CRP 514: Geographic Information Systems

Term Paper

GIS & Geoscience
Integrating Remote sensing-GIS and Ground Penetrating Radar to Study Two Active Faults, Western Gangetic Plains, India

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Abstract

Remote Sensing is a science of acquiring information (spatial, spectral…..etc) about material objects, phenomenon, or an area done usually through satellites. Ground Penetrating Radar "GPR" is a geophysical tool used in exploration and studying shallow geological features through electromagnetic waves send to the ground from the GPR antenna. One of the uses of GPR is to detect and study faults.

The main purpose of this project is to integrate GIS, Remote Sensing technology in determining positions of faults & Ground Penetrating Radar "GPR" in finding their geology (structure, depth………..etc).

The Remote Sensing-GIS is used to locate the active faults, their directions and their activity. The Ground Penetrating Radar is used to make a survey along the faults in order to study their structure and types after being located through Remote Sensing.

Through Remote Sensing there are two faults systems. One is in the N-S direction & the other is E-W direction. The GPR measurements showed the structure of these faults.

I. Introduction

Geographic Information Systems and its methods and applications become so important for a wide range of people specialists and public. The revolution in the communications especially the internet and in the computers assists GIS applications to be more powerful and easy to handle by normal people in daily life. The use of GIS tools in earth science studies become a pillar not just a supporter tool. For example, Global Positioning Systems (GPS) become an important tool in Gravity exploration and many other methods. Other GIS tool that is used frequently is Remote Sensing which I will talk in the report about and how can it help us in our exploration geophysics work. I will give an example about how to integrate Remote Sensing with one of geophysical exploration methods the GPR which is Ground Penetrating Radar.

II. Literature Review

A. Remote Sensing

Remote Sensing can be defined as the art, science, and technology of obtaining reliable information about physical objects and the environment, through the process of recording, measuring, and interpreting imagery and digital representation of energy patterns derived from non contact sensor system. There are so many applications for remote sensing like Land-use mappingForest and agriculture applications, Telecommunication planning, Environmental applications, Hydrology and coastal mapping, Urban planning, Emergencies and Hazards, Global change and Meteorology.

Through remote sensing many approaches are accomplished and many things get easier than before. These advantages of remote sensing can be summarized in:

1) Provides a regional view (large areas).
2) Provides repetitive looks at the same area.
3) Remote sensors "see" over a broader portionof the spectrum than the human eye.
4) Sensors can focus in on a very specificbandwidth in an image or a number of bandwidths simultaneously.
5) Provides geo-referenced, digital, data.
6) Some remote sensors operate in all seasons,at night, and in bad weather.

In geoscience remote sensing is used to study major geological features like volcanic activities and to detect new geological features. The process that remote sensing follows can be described in these steps:

- Energy Source or Illumination (A): The first requirement forremote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest.
- Radiation and the Atmosphere (B) : As the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place asecond time as the energy travels from the target to the sensor.
- Interaction with the Target (C) : Once the energy makes its way to thetarget through the atmosphere, it interacts with the target depending onthe properties of both the target and the radiation.
- Recording of Energy by the Sensor (D) : After the energy has beenscattered by, or emitted from the target, we require a sensor (remote -not in contact with the target) to collect and record the electromagneticradiation.
- Transmission, Reception, and Processing (E) - the energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital).
- Interpretation and Analysis (F) - the processed image is interpreted,visually and/or digitally or electronically, to extract information about the target which was illuminated.
- Application (G) - the final element of the remote sensing process is achieved when we apply the information that we have been able to extract from the imagery about the target, in order to better understand it, reveal some new information, or assist in solvinga particular problem.

These steps can be summarized in the next figure.

