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Comparison of Iran Provinces Regarding to the Chemical Fertilizer Consumption in Crop Production Using the t-map Package of the R Software

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ABSTRACT

One of the best method for presenting both spatial and temporal information in a map is through spatiotemporal maps. In this study, creation of spatiotemporal maps of chemical fertilizer consumption in Iran agriculture has been considered. The necessary primary data of this study,that contained recorded data of the years 1395 to 1399, was obtained from Internet resources and after some modifications with the aid of the t-map package of the R software, final data was converted to spatiotemporal maps. According to the results of this study, the largest chemical fertilizer consumer among Iran provinces was the Khuzestan province that consumed more than 200000 tons per year in the all years considered herein. Other provinces with high fertilizer consumption have been Fars, Golestan, Khorasan-e-Razavi, Mazandartan, and Kermanshahan. Moreover, provinces located in the Iran's central Kavir consumed more chemical fertilizer per unit area of croplands. For example, specific fertilizer consumption of Yazd province is more than 300 kg ha^{-1} in this time period. It seems that the farmers of these provinces have tried to compensate for the severe environmental conditions for crop production in these regions by aiding the crops with more chemical fertilizing.

Keywords: Chemical fertilizer, R software, Spatiotemporal map

INTRODUCTION

A dilemma exists in the process of fertilizer consumption for crop production: chemical fertilizers promotes production of agricultural crops (Fageria and Baligar, 2005; Heffer, 2009). In this regard, Huber and Thompson demonstrated that nitrogen is one of the most limiting elements of agriculture in arid and semi-arid regions, because in soils with low organic matter content, it occurs in low levels (Huber and Thompson 2007); however, application of excess chemical fertilizers have negative environmental consequences, as well as human health problems (Tilman *et al*., 2001). As an evidence, Liu *et al.,* (2021) showed that excessive application of organophosphorus pesticides and chemical fertilizer causing surface water eutrophication. Similar results have been obtained in the studies conducted by Huang *et al*. (2017), and Ni *et al*. (2017). Therefore, having accurate information about chemical fertilizer consumption, can help decision makers do their best in managing the utilization of these agricultural inputs (Motesharehzadeh *et al.,* 2017).

In this study the comparison of Iran provinces regarding to chemical fertilizer consumption in the time period of 1395 to 1399 has been carried out using the capabilities of the t-map package of the R software in creating spatiotemporal maps.

MATERIALS AND METHODS

In this study, the required data of chemical fertilizer consumption in crop production was obtained from the online statistical data of Ministry of Agriculture-Jahad website[1]. Province-wide statistical data of chemical fertilizer consumption of years 1395 to 1399 were used to convert to spatiotemporal maps with the aid of the t-map package of the R software. The necessary steps for creation of the maps have been reviewed below:

Generally, to create a spatiotemporal map, two types of data is required: A spatial file containing geometries of the boarders of the district divisions, and a data file containing the data series of the information considered. In this paper, the spatial file is a shape (irn_admbnda_adm1_unhcr_20190514.shp) file containing the geometries of the borders of Iran provinces. This file was downloaded from an Internet resource[2]. Moreover, the prepared data file (an excel file named spatiotemporal.csv), is a data frame having four columns. The first column ("YEAR") has been composed of the year's numbers from 1395 to 1399, each of which have been repeated 31 times (31 is the number of Iran provinces). The second column ("Province") contains the names of Iran provinces that is repeated 5 times (5 is the number of years from 1395 to 1399). The third column contains chemical fertilizer consumption data (tons) of all provinces in all years, each individual data has been located in its corresponding cell devoted to the special province at the specific year. The forth column contains the data of chemical fertilizer consumption per unit area of croplands of each province at each year (kg per hectare). In the next step, the spatial and data files have been combined in order to convert to the final file that can be uploaded to R. Because the number of rows of the data file is 155 and for spatial file is 31, the content of the spatial file must be repeated 5 times in order to be matched with the number of rows of the data file (this has been done in the file named modifyframe). Finally, the final data frame (finalframe) has been converted to spatiotemporal maps using the following R-codes:

```
Install.packages("sf")
Install.packages("tmap")
Install.packages("dplyr")
Install.packages("gifski")
Library(sf)
```

[1] - https://www.maj.ir/page-amar/FA/65/form/pid3352

[2] - https://data.humdata.org/dataset/cod-ab-irn

```
Library(tmap)
Setwd("C:/Users/......")                    #Setting the address of the working directory#
Getwd()
Iran <- st_read("irn_admbnda_adm1_unhcr_20190514.shp")
Newcolumn<-read.csv("spatiotemporal.csv")
Library(dplyr)
Modifyframe<-bind_rows(replicate(5, iran, simplify = FALSE))
Finalframe<-cbind(modifyframe,newcolumn)
Library(gifski)
Fert_Cons<-tm_shape(finalframe)+tm_polygons(col="Fer_Cons_Tons")+
Tm_facets(along = "YEAR", free.coords = FALSE)
Tmap_animation(Fert_Cons, filename = "Fert_Cons.gif", delay = 120)
Fert_Cons_spec<-tm_shape(finalframe)+tm_polygons(col="Fer_Cons_Kg_per_Hectar")+
Tm_facets(along = "YEAR", free.coords = FALSE)+tmap_style("gray")
Tmap_animation(Fert_Cons_spec, filename = "Fert_Cons_spec_col_gray.gif", delay = 120)
```

RESULTS AND DISCUSSION

The results showed that the spatial maps of the chemical fertilizer, and fertilizer per unit area of province-wide crop lands in the years 1395 and 1399 (The animated version of the spatiotemporal maps have been attached to this paper as supplementary materials) (Figure 1 and 2).

