Comparison of Surface Flows Derived from Different Resolution DEM

Bashir Rokni Deilami[1], Malik Rashid Abbas Al-Saffar[1], Afsaneh Sheikhi[1], Muhammad Isa Bala[2], Dermayana Arsal[3]

[1]Department of Remote sensing, Faculty of Geo Information and Real Estate, Universiti Teknologi Malaysia, Johor Bahru,, Malaysia

[2]Department of Landscape Architecture, Faculty of Built Environment, Universiti Teknologi Malaysia, Johor Bahru,, Malaysia

[3]Department of Urban and Regional Planning, Faculty of Built Environment, Universiti Teknologi Malaysia, Johor Bahru,, Malaysia

(bashirrokni@yahoo.com)

***Abstract*-- This paper presents the comparison of two digital elevation model (Dem) at different spatial resolution in Scania (Sweden). Dem as being digital representation of landscape topography consists of elevation values in an array; landscape features such as slope, aspect, drainage areas and channel network can be rapidly extracted using specialized numerical algorithms.Two elevation datasets have been used in this study: Shuttle Radar Topography Mission (SRTM) 90m resolution and GSD-Höjddata 50 m spatial resolution. The Study area is Skåne County also known as Scania County in English. It is the southernmost administrative county, of Sweden with an area of 11300 km2 (55°59′43″N 13°26′30″E). Arcgis software was used in this paper for analysis. The method has four subdivisions: data harmonization, investigating and filling sinks, modelling the surface flows and comparing the surface flows with a settled evaluation test. First, flow direction was extracted from DEM (D8 method) and sink areas were inspected and filled, and then flow accumulation and stream network were produced. Finally, streams were derived from both DEMs and compared with river vector data (reality). The result shows that the streams derived from GSD-Höjddata 50m resolution fits better to river data (reality) in comparison with streams extracted from resampled SRTM 90m resolution DEM,**

***Index Term*— DEM, GIS, Spatial resolution, Sweden**

I. INTRODUCTION

Water Resource models are one of the most important applications in environmental modelling [7]. Hydrological modelling of watershed, hydraulic modelling of rivers and water quality modelling of lakes are examples of water resource models.

Hydrological modelling is application of water resource modelling, which is the representation of water flow through the use of mathematical models on the land surface (Surface–Water Hydrology) or subsurface (Ground water Hydrology) [2]. It is also important for hydrological prediction and hydrologic cycle investigation, Hydrological climate change, electrical power engineering, and water resource management [10].GIS can be a suitable tool for the delineation of watersheds and stream grid networks by using spatial data, such as digital elevation data as the input data source [7]. One issue still facing the GIS and scientific community is determining the ideal spatial scale of these digital elevation data to be used for hydrologic analysis. Digital elevation models (DEMs) are defined as a digital representation arrays of cells representing point elevation data. Most landscape elements like slope, aspect, flow length, drainage network, and watershed can be extracted from DEMs by means of automated techniques [2]. In addition, DEM's cell size affects the accuracy of hydrological parameters extracted from DEM. From the literature review, it is not suitable to use a single spatial scale for all hydrologic studies.[4]For example, in one-study researchers have found out that using coarse data sets for groundwater models is more appropriate [11]. Moreover, it has been shown that spatial scale did have a significant impact on hydrologic predictions using finer data sets [6] - [13].

This paper presents a comparison of surface flow networks generated from two data sets with different scale (resolution) in Scania County in Sweden.

II. MATERIAL AND METHODS

A. Case study

Scania (Skåne) region is the southernmost region in Sweden and has an area of about 11,300 (km) [8] (Fig. 1). Scania is known as the region with a flat landscape; it is not quite flat. The topography of Scania region could be described by long and narrow rock horsts which run from northwest to southwest direction. The highest point of the Scania is 212 meters above sea level and is located on Söderåsen ridge. The lowest point is 2.4 meters below sea level, which is situated just outside Kristianstad [8]. Compared to other parts of Sweden, Scania has few and small rivers and lakes.

