ESTABLISHMENT OF A GIS BASED DISASTER INFORMATION AND METEOROLOGICAL EARLY WARNING SYSTEMS IN RIZE PROVINCE OF TURKEY

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Abstract

The Rize province is located in the northeast of Turkey. The total annual rainfall in this region is about 2200 mm, which is quite greater than the average rainfall of Turkey. Therefore, this region is largely affected by flood and landslide disasters. In order to minimize the impact loss of property against the disasters that will affect Rize city and provincial area, a new system will be established using GIS, remote sensing and meteorological early warning systems. This project consists of four sub-study groups: establishment of disaster information system, remote sensing studies, installation of a meteorological early warning system and geological studies. With the realization of the study, a system which can be used for disaster management, loss estimation, planning and application of emergency response has been established. Also a decision-support system functioning for governmental and local authorities will be ready. The first proposal of the project was prepared and submitted to the Scientific & Technical Research Council of Turkey in the beginning of 2006 and was funded in the beginning of 2007 after a long evaluation by the Council. This paper will give an overview of the scopes of the project and works carried out.[1]

Introduction

The fast and efficient accessibility to the data belonging to the hazardous regions is very important in order to be prepared to and able to mitigate the damage before the disaster happens and be able to organize the response and recovery phases after and during the disaster. In this aspect disaster management plays an important role to overcome the adversities of all kinds of disasters (www.fema.gov, Waugh 2000). Therefore, there have been various methods used by the decision makers to coordinate the disaster dependent life. In the past few years a relative new technology "Geographic Information Systems" shortly referred as GIS has come up as a new method to be used in disaster management (ESRI, 2001).

In this study a GIS based system is tried to be established in order to generate a disaster management system. The major inputs to this system are remote sensing images, meteorological data acquired from the Automated Weather Observation System and

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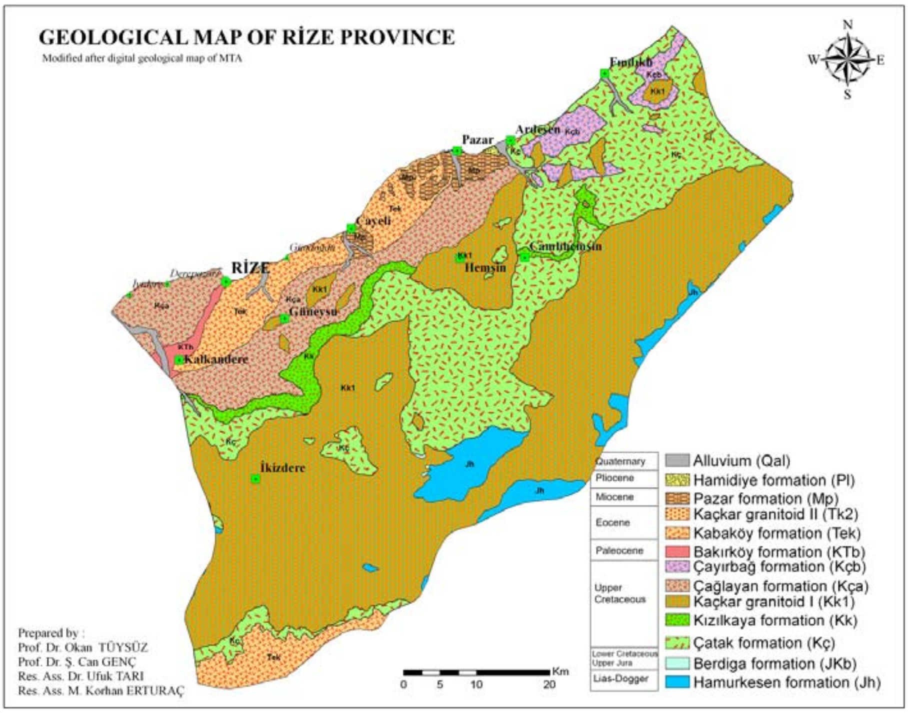
geological data. The realization of the project, will form a system which to be used in disaster management, loss estimation, organization of emergency response. Also a decision support system functioning for governmental and local authorities will be created. This system is going to be a standard model and also a prototype for Turkey. Project will also include the standards described in Turkey Disaster Information System (TABIS) catalogue which is first and unique in Turkey (TABIS Standards, September 2002; Karaman and Sahin, 2005). Besides, as this study requires a great amount of data to be collected from the governmental and local administrations and will establish a system depending on these data, the project will provide a standardized database for these administrations. On the other hand the services of these corporations will be more efficient and transparent in the relationship with citizens. The cooperation of the corporations will be easier, faster and more reliable. By this way the e-state project will be applied in a city basis for the first time in Turkey. In addition, this project can be assumed as a model for Turkey in the future. In means of technological development, the wireless communication systems will be used in a very different aspect as they will be used for early warning systems on a very rough terrain. So, such systems will be able to be established in other cities of Turkey benefiting from the experiences during the project.

