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Raster Least Cost Approach for Automated Corridor Alignment in Undulated Terrain

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Abstract: A raster based route alignment using multi criteria factors created as raster layers is useful for evolving total cost raster layer utilized at different stages for multi-criteria decision analysis (MCDA). The integration of least cost path algorithm into the 3-D view of the terrain or false color composite Remote sensing data can give value addition in planning process and formulation of action plans. The designing of optimum route alignment depends upon the number of factor considered in the process of corridor analysis model for finding the optimum route for alignment to ensure designing of the road from source to a destination within two specified end point locations. The raster data layer on land use and land cover type can be prepared for generating relative cost layer using the image classification algorithms and the slope raster layer can be obtained from the digital Elevation Model. The optimum route has the least cost and it can incorporate parameters on environmental, technical, social, and economic issues. The raster corridor analysis has been implemented to design optimum route alignment between two locations in the Himalayan region of India to consider the suitability of the technique for hill road construction. The details of the same are given in the paper.

Index Terms: Cost raster layer, Route alignment planning, Geographic information system (GIS), weighted overlay, Multi-criteria analysis, slope layer, least cost path.

I. INTRODUCTION

The area surrounding the Himalayan belt is governed by exaggerated slope. This can create problems in hill road alignment and construction. The extreme slopes should be avoided due to steeper and uneven topography in the mountainous area. The raster path analysis builds virtual cost raster layer that defines the cost of moving through each cell of the raster layer [4]. This is useful for locating new hill roads that is having least construction and environmental costs. The least cost path is a helpful application for road alignment in Geographic information System [5].

The design of highways comprises of problem that has component of finding the most economical alignment connecting two given end points on the basis of topography, socioeconomic factors and environmental impacts, while satisfying a set of design and operational constraints.

The least cost path gives the most suitable passage through the land. In a cost layer some of the factors that can influence the costs include distance from source to destination, closeness to built-up area, number of stream crossings, slope etc. In the initial planning phase of highway, it is highly pertinent to take the right decisions as far as selecting alternative alignments and screening them as it proves to be the time and money saving methods [6].

In a virtual cost layer the cost can be relative cost ranked from 1 to 5 with 5 being highest cost value. The total cost incurred by different factors is obtained by adding the individual cost layers created for different factors to generate total cost raster layer. The cost distance measure is obtained in eight cardinal directions that includes the four lateral and four diagonal links [9]. Every cell value gives the cost incurred for the movement and the cost of movement from one cell to another adjacent cell will be obtained by averaging the cost of those two cells with consideration of link length as 1.0 for lateral links and 1.414 for diagonal links.

The accumulated cost surface computes the cumulative cost of each cell from the start point using an algorithm that searches the lowest value [11]. The Dijkstra's algorithm is used to obtain raster based least cost path between source and destination points [12]. The cost accumulated raster layer is created by considering all roads planning criteria and combining using a multi criteria approach. The tool is useful in rugged terrain and saves time apart from being easily alterable [11].

II. MATERIAL AND METHODS

The least cost path raster analysis was tested in Lower Himalayan region by using the spatial analysis module of GIS. The raster layers of land use/land cover generated using the image classification techniques was assigned relative cost based on the ease of movement[8]. On the same lines the slope layer was generated using the Digital Elevation Model and was given relative costing. Subsequently both the

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relative cost layers were summed up to obtain total cost layer. The relative costing values ranged from 1 to 5. A weightage of 2 was given to slope cost layer to evolve the total cost layer [9]. Fig.1 gives the details of the methodology followed in the process.

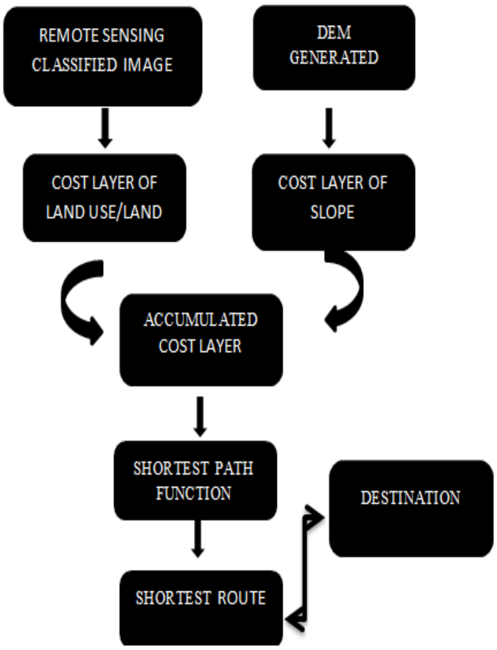
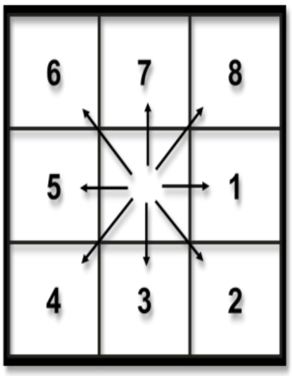


