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Application of Data collection Technologies in River Catchments (Case study: Sue River, South Sudan)

إستخدام التقنيات الحديثة لتجميع البيانات الحقلية لأحواض الأنهار

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خلاصة:

تعتبر دراسات الجدوى للمشاريع الكبيرة هى أحد أهم محاور التنمية في اقتصاديات الدول، كما أنها تساعد في إعادة النظر في نقاط القوة والضعف وكذلك التهديدات التي تواجه تلك المشاريع. وفيما يخص قطاع المياه، وضعت معظم الدول النامية إستراتيجيات وخطط طويلة المدى للحصول على أفضل استغلال لمواردها من الأراضى والمياه. وبناء عليه، أصبحت مشاريع إدارة الموارد المائية واحدة من أهم أولويات هذه الدول، ولكن عدم توافر المعلومات والبيانات الازمة للدراسات المطلوبة هى أحد أهم معوقات إنطلاق هذه المشاريع. وتعرض هذه الورقة البحثية إستخدام التقنيات الحديثة لتجميع البيانات وتحليلها من أجل بناء سد متعدد الأغراض في حوض نهر سيوى بدولة جنوب السودان، حيث تتطلب دراسات الجدوى لبناء هذا السد الكثير من البيانات والمعلومات. وقد تم دمج طرق القياسات الحقلية التقليدية (قياس مناسيب القاع وطبوغرافية الأرض)، ونظام الاستشعار عن بعد (RS) ونماذج الأرتفاعات الرقمية (DEM) ونظم المعلومات الجغرافية (GIS)، وذلك للحصول على المعلومات المطلوبة في وقت مناسب وبدقة مقبولة.

ABSTRACT:

Feasibility studies of the big projects playing an important role in the economy of the countries, as it helps in reviewing the strengths, weaknesses, opportunities, and threats that effects those projects. In the water sector, the main focus developing countries nowadays is to start study and develop a long-term plan to develop a strategy for the best utilization of land and water resources. Under this plan, managing water projects was determined to be one of the high priorities. One of the main constraints in starting those projects is the lack of capacity and information to start a feasibility study of these projects, thus data collection from the project sites is needed. The present research paper presents the use of recent technology of data collection and analysis for constructing a multi-purpose dam in the basin of Sue River, South Sudan. Feasibility study for constructing this dam requires huge amount of data and information about the site. Bathymetric and topographic survey, remote sensing (RS), digital elevation model (DEM) and geographic information system (GIS) was integrated in order to collect the required information in a suitable time with accepted accuracy.

Keywords: RS; GIS; DEM; Satellite images; Sue River; South Sudan.

1. INTRODUCTION

Integration of field measurements, GIS data with remotely sensed imagery has witnessed increased interest for the following reasons:

- Increased data availability, quality, and decreased data costs across large study extents, (Davis et al., 1991; Emch et al, 2005; Treitz and Rogan, 2004),
- Growing need for automated mapping and map updating in complex landscapes using expertsystems/knowledge-based classification (X. Huang and Jensen, 1997; Lees and Ritman, 1991; Raclot et al., 2005), and
- Demonstrated potential of data fusion for predictive forest change mapping (Baker, 1989; Mladenoff, 2005; Rogan et al., 2003).

Feasibility study of a multipurpose dam at Sue River, South Sudan was carried out. This kind of studies require huge amount of information concerning the river bed configuration, banks levels, land use, etc. In order to collect this information, new integrated logical system that accelerates very much data collection process with accepted accuracy was developed. This system , mainly depends on the integration between direct field measurements, RS, DEM and GIS technique, as well as recent satellite images. This paper in its successive sections presents the developed integrated system with its different components functionality and outputs.

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2. SITE DESCRIPTION

The Sue and the Bussere rivers meet to form the Jur River just south of Wau city, the capital of the Bahr El Ghazal region, South Sudan. Sue River is the main collector of the run-off from the fertile southern watershed area, though for much of this distance it goes through almost uninhabited land. For 80 Km upstream the confluence it flows slowly in 2-3 Km wide grassy flood plains. Figure (1), shows the location of the Sue River, South Sudan (Hydraulic Research Institute, 2010).