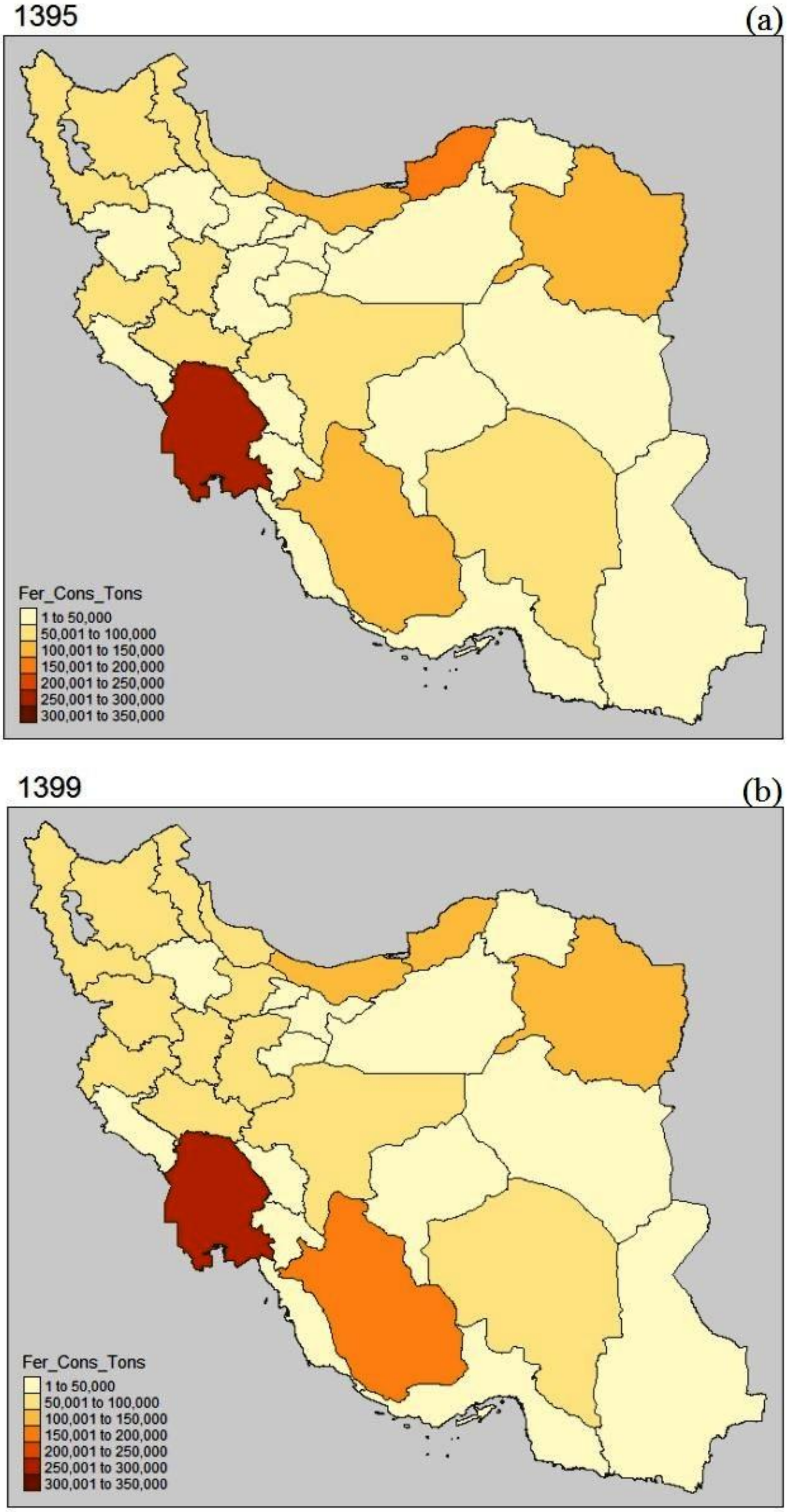

Figure 1- Spatial maps of the chemical fertilizer consumption in the year 1395 (a), and 1399 (b)