Theory and Method

Rize is located on the southeast coasts of the Black-Sea between the 40°22' - 41°28' eastern longitudes and 40°20' - 41°20' northern latitudes. It is surrounded by Trabzon province in west, Artvin province in east, Erzurum province in south and Black-Sea in the north direction. The area of Rize is about 3920 km^2 and 78% of it is covered with mountains. In Rize three forms of morphologic structures are seen from north coast to south border (Fig 1). The coastal line in Rize is almost 80 km and the depth of the coastal band varies between 20-150 m. In this part, there can be seen some alluvium plains which are formed by the rivers flowing in the south-north direction and pouring to the Black-Sea.

Figure 1 - Geological Map of Rize



The second part is the mountain area split by the valleys. The height in this region increases sharply to 150-200 m. after the coastal band. Sharp and adjacent mountain shoulders create "V" profiled valleys that are almost 2000 m. high. The third part is defined as high mountain and glacier area. It starts from 2000 m. and rises till 3000 – 3200 m. high. The area above

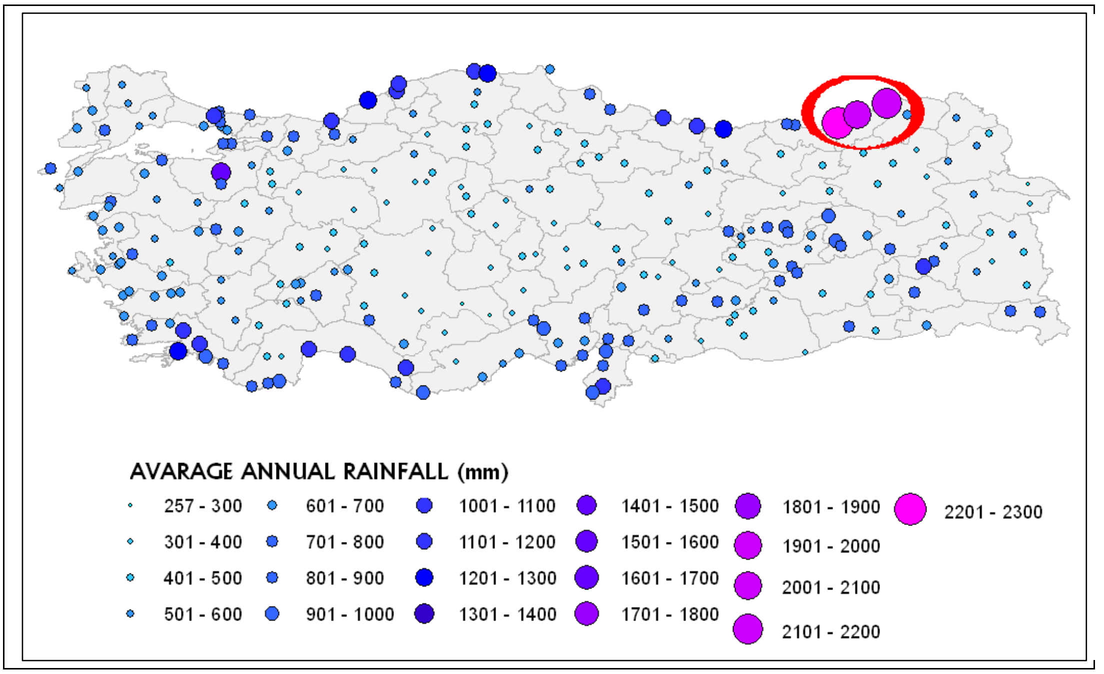
3000 m. is the roughest terrain that can be seen in Rize and usually formed of "U" type valleys. In geological means, Rize is located on East Black-Sea magma plate. The rivers in Rize are mostly short and have horizontal tendency. There are 23 rivers longer than 5 km. 16 of these rivers reach Black Sea while the others connect to these main rivers as arms. The rivers in Rize have regular regime and carry less sediment compared to other rivers in Turkey (www.rize.gov.tr).

