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Space Technology as the Tool in Climate Change Monitoring System

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1.Introduction

Today the climate change as an important issue is discussed widely around the world. Many scientists relate global warming and its consequences to human activities and not to natural fluctuations. The reasoning of this approach is the time scale of climate change.

Recent warming of the earth is considered to be abrupt compared to the time scale usually accompanied with natural climate change episodes. As obvious the Earth's natural climate changes happen gradually in a long period of time (tens of thousands to millions of years) but we are witnessing an abrupt change over the past 200 years. The main reason is the industrial revolution with fossil fuels as its main source of energy which is setting a steady emission increase of Carbon dioxide and other greenhouse gases which trap heat causing an increase of temperature in the lower atmosphere. Climate change is recognized as the significant aspect for investigation and international communities through the United Nations created special groups to focus on climate change effects and initiated protocols to organize a global response to deal with its consequences. Unusually behaviors of the strong tropical storms, heavy precipitations causing a devastating floods, more frequent heat waves, frequents drought and other similar natural events are connected to a modern climate change. The UN Secretary - General Ban Ki-moon, refer to climate change as the "defining issue of our era". This calls, among others, for implementation of commitment to stabilize greenhouse emissions and furnish a report about the current status of climate change to the UN Framework Convention on Climate Change (UNFCCC) on the status of greenhouse gases and climate change impacts and mitigation.

Climate change problem has a global scale which must be addressed with global models and global data are needed as input to these models. Currently there are sufficient space data sources with different spatial resolution which successfully implementing and applying for climate change monitoring and study purposes. Earth Observation from Space has a unique capacity to provide such global data sets in a continuous way. However the Earth Observation from Space also provides data on national and local scales which can successfully support in an implementation of the convention and protocol and encourage

the Parties in their reporting duties. Currently some of countries develops and operates Earth Observation satellites which are monitoring the environment of the Earth.

For the successful climate change monitoring is required to be identified necessary indicators needed to be monitored. The vegetation indices, fire location, timing and area affected as well as additional information on the vegetation growth cycle (timing, duration, spatial and temporal variability) are being estimated globally within the GlobCarbon project implementing for the purpose of climate change.

In the meantime the greenhouse gases and aerosols are the primary agents in forcing climate change; continuous observations that are spatially and temporally homogeneous are therefore required.

Currently global climate change is recognized as one of the most urgent and crucial issues for humankind's sustainable future. In this regard application space technology is playing an important role as a key source of critical data because of its global monitoring capability. At the same time space is expected to be contributed much more extensively from various points of view in the future.

Space technologies have led to a number of inventions that benefit the environment and save energy. Satellite - based systems are reducing vehicles carbon dioxide emissions, remote sensing technology is making wind turbines more efficient and information from weather satellites is helping solar cells to produce more energy. These are just some examples of how spin - offs from space technology and satellite services can make a difference.

Undoubtedly climate change can occur over longer periods of time such as centuries and millennia or rapidly over decades. Monitoring of climatic parameters during past decades has revealed significant changes in the Earth climate. For example, sea levels increased by 0.1 to 0.2 m during the 20th century, global average temperature increased between 0.4 and 0.8°C during the last decade. The decadal precipitation increase was observed in the Northern Hemisphere and salinity anomalies have been detected in the North Atlantic Ocean. Recently there has been growing concern among scientists with respect to the possible role or influence of human activities in changing the Earth's climate.

It is necessary to use most effective technology and methods for climate change investigations in order to get advantage on analyzing and evaluation of the huge of different data sources. There are number of methods and technologies are used for climate change studies. For instance most LiDAR (Light Detection and Ranging) applications focus on remote sensing of the atmosphere and Earth surface but several oceans - related parameters allowing the calculation of the mass - balance of ice sheets can also be measured. Radar altimetry data assist both in deriving dynamic sea surface topography, including large - scale ocean currents and eddies (to within a few centimeters accuracy) and in inferring sea surface wind speeds and significant wave heights. Gravity sensors improve the physical model of the Earth used for ocean current modeling, ice sheet thickness analysis and geodynamic studies. Synthetic Aperture Radar (SAR) is used to detect the snow and ice properties, ice melting and ice type. Interferometric SAR data provides information about the flow and movements of sea ice. Wind speed is deducted from the ocean surface by measuring wave patterns. Microwave scatterometers measure the two-dimensional velocity vectors of near - surface sea winds. The design concept of this study involves continuous, space - based, ice and salinity monitoring capability by three proposed remote sensing payloads on a near polar inclination platform:

i.   L - band radiometer for measuring sea surface salinity,

ii. LiDAR for high resolution ice topography, and

iii. Advanced Synthetic Aperture Radar for all - weather monitoring of ice topography.

Today is possible the use of a new technologies such as formations of a small satellites with single payloads for combining the data from LiDAR and SAR instruments as an another alternative. For example, LiDAR high - resolution capabilities could be combined with SAR all - weather capability on a single satellite platform although this would result in a relatively large and heavy platform. Based on this methods of remote sensing are successfully using for different areas of climate changes investigations. It is collection of data, analyzing and processing for the aim of problem solving.

At the same time climate change is a geographic problem and we assure solving it takes a geographic solution. Geographical information system (GIS) has a long history of driving environmental understanding and decision making. Policymakers, planners, scientists, and many others worldwide rely on GIS for data management and scientific analysis. GIS users represent a vast reservoir of knowledge, expertise and best practices in applying this cornerstone technology to climate science, carbon management, renewable energy, sustainability and disaster management and other wide areas of human life and industry.

Scientists for years have been using sophisticated computer models such as general circulation, atmosphere - ocean interaction and radiative convective process models in an attempt to visualise the future of the Earth's climate. The output of a particular model can be enlightening but combining data from multiple sources both past and future, gives us the best chance for a comprehensive and accurate vision of what the future holds and expectations for our planet.

It is required to clarify that how our dynamic climate may change in the coming decades and centuries. For this reason we have to understand and undertake the following aspects:

•   the Earth temperature, atmospheric pressure and other required parameters definitions;

•   the stress human populations impact on the planet contributing to climate change;

•   potential factors can significantly contributing our ability to thrive and survive as a species;

•   additional type of environmental monitoring doing today to improve climate change in the future.

It is obvious that there is just one way through careful observation of data, application of scientific principals and using the advance technologies give the hope and opportunities of truly understanding the stressors and impacts on Earth's climate change variations.

2. Advances of space technologies and methods – remote sensing and geographic information system

Undoubtedly two general types of data are useful in studying climate change: past observations and future predictions. Examining and cross - referencing past and future data can help us identify changes already occurring, as well as help us predict patterns and trends that could impact our long - term fate.