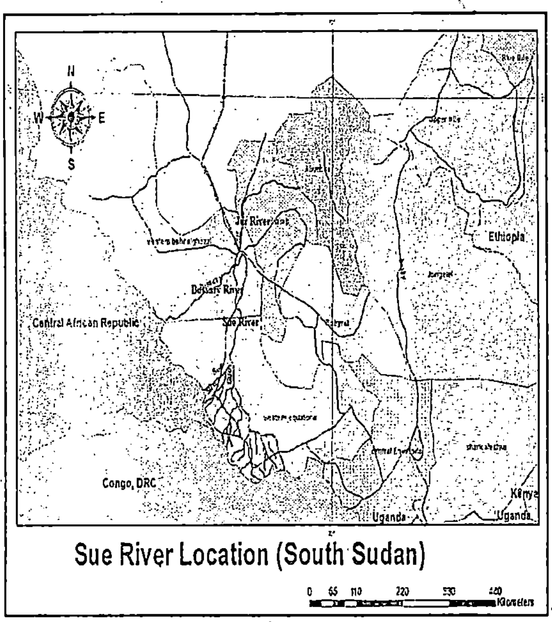

Fig. 1: Site Layout

3. METHODOLOGY

Geographic Information System and Digital Elevation Model in combination with recent satellite images are used to establish a three dimensional views of the Sue river basin and its land use. The GIS model was developed based on following items:

- Control points
- Derivation of DEM
  - Bathometric survey
  - Topographic survey
- Analyzing recent satellite images

Figure (2), shows the methodology of the data collection.

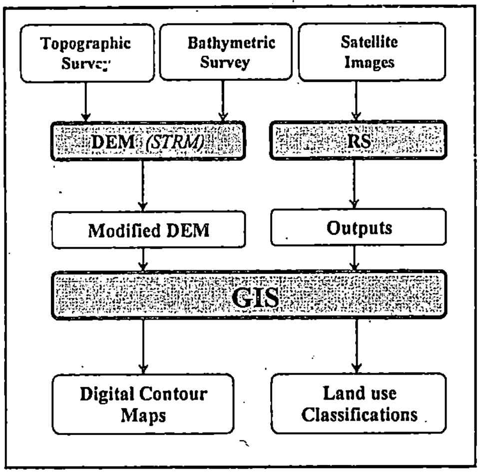

Fig. 2: Methodology of data

4. CONTROL POINTS

Differential GPS is the primary survey reference for all types of present-day engineering and surveying activities. GPS is a continuous, all-weather, worldwide, satellite-based electronic positioning system. It is available to the general public and is known as a standard positioning service. Over the past several years, a technique has been developed to process signals from two GPS receivers operating simultaneously to determine the 3-D line vector between the two receivers. This technique is known as "differential positioning" (DGPS) and can produce real-time positions of a moving vessel, see Figure (3).

The accuracy of the collected data is directly based on the accuracy of control points, (BMS). The position (X, Y, Z) of the control points was determined to a high degree of accuracy. The horizontal coordinates, (X, Y) of four points were calculated accurately in WGS84 coordinate system using single point positioning technique of GPS which has been applied for several hours of observation spanning in three consecutive days. The vertical coordinate of these points, (Z) was determined by double run leveling technique using precise leveling between them and the Sue River gauge which located at Km 7.16, see Photo (1).