It is possible to mention that Rize province is affected from two main types of disasters which can be categorized as geological disasters and meteorological disasters.

Earthquake is the main natural disaster in Turkey. On the contrary Rize is one of the luckiest cities in Turkey. According to the geological data, there are no active faults that can cause a destructive earthquake in Rize. The closest fault to Rize is the North Anatolian Fault and it is quite far from the city. According to the records the biggest earthquake this fault created had the force of 7.9 Mw. Although such earthquakes are not taken into account in means of creating a big damage in Rize, it is known that they can trigger landslide and rock falls.

The most destructive disasters occurred in Rize province are landslide and flood. Landslides can happen when the ground substance loses its stability and slides in the suitable geologic and meteorological conditions. The high slope values in Rize province causes these slides very often. This type of morphology makes it more possible to generate a landslide. On the other hand the most important factor is the rainfall. Rain makes the ground much more unstable than usual and triggers the landslide. The other disaster, flood is also mainly dependent on the meteorological effects but it is also affected by geological and geomorphologic parameters. Impervious soil structure, large feeding area, narrow discharge section and the amount of carried sediment are important factors in floods. Taking into account that Rize has very high rainfall values (Fig 2) and sharp geography, these disasters are the most hazardous ones affecting Rize.

Figure 2 – Annual Rainfall Values in Turkey (mm)