Careful observation and analysis of past records might help us answer questions such as: Are recent weather phenomena a short - term blip or a long - term trend? What past climate changes are due to the Earth's natural cycle versus what changes may have been caused by volcanic eruption, meteorite impact, or other cataclysmic disasters?

The key to understanding our dynamic climate is creating a framework to take many different pieces of past and future data from a variety of sources and merge them together in

a single system. Information technology brings together data from these many different sources into a common computer database. A geographic information system (GIS) is a sophisticated technology tool used by planners, engineers and scientists to display and analyze all forms of location - referenced data including meteorological information merged into coordinate system. GIS creates a new framework for studying global climate change by allowing users to inventory and display large, complex spatial data sets. They can also analyze the potential interplay between various factors, getting us closer to a true understanding of how our dynamic climate may change in the coming decades and centuries.

One of the important issues is the Earth getting hotter or colder? Is the stress human populations are putting on the planet contributing to climate change? What potential factors may significantly impact our ability to thrive and survive as a species? What additional sorts of environmental monitoring can we be doing today to improve climate change tomorrow? Only through careful observation of the data, application of scientific principals and by using the latest and advance technology do we have any hope of truly understanding the stressors and impacts on the incredibly complex system of Earth's climate.

It is important to identify a suitable indicator or indicators with significant impact influence on climate change. It can be create a good environment for clear understanding of climate change reasons. The study of ocean and consequences of the changing some of parameters is a very useful instrument of climate change investigations.

Most organizations involved in studying climate change focus on observations and recommendations useful for long - term actions. New research programs should be initiated to improve the understanding of those aspects of the climate system that are thought to have participated in past abrupt changes and are likely to trigger such changes in the future (Alley et al. , 2003).

Due to the complexity of the processes involved in climate, numerical models are the primary tools for testing the hypotheses about Abrupt Climate Change (ACC). Current climate models range in complexity but the majority of them are complex, comprehensive, coupled models of the ocean and atmosphere. However, model complexity and reliability are often compromised by:

i.   the lack of sufficient appropriate old data for further compare and analyzing with existing data;
ii.   integration times, limited resolution and insufficient computing power;
iii. little understanding of several small - scale processes in the oceans and atmosphere and ;
iv.   the lack of paleoclimatic data for model validation.

Climate change is an issue that will increasingly require policy consideration but for which knowledge and information at the local or landscape scale is either lacking or largely inaccessible. It is necessary to explore the scope for reinterpreting climate impacts information and presenting it through GIS - based visualizations in a manner that might assist decision - making at the local level. Such initiatives are possible because improvements in computer technology and the availability of digital databases have made it practical to generate realistic landscape views and virtual environments in much easier (and cheaper) ways (Ervin and Hasbrouck , 2001; Appleton et al., 2002).

One of the priority of the monitoring system is also including a measurements of the vertical profiles of oxygen and CO_2 content in water, dissolved nutrients, or human induced tracers as they would assist in determining flow paths and identifying possible changes in circulation. Ocean surface temperature and salinity are important for understanding the

small - scale processes involved in ocean circulation. While global measurements of sea surface temperature are taken from several remote sensing satellites, ocean circulation science is lacking global surface salinity measurements.

The need for the following ocean - based paleoclimatic scientific goals has been identified, which includes and extends some recommendations from the Committee on Abrupt Climate Change (NAS, 2002):

i.   higher spatial and temporal resolution of paleoclimatic data;
ii. substantial and independent duplication of data for validation and reproducibility;
iii. generation of a high resolution, North Atlantic, marine record comparable with the Greenland ice records; and
iv. improved modeling simulations of past warm climates.

2.1 Monitoring systems based on satellites data

The development of models for accurate simulation of Abrupt Climate Change (ACC) is highly dependent on the collection of good - quality observational data used both for model initialization and validation.

Data acquired by passive microwave radiometers are used to infer the temperature of the sea surface, to delineate sea ice and to observe pollutants, oil spills and slicks. Proposed future satellite missions also aim at providing global sea surface salinity data.

Most LiDAR (Light Detection and Ranging) applications focus on remote sensing of the atmosphere and the Earth surface but several ocean - related parameters allowing the calculation of the mass - balance of ice sheets can also be measured. Radar altimetry data assist both in deriving dynamic sea surface topography including large - scale ocean currents and eddies (to within a few centimeters accuracy) and in inferring sea surface wind speeds and significant wave heights. Gravity sensors improve the physical model of the Earth used for ocean current modeling, ice sheet thickness analysis and geodynamic studies. Synthetic Aperture Radar (SAR) is used to detect the snow and ice properties, ice melting and ice type. Interferometric SAR data provide information about the flow and movements of sea ice. Wind speed is deducted from the ocean surface by measuring wave patterns.

2.2 Geographic information system functionality

It is identified that approximately about 80% of all available information has a spatial or geographic component. In other words, most information is tied to a place integrating into the coordinate system. So when making decisions about sitting new facilities, creating hiking trails, protecting wetlands, directing emergency response vehicles, designating historic neighborhoods or redrawing legislative districts, geography plays a significant role.

Geographic Information Systems (GIS) technology is a computer - based data collection, storage, and analysis tool that combines previously unrelated information into easily understood maps. But GIS is not limited only map development. A GIS can perform complicated analytical functions and then present the results visually as maps, tables or graphs, allowing decision - makers to virtually see the issues before them and then select the best course of action for problem solving.

Add the Internet and GIS offers a consistent and cost - effective means for the sharing and analysis of geographic data among government agencies, private industry, non - profit organizations, and the general public. Climate change is a geographic problem and it is obvious that it solving makes a necessary of a geographic solution.

GIS users represent a vast reservoir of knowledge, expertise and best practices in applying this cornerstone technology to the science of climate change and understanding its impact on natural and human systems.

A GIS - based framework helps us gain a scientific understanding of earth systems at a truly global scale and leads to more thoughtful, informed decision making:

- Deforestation analysis spurs successful reforestation programs and sustainable management.
- Study of potential sea level rise leads to adaptive engineering projects.
- Emissions assessment brings about research into alternative energy sources such as wind turbine sitting and residential solar rooftop programs.

GIS has the robust capacity and capability to design the building blocks for carbon accounting systems including data, models, and delivery systems. It provides the tools needed for analyzing environmental practices as well as developing and monitoring sustainable greenhouse gas reduction plans.

An attempt to use GIS technology (ArcGIS 9.2) to compare the present climate to the future is carried out using local meteorological data and output data from an advanced climate model. Surface temperature, precipitation, surface evaporation, surface wind speeds, and runoff will be studied to gain insight on the impacts of climate change on water resources of needed to be considered in the climate change investigations.

