USING VIEWSHED ANALYSIS FOR RIVER MONITORING AND MANAGEMENT

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ABSTRACT: Rivers are valuable and important water resources for human beings, but sustainable development and usage of the river has become a complex issue in modem times. River usage includes both legal (agricultural water, recreation and tourism), and illegal (quarrying, and dumping of waste into the river) activities all of which need to be monitored. However, the area is large, including the many tributaries draining into large river basins, which, in Taiwan are comprised of complex tectonic terrain. It costs money and time for river patrols to monitor these areas. The objective of this study is to develop a Viewshed analysis method based on the Geographic Information Systems (GIS) that can be used for locating optimized observation points to facilitate carrying out river patrols. Viewshed analysis can be utilized to define both the visible and invisible range from each observation point by combining digital terrain model (DTM) and road vector data. The method is designed to first locate several observation points about 2 km along the closest road near the river, after which Viewshed analysis is run. If there are some invisible areas left after the first Viewshed analysis, new observation points can be added and the Viewshed analysis run again. This process is iterated until the whole river area is visible. This study attempts to define the optimal observation points for river patrolmen in order to save time and resources.

1. INTRODUCTION

Most important pathways for fresh water resource come from the river. However, abuse of development near our rivers is complicating the situation. There is variety of reasons for this, such as the legal usage of agricultural water, recreation and tourism, as well as illegal sandstone quarrying, dumping of garbage in to the river, which can damage the protected river embankment.

We look at the problems faced by those patrols which are an important for monitoring and managing the river usage. The traditional methods require a lot of time and human resources. The traditional methods require a lot of time and human resources. In order to solve this problem, we apply Geographic Information Systems (GIS) Viewshed analysis as the main method to monitor and manage river resources more efficiently. Applying this kind of method will reduce the costs, including those of manpower, money, and procedures.

GIS has been applied extensively for different purposes. Recently, GIS has been used in many new techniques. Viewshed analysis is a standard tool in the GIS software which has been used for a wide range of applications such as evaluating urban environment planning and optimal path route planning (Lee and Stucky, 1998; Lake et al., 1998). In our study, we choose two study areas, around the Wu River and Jhuoshuei River in Taiwan to examine using the Viewshed technique for different cases. Veiwshed analysis is employed along the entire river beds in order to find the optimal observation points. These observation points would assist the river patrols to monitor and manage river resources with the lowest cost. The Viewshed analysis also helps the river patrols to explore where the areas for high occultation areas which may be out of sight.

2. METHODOLOGY

Viewshed analysis is a kind of spatial analysis method that takes advantage of GIS. A viewshed stands for a better View Point position from which to observe the environment (Wang, 1996). The output of Viewshed is given in raster data format and the system examines each raster to find out which area can be seen and which cannot be seen

from the View Point. In Figure 1, the yellow triangle represents the View Point and each pixel stands for the target pixels. After deciding on the View Point, the target points will be examined by observing each of the pixels from the View Point to the target points directly; in short, it all depends on the "line-of-sight". If there are objects or high landforms between the View Point and target points, they are represented as something blocking the line-of-sight and the target points are invisible (Burrough and McDonnel, 1998). The system assigns these kinds of pixels a 0 value (False) (Figure 1, red area). On the other hand, when the target points are visible their value is 1 (True) (Figure 1, green area).

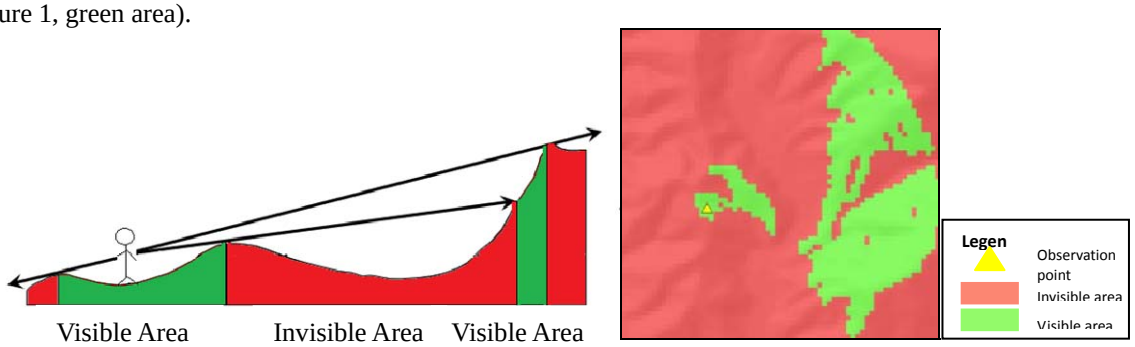

Figure 1. Viewshed Analysis Diagram

Before performing Viewshed analysis, four parameters are set with Arc GIS10, designed by ESRI. These are OFFSET, AZIMUTH, VERTICAL ANGLE and RADIUS.