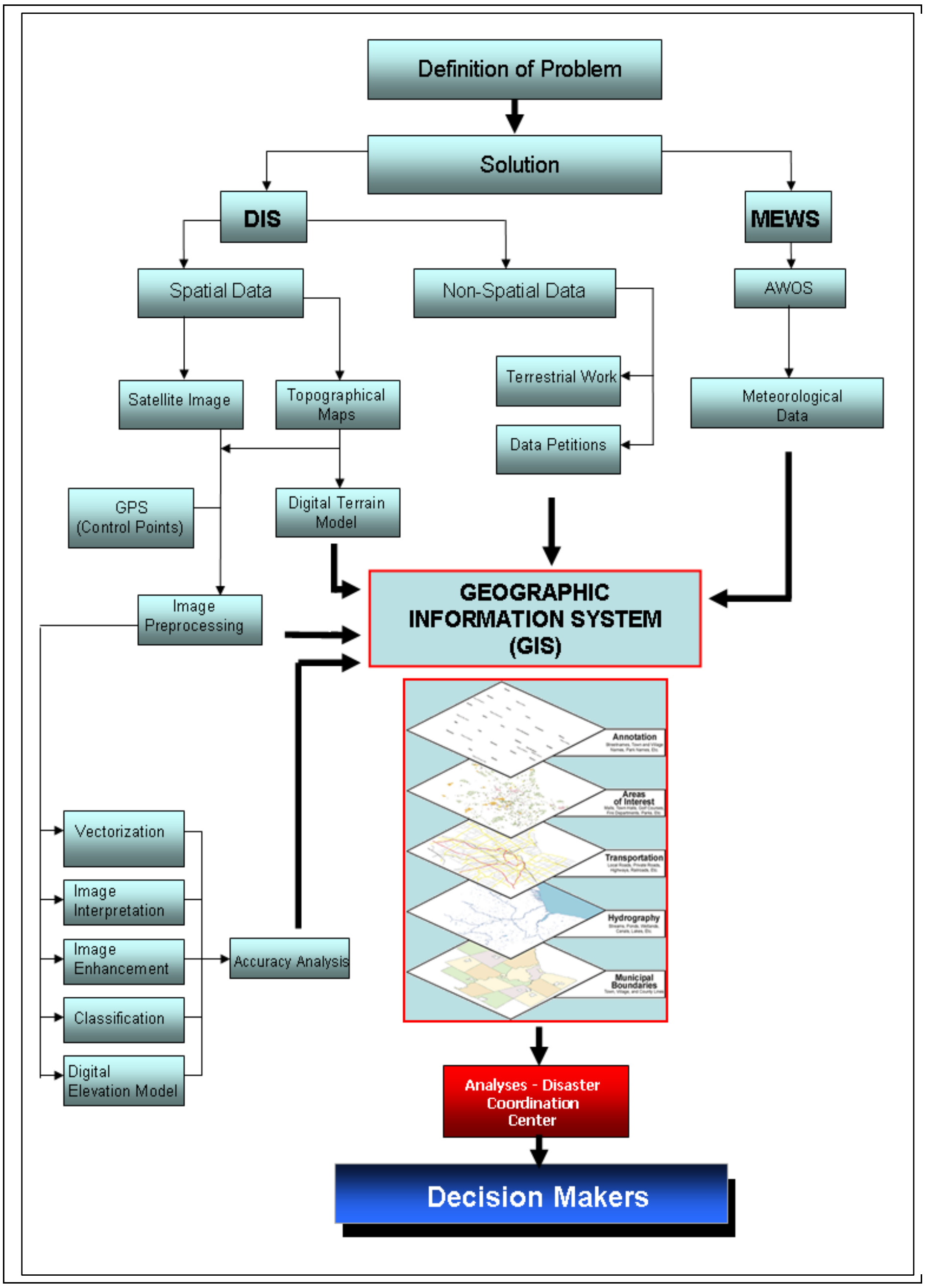
In this study it has been planned to create a system especially using GIS, Remote Sensing Techniques and Meteorological Techniques, to lower the loss of human life and physical losses which occur as results of natural disasters.

The aim of this project has been, using the methods mentioned above, to apply a GIS based information and administration system model to serve for planning and applying of the emergency preparations, disaster management, loss estimation and decision support for local authorities.

Method

Although there are various and many stages in the project process, the project can be considered in two main parts (Table -1).

Figure 3 - General Work Flow of the RABIS Project



In this sense, a Disaster Coordination Center (AKOM) will be established and this center will be coordination station of the system. The two parts of the project are as below:

1. Establishment of disaster information system (DIS)
2. Establishment of meteorological early warning system (MEWS)

Disaster Information System is playing a role as the core of the structure. It is a GIS based system and the emergency management will be based on the data recorded in it. Two types of data are (spatial and non-spatial) used. Spatial data are gathered from the administrative units which are topographic maps and city plans. The remaining spatial data are obtained by benefiting from remote sensing technique and hence satellite images have been used. These images are used for creating the actual and most recent state of the city and landscape. After digitization of these images, there has been organized a fieldwork to obtain attribute data (non-spatial data). The database has been designed based on TABIS catalogue and therefore the data collected during fieldwork has been acquired depending on the rules of the catalogue. As a result system includes all of the needs of an emergency management process.