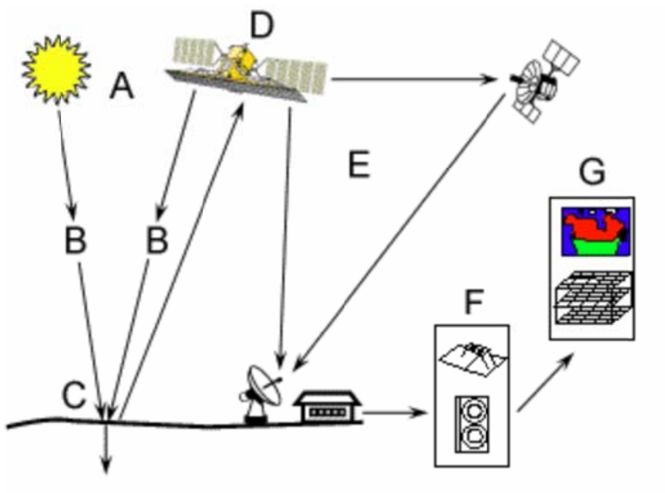


Figure 1: Steps of the Remote Sensing Process (Google image)

Remote Sensing can be classified according to their source to two types Active Remote Sensing and Passive Remote Sensing. In the active one an active sensor emits radiation which isdirected toward the target to be investigated.The radiation reflected from that target isdetected and measured by the sensor (Figure 2).

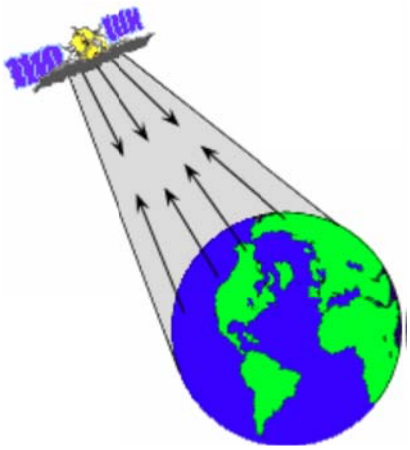


Figure 2: An example of Active remote Sensing (Robert Sanderson)

For the passive type the sun provides a very convenientsource of energy for remote sensing.The sun's energy is reflected for visiblewavelengths, or absorbed and then re-emitted forthermal IR wavelengths. For all reflected energy, this can only take placeduring the time when the sun is illuminating theEarth. Energy that is naturally emitted (such as thermalinfrared) can be detected day or night, as long asthe amount of energy is large enough to be recorded (Figure 3).

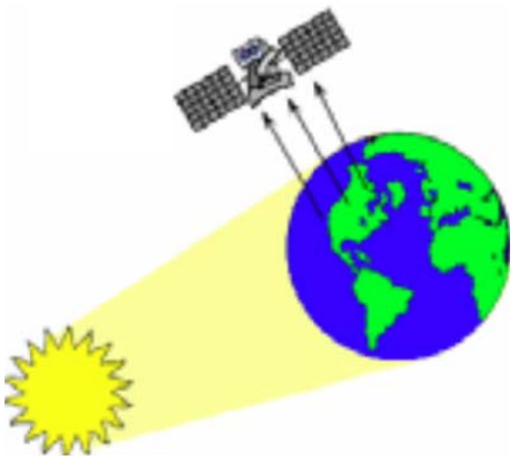


Figure 3: Passive Remote Sensing (Robert Sanderson)

B. Ground Penetrating Radar (GPR)

Ground-penetrating radar (GPR) is a geophysical method that uses radar pulses to image the subsurface. This nondestructive method uses electromagnetic radiation in the microwave band of the radio spectrum, and detects the reflected signals from subsurface structures. GPR can be used in a variety of media, including rock, soil, ice, fresh water, pavements and structures. It can detect objects, changes in material, and voids and cracks. The GPR components are: An antenna that has a transmitter and a receiver for electromagnetic waves sent to the ground, Monitor and a cart to pick the whole set (Figure 4).

Figure 4: GPR Components (Google Image)