Fig.1 Flow chart Methodology for Automated Routing Process

The cost distance measure indicates the least accumulated cost for each cell to the nearest source. The direction raster provides a road map to recognize the route to take from consideration cell along with the cheapest path that identifies the shortest route between the source and the selected destination [11], while the output cost distance raster identifies the accumulated cost for every cell to return to the closest location. However it does not show which source cell to return. So the cost back link tool returns a direction raster as output providing what is essentially a road map that identifies the route to be taken from any cell along the least cost path back to the nearest source.

The least cost path is based upon an algorithm that creates a sequence of integers from 0 to 8. Here value of '0' represents the source location and values 1 to 8 encode the directions in a clock wise manner starting from right. This is illustrated in Fig-2.



0	Source
1	Right
2	Lower-Right
3	Down
4	Lower-Left
5	Left
6	Upper-Left
7	Up
8	Upper-Right

Fig.2 Eight Movement Directions given in the Algorithm

The computation process for slope is through use of Digital Elevation Model in which every pixel represents elevation value. The same is given in Figure-3. The steepest slope layer is utilized for creation of slope raster in eight direction of cost path model.

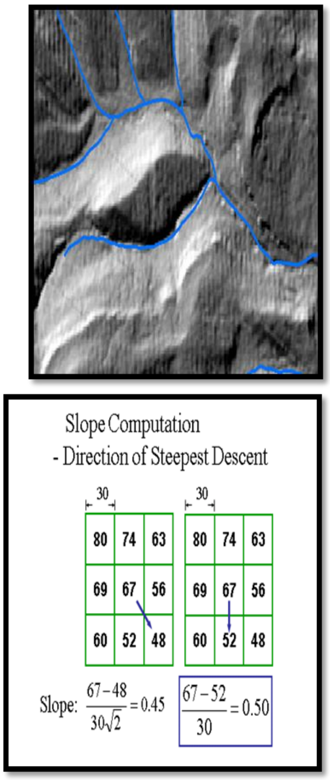


Fig.3 DEM of Area with Slope Computation

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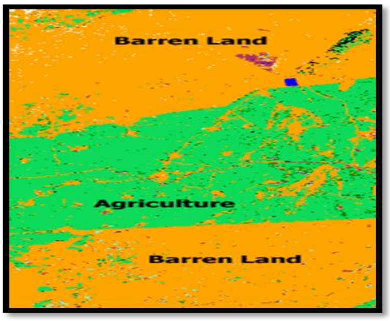

Fig.4 Supervised Classified Image input for computing land use/land cover cost layer

The land cover/ land use raster layer generated using maximum likelihood supervised image classification is shown in Fig.4 was used for generation of land use/land cover cost layer.. This layer was used to obtain relative cost layer for land use/land cover by assigning lesser cost value to barren land and more cost value to agricultural land in the area.

III. RESULT AND DISCUSSION

A cost raster defines the cost or impedance to move through each cell based on node-link cell representation. The least cost path can be improved by incorporating different parameters such as traffic density, environmental issues, and water gaps with appropriate weightages. The start and destination points defined can be alterable. The multi criteria analysis identifies a least cost path, which needs to be evaluated with respect to the terrain, land use, slope variation etc. through which it passes. Fig.5 shows the least cost corridor for the area between the two end points. This is the new road line passing through lesser rugged regions taking into account the minimum gradient issue. The alignments obtained appear to be irregular polyline starting from the start point passing through different features considering cost along its shortest possible path.

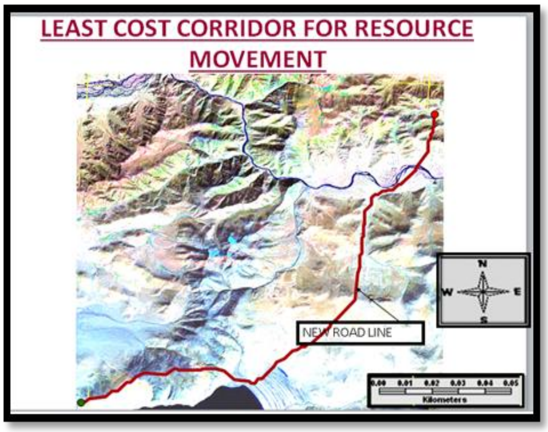

Fig.5 Least Cost Corridor showing least cost path between two end points

This alignment as seen is crossing the river site at more than two locations requiring bridging. The alignment has been placed over 3-D view of the terrain shown in Figure-6 to simulate the road in the area with clear appreciation for cut and fill area.