The most important part of the MEWS is its database which includes:

1. Vegetation data with high resolution
2. Ground soil type with high resolution
3. Precipitation and temperature data recorded in various points for a long period
4. Soil moisture measured in different points and at different depths for long period
5. The flow data of the rivers

In addition to these data each landslide will be recorded to database with the location and date that the event occurred. Just like landslides, flood events will also be recorded in database in the same manner. The automated weather observing system (AWOS) stations have been established to record the meteorological data in selected regions. Furthermore, estimations will be made intended to flood and landslide events. In this aspect both dynamic and static stochastic modeling techniques have been used. In order to do that a mezzo scale atmosphere model has been used. The model was chosen as MM5 model which is also widespread in many countries around the world. Once the model starts to process, low resolution data gathered from European Center for Medium Range Forecasts (ECMWF) has been benefited to generate high resolution weather forecast data for Rize province. Afterwards these data are being evaluated with the data in database and landslide and flood forecasts are made. The database needed in this system is integrated with the DIS. This integration makes it possible to forecast the landslide flood events.

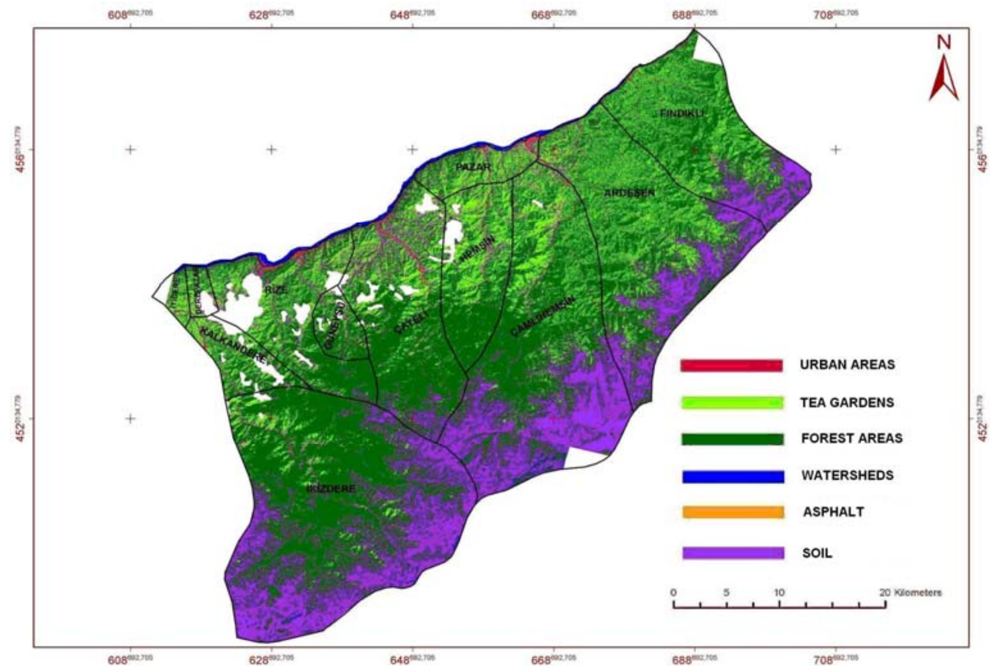
Results

RABIS Project started at the beginning of 2006 and finished at the end of 2008. As mentioned above there have been some goals that have been expected from the responsible corporations. There are four sub-study groups which are DIS& Software (NetCAD) workgroup, Remote Sensing workgroup, Geology workgroup, Meteorology workgroup. Although the groups worked in coordination between each other, all had different aspects and aims during the project.

Establishment of DIS can be divided into several work packages. These packages can be mentioned as software development, providing hardware, attribute data acquisition. Firstly hardware was provided since the system was going to work on this infrastructure. In this aspect, hardware system in Rize Governorship and Municipality have been improved and updated. So these corporations have obtained a very efficient hardware system which makes it possible to operate rapidly. While some of the responsibles were working on that, some others had already started to develop the software which was later going to be used as emergency management software. In means of software development, the company that is co-worked with during the project (ULUSAL CAD ve GIS A.Ş.) updated their own software Netcad in a way to operate based on emergency management needs. In order to serve for the governorship and municipality, there has been a developed web portal for each unit. Hence they can perform the administrative works through these portals which have increased the efficiency and made coordination easier. The portals can be reached from www.rabisportal.com. In addition the web site serves for the people living in the city as presenting the address information, meteorological information and hazard risk information. One of the most important part of the system used there is that database is constituted based on TABIS catalogue. Therefore a national standard is applied in this structure. Another important point that DIS workgroup is responsible for is the attribute data acquisition. Firstly there has been made correspondence with municipalities and governorship to gather the data that they already have. After the receipt of these data the remaining data has been provided by a fieldwork. The fieldwork was organized and by using outsourcing, the fieldwork has been carried out. The fieldwork took 4.5 months, almost 60 people worked on it and data of Rize province are collected from the biggest urban areas to the least developed country regions.