3. Space technology and climate change / natural disaster correlations

The gradual warming of the earth's atmosphere has become one of the main reasons of increasing a frequency and severity of climate - related disasters, such as drought, flooding, and catastrophic storms. The impacts of the climate change are reflected on ecosystems, forest and wetland conservation, water supply and sea level change etc.

An identification of the correlation between climate change and natural disaster is a highly important and key issue in point of view global warning prognosis.

The study of flooding as a very sensitive natural disaster to the climate change impacts is very interesting instrument which needed to be monitored for understanding of a huge of processes. In the meantime the use of advances in information systems, satellites imaging systems and improved software technologies open a wide opportunities for investigation of a very sensitive natural phenomena. The integration of this data provides a wide scale of analysis tools and information products on the base of developed geographical information system (GIS) created on application of space technology.

This presented research work has been dedicated for study of the river flood. During exploration of above indicated impacts of the natural disaster river flood has been carefully classified and analyzed. The outcomes of the conducted researches have shown a direct dependence and relation of the river flooding on climatic conditions based on the meteorological data for the indicated region selected for investigation.

The forecasting, mitigation and preparedness of the natural disaster impacts require relevant information regarding the disaster desirable in real time. In the meantime it is requiring the rapid and continuous data and information generation or gathering for possible prediction and monitoring of the natural disaster. Since disasters that cause huge social and economic disruptions normally affect large areas or territories and are linked to global change. The use of traditional and conventional methods for management of the natural disaster impact can not be effectively implemented for initial data collection with the

further processing. The space technology or remote sensing tools offer excellent possibilities of collecting vital data. The main reason is capability of this technology of collecting data at global and regional scales rapidly and repetitively. This is unchallenged advantage of the space methods and technology.

The satellite or remote sensing techniques can be used to monitor the current situation, the situation before based on the data in sight, as well as after disaster occurred. They can be used to provide baseline data against which future changes can be compared while the GIS techniques provide a suitable framework for integrating and analyzing the many types of data sources required for disaster monitoring.

Developed GIS is an excellent instrument for definition of the social impact status of the natural disaster which can be undertaken in the future database developments. This methodology is a good source for analysis and dynamic change studies of the natural disaster impacts.

Like in all other countries, rivers have different feeding sources in Azerbaijan. Most rivers are fed by snow, rainfalls and ground waters. Snow is the predominant feeding source for the rivers of the Major Caucasus, while ground waters contribute the most to water supply of rivers in the Minor Caucasus. The Kura and Araz rivers pass Azerbaijan in their lower and middle courses.

There is a highly important of implementation of the permanent monitoring of Kura River condition in any climate season where it is directly related to the issue of the economy of Azerbaijan. In the meantime the other significant issue is to safe the human life and those properties.

3.1 Methodology

The geographical area of interest is the Kura River basin in Saylan district of Azerbaijan (Figure 1). The area comprises approximately 24 km2. The Kura watershed is one of Azerbaijan's most important agricultural production areas. During the last 10 years, it was affected by 5 excessive floods, causing a lot of damage to people and goods. The one of major source of Azerbaijan freshwater is the Kura River.

For carrying out of the goals undertaken within the framework of the project execution the following methods have been used:

- The use of ALOS space imagery to be created the land use / land cover basic map for the investigated area using urban, agriculture, garden, scrub, open area, river, stream, canal, road, railroad basic classes;
- The use of Landsat ETM space imagery to be detected potential flood inundation areas within the Kura River watershed in the Salyan district of Azerbaijan using a tasseled cap transformation;
- The derive 1 m Digital Elevation Model (DEM) from contour lines and elevation points of the investigated area to be generated a deterministic model of potential inundated areas for the region using the DEM and a convex-areas surface;
- The evaluate the sensitivity of each approach to be characterized the flood inundations through statistical tests involving comparison of flooding areas extracted from an inventory of soils and a geomorphology maps.

The results presented in this chapter have been mainly based on the project carried out within the framework of the ProVention Consortium programme ("Research & Action Grants for Disaster Risk Reduction, 2007-2008") developed in association with the University of Wisconsin-Madison, Disaster Management Centre.
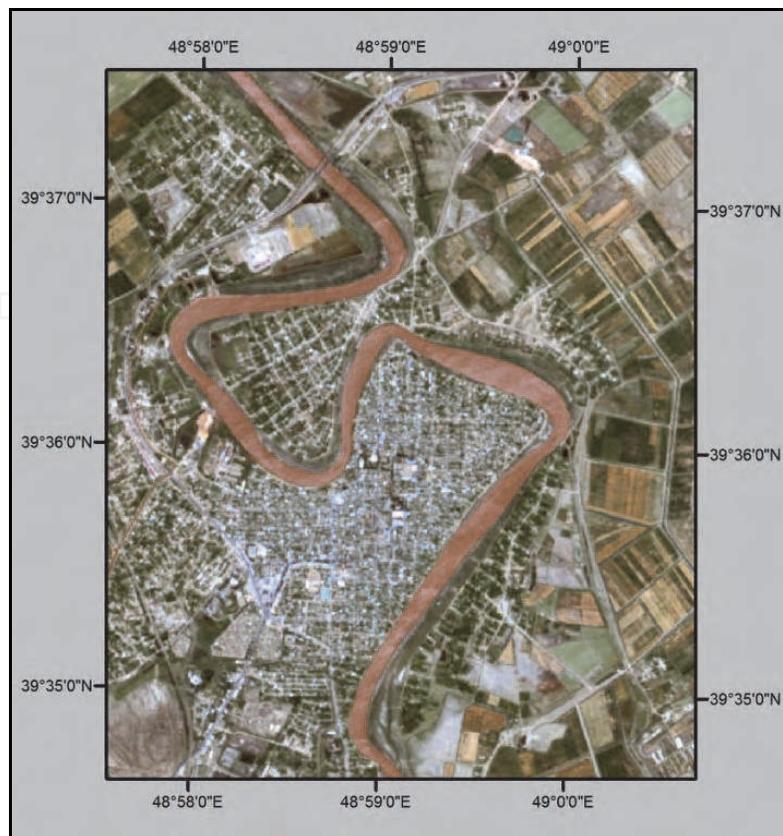
Fig. 1. ALOS imagery of the selected area

The results of the carried out project "Application of Remote Sensing and GIS Technology to Reduce Flood Risk" is concerned to the high technology application. It is important to note that the space technology, project development approach used for the project implementation are very useful issues which definitely will be find out a place in our future activities for the similar problem solving.

