Setting regional division of Shizuoka prefecture based on database of natural disasters

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Abstract: In order for effective damage prevention, it is necessary to have some idea of when, where, why and what kind of natural disasters may strike, and how large they may be. In this study, I made a database which can be use for GIS to facilitate multivariate analysis of presently available data for Shizuoka prefecture. This analysis can map out likely natural disaster locations and causes. Using the result of this analysis for GIS, a regional range of the disaster categorized by factors can be shown and analyzed visually and easily updated when a disaster occurs in the future.

Keywords: Natural disasters, Database, GIS, Multivariate analysis.

1. Introduction

Shizuoka prefecture of Japan, has a mild climate and a plentiful sunshine and precipitation. Beautiful forests in mountain areas, cultivations of green tea and mikan (a kind of orange) in plateau areas and cultivations of melon and strawberry in plain areas are dependent on this fortunate climate. On the other hand, it also has many breaks of natural disasters caused by typhoons, local severe rain, or approaching of cyclones. These influence lives of residents and industry in this prefecture. So in order for effective damage prevention, it is necessary to have some idea of when, where, why and what kind of natural disasters may strike, and how large they may be.

At present, we have books about weather disasters for Shizuoka prefecture published by Shizuoka Local Meteorological Observatory in 1980 and 1990. They have the best of information to help us to know actual situations about the weather disasters.

But these books have some problems. The first problem is the biggest, that all of the information is text data. Though the book has information for about last 100 years, we cannot put it practical use because this data is only in text format. Second problem is that it is published one time in 10 years. So we cannot get the latest information.

In this study, I made a database which can be used for GIS to put presently available data for Shizuoka prefecture to practical use. This analysis can map out likely natural disaster locations and causes. And the data can be easily updated when a disaster occurs in the future one by one. Furthermore I adopted multivariate analysis for this data to set the regional division based on the weather disasters and their factors. There are some former studies in meteorology that adopted multivariate analysis but no former studies about the case of disasters. Using the result of this analysis for GIS, a regional range of the disaster categorized by factors can be shown and analyzed visually. The characteristic of this study is to have made a database of information about weather disasters that have been studied before and to have analyzed this data to set the regional division.

2. About Shizuoka prefecture

1) The terrain

Shizuoka prefecture is located between 34degrees 30minutes to 35degrees 30minutes N. latitude and 137degrees 30minutes to 139degrees 30minutes E. longitude, in almost center of Japan on the Pacific coast. It has 7,779km2 in area.

To the north, it has the Akaishi Mountains, and the elevation is more than 3,000m. And it also has Kiso Mountains and Hida Mountains in the further north part and Mt. Fuji and Mt. Hakone in the northeast.

To the west, there are Makinohara Plateau and Iwata Plateau, with evaluations at about 200m, there are a coastal dune facing Ensyu Bay and Hamanako Lake, which borders Aichi prefecture. The Fuji River, Abe River, Ohi River and Tenryu River start from Akaishi Mountains are vital rivers that flow rapidly, and form alluvial plains in the lower reaches of them.

To the southeast, Izu Peninsula is located beyond Suruga Bay, with the Amagi Mountains. The evaluation is about 1,400m along the center of the peninsula. Its coastline forms cliff.

2) The climatic stations

In Shizuoka prefecture, there are 33 climatic stations,

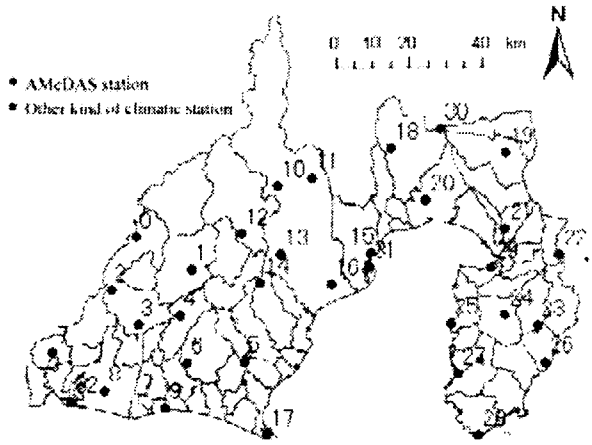

Fig. 1. 33 climatic stations in Shizuoka pref.