1. **OFFSET**: Item indicates a vertical distance in surface units to be added to the z-value of the observation point. The z-value must be positive. In this study, the OFFSET is 5 meters.
2. **AZIMUTH**: Items specify horizontal angle limits to the scan. The sweep proceeds in a clockwise direction from AZIMUTH1 to AZIMUTH2. If the AZIMUTH1 and AZIMUTH2 are not to be delimited, the AZIMUTH1 is 0 degrees and AZIMUTH2 is 360 degrees.
3. **VERTICAL ANGLE**: The items specify vertical angle limits to the scan. The VERT1 is the upper limit of the scan, and VERT2 is the lower limit. The default values are 90 degrees for VERT1 and -90 degrees for VERT2.
4. **RADIUS**: RADIUS is the visible radius. Item is the distance from the observation point to the target point. The radius value is 2000 meters in this study.

The digital elevation model (DEM) is the most important information for Viewshed analysis. This study employs 40 meter spatial resolution DTMs made by the Aerial Survey Office, Forestry Bureau of Taiwan in 1990.

2.1 Procedures of Study

In Viewshed analysis, the View Points and target points are matched by the line-of-sight. Target points and the View Points are mutually visible from certain heights, meaning no obstructions between the View Points and target points. This area can be called the visible area, in which there is low occultation and it is easier to be seen. In contrast, the other type of area is the high occultation area where it is not easy to observe. This study will apply this idea to define the optimized View Points on the road side for river patrols to inspect the entire river basin, which could save more time and resources. Additionally, the Viewshed analysis estimates areas of high occultation where observations is not easy for the river patrols. These areas can be monitored by satellite images. Figure 2 shows a flowchart of Viewshed analysis. Figure 3 shows an illustration of observation point setting.