3.2 Potential flood inundation areas identification and mapping
3.2.1 Space image processing
ALOS imagery was acquired 10 June 2007 (Figure 1). The image was georeferenced to UTM zone 39 North, WGS84 using a first degree polynomial rectification algorithm with 30 ground control points (GCPs) extracted from a digitized topographic map at the scale of 1:100 000. The root mean square (RMS) error was equal to 0.5 pixel (5 m).
The image was classified between follow general classes (Figure 2):
1. Urban or Built-up Land
2. Agricultural Land
3. Garden
4. Scrub
5. Open area
6. River
7. Stream
8. Canal
9. Road
10. Railroad

One Landsat Enhanced Thematic Mapper (ETM) satellite image from June 2000 (path 167, row 32) was selected for analysis. The image was georeferenced to UTM zone 39 North, WGS84 using a first degree polynomial rectification algorithm with 25 ground control points (GCPs) extracted from a digitized topographic map at the scale of 1:100 000. The image pixels were resampled to 28.5 x 28.5 m using a nearest-neighbor interpolation method to preserve radiometric integrity. The root mean square (RMS) error obtained in the rectification process was less than 1 pixel (28.5 m).
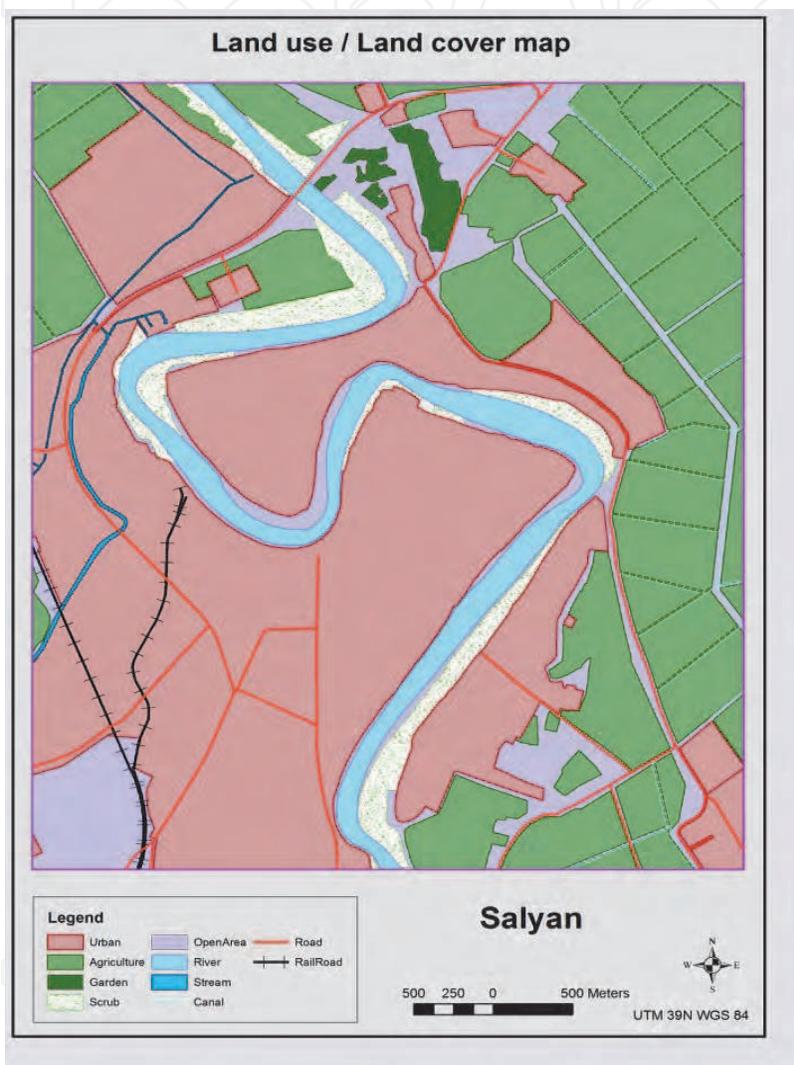
Fig. 2. Land use/Land cover map

3.2.2 Tasseled cap transformation

A tasseled cap transformation was applied to this image to optimize data viewing (Figure 3). The tasseled cap transformation offers three types of data structures axes that can be used to define vegetation information content (Crist and Kauth, 1986):

Brightness: a weighted sum of all bands defined in the direction of the principal; variation in soil reflectance.

Greenness: orthogonal to brightness, a contrast between the near-infrared and visible bands that strongly related to the amount of green vegetation in the scene.

Wetness: relates to canopy and soil moisture and effective to discriminate wet areas (Lilesand and Kiefer, 1987).

The tasseled cap algorithm using coefficients for ETM imagery are:

First Landsat-7 image was converted to at-satellite radiance using equation (1),

$$L_{sat} = \frac{L_{\max sat} - L_{\min sat}}{DN_{\max} - DN_{\min}} \cdot (DN - DN_{\min}) + L_{\min sat} \tag{1}$$

where,

$L_{\max sat}$ – is band-specific spectral radiance scaled to $DN_{\max}$,

$L_{\min sat}$ – is band-specific spectral radiance scaled to $DN_{\min}$,

$DN_{\max}$ – is maximum quantized calibrated digital number (255), and

$DN_{\min}$ – is minimum-quantized calibrated digital number (0 for LPGS data, 1 for NLAPS data).

Equation (1) accounts for gain state (i.e., high/low setting) by using the respective published LMIN/LMAX values (Landsat 7 Science Data User's Handbook).

After conversion to at-satellite radiance, the image was exposed to Tasseled Cap transformation. The Tasseled Cap operation (also known as Kauth's Tasseled Cap) computes the three Kauth biophysical indices (greenness, brightness, and wetness) from raster objects that contain the six spectral bands of ETM imagery: ETM1, ETM2, ETM3, ETM4, ETM5, ETM7. This spectral information is translated into values that represent a site's biophysical properties. The process produces three output raster objects that represent greenness, brightness, and wetness using a set of linear combinations of Landsat ETM spectral bands.
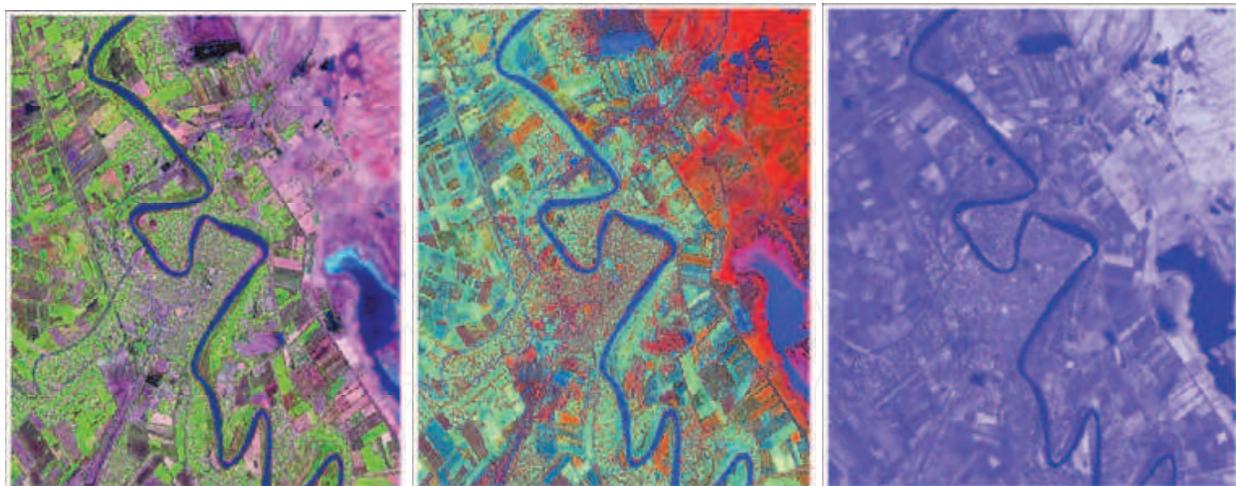
| RGB composite with bands 5,4,3 | RGB composite with layers brightness, greenness, and wetness | Pseudo color composite with wetness index |