29 AMeDAS[1] stations and 4 other kinds of stations. Their locations are showed as Fig.1

3. Data and method

1) Construction of database

In this study, I constructed a database with the data offered by Japan Meteorological Agency, named *Shizuokaken kisho saigai houkoku*. This data is gathered only for Shizuoka prefecture from the information of weather disaster in Japan. I used data ranging from January 1990 to July 2003. I put values following the headings based on the data. This database has the number of times of weather observation when a weather disaster occurred and observed value of precipitation or temperature etc. at each climate stations.

2) Method of describing with GIS

I mainly used ArcMap, a part of ArcGIS made by ESRI, as GIS software in this study. This is the main application of ArcGIS, it is used for works with maps such as making, analyzing, or editing them. Using its function which makes maps with adding the data of x,y coordinates, I put the constructed database on GIS.

The added data is described as the symbolized forms. On the maps, we can represent values with changing their color or size used for drawing futures. So we can describe or analyze value data of a constructed database.

4. Appearance of disaster distribution for each factor

With the method mentioned above, here is a part of conclusion maps, Fig. 2-1– Fig. 2-4. On these maps, the totals of observed values are divided by the number of times weather disasters occurred and they are described for each climate stations where the values have been observed. When the data is symbolized, it is classified to 10 classes with equal intervals and the values of 0 are excluded. What these maps mention are written below.

[1] Automated Meteorological Data Acquisition System

Fig.2-1: This map represents that the precipitation value concerning to disasters whose factor is much rain, per one disaster. It mentions where disasters might be caused by much rain and its value. Around the climate stations of Amagisan, Ikawa and Umegashima, disasters are liable to be caused by much rain. The common point of the three is they are located on the southeast sides of slopes. This result corresponds with the climate characteristic of Shizuoka prefecture that is to have much rain on the southeast sides of mountains.

Fig.2-2: This map represents the precipitation value concerning disasters whose factor is lack of rain, per one disaster. It mentions where disasters might be caused by lack of rain and its value. Around the climate stations of Shizuoka, Hamamatsu, Mishima, Ajiro, Toi and Hukude, disasters are liable to be caused by lack of rain. Therefore it can be said that we are tend to have lack of rain in plains along the coast. Apart from the above stations, Omaezaki and Irozaki have a common point. It is that both of them locate at the southern end of land facing the sea. Judging from the synoptic weather appearance, it can be seen that the Pacific anticyclone and the topographical effect are related to that. Therefore, in this case, the factors are effected by the landforms and the locations of the two stations.

Fig.2-3: This map represents the temperature value concerning disasters whose factor is high temperature, per one disaster. It mentions where disasters might be caused by high temperature and its value. Around the climate stations of Hukude and Hamamatsu, disasters are liable to be caused by high temperature. In Hukude's case, because the record drought damage and intense heat damage occurred in from 24 June 2001 to 16 August 2003, the observed values of these disaster are represented in the map conspicuously. In Hamamatsu's case, because the record drought damage and intense heat damage occurred in from 1 June 1994 to 31 August 1994 and the same disaster as Hukude's case, the observed values of these disaster have an effect on the map's appearance. Therefore the drought damage and intense heat damage occurred in from 24 June 2001 to 16 August 2003 caused by lack of rain and high temperature for a long term represent an extremely big weather disaster in a 13 year period (January 1990 – July 2003).

Fig.2-4: This map represents the temperature value concerning disasters whose factor is low temperature, per one disaster. It mentions where disasters might be caused by low temperature and its value. Around the climate stations of Sakuuma, Honkawane, Ikawa and Gotemba, the disasters are liable to be caused by low temperature. The common point of these four is that the kind of

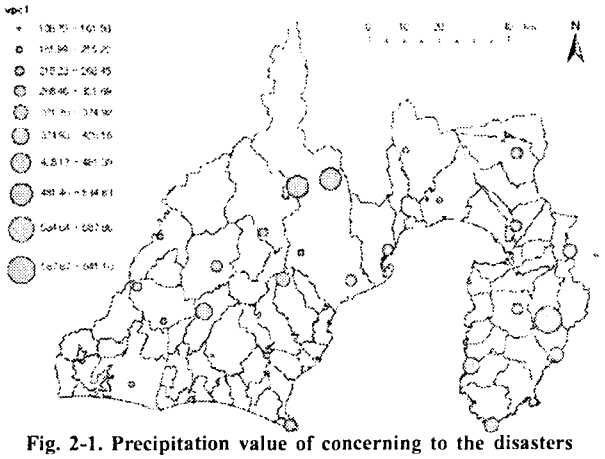

Fig. 2-1. Precipitation value of concerning to the disasters whose factor is much of rain, per one disaster (mm)