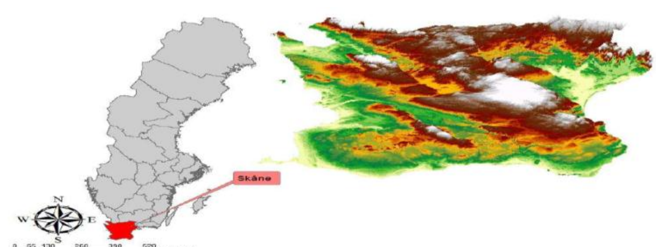

Fig. 1. Location of Scania in Sweden [8]

B. DATA

The data used for this research consists of Digital elevation data from Swedish surveying authority (GSD-Höjddata) [3] and Shuttle Radar Topography. Mission (SRTM) is provided for free download via the National Center for Earth Resources Observations and Science (EROS) seamless data website [9].GSD-Höjddata (LM 50m DEM) has a spatial resolution size of 50 meters; whereas data from the SRTM have the spatial resolution size of 90 meters. In addition, vector data of rivers and border of the Scania from the Swedish surveying authority were used.

C. *METHOD*

The analysis in this paper was done using ArcGIS software. Prior to analysis, it was necessary to convert all coordinate systems of DEMs to the same measurement units and projection; thus the SRTM 90m DEM (UTM WGS84) was projected to Swedish National Projected Coordinate System "RT90 25gonV" but the LM 50m DEM was originally given in "RT90 25gonV" Coordinate System. After harmonization, the extent of Scania was masked by use of vector layer of region border. As the SRTM has 90m resolution, after projection the resolution for Scania region appears to be about 71m. Finally, it was necessary to resample SRTM DEM with 71m resolution to 50m to get comparable results with comparative evaluation; however, this adds extra errors to the data. ArcGIS software contains hydrological toolset, which includes all the necessary tools for surface flow extraction. The extraction procedure is shown in the work flow diagram shown in Fig.2

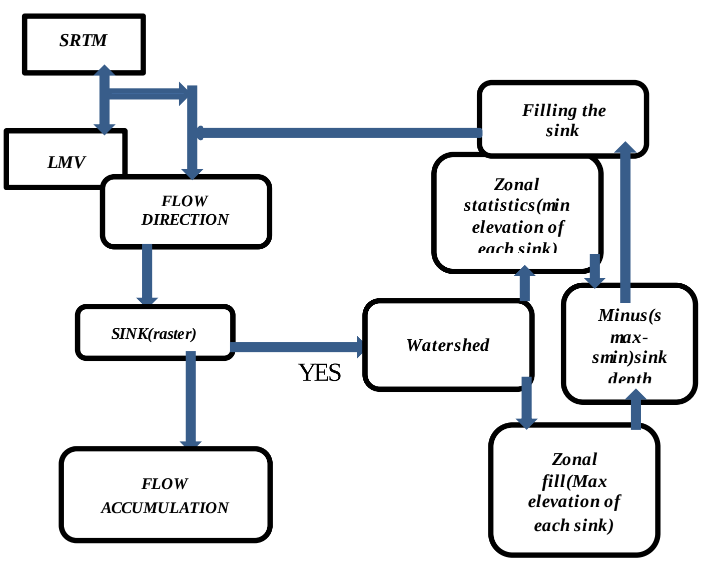

Fig. 2. work flow diagram for surface flow modelling

For surface flow extraction first of all, it is necessary to produce flow direction raster from the DEM. Flow direction in ArcGIS software was calculated by single flow direction D8 method, which takes flow direction as a direction from each cell to its steepest downslope neighbour cell that is 8 possible directions. The second step is inspection of the sinks which are a cell or set of spatially connected cells whose flow direction cannot be assigned one of the eight valid values in flow direction raster [1]. (Fig. 3)

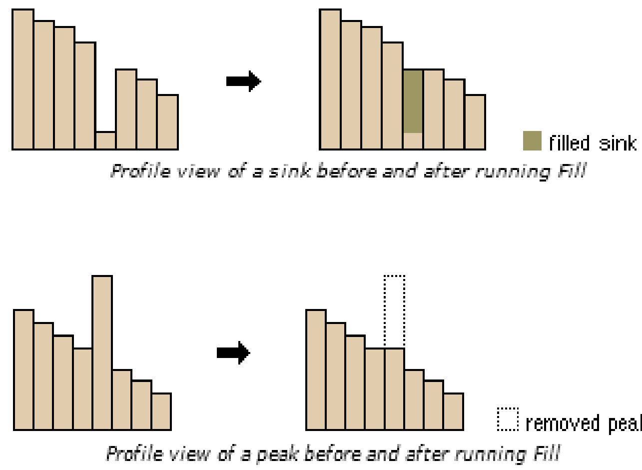

Fig. 3. Result of sinks filling[1]