Remote Sensing workgroup is mainly responsible of gathering, analyzing, evaluating the satellite images and forming meaningful geodetic based images of Rize province from them. In this sense, workgroup used the geodetic survey results for geometric transformation. After that the mosaics were constructed but because of the time difference between the acquisition dates, there occurred some contrast variances. This problem was overcome by using image enhancement techniques. The distributions on the images and the object properties are taken into account so that the multi-spectral and panchromatic images could be evaluated together. During the evaluation, images were integrated with digital terrain model and analyses depending on heights could be carried out. Lastly the classification process was done in two ways: unsupervised using ISODATA algorithms and supervised. In supervised classification, 6 classes were obtained consisting of water, urban, asphalt roads, tea fields, forest areas, soil areas and blank areas (Fig 3). During this whole remote sensing process, IKONOS and SPOT images were used.

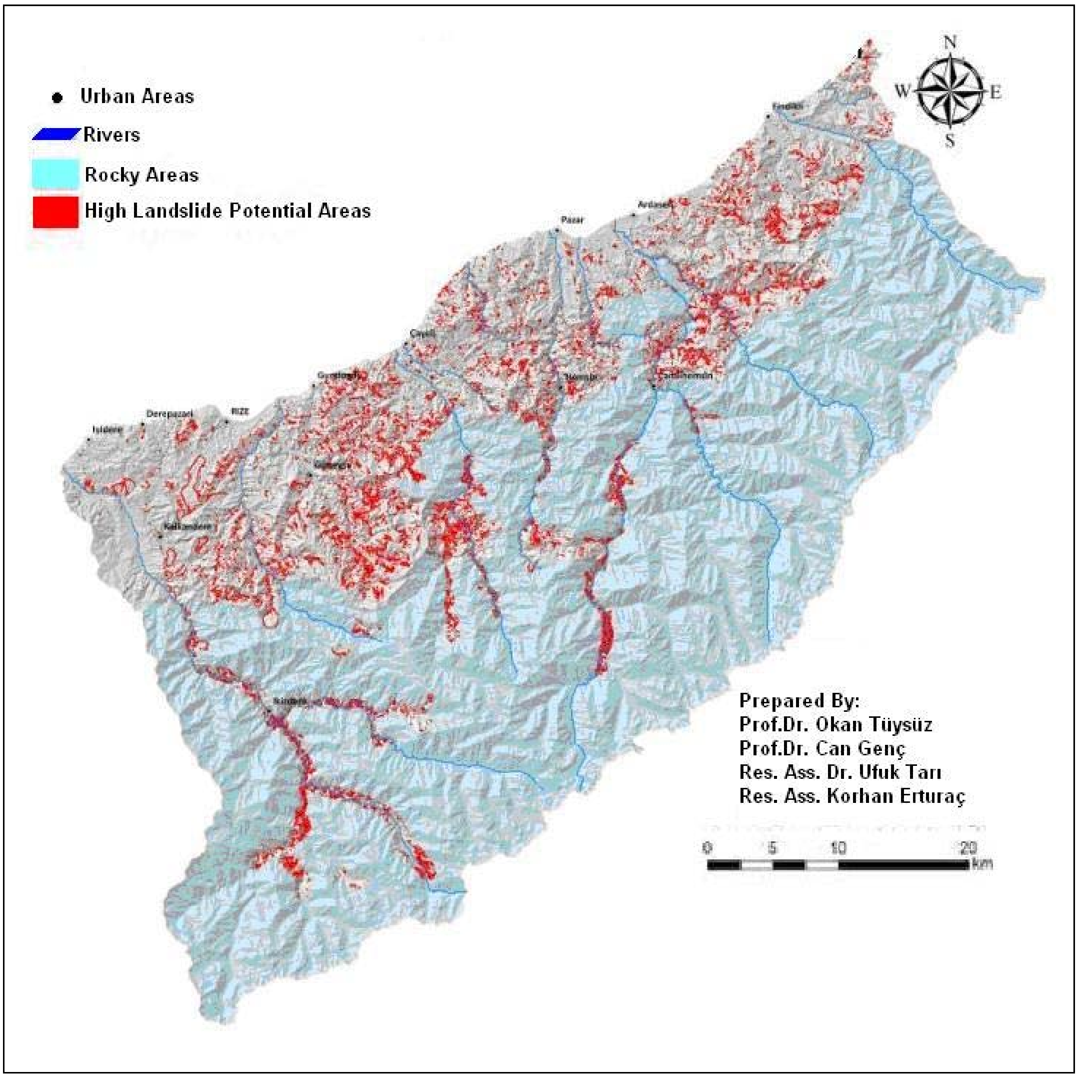
Figure 4 - Supervised Classification