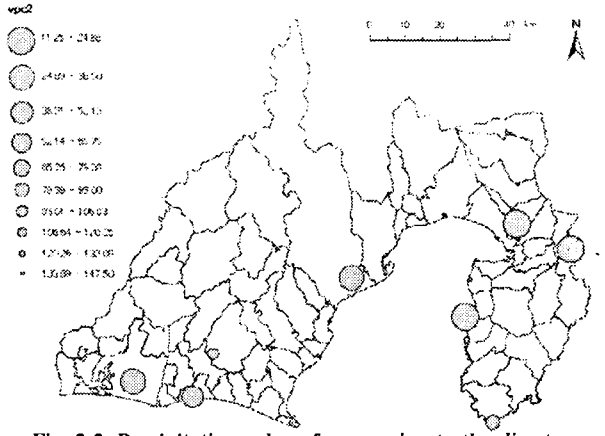

Fig. 2-2. Precipitation value of concerning to the disasters whose factor is lack of rain, per one disaster (mm).

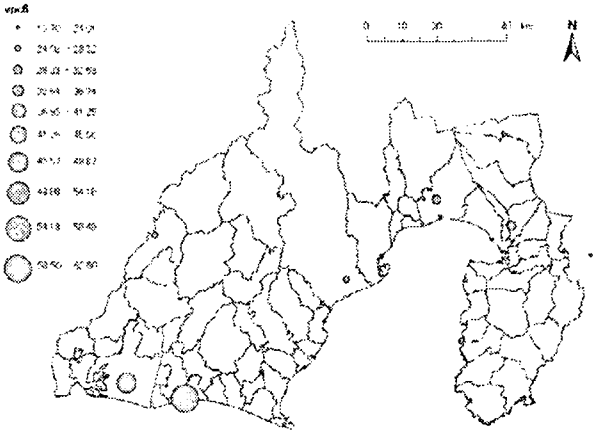

Fig. 2-3. Temperature value of concerning to the disasters whose factor is high temperature, per one disaster (degrees).

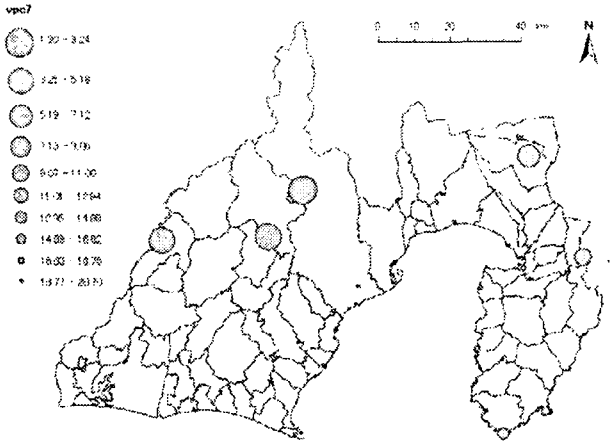

Fig. 2-4. Temperature value of concerning to the disasters whose factor is low temperature, per one disaster (degrees).

disasters is frost injury. These places are located on mountains in the north part of the prefecture which are areas having heavy snow and low temperature. I n these places we tend to have frost, which may be a factor of a disaster.

These maps mentioned above are a part of the result. I also have results concerning duration of sunshine, air pressure, wind force, amount of snow cover, wave height, tidal level and humidity.

5. Setting regional division

To set regional division in Shizuoka prefecture based on the data of the database constructed above, I adopted multivariate analysis. The method is consists of three steps. (1) I used principal component analysis to find outstanding patterns concerning the number of times occurred disasters on their each factor, and then I obtained their characteristic value. (2) With the similarity of the characteristic values, I did cluster analysis for grouping. (3) I set the regional division based on the result of cluster analysis and the value of evaluation with GIS.

I used the values of factor number I, II, and III based on the result of principal component analysis. The percent age of total variance of each factors are 68.3% (Factor I), 13.9% (Factor II), and 8.7% (Factor III), these explain more than 90% of the total variation. Then I obtained the factor loadings for each climate station for each factor. The factor loading mentions what kind of factor the disasters on each station are concerned with.