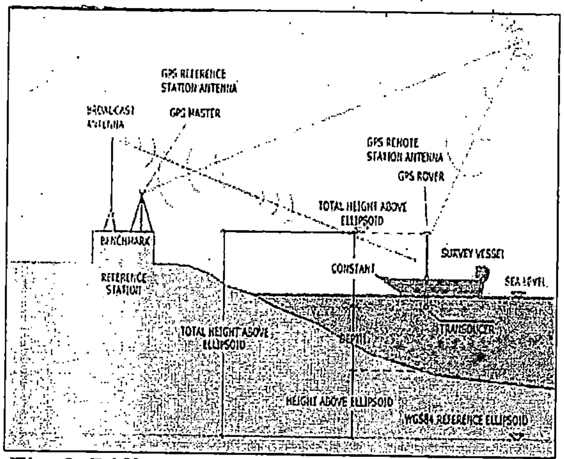

Fig. 3: Differential GPS real-time measurement of position of survey vessel

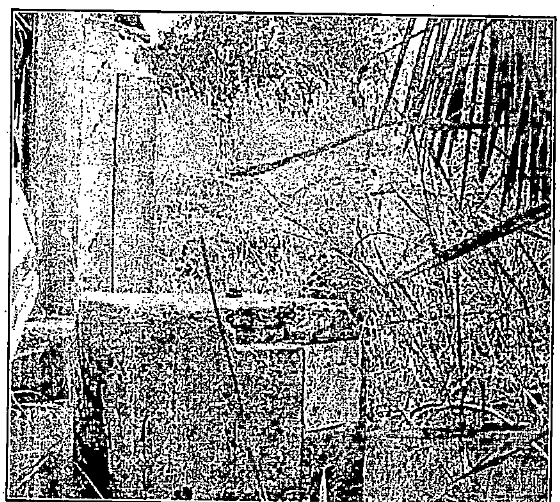

Photo 1: Sue River Gauge at Km 7.16

5. DERIVATION OF DEM

NASA Shuttle Radar Topographic Mission (SRTM) has provided digital elevation data for over 80% of the globe. This data is currently distributed free of charge. The SRTM data is available as 3 arc second (approximately 90m resolution) DEMs, Figure (4). The vertical error of the DEM's is reported to be less than 8m. The outputs of this model were enhanced by using topographic and bathymetric survey. In the following subsections the enhancement process will be described.

5.1 Topographic Survey

Topographic survey covered a distance of 30 km of the Sue River banks was carried out using rover units of GPS. DGPS system was used to correct the coordinates and levels of the measured points based on the control points (Reference point).

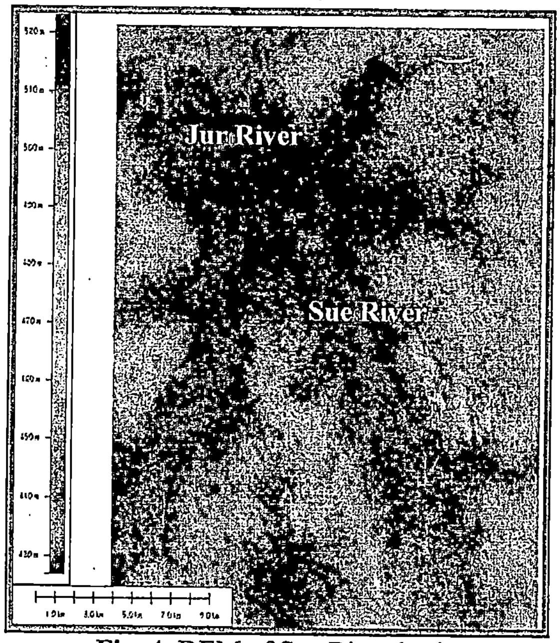

Fig. 4: DEM of Sue River basin

5.2 Bathymetric Survey

Bathymetric survey covered a length of 32 km of Sue River and 5.5 Km from Jur River was carried out. The survey was carried out using DSF-600 Digital Echo Sounder for water depth measurements. The sounder transducer was deployed from the side of the survey vessel. It was calibrated by the "bar cheek" method before and after each period of sounding. The survey was carried out using GPS unites. The First unit, (reference unit) was deployed on the river bank at a control point while, the second unit was deployed from the side of the survey vessel over the echo sounder transducer. The data was collected and digitally stored during the boat movements. The average distance between the measured cross section is ranged between 20 to 30m, Figure (5).

5.3 Modified DEM

The results of SRTM DEM were enhanced according to the following technique:

- Derivation a relation between its results and the results of the topographic survey using a huge number of measured points covering reasonable areas of the river banks.