One of the major problems for this group was gathering the satellite images. In the project proposal it was aimed to obtain QUICKBIRD images but because of some bureaucratic processes the images could not be obtained. Instead of these images, IKONOS images were gathered and used. In September 2008 newly acquired IKONOS images covering city center have been bought and they were digitized for the system. After that the most actual and updated spatial data of Rize had been gathered.

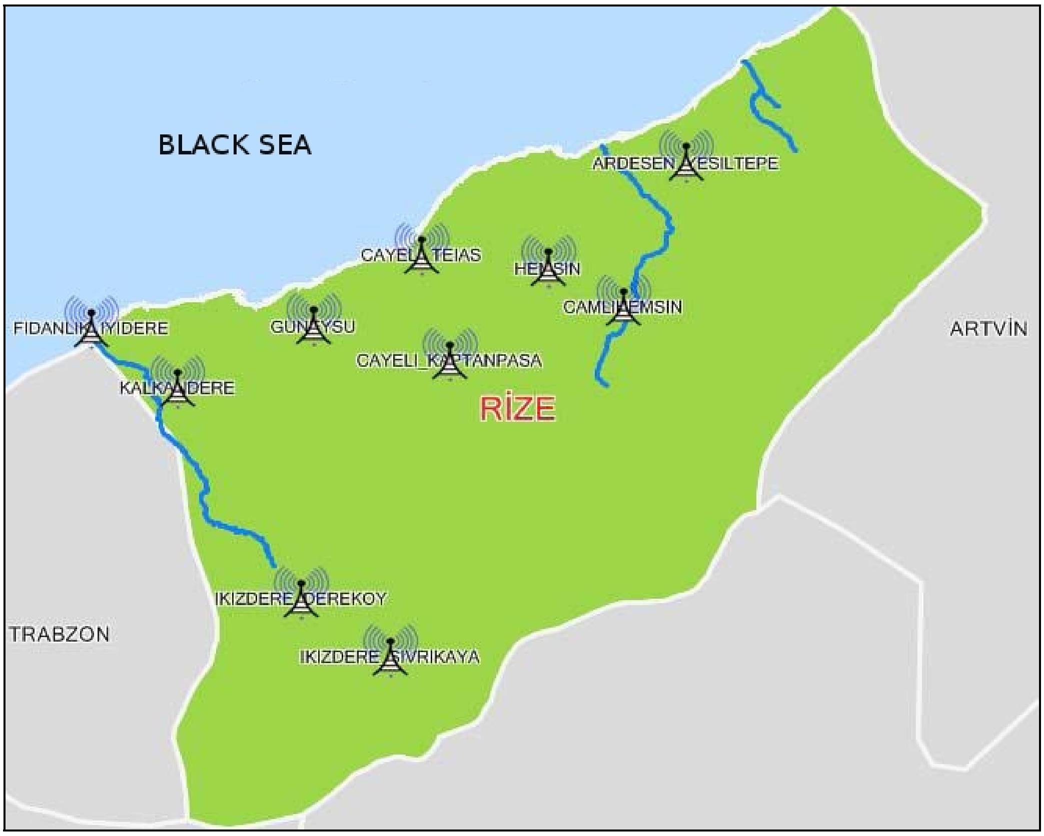
Geology workgroup has been generally responsible of making geology map, digital elevation model, geomorphology map and landslide map of the Rize province. Through the period, digital geology map and soil thickness map with 1/25000 scale, were formed. In order to create these maps various reproduction processes and geophysical methods were applied. Besides, 3D Digital Elevation Model and 1/25000 scaled slope and aspect maps of Rize were made. Geomorphology maps were produced in 1/25000 scale and digital elevation model was analyzed in means of geomorphology. Lastly benefiting from all these maps and data, SHALSTAB method is used and the geologically analyzed landslide hazard map was constituted (Fig 4).