Fig. 3. The original ETM image, the image applied the tasseled cap transformation, and the derived wetness layer.

Output is generated according to the following formulas:

Brightness = 0.3561(ETM1) + 0.3972(ETM2) + 0.3904 (ETM3) + 0.6966 (ETM4) + 0.2286 (ETM5) + 0.1596 (ETM7)

Greenness = -0.3344 (ETM1) - 0.3544 (ETM2) - 0.4556 (ETM3) + 0.6966 (ETM4) - 0.0242 (ETM5) - 0.2630 (ETM7)

Potential flood inundation areas determined by the wetness index of the tasseled cap transformation have been reflected in the Figure 4.
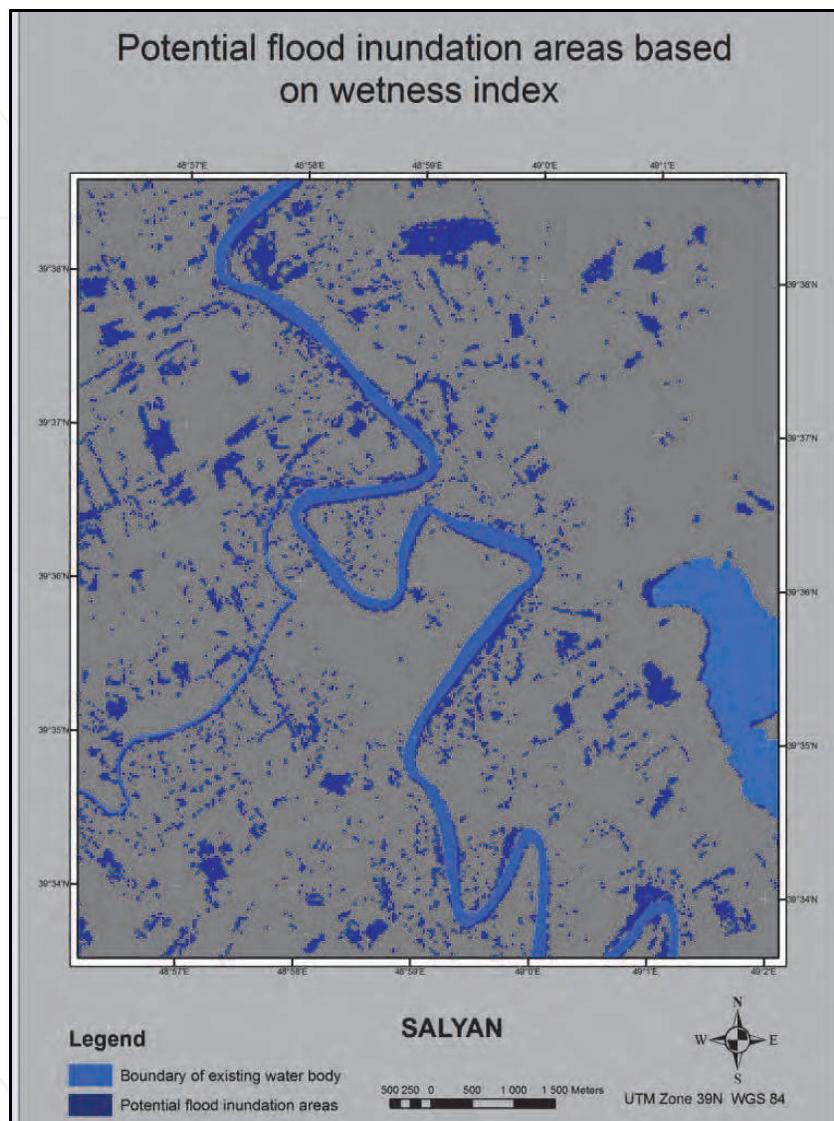

Fig. 4. Potential flood inundation areas based on wetness index

3.2.3 Digital Elevation Model development

The digital elevation model (DEM) was developed using the common method of digitizing of the contour lines and elevation points from topographic map (Figure 5). The digitized lines in shapefile format were converted to points in ArcGIS 9.2 using the "Feature to Point" transformation tools. The points were interpolated using the IDW – inverse distance weighting method.

GIS neighborhood operations make available to calculate the mean DEM. The selected potentially flooding areas where discovered of convex and fall of an elevation range between -26 m and – 21 m, which is approximately the elevation range corresponding to the lower alluvial plain. It is the generally affected when occurs of the severe flooding.
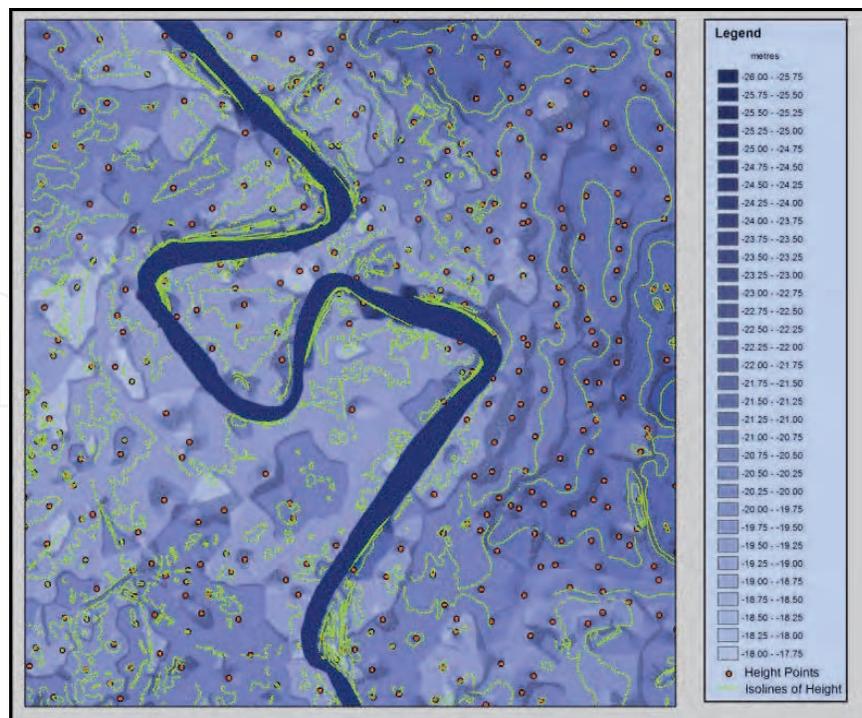
Fig. 5. Digital Elevation Model of the selected area with high points and isolines.