- Producing a gird for the bathymetric survey results using surfer software and replace it with its similar spatial location in the DEM.

This enhancement produced an overall topographical view of the river basin, both above and below water surface.

Comparing the results of SRTM DEM after modification and the other set of measurements shows a good agreement, as the average levels error is found to be less than 1.0 m, Figure (6).

Fig. 5: Survey boat data along the Sue River

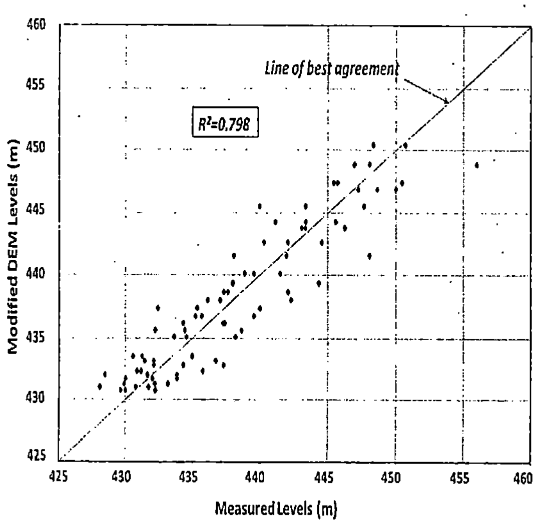

Fig. 6: Comparison of measured levels and modified DEM levels

6. ANALYZING RECENT SATELLITE IMAGES

The remote sensing, (RS) division has strong expertise and extensive experience in the application of RS technology in various sectors. This division provides services in satellite images processing, geo-referencing and maps preparation, land use and land cover classification, flood coverage, disaster monitoring and damage assessment including erosion mapping and monitoring. The division also, conducts analysis of spatial and temporal data derived from satellite images and training on RS.

Classification was performed on multiple image channels to separate houses location, forests, crops, roads, wetland, etc according to their different scattering or spectral characteristics. Digital image classification procedures are differentiated as being either supervised or unsupervised clustering. Figure (7) shows land-use map of the Sue River basin.

7. GIS OUTPUT

For ease of presenting the output of Sue river basin, it was divided into seven zones, as shown in Figure (8). Samples of the output can be summarized as follow:

- Figure (9) presents sample of contour maps of the topographic survey and the river bed iso-levels is shown in Figure (10). While Figure (11) represents sample of the count and location of houses in the study area at each zone while
- Tables (1), tabulates different elevations of wet land areas.
- Figure (12) and (13), present sample of forests and wetland along the study area, respectively.

It is worth to mention that; all houses locations on the study area were determined in (X, Y) format.