If there is a resemblance about the number of times disasters occurred per factor among some stations, there is also a resemblance about the factor loadings among them. Therefore I did cluster analysis for grouping with them in order to know what factor the disasters on each groups are concerned with. The process of organizing clusters can be shown as dendrogram and clusters hard to unite near its distance 0.014. In such a case, distributions are similar in each cluster but not similar among clusters. As the result five clusters on the distance 0.014 were adopted and added the grouping numbers each of them.

After that, I created thiessen polygons[2] by a series of

[2] Thiessen polygons are constructed by connecting a series of point locations with line segments, erecting perpendiculars to those line segments at their midpoints, and then extending those perpendiculars until they intersect.

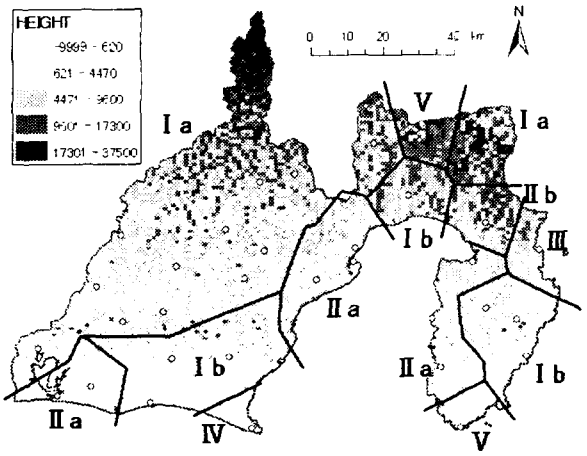

Fig. 3. Division of Shizuoka pref. into 7 types of region.

climate station points and did dissolve[3] for them based on their grouping numbers. With this method I could set the division based on the data objectively. And I added the evaluation layer to this map then set more the division judging from differences of evaluation. Here is the map with the regional division set by the method above, Fig. 3. The numbers I, II, III, IV, and V mean divisions set by multivariate analysis, and the alphabets a and b mean divisions set by it included judging from evaluation. The characteristics of each 7 clusters are mentioned below.

Ia: The area that is mainly located on mountains in the prefecture. Disasters are liable to be caused by much rain or low temperature. Especially in the high evaluation area disasters are also liable to be caused by heavy snow.

Ib: The area that is mainly located on plains in the prefecture. It can be said that weather disasters are few in this area.

IIa: The area that is mainly located on plains along the coast in the prefecture. Also the place which has high population. Disasters are liable to be caused by lack of rain but the area has the most disasters for any factor of all the areas in the prefecture.

IIb: The area around the Mishima climate station. Similar to the area IIa, disasters are liable to be caused by lack of rain but moreover by lack of duration of sunshine.

III: The area around the Ajiro climate station. Disasters are liable to be especially caused by lack of rain, low temperature, strong wind and continuation of days without rain. Judging from that, this area has a intermediate factor of Ia and IV.

IV: The area around the Omaezaki climate station. Because its landform is hanging out into the sea, disasters are liable to be caused by strong wind and continuation of days without raining.

V: the area around the Irozaki and Mt. Fuji climate stations. Concerned with the difference of evaluation, it can be said that there is no common point belonging to same cluster. But these two stations are united as a cluster at the former level on the dendrogram. It means they have common point that disasters are liable to be caused by strong wind because of the landform of Irozaki station which is hanging out into the sea and the high evaluation of Mt. Fuji station.

This result means that the 7 divisions, based on the number of times disasters occurred for each of their factors, are concerned with geographical factors like the mountain area, the plain area, and the coast area, and also with social factors like population.

6. Conclusions

In this study, I made a database which can be use d for GIS to put presently available data for Shizuo ka prefecture to practical use. It made it possible to analyze and show visually its data on maps. As the result, the areas where disasters are liable to occur by much rain corresponded with those that have rai n quite often. I divided the prefecture into 7 regions based on the result of multivariate analysis for this data and thiessen polygons by a series of climate st ations to this division. With this method I could set the division based on the data objectively. As a res ult, these 7 divisions are concerned with geographic al factors and also with social factors. How this res ult applies concretely to regional disaster measures i s open to further studying.

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[3] Dissolve is used when you want to aggregate features based on a specified attribute.