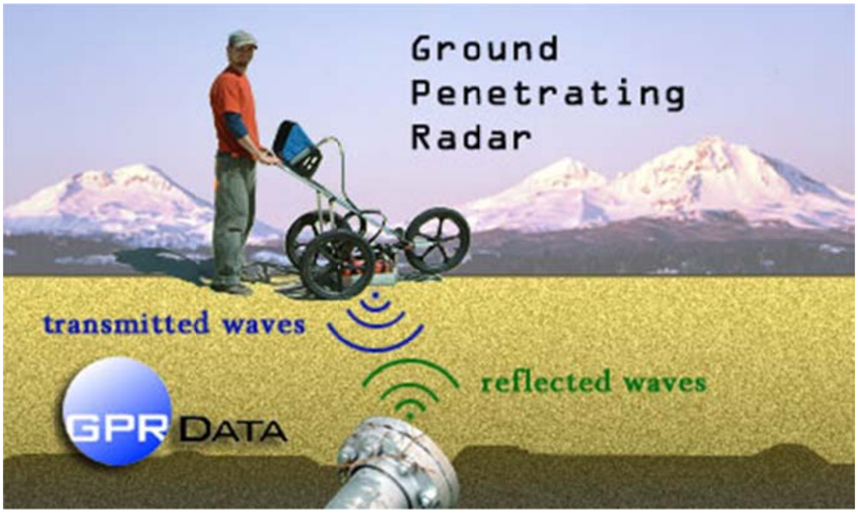


Figure 5: The Mechanism at which GPR Works (Google Image)

GPR is used by a wide range of people including:

•Civil Engineers & Archaeologists

•Geologists

•Geotechnical Engineers

•Glaciologists

•Forensic Investigators

•Environmental Scientists

•Hydrologists

Figure 6: Some Applications of the GPR (Google Image)

The beauty of GPR is that it is quick, easy to use and inexpensive in comparison to other investigation methods.   It is capable of probing down to a few tens of meters (depending on the system type & ground conditions& the antenna frequency) and provides the user with a ‘cross-sectional’ image of the sub-surface with high resolution. However, GPR has some limitations like the depth is so shallow, it may not work properly in areas that have conducted materials like clay.

III. Case Study

The area that has been studied is located in the northern part of India in Ganga-Yamuna interfluve in the upper western part plains. The aim of the study is to locate active faults in that area first by using Remote Sensing and GIS techniques and then use the GPR to located precisely and to get more information about the nature of the faults (Geology).

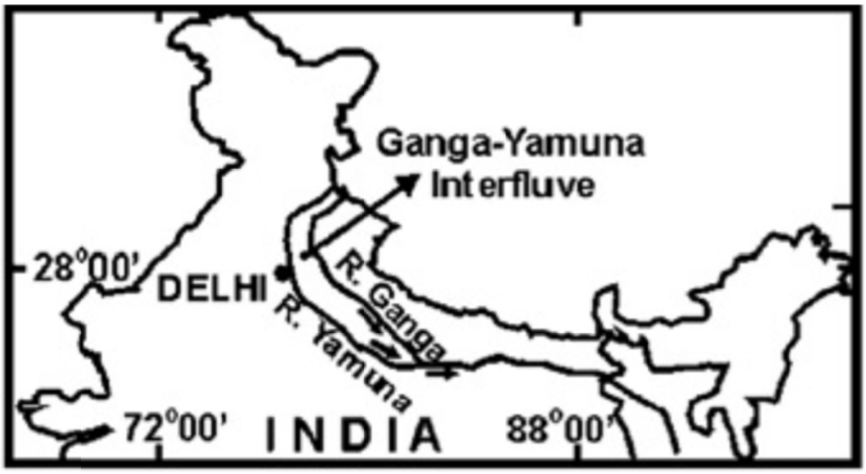
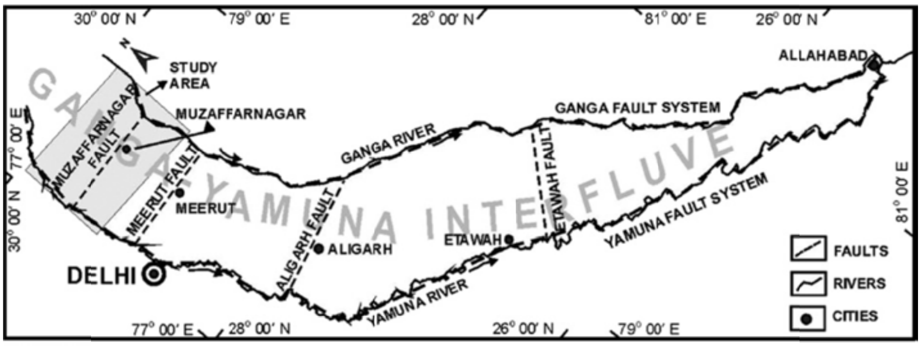


Figure 7: Location of Study Area (Balaji Bhosle)