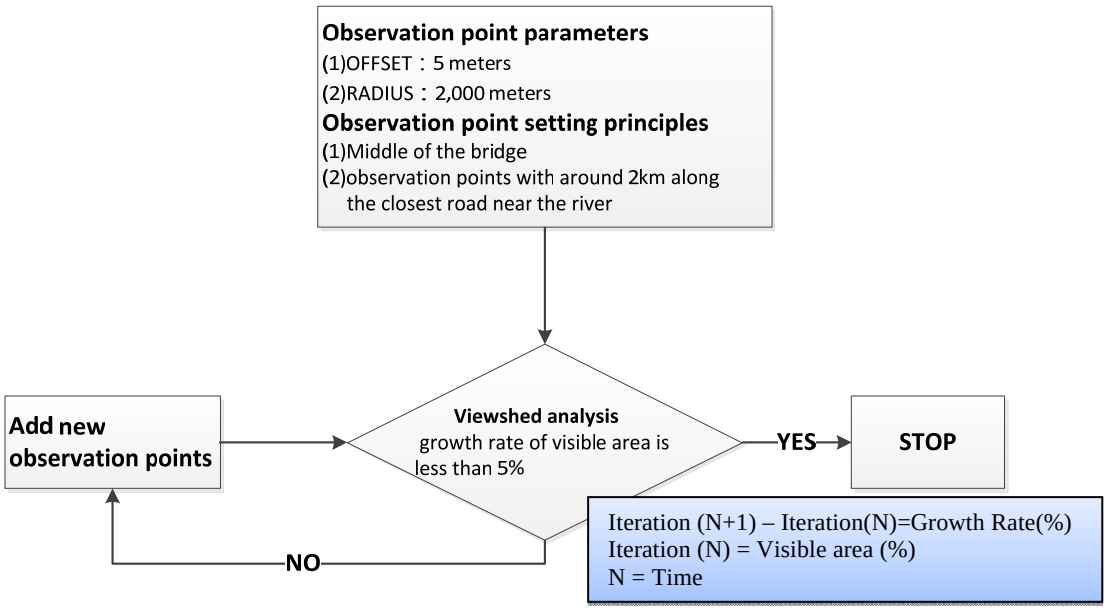

Figure 2. The Flowchart of Viewshed Analysis

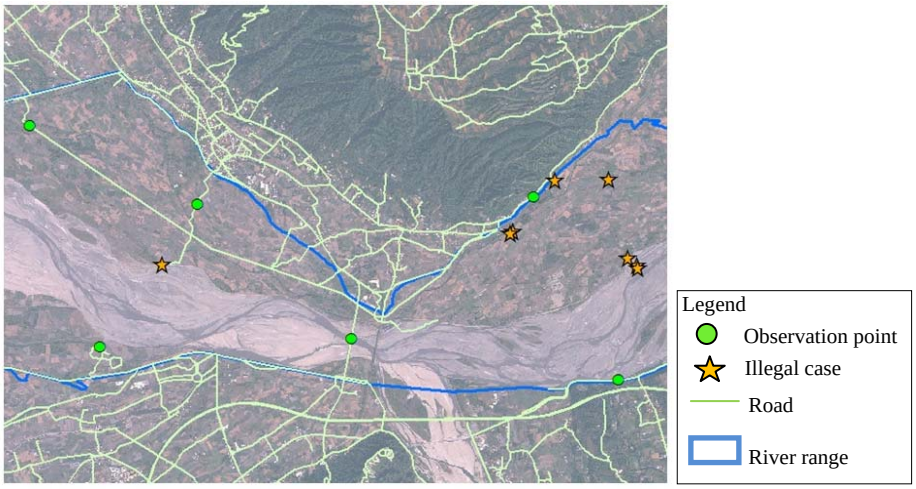

Figure 3. Observation Point Setting Diagram

The View Point setting principles and analysis processes are followed. First, the method is designed to locate several View Points around 2km along the closest road near the river. After this Viewshed analysis is carried out. If there are some invisible areas remaining after the first Viewshed analysis, new View Points are added and Viewshed analysis again executed. The process is repeated until the growth rate in the visible area is less than 5%; the final results are visible.

3. RESULTS

There has been a lot of illegal sandstone quarrying from the river basin, the first two of importance being the Wu River and Jhuoshuei River in Taiwan. Therefore, the main streams of the Wu River and Jhuoshuei River are chosen as the study cases. First, Viewshed analysis has to find the nearest location between the View Points along the closest road and the river. The OFFSET of the View Points is 5 meters and the RADIUS is 2,000 meters. The results can find the optimized View Points near the main streams of the Wu River and Jhuoshuei River. This outcome could save manpower and resources, both in terms of money and time, for river patrols. At the same time, it can also provide a reference for setting the View Points.

3.1 The Results of Viewshed Analysis for Wu River

The main stream of the Wu River is 79 kilometers long. There are 9 illegal sandstone quarrying spots in this area. The results of Viewshed analysis indicate that 70 View Points are needed to monitor 75% of the river basin area. As a consequence of the roads' sparser parts in the mountainous area and the influence of the high terrain along the Wu

River, the highly occulted areas are mainly located upstream on the river (Figure 4, red frame),