3.2.4 Potential flood inundation areas mapping

The study and identification of the potentially flood inundation areas in advance is a useful and important aspect of the natural disaster impact reduction.

For this reason the areas potentially flood inundation with a high probability of flooding has been developed and mapped. In this measurements and calculations the staring point has been undertaken as -26m.

The result reflects the potential flood inundation areas based on the height data supposed being as -22m. The result of data calculation and processing from DEM has been demonstrated in a Figure 6. RF indicated zones reflect potentially flood inundation areas in case of the river level will be increased up to 4m.

This methodology can be successfully applied for potentially flood inundation areas after implementation of geodetic measurements related to the river level for acceptance of the high accuracy data.

All processed information was compared with the meteorological data in order to find appropriate correlations between natural disaster particularly river flood and climate condition for the selected period. It has been confirmed that there is uncertainties for the climate phenomena which was not common for the area. For this period the river flood was observed with no expected impact. It assures that natural disaster impact can be used as a key instrument for the identification and correlation of the climate change.

3.2.5 Modification of the 3D model of the selected areas

3D model of the selected areas for the zones of Z5 and Z8 has been developed. The main reason of this development was the achievement of the more effective views of the selected areas. The result of this developments have been reflected in the Figure 7a and 7b.

For this modeling the vertical exaggerations have been identified 5 and 8 consequently for Z5 and Z8.

Fig. 6. Forecasting of the potentially flood inundation areas.

| a) For Z8. | b) For Z5 |

Fig. 7. 3D modified view of the selected area.

The main target has been undertaken to assist the local authorities to build useful database in disaster risk reduction in particularly for the selected area with a more sensitively part of country in point of view the river flood.

In the meantime has been demonstrated a contribution of the possibility and advantage of remote sensing methods and GIS technology use based on space image data collection and data processing for application of similarity problem solving.

Using the higher resolution of space imagery and change detection analysis natural disaster awareness and damage assessment can be conducted rapidly and accurately.

On the base of the developed database using the remote sensing methods and GIS technology there is resources and opportunities of prediction, reduction of natural risk due to the timely implementation of appropriate engineering and technological activities.

Based on those results as well as existed database for the river level change there is approach of study and identification of the dynamic change of the Kura river level. It is an advantage of development of GIS which can be play a significant place on river flood problem solution especially valuable and extremely important instrument for decision maker of the local authorities.

It has been correlated all above results with data reflected climate circumstances for the appropriate period of investigations and has been found relationships between river flood natural disaster and climatic parameters for the selected area.

The results of project presented in this paper have the following key findings:

- Space technologies are to develop of an advance tool for monitoring, data collection, data processing, review and report on progress and challenges in the implementation of disaster risk reduction and recovery actions undertaken at the national level.
- As a further step a wide scale of river monitoring is required for successful and effectively forecasting, preparedness and reduces of the natural disaster impact.
- Awareness information program of this hazard has to be developed and implemented in order to safe the human life, properties as well as to reduce disaster damage impacts.
- Potential flood inundation areas can by identified by satellite imagery and ground-based measurements.
- The mapping of potential flood areas can help for further settlement planning in this region.

All this indicated accepts have to be undertaken for further successful management in order to be able to reduce the effect of natural disaster on river flood. An appropriate sufficient with high accuracy database has to be developed for local authorities for decision making.

4. Regional approach of the global climate change problem

4.1 Objective

As it has been already identified the climate of the Earth system is a consequence of a complex interplay of external solar forcing and internal interactions among the atmosphere, the oceans, the land surface, biosphere and cryosphere. As far as obvious the human activities are increasingly recognized as a potential factor influencing the change in the global system by altering the chemical composition of the atmospheric concentrations of powerful greenhouse gases mainly such as CO_2 and CH_4 are predicted to lead to accelerated global climate change, a central environmental issues of concern to Governments around the World. Particular interests are the potential regional impacts of such changes on coastal areas, fresh water resources, food prediction systems and natural ecosystems.

Space based technology has advanced to a point that we are able to accurately observe and sense globally the entire Earth system and to understand Earth system processes that are central to Earth's climate. We need to document and understand an interrelations between Sun-Earth as an external forcing of the Earth's climate and also need to better understand the Earth's intricately linked internal processes such as the global water, energy and carbon

cycles. Space based platforms with their unique capacity to observe the Earth on global bases, complement surface based and in-situ measurements. Together with advances in computing and information systems technology, modern data assimilation techniques, diagnostic and prediction models, they provide a powerful combination of tools for understanding of the Earth system and applying the knowledge and tools to the management of natural resources and the mitigation of natural hazards.

4.2 Implementation

Use of the space science and technologies and applications offer and provide opportunities a wide scale of possibilities in a huge of areas of human life and industry. User communities are often not aware of the potential synergies, savings and new operations enabled through space.

Recent innovations and advances in space science and technology have dramatically changed the nature and structure of space-related development applications in recent years, making space a more versatile and flexible tool for the development community. Much has been accomplished in this area, but little is known about these successes that is availability of a wide applications in the needed areas of human society. Space applications must be a perfect tool for the development projects and offer a veritable path to sustainable having an excellent outcomes with a high accuracy and comparatively immediate feedbacks.

The success of advances space technology applications in a variety of areas of our life depend of the degree use of those capacities. Integration of the capacity of the countries would be much better contributed for natural resources investigations, natural disaster, climate change, security and many other strictly important problems.

Cooperation can be likely developed within the framework of existed programmers. For instance, as per identified Global Monitoring for Environment and Security (GMES) is a joint initiative of the European Commission (EC) and the European Space Agency (ESA), designed to establish a European capacity for the provision and use of operational information for Global Monitoring of Environment and Security (GMES).

The UN SPIDER capacity is a one more opportunity for the enhancement of the foregoing mentioned issue for the success of the international cooperative relationship establishment.

It is obvious that there is a highly need for collection of appropriate processed data for the indentified purposes and the main issue is to share of data among the communities who needs for this data.