Figure 5 - Landslide Hazard Map of Rize



Meteorology workgroup is totally focused on constituting the MEWS. In this aspect studies have been carried out in order to test the compatibility of the system to the Rize terrain. Thus some field work have been carried out in selected points whether they are suitable (electricity availability, GSM availability, meteorological representation capacity) for the automated systems to operate there. After that the bid for the AWOS stations had been made and after two months gathering and establishment of the stations were made (Fig6). The stations measure wind direction and speed, weather temperature, moisture, rainfall, pressure, soil moisture. Mezzo scale atmosphere model (MM5) is selected for meteorological model which

Figure 6 - AWOS Locations



is also used by State Meteorological Administration. So the integration of the stations to the national station network will be very easy. The most important task of the workgroup has been the integration of landslide hazard analysis (made by geology workgroup) with the meteorological model. In this aspect an algorithm is developed and with the collaboration of the software company (ULUSAL) the threshold rainfall value that triggers a landslide is estimated. As a result a system is developed which sends warning messages to decision makers when the rainfall threshold value is passed in the most hazardous landslide zones.

Discussion

As a result, the project is finished with satisfactory results. As mentioned, the main aim of the project has been to create a GIS based disaster management system for Rize province. For doing this, a multidisciplinary work has been carried out. These disciplines have mainly been geomatics, geology, and meteorology and software development. The system is basically focused on disaster management but it will also serve as an urban-land information system. Governorship and municipality will be able to use the system for data sharing. It is planned to increase the cooperation and coordination between these state units and so the quality of the service made to the community. As mentioned several times the disaster management is the core aspect of the system. All of the studies have resulted as an efficient tool which makes decision makers aware of the risks. After the integration of geologically analyzed landslide model and meteorological model, the system is capable of determining the risk including zones. If the rainfall threshold value is passed the warning massages are sent to authorities. An SMS and an e-mail are sent and SMS includes a message which warns the decision maker to check his/her e-mail in which the risk including zones is presented. Based on the warning messages the decision maker can decide better and efficiently to act against the hazards.

Although the system operates efficiently, naturally there can be made some improvements in the future. Firstly the representation of the climate structure of the province can be made better with the updates on meteorological model. To improve the model there has to be made some observations and validation. The landslide events have to be recorded and the coefficients of the model must be changed based on these data. Since there have been no archive data that can be examined, it was not possible to verify the model with previous landslide data. So it is now a very important task for the responsible personnel to work on this and follow the actual landslide events. After that models can be improved by the academics and to a system with higher accuracy can be reached.

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Author Biography

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He is born in 10.11.1965 in Rize province of Turkey. He has been the head of Surveying Techniques Department since September 2004. He has accomplished HAZTURK project and RABIS projects. He has still been carrying out ISTABIS project. His primary profession is GIS based disaster management and loss estimation models. Recently he is working as the rector of Istanbul Technical Universty for 8 months. More information can be found in http://atlas.cc.itu.edu.tr/~sahin/muhammed_sahin.html.