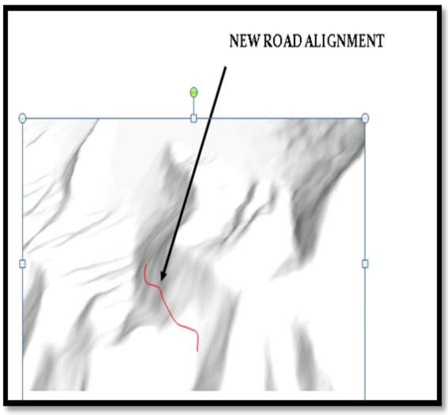

Fig.6 3-D simulated view of the path giving Earthwork appreciation

The GIS model applied in obtaining cost path were quite successful in avoiding settlements, important agricultural land, lakes and areas with higher slopes owing to the higher relative cost values assigned to those regions. The alignment has crossed the sites for bridges without showing any consideration for factors governing site selection for bridges. This is because those factors were not considered in the model. It can be viewed that the objective of the study is satisfied within the selected criteria.

IV. CONCLUSION

The raster based analysis for determination of least cost path dwells upon the concept of multi criteria evaluation in obtaining the path. This can help in avoiding the cumbersome ground based traditional exercise. The method can also carry out alteration, addition or deletion of raster data layers to improve upon the ground based efficiency of the route. The technique can also be applicable for re-alignment of existing routes in the complex planning process. The viability of linking the output of this methodology with roadway design software can be considered. This is expected to take this methodology into another domain on preliminary design of alternatives apart from enabling on the issue regarding recalculating the construction cost from the outputs given by the roadway design software. It is recommended to develop a GIS model to be a decision making tool involving automatic analysis and calculation tool for earthworks volumes and to study the impact on different areas.

REFERENCES

1. Anderson, J. R., Harday, E. E., Roach, J. T., & Witmer,R. E. (1976).A Land Use and Land Cover Classification System. Washington D.C: United States Government Printing Office.
2. Bagli, S., Geneletti, D., & F, O. (2011). Routing ofpower lines through least-cost path analysis and multi-criteria evaluation to minimize environmental impacts. Env. Impact Assessment review.

3. Blaschke T (2013) Land suitability analysis for Tabriz County, Iran: a multi-criteria evaluation approach using GIS. J Environ Planning Mgmt 56(1):1–23.
4. Carver SJ (1991) Integrating multi-criteria evaluation with geographical information systems. Int J Geogr Inf Syst 5(3):321–339.
5. Collischonn W, Pilar JV (2000) A directional dependent least-cost path algorithm for roads and canals. Int J Geogr Inform Sci 14(4):397–406.
6. Eastman IR et al (1995) Raster procedures for multi-criteria/multi-objectives decisions. Photogram Eng Remote Sens 61(5):539–547.
7. Garber, N.J. and Hoel, L.A. (1999). Traffic and Highway Engineering, 2nd edition. Pacific Grove, CA: Brooks/Cole Publishing Company.
8. Ibrahim, A. A. (2011). Assessment of the urban canopy heat island (UCHI) of Kano state during dry season. International conference on climate change impacts risk and opportunities, 1359-1367.
9. Jankowski P (1995) Integrating geographical information systems and multiple criteria decision-making methods. Int J Geogr Inf Syst 9(3):251–273.
10. Khanna, S. K., & Justo, C. E. (2011).Highway Engineering (Ninth edition ed.). (M. I. Justo, Ed.) Delhi:Nem Chand and Bros.
11. Manoj, K. J., & Paul, S. (2004). A highway alignment optimization model using geographic information systems. Transportation Research Part A: Policy and Practice , 455-481.
12. Malczewski J (2006) GIS-based multi-criteria decision analysis: a survey of the literature. Int J Geogr Inf Sci 20(7):703–726.
13. Shaw, S.L. and Xin, X. (2003). Integrated land use and transportation interaction: temporal GIS exploratory data approach. Journal of Transport Geography 11 (2),103-115.

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