Inviting efforts from different countries are undertaking a necessity of integration within the Black and Caspian Seas region as a testing region for a global climate change identification. Development and implementation of projects, as a first step, for common needs would be an excellent way for significant contribution of scientists and professionals in application of space science and technology for natural disaster studies.

The following approach can be considered for project implementation:

- Conduct of global and regional reviews of global climate changes research needs and opportunities in the context of development issues;
- Creation of alliances among institutions to increase their effectiveness and to coverage of urgent issues;
- Facilitation of national collaborative research networks;
- Stimulation of the creation of new centers and networks where gaps are found;
- Mobilization and coordination of resources.

The eight Millennium Development Goals have been adopted by the international communities as a framework for the development activities of over 190 countries divided for a ten regions. They are eradicate extreme poverty and hunger, achieve universal primary education, promote gender equality and empower woman, reduce child mortality, improve maternal health, combat HIV/AIDS, malaria and other diseases, ensure environmental sustainability and develop a global partnership for development. The targets for each foregoing goals implementation are undertaken:

- Halve, between 1990 an 2015, the proportion of people whose income is less than $1 a day: achieve full and productive employment and decent work for all, including woman and young people: halve between 1990 and 2015 the proportion of people who suffer from hunger;
- Ensure that 2015, children everywhere, boys and girls alike will be able to complete a full course of primary schooling;
- Eliminate gender disparity in primary and secondary education, preferable by 2005 and in all levels of education no latter than 2015;
- Reduce by two thirds between 1990 and 2015 the under-five mortality rate;
- Reduce by three quarters between 1990 and 2015 the maternal mortality ratio: achieve by 2015 universal access to reproductive health;
- Have halted by 2015 and begun to reverse the spread of HIV/AIDS: have halted by 2015 and begun to reverse the incident of malaria and other major diseases;
- Integrate the principles of sustainable development into country polices and programmes and reverence the loss of environmental resources: reduce biodiversity loss, achieving, by 2010 a significant reduction in the rate of loss: halve by 2015 the proportion of the population without sustainable access to safe drinking water and basic sanitation: by 2020 to have achieved a significant improvement in the lives of at least 100 million slum dwellers;
- Address the special needs of the least developed countries land locked countries and small island developing states: develop further an open, rule – based, predictable, non – discriminatory trading and financial system: deal comprehensively with developing countries debt: in cooperation with pharmaceutical companies, provide access to affordable essential drugs in developing countries: in cooperation with the private sector, make available the benefits of new technologies, especially information and communication.

Within the framework of indicated above goals and developed targets are the sources for the successful investigations of the global climate change problems. We must strengthen global cooperation and redouble our efforts to reach the MDGs and advance the broader development agenda. In the meantime the use of the existed international communities in the area of the global monitoring of the Earth and atmosphere studies with application of the recent advance space technologies and methods can provide and develop a wide opportunities for study and exploration of the climate change impacts.

It is understandable that the global phenomena demands use and application tools available to provide a significant contribution for solution. Problem of global climate change is a problem with a wide scale impact for the human society needed to be investigated with tools which creates of the operative collection of the appropriate data with further processing. In this connection the use and application of space technology mainly Remote Sensing methods and GIS technology needed to be applied for this purpose.

Taking into account a big scale of the problem it is my vision that the success in this developments depends how luckily will be integrated and engaged of the countries divided into regions in data collections, processing and sharing of this data among country participants.

The importance of water and air in our daily life is clear to everyone, though they represent fragile earth resources that can change abruptly at times. Understanding the mechanics of climate change provide us with an essential need to prepare for the future.

4.3 Providing Regional Climates for Impact Studies

Providing Regional Climates for Impact Studies (PRECIS) is a regional climate modeling system that can be run on a PC. The United Kingdom Met Office's Hadley Center for Climate Prediction and Research is the provider and the developer of this software. The data for the boundary condition is supplied by the Hadley Center Global Climate Model (GCM), UK Met Office. PRECIS comes with a user interface to carry on climate experiments. Prediction of future climate change is done globally with world wide support through United Nations organizations. Very few countries have the capability to designate a dedicated group of highly trained scientists and provide extremely fast computers to run GCMs' models to generate climate change scenarios, and perform the necessary analysis to investigate the regional impacts of climate change on their specific regions. The United Nations Development Program (UNDP), The UK Department for Environment, Food and Rural Affairs (DEFRA), and the UK Department of International Development started funding PRECIS to be available to developing countries to generate their own climate change scenarios with using a personal computer only. The UK Met Office's Hadley Centre will supply the software, the boundary conditions and other fields of global quantities required to run PRECIS [**Jones R.G., Noguer M., Hassell D.C., Hudson D., Wilson S.S., Jenkins G.J. and Mitchell J.F.B., 2004, Generating high resolution climate change scenarious using PRECIS, Met Office Hadley Center, Exeter, UK, 40pp**]. Emission scenarios describing population, energy, and economics are taken from IPCC SRES (A1T, A1FI, A1B, A2, B1 and B2).

4.4 Methodology used for plan development PRECIS implementation

There are three parts for this research. First is to set up the regional climate model (PRECIS) and run the three experiments.

Second is to do basic analysis to the output data to get specific information about climate fields and calculate the predicted state of the future from the simulation and the historical data. Third is to use ArcGIS 9.2 to present the climate variables outputs and do further analysis.

It has been installed the Linux operational system (open SUSE 10.2) and Precis (version 1.4.6) into three separate personal computers. Two of them have processors (CPU): Intel® Pentium® 4 with speed 3.2 GHz. The third one is with an Intel centrino core duo processor with speed of 2.16 GHz. Three experiments were designed to perform present, future and reanalysis data in order to get proper statistical information. Present and future experiments were based on Hadley Center's GCM data. The final experiment is dedicated to get a high resolution of ECMWF reanalysis data (ERA40).