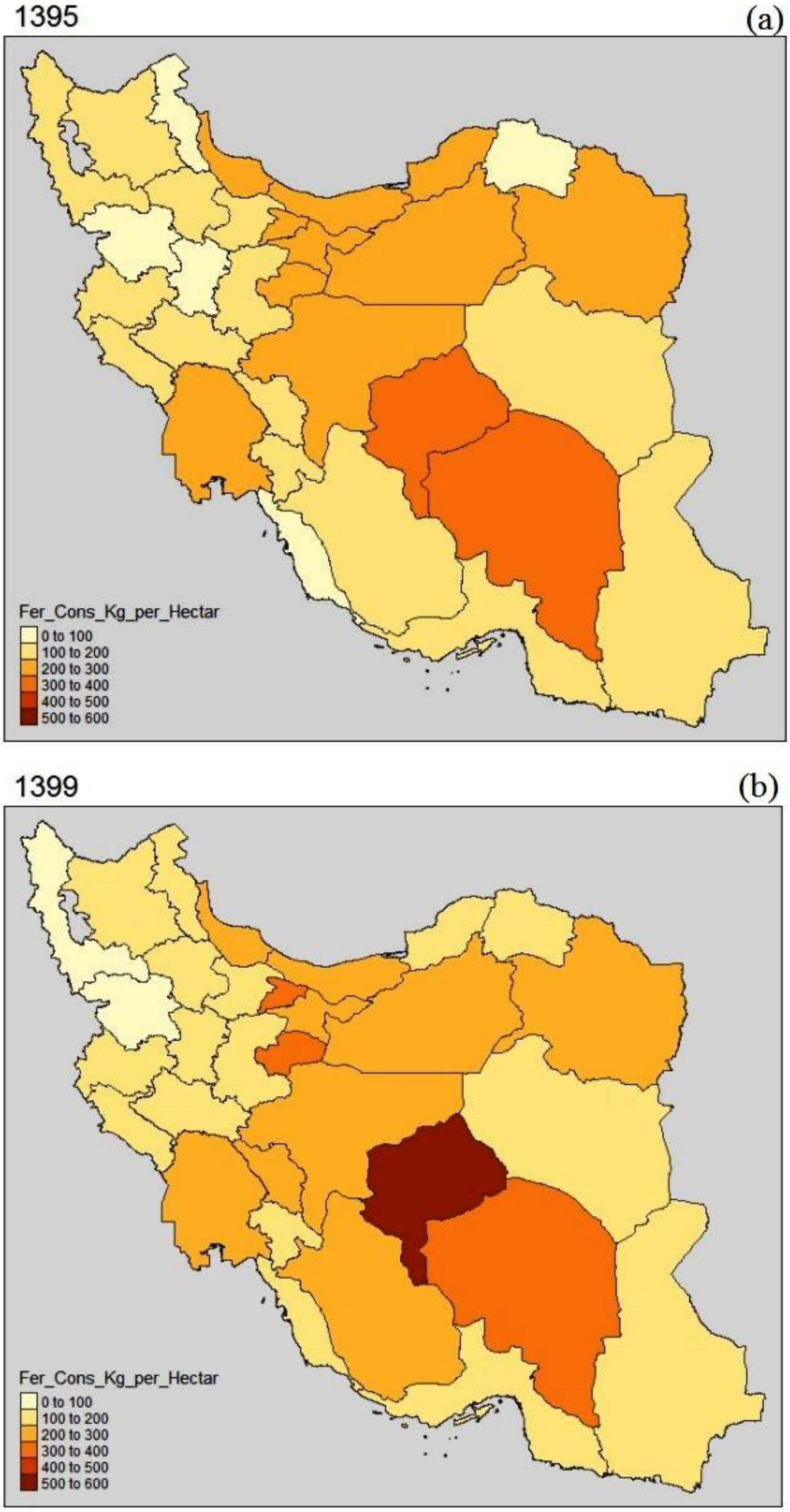

Figure 2- Spatial maps of the chemical fertilizer consumption per unit area of province-wide crop lands in the year 1395 (a), and 1399 (b)

Figure 1 shows that the largest chemical fertilizer consumer among Iran provinces is Khuzestan province that consumed more than 200000 tons per year in the all years considered herein. Other provinces with high fertilizer consumption have been Fars, Golestan, Khorasan-e-Razavi, Mazandartan, and Kermanshahan. Other provinces of Iran consumed chemical fertilizer moderately that is lower than 150000 tons per year, in this time period. From the overall fertilizer consumption vantage point, the consumption of chemical fertilizers in Iran was around 2000000 tons. This differs greatly from values presented in the study of Javedan *et al.* (2011) that predicted the consumption of 7500000 tons of chemical fertilizers for crop production in the year 1397.

On the other hand, Figure 2 shows that provinces located in the Iran's central Kavir consumed more chemical fertilizer per unit area of croplands. For example, specific fertilizer consumption of Yazd province is more than 300 kg ha^{-1} of croplands in this time period. Therefore although there are variations in specific fertilizer consumption in different provinces from 1395 to 1399, the dry central provinces consumed generally more fertilizer per unit area of croplands. It seems that the farmers of these provinces have tried to compensate for the severe environmental conditions for crop production in these regions by aiding the crops with more chemical fertilizing.

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