After that, it is necessary to fill all the sinks to produce depressionless DEMs, (Fig.3). For filling, it is necessary to find sink depth, which is derived by calculating maximum and minimum elevations for a watershed of each sink. After having depressionless DEMs and calculating flow direction, it is possible to extract accumulated flow to each cell where flow accumulation is "upstream area drains into each pixel" [4]. Stream extraction from flow accumulation is the next step and the threshold for extracting stream where chosen to be the first break value from the standard deviation classification method (Fig. 4).

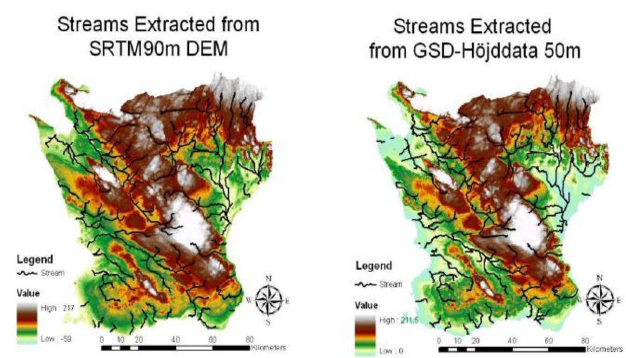

Fig. 4. Streams extracted from both datasets

Finally, river vector data from the Swedish surveying authority compared with streams derived from both DEMs. The chosen method is; firstly to create accumulated cost surface from the source (River Raster) and then extract overlap values for each stream data; that is for each pixel in stream data assigns the overlapped value from the accumulated cost surface (Fig.5). The Accumulated cost surface is the "minimum accumulative travel cost from a source to each cell location on a raster" [1].

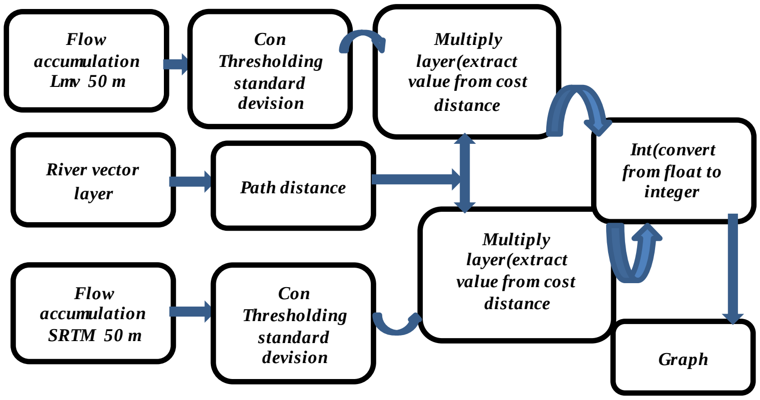

Fig. 5.Work flow diagram for comparison method two dataset and reality

III. RESULT AND DISCUSSION

The result graphs contain the frequency distribution of the flow surface pixels of both DEMs depending on the distance from river raster, and they normalized by the number of the stream pixels (Fig. 6).

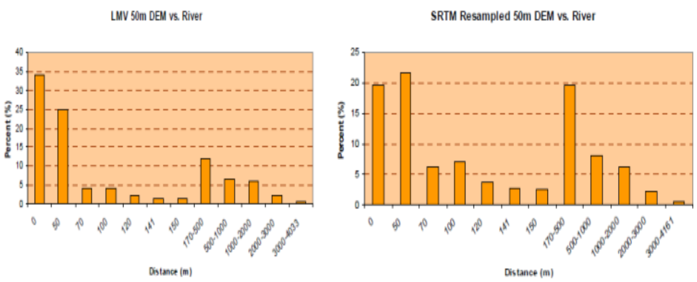

Fig. 6. Comparison result graphs for streams extracted from LMV 50m, SRTM 50m and SRTM 71m DEMs (Overall 100% per graph)