4.5 Analysis of results

The science of climate change requires running huge amount of world wide data, and presently few places conduct climate modeling for a hundred years of the future which is

regarded as climatologist's common sense of research. It is widely accepted to take the period spanning 30 years from 1961 to 1990 as a baseline in carrying out model simulations. The future climate fields are determined from the results of the regional climate model simulation of present day carbon dioxide concentration value and the future when the concentration of CO_2 is doubled. The following are the calculations carried out by Loa´iciga H.A [**Loa´iciga H.A., 2007, Climate Change and Groundwater, available at http://ncsp.va-network.org/section/resources/resource_water**]:

$$T_{scenario} = T_{historical} + \left(T_{f2 \times co2} - T_{b1 \times co2}\right) \tag{1}$$

$$W_{scenario} = W_{historical} + \left(W_{f2 \times co2} - W_{b1 \times co2}\right) \tag{2}$$

$$P_{scenario} = P_{historical} \times \left(P_{f2 \times co2} \Big/ P_{b1 \times co2}\right) \tag{3}$$

$$E_{scenario} = E_{historical} \times \left(E_{f2 \times co2} \Big/ E_{b1 \times co2}\right) \tag{4}$$

$$\left(P - E\right)_{scenario} = \left(P - E\right)_{historical} \times \left\{\left(P - E\right)_{f2 \times co2} \Big/ \left(P - E\right)_{b1 \times co2}\right\} \tag{5}$$

$$Q_{scenario} = Q_{historical} \times \left(Q_{f2 \times co2} \Big/ Q_{b1 \times co2}\right) \tag{6}$$

Where T, W, P, E, (P-E) and Q accordingly represent temperatures in degrees Celsius, wind speeds in meters per seconds, total precipitation, surface evaporation in millimeters per day, the resultant of subtraction of surface evaporation from total precipitation in millimeters per day, and the mean runoff in millimeters per day. The subscript (f) is for future simulation, and the subscript (b) is for the baseline simulation.

5. Conclusion

The means of climate fields were created as features in every region and every meteorological station. Historical, predicted, and percentages of climate change results were viewed as multi variable bar charts by implementing "symbology" in layer's properties. The technique of applying "Spatial Analyst" from "Toolbars", interpolating the data to Raster, and using Kriging option to produce filled contours was carried out on climate variables for comparison and study.

It is easy to push a lot of technology into the climate change corner – in a catch all way. But there are many other important and useful reasons for using GIS technology.

1. Environmental Pollution / Health: The quality of the environment is only ascertained through the use of technologies that can measure environmental factors. GIS not only holds this information, but enables the processing of environmental data between places over time;

2. Water: On any given day can be seen the shortage of water around the planet growing. This means it must either be able to create more water or use the existing water available, more efficiently. GIS provides a toolset that enables the monitoring and management of water more effectively;

3. Transport Planning: Obvious that people are moving toward public transportation. But before that even happens, a need exists to understand where to build transport infrastructure. To determine that means that we understand where people are and where they are going to be 10, 20, 30 years ahead of time. GIS can determine these pieces of information. We are already seeing increases in investment in transport;

4. Food: While food prices increased last year, we are not out of the woods yet. You can expect to see agricultural production increase in cost because producers are currently having a more difficult time to acquire lending to support future crops – due to the bank situation. It feedback will on future production, necessitating increased agricultural management and efficiency. GIS is a tool of choice for land management and variable rate farming;

5. Energy / Efficiency: Current low prices have taken the edge off of renewable resources – slightly. This is not bound to last long and prices for non - renewable will rise. At minimum they are limited resources. Now is actually a good time to be investing in energy because of lower prices. GIS is useful for all energy types, from wind turbines and solar arrays, to geological analysis and bio - production, these tools enable 2-D, 3-D and 4-D analysis and visualization;

6. Oversight and Accountability: The current financial climate is going to result in increased accountability and transparency. People will demand more exacting answers and have many more critical questions about processes and investments. Quality data and accuracy will be increasingly important. Tools and technologies that enable that will be in high demand;

7. Inventory: As the news is telling, many companies and organizations do not know the resources they own and control. Strange as this may seem, the shift is underway to find out – now. GIS will enable inventory control;

8. Risk Management: Few people are willing to risk under the current operating environment. Fewer are even willing to invest. Tools that help to understand and reduce risk are going to become popular;

9. Visualization: Data is showing that people are travelling less, conserving funds and reducing costs. But they are also showing that people are engaging each other through virtual technologies, games and visualization. GIS are graphical environments that link databases to visualization;

10. Convergence of data: A large number of high resolution data sources are now coming together. To really leverage their value (which is substantial) will mean greater processing of the data and understanding society in new ways. Part of this is research, part is integration and part is political change. The winds of change are happening and tools that enable understanding change are critically important.

In climate or systems modeling, the value of geographic analysis and spatial visualization is well recognized because it is able to improve interpretation of the overall modeling outcomes as single site simulation has limited applicability. Therefore, use of GIS software is widespread, but is not an easy task with many potential users not equipped to take advantage of the comprehensive spatial and visualization analysis features. One possible solution is to develop a simplified task - specific system that can be easily used by non-GIS users. Such a system can either incorporate GIS ActiveX controls or embed GIS software such as ArcGIS . These GIS enhanced systems can be useful for specific tasks. For example, the GIS - based Sediment Assessment Tool for Effective Erosion Control (SATEEC) was developed to estimate soil loss and sediment yield and can be used to identify areas

vulnerable to soil loss and to develop efficient soil erosion management plans. However, it is difficult to implement in a portable end - user tool if the database is very large and/or the format of input data differs from the embedded tool.

Studies on potential impacts of climate change on agriculture and/or the environment have rapidly increased in recent years. Understanding the regional impacts of climate change on biophysical systems requires a modeling approach incorporating Global Climate Model data, the cornerstone of the climate change research. However, climate model projections at higher temporal and spatial resolutions are not adapted to describe local effects and thus statistical methods are needed to correct the projections from the GCM using historical climate information.

In particular, many climate and agricultural indices are used to describe the system being investigated and are therefore useful to translate the large - scale climate change information to model the impacts of climate change and develop the appropriate adaptation strategies. A GIS framework provides an enhanced ability to assess the possible responses from a range of adaptation strategies to climate change by integrating the outputs from GCMs and various modeling efforts in agriculture. The purpose of this work was to develop a GIS - based risk assessment tool to utilize the generic output from the GCMs and apply them, through a modeling framework, to assess the specific responses required by each of the major agriculture sectors. As a case study, the impact of climate change on wheat flowering and its implications in term of adaptation strategy are outlined in this communication.

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Smakhtin, V. U. and Eriyagama,N. (2008). Developing a software package for global desktop assessment of environmental flows, *Environmental Modeling & Software*, No. 23, pp. 1396-1406

This book provides an interdisciplinary view of how to prepare the ecological and socio-economic systems to the reality of climate change. Scientifically sound tools are needed to predict its effects on regional, rather than global, scales, as it is the level at which socio-economic plans are designed and natural ecosystem reacts. The first section of this book describes a series of methods and models to downscale the global predictions of climate change, estimate its effects on biophysical systems and monitor the changes as they occur. To reduce the magnitude of these changes, new ways of economic activity must be implemented. The second section of this book explores different options to reduce greenhouse emissions from activities such as forestry, industry and urban development. However, it is becoming increasingly clear that climate change can be minimized, but not avoided, and therefore the socio-economic systems around the world will have to adapt to the new conditions to reduce the adverse impacts to the minimum. The last section of this book explores some options for adaptation.

How to reference

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