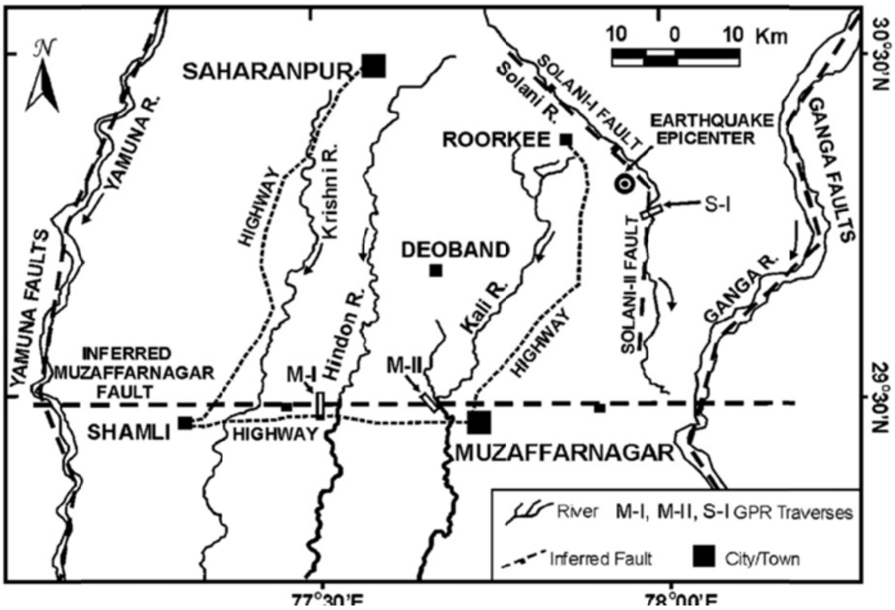


Figure 8: Close View to Study Area & Faults appear (Balaji Bhosle)

IV. Methodology& Observations

A. Remote Sensing

The software that are used for preparing the remote sensing images are SurferVersion 8, ERDAS Imagine Version 8.5 and Arc-ViewVersion 3.1 software. Through that process remote sensing confirms the presence of the Solani-II fault and Muzaffarnagar fault that extends E-W through the city of Muzaffarnagar (Figure 9).

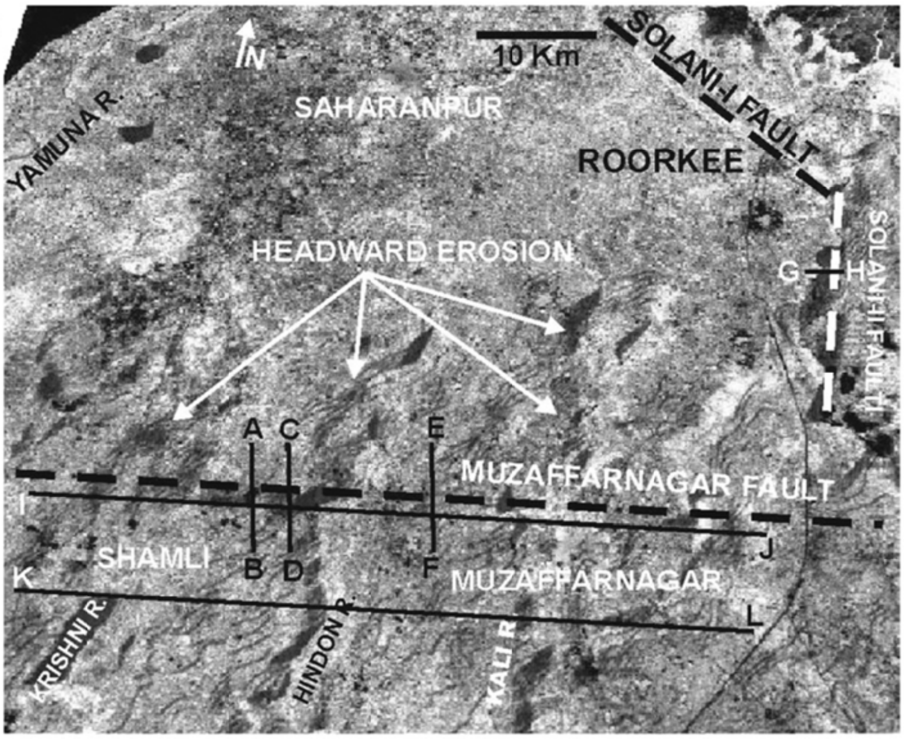


Figure 9: Solani-I, Solani-II, Muzaffarnagar Faults (Balaji Bhosle)

B. GPR Part

Two GPR traverses M-I and M-II of 450 m and 200 m lengths respectively were taken across the Muzaffarnagar Fault (Figure 10a) and a short traverse S-I of 30 m length was taken across the Solani-II Fault (Figure 10b). The traverses across the Muzaffarnagar Fault were taken in approximately N–S direction and that across the Solani-II Fault from west to east direction. The faults detected by the GPR classified into major and small faults according to their lengths.