The 0 m distance illustrates the pixels from streams derived from the both DEMS which overlap with streams in river raster. For example, 70m distance from the river raster illustrates accumulated cost distance to the stream. It can be seen that 33.83% of the streams extracted from LMV 50m resolution DEM totally fits (0m) to river data compared to 19.54% of SRTM90m resampled 50m resolution DEM. It can easily be seen that, the streams extracted from the LMV 50m data fits much better than streams extracted from resampled SRTM90m 50m resolution DEM. However it can be argued that the resampling can add error, but the same analysis was done for streams extracted SRTM 71m resolution and it shows 27.27% overlap. To compare two DEMs (LMV and SRTM), it can be shown DEM without resampling gave better results than resampled DEM. Recollect that the SRTM data were plagued with what seemed like problems from the get-go. For example, radar produces somewhat heavy backscatter causing spikes in the data where water resided. Many voids in the data occurred during collection, thus requiring interpolation to occur

by data processors. These are easily some reasons for such large variations in final estimated parameters.

Data collection methods, spatial scale, and spatial resolution required to produce each type of data clearly have a large implication on how hydrologic drainage networks are computed. These are easily some reasons for such large variations in final estimated parameters. The stream definition threshold undoubtedly has a large influence on how drainage density is estimated in hydrological network modelling, and the impact of the stream definition threshold on drainage density calculations, needs to be determined [12]. Moreover, it has been shown that a smaller threshold would yield better results; however, it may also be possible that lowering the threshold too much, especially in regions of flat terrain as pointed out, may overestimate the drainage density [7]. Further research in this field may help resolve these outstanding issues.

IV. CONCLUSION

Several conclusions at the technological, theoretical, and application levels have been developed out of this study. At the technological level, GIS has proven to be
a useful tool for extraction multiple parameters from a grid of elevation data and create a hydrological network database out of it. At the theoretical level, this research has examined the degree that spatial resolution has on hydrological network modelling. At the application level, this research has instituted a well-documented case study with a focus on the Scania country (Sweden) for a rigorous methodology for the comparison of digital elevation data of same types and different spatial resolutions. Finally, DEM is a core of the hydrological modelling and is making possible to extract hydrological parameters in an automated and efficient way. Further development of DEM by sampling and compiling finer resolution, instead of using global datasets like SRTM90m is justified as it has led to a better hydrological models. It can be gained from this study that it is very important to choose DEM with the resolution which is appropriate for certain application.

ACKNOWLEDGMENT

We are thankful to the Department of Remote sensing in Universiti Teknologi Malaysia (UTM) and International Doctorial Fellowship (IDF) for providing facilities for this investigation.

REFERENCES

[1] ArcGISHelp,(2010)Availableat http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#//009z00000065000000.htm

[2] Garbrecht, J. and Martz, L. W., ’’Digital elevation model issues in water resource modeling’’. *Proceedings of the 19th ESRI International User Conference Presentation*, San Diego, CA,1999.

[3] Höjddata (2010) Höjddata grid 50+ Documentation (In Swedish) Available <http://www.metria.se/templates/M_LmvMirrorPage.aspx?id=1478>

[4] Horning N. and et. al., Remote sensing for Ecology and Conservation, New York, Oxford University Press,2010

[5] Johnson L., Geographic Information Systems in Water Resources Engineering, Taylor &Francis Group, 2009

[6] Kenward, T., Lettenmaier, D., Wood, E. and Fielding, E.,‘’Effects of digital elevation model accuracy on hydrologic predictions’’Remote Sensing and Environment, 74, 432-444,2000.

[7] Maidment, D.,, Arc Hydro GIS for Water Resources,chp8,p167-168,2002 (Redlands: ESRI Press).

[8] Skånepress (2010)Availableat http://press.skane.org/en/content/skanes-geography-and-climate

IJENS

[9] USGS, 1999, National Elevation Dataset, Availableat http://seamless.usgs.gov
[10] Vieux, B. E. Distributed hydrologic modeling using GIS. Springer, 2004
[11] Wolock, D.M. and Price, C.V., ''Effects of digital elevation map scale and data resolution on a topographically-based watershed model''. Water Resources Research, 30, 3041-3052,1994.
[12] Yildiz, O., ''An investigation of the effect of drainage density on hydrologicresponse''. *Turkish Engineering Environmental Science*, 28, 85-94, 2004
[13] Zhang, W. and Montgomery, D.R., ''Digital elevation model grid size, landscape representation, and hydrologic simulations''. Water Resources Research, 30, 1019-1028, 1994.