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The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

TECHNICAL BRIEF

Hydrology

Improving SA's river network coverage

A completed Water Research Commission (WRC) study looked to develop methods for converting digitised rivers into a hydrological drainage network.

Background

Spatial databases of drainage networks are invaluable in many fields, for example, spatial analysis and hydrological modelling. River lines in a hydrological network must be seamlessly connected and must have flow direction.

Hydrological modelling is an essential component of water resource management and the importance of river network databases is evidenced in the extensive efforts that have been undertaken to date in attempting to develop standard river network datasets for South Africa.

These efforts date back to the 1990s when the then Department of Water Affairs started projects to produced river lines for use in GIS modelling from the country's 1:50 000 topographic maps. Resource Quality Services (RQS) and the Directorate of Spatial and Land Information Management worked on river networks visible on the 1:500 000 scale and the 1:50 000 topographic maps, respectively.

The Department of Rural Development and Land Reform Chief Directorate: National Geospatial Information (NGI) is responsible for the 1:50 000 topographic maps (including river lines). The focus of these datasets is on the geographic representation of the data. Their utility remains and continues to be substantially constrained by numerous inconsistencies and inaccuracies imparted by compilation from aerial photographs.

Methodology

In this WRC-funded study techniques were investigated to create a South African river network that is repeatable and applicable to all the water catchments in South Africa. The aim was to develop a semi-automated methodology to create robust, country-wide, accurate river network coverage for use in GIS projects and other planning initiatives in South Africa.

The methodology was implemented on two selected catchments, namely the Molopo and the Mzimvubu.

The Molopo catchment falls in a low rainfall regime area with a groundwater mean annual recharge of only 0.1 to 5 mm and is located on the border of South Africa, Botswana and Namibia. The area is drained by the Nossob, Aub and Molopo rivers and is 250 000 km^2 in size of which 23% or 57 000 km^2 is within the borders of South Africa.

The Mzimvubu River catchment is classified as a primary catchment and falls in a sub-humid climate with a groundwater mean annual recharge of 12-70 mm. It has a drainage area of 19 826 km^2 and a flow length of around 350 km from north to south.

Developing the river editing tool

The river editing tool developed for this project simplifies the editing of both line features and attribute data. Among others, it has the following functionality:

- Automatically applying flow direction of stream lines from a digital elevation model (DEM).
- Automatically applying flow direction from the mouth of a river network.
- Finding loops in the river network.
- Selecting upstream or downstream line segments from a

specified position.
- Assigning attributes to all selected stream lines
- Calculating stream order of river segments in a river network.

The river editing tool was used to calculate stream order values for four different stream order types. During the calculation of the stream orders, the distance of the longest upstream path in the river network was also calculated and stored.

Extraction of river networks from Shuttle Radar Topography Mission (SRTM) flow paths

The river centre lines of NGI are only available for South Africa. Flow paths were therefore calculated from the hydrologically improved DEM for cross-border areas of the Molopo catchment. A thresholds of 100 was used to indicate the start of flow paths from a flow accumulation grid.

River networks were selected from flow paths, taking into consideration homogenous areas with respect to drainage density (DD) and environmental variables such as precipitation, land cover, soils and terrain. This task was based on the conjunctive use of digital elevation data and environmental parameters in a grid-based GIS. The landscape was manually stratified into drainage density classes.

Two parameters that showed a high correlation with DD were the Arenosols soils group and mountainous areas. Particular characteristics of Arenosols are low reserves of weaterable minerals and low silt: clay ratios.

The mountainous areas were derived from the SRTM DEM. They had a high DD while Arenosols had a low DD. All areas were ranked according to rainfall and vegetation with sparser vegetation and higher rainfall areas resulting in higher DD.

Conclusions and recommendations

River networks were successfully developed for the Molopo and Mzimvubu catchments. This was achieved through the following:
- Development of river editing tool
- Calculation of flow paths from a DEM
- Extraction of river networks from SRTM flow paths
- Derivation of supporting information from imagery.

The networks were in sharp contrast to each other, mainly due to the huge difference in rainfall and steepness of terrain. The Mzimvubu catchment has a well-defined river network with a high DD, while the river network of the Molopo catchment is intermittent with a low DD.

The Molopo catchment had numerous small river networks, which were not connected to the main stem, but ended in pans. The perennial status of streams in the Mzimvubu River was either perennial or non-perennial, while the streams in the Molopo could be ephemeral or non-perennial.

The four different stream order types that were calculated make it possible to do subsets of the river network. For example, it was illustrated that it is possible to select stream lines at the same level of detail that are displayed on the 1:250 000 maps from the 1:50 000 dataset.

A product was developed indicating the number of times that surface water was classified from the SPOT 5 mosaics for the period 2005-2011. By applying some level of interpretation the following information can be derived from this dataset:
- Perennial status of large rivers.
- Area covered by dams.
- Selecting the most significant branch in braided systems.

For the Molopo catchment it was not possible to classify open water, due to the fact that the riverbeds were mostly dry. A classification of vegetation was done instead and was included as one of the layers used as backdrop during the editing of stream lines.

Riparian vegetation often indicated the actual position of streams, when it was unclear on the colour image itself.

It can be concluded that the river editing tool was successfully tested on a large dataset such as the Mzimvubu river network. The river editing tool was found to be useful during the editing of the data to develop river networks. Some of the functions take time of execute, but it is significantly faster than manual editing. A large improvement from previous versions of the river line data is that most streams have been connected by NGI.

Remote sensing imagery was useful in correcting errors in the river centre line data and also to identify the perennial status of streams from derived products.

Further reading:
To order the report, *Developing methods for converting digitised rivers into a hydrological drainage network* (**Report No. 2164/1/15**) contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.