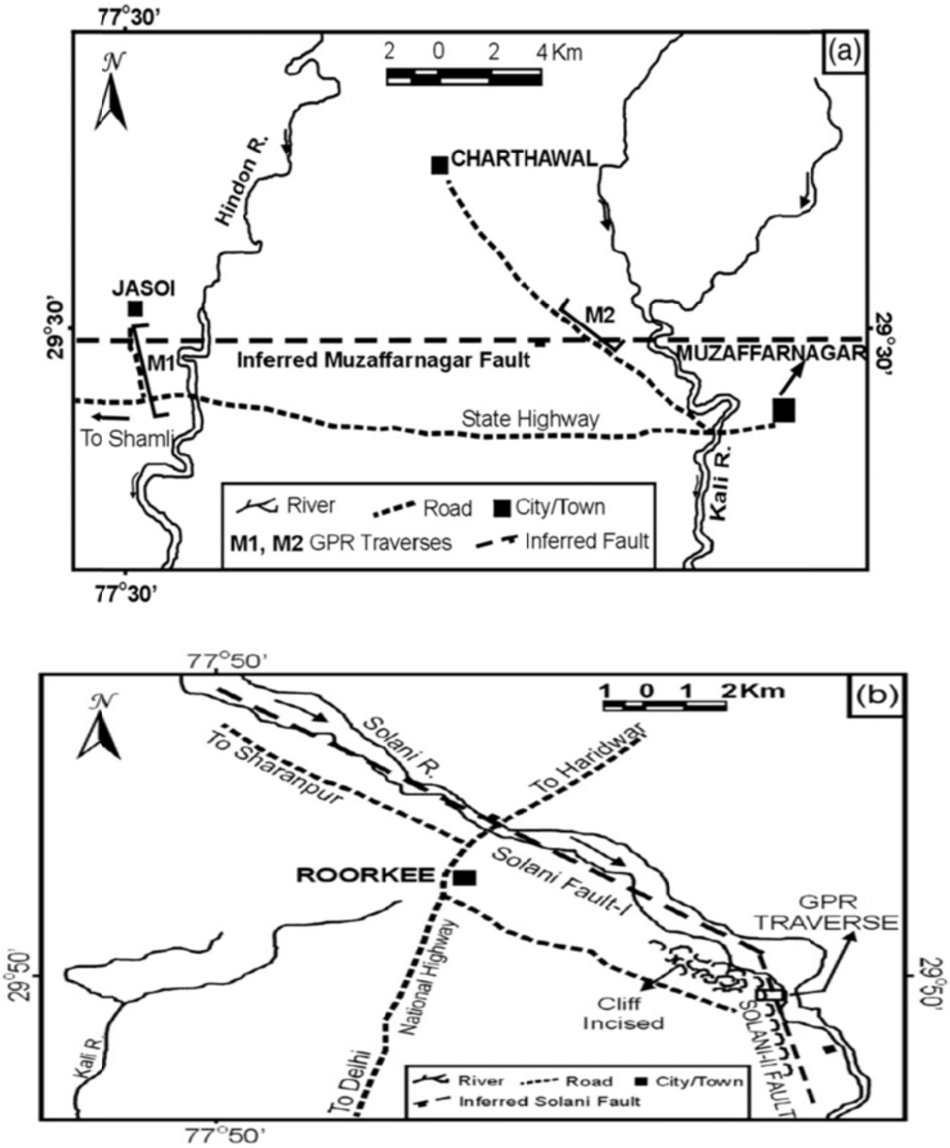


Figure 10: (a) GPR profile along M-I and M-II. (b) GPR profile along S-I (Balaji Bhosle)

Along M-I line three major faults (8 m) observed and several small faults (Figure 11a). In M-II 200 m profile number of major faults (8 – 10 m) observed all of them are normal except two and several small faults observed (Figure 11b). In the last profile along S-I six small faults observed in addition to other nine major ones (Figure 11c). These observations show that the area is geologically active.