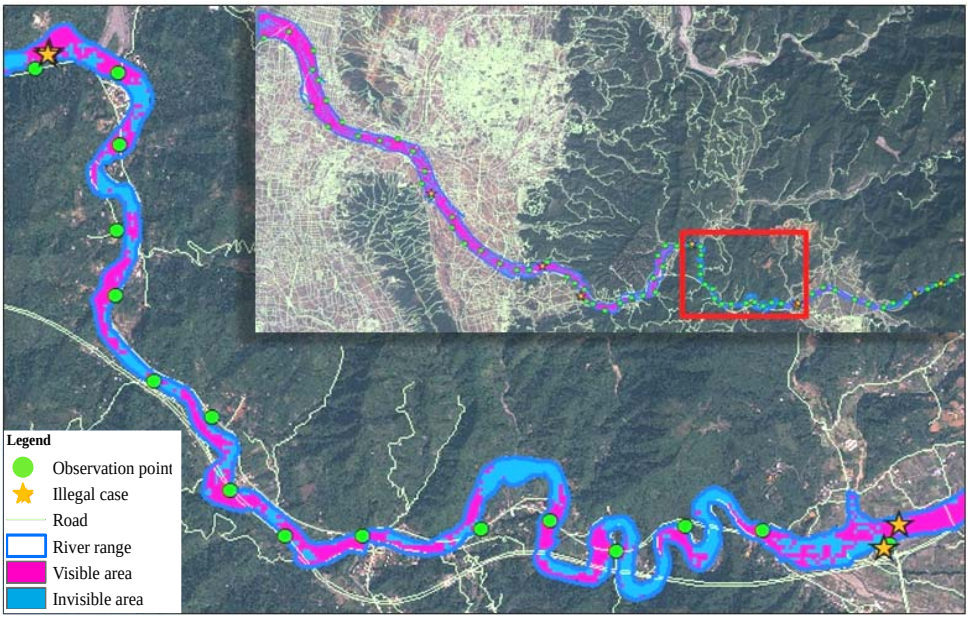

Figure 4. The Result of Viewshed Analysis for Wu River

3.2 The Results of Viewshed Analysis for Jhuoshuei River

The main stream of the Jhuoshuei River is 72 kilometers in length. There are 13 illegal sandstone quarrying spots. The Viewshed analysis results indicate that there are 87 observation points needed along the Wu River to monitor 70% of the river basin area. However, this watercourse is wider and there are fewer roads along it. Thus, there are fewer View Points set and most of the areas of high occultation are located on the wider watercourse of the river (Figure 5, red frame).

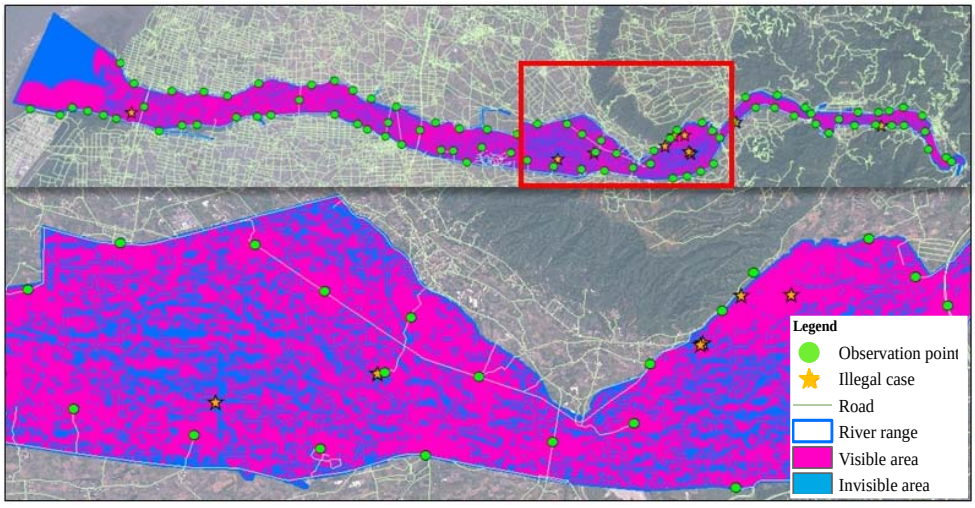

Figure 5. The Result of Viewshed Analysis for Jhuoshuei River

4. CONCLUSION

The monitoring and management of river resources in Taiwan is very important. Due to the manpower limitations of the River management office, it is extremely difficult to execute such monitoring effectively and efficiently. Even with ample manpower, time costs are high. Therefore, the application of the Viewshed spatial analysis to analyze the optimized View Points is necessary.

Viewshed analysis is one of the functions in ArcGIS10. Most quantitative approaches are based on line-of-sight visibility analysis which uses three-dimension to determine whether two points in space are visible or not (Germino et al., 2001). In addition to the surface elevation, objects on the surface can also influence the results of Viewshed

analysis. For example, structures and trees are near the river. This study took DTM as a factor in the present analysis and we will add DSM as another factor to improve Viewshed analysis in future. The results should be more objective and comprehensive.

This objective of this research is to use Viewshed analysis of GIS for Wu River and Jhuoshuei River monitoring and management. The Viewshed analysis results show the optimized View Points which can be provided to river patrols as a kind of reference enabling them to save time. At the same time, it also can estimate where the areas of high occultation are. However, the efficiency of Viewshed analysis can be affected by road density, terrain and river width. There are still a lot of invisible areas on the whole river even if we add more View Points. There are a lot of blind areas near rivers. Accordingly, it is also necessary to use remote sensing imagery for monitoring.

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