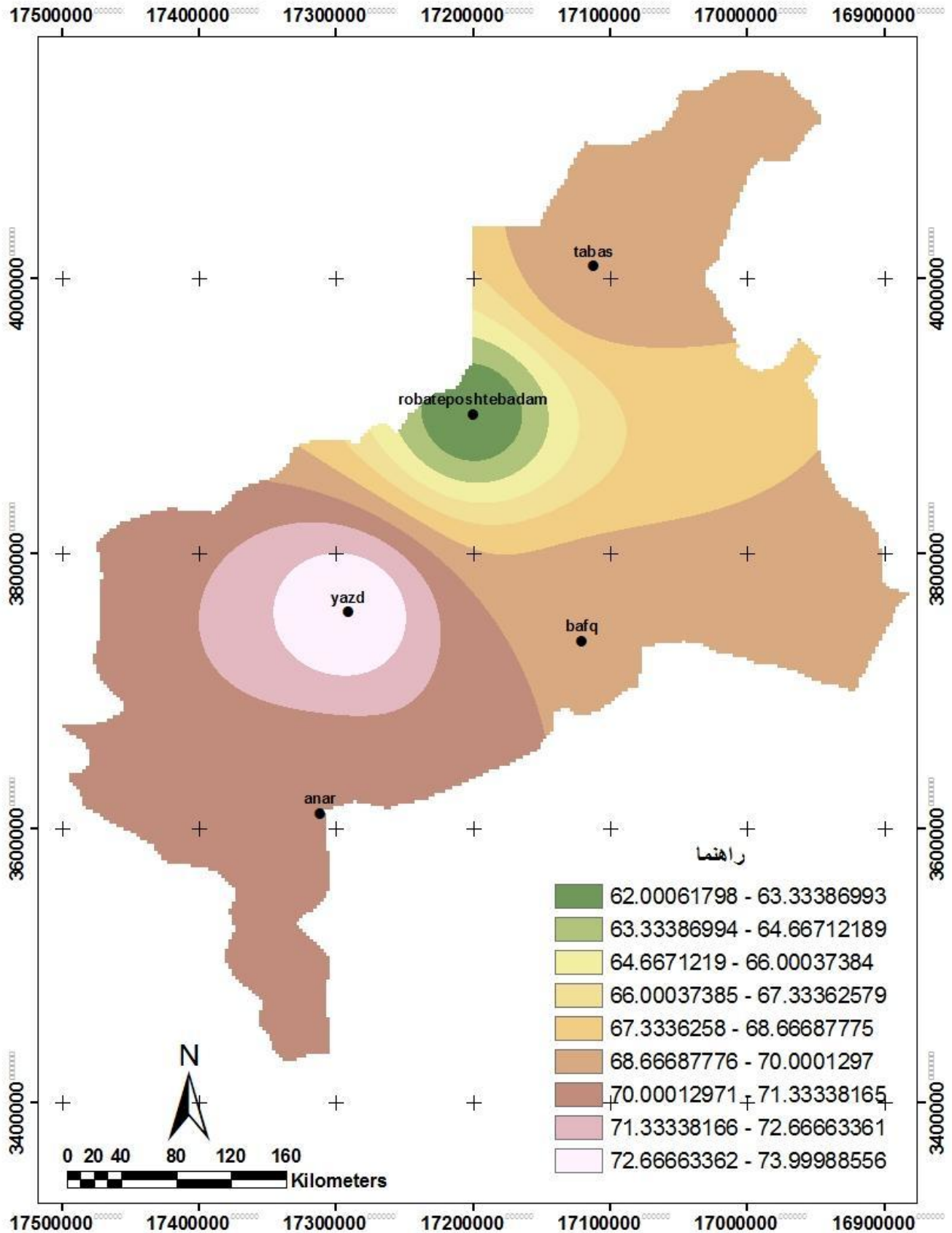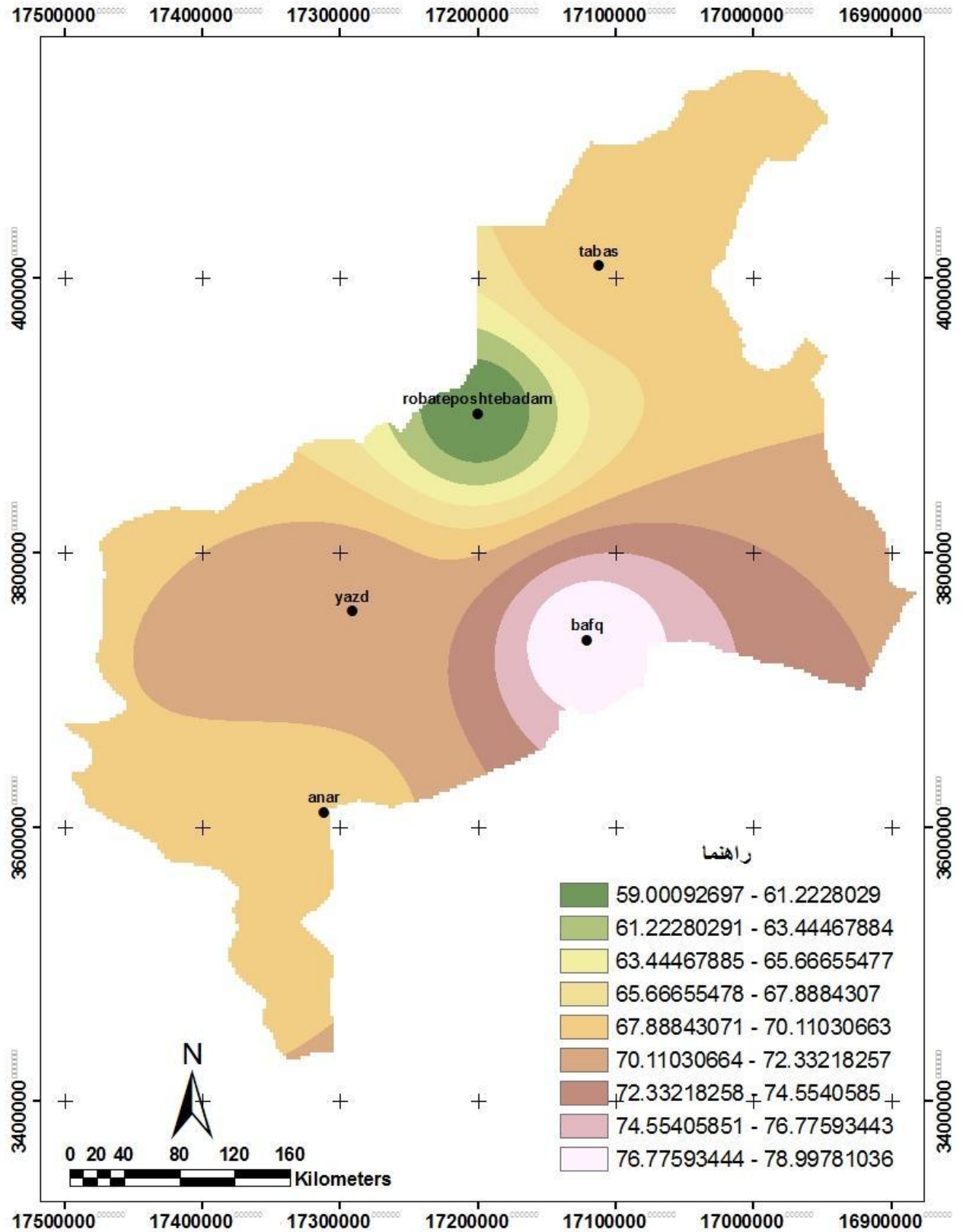|	
■	59.00092697 - 61.2228029
■	61.22280291 - 63.44467884
■	63.44467885 - 65.66655477
■	65.66655478 - 67.8884307
■	67.88843071 - 70.11030663
■	70.11030664 - 72.33218257
■	72.33218258 - 74.5540585
■	74.55405851 - 76.77593443
■	76.77593444 - 78.99781036

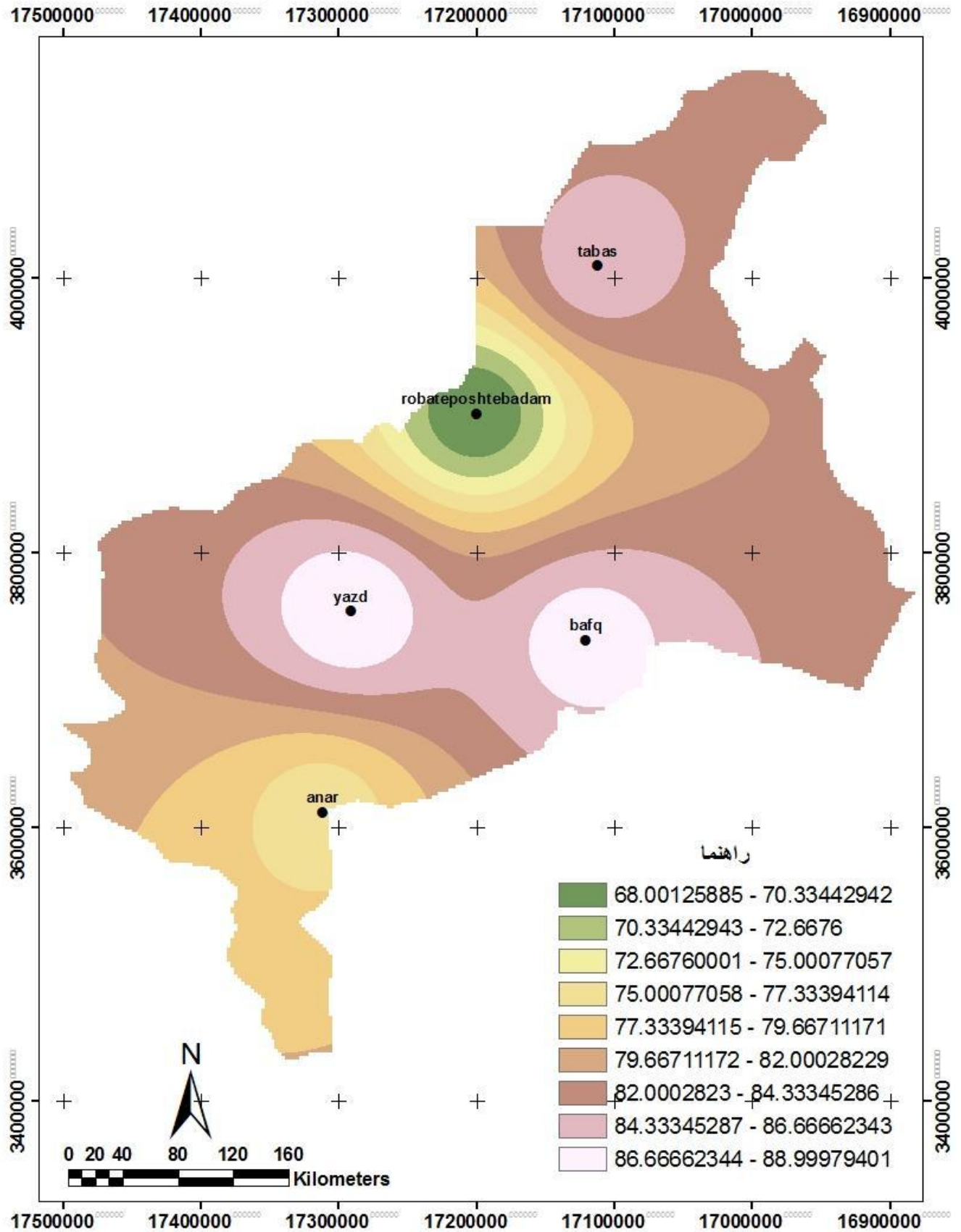**Figure 11.** TCI zoning for February.

Figure 12. TCI zoning for March.

climate data and calculating TCI climate comfort for Yazd province, it has been found that the best environmental conditions for tourism with regard to climate in Yazd province is the months of October. Since in this month, the Figure 8 has been extracted as the output mean for the province and the worst month has been evaluated to be in July with TCI mean of 51. In this province the best seasons are introduced respectively as fall, spring, winter, and finally summer. However, considering TCI output for the entire year, Anaar region, which is located in the southwest of the province has better bioclimate condition for tourist through the year, and other regions including Posht-e Badam, Bafgh, Tabas and finally Yazd city, respectively takes the next ranks. Anyway, considering all the aforementioned cases, emphasizing tourists' health and inflow of foreign currency to the province, it should be noted that global warming and future climate oscillations which are originated from the use of fossil fuel, population growth and greenhouse gases emission, etc… might transfer favorable time with regard to tourism climate from October to other months as November. Therefore, being aware of such climate oscillations, we should identify appropriate and unfavorable periods and by adopting proper management, and considering environmental potentials and tourists' health and comfort, make the required planning, so that while considering tourists' health, we would not face any decrease in the flow of tourists and foreign currency to the region.

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