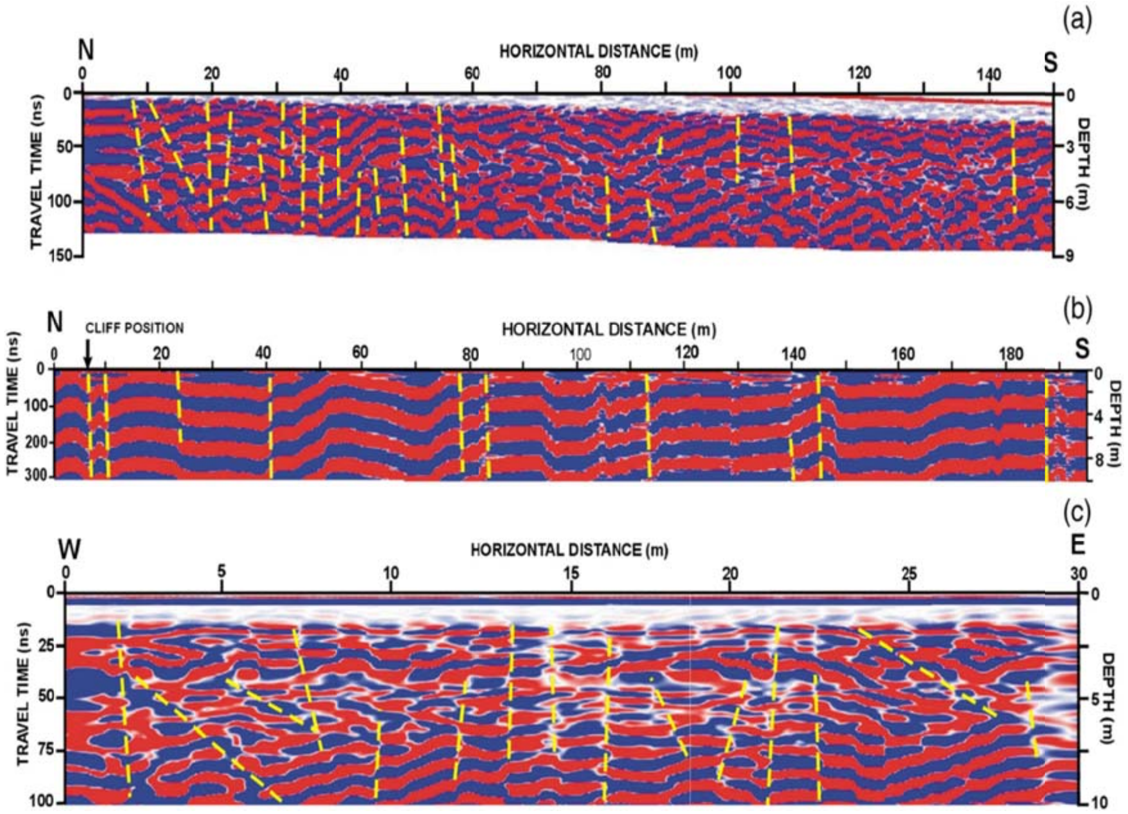


Figure 11: Major and Small Faults observed: (a) M-I profile. (b)M-II profile. (c) S-I profile (Balaji Bhosle)

Conclusion

Integrating remote sensing-GIS and the ground penetrating radar was a good approach. Digital analysis of remote sensing data has proved to be very useful in locating active faults even in almost flat or gently sloping areas. The GPR investigations indicate that both the longitudinal Solani-II Fault and transverse Muzaffarnagar Fault are characterized by 2–3 major vertical/steeply dipping normal fault at shallow depth (<10 m).

Acknowledgment

I want to thank Dr. Baqer Al-Ramadan for his help and support and guidance during this semester and I want to appreciate his cooperation with us in learning how to deal with ArcGIS and for the tutorial of the software. Finally, I want to thank CRP department for providing this course and I hope that they provide more courses in the future for students from different majors.

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Appendix