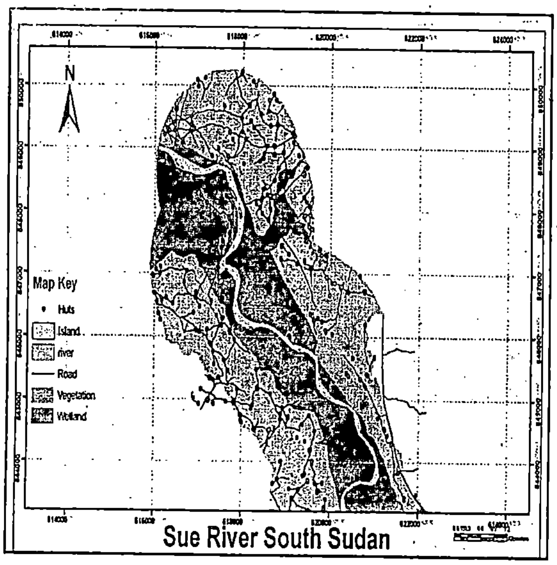

Fig. 7: Land-use Map of Sue River basin

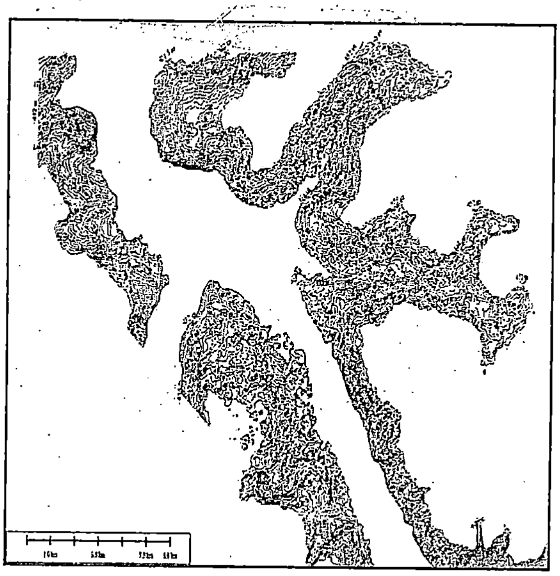

Fig. 9: contour map of the banks

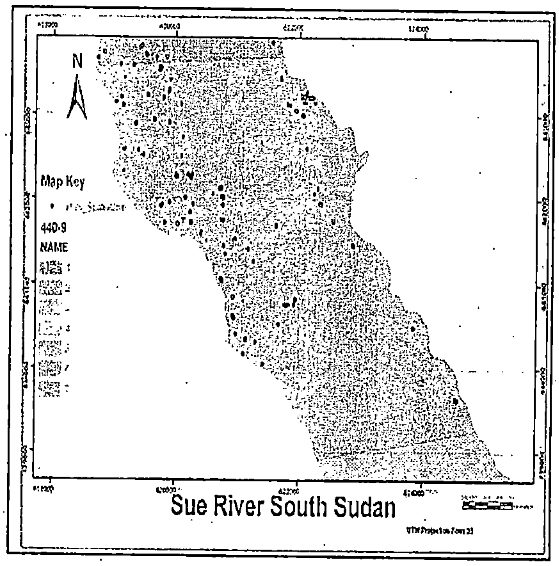

Fig. 8: Zones of Sue River basin

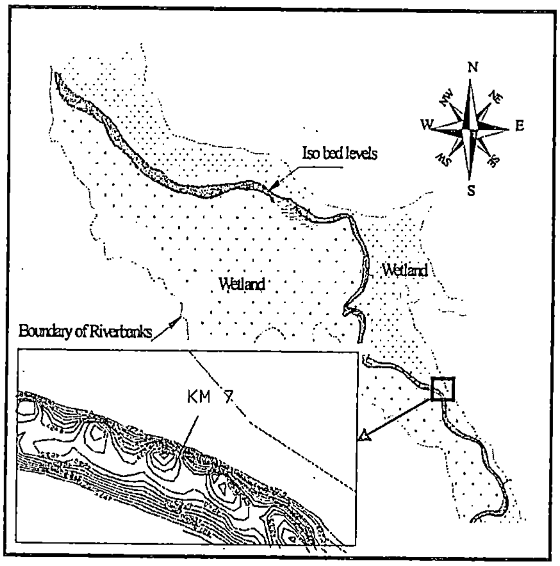

Fig. 10: Contour map of bed levels

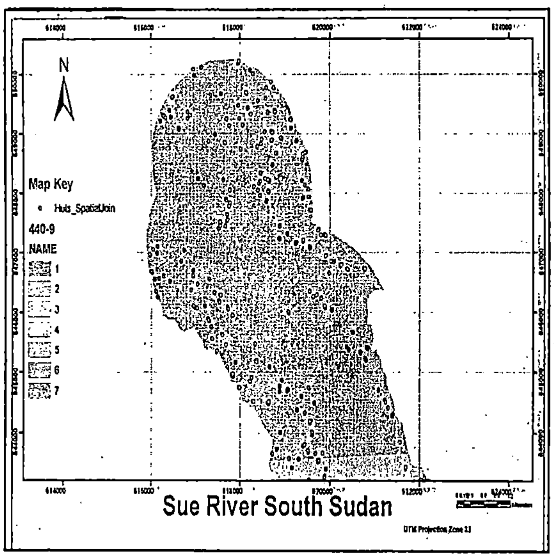

Fig. 11: Houses location within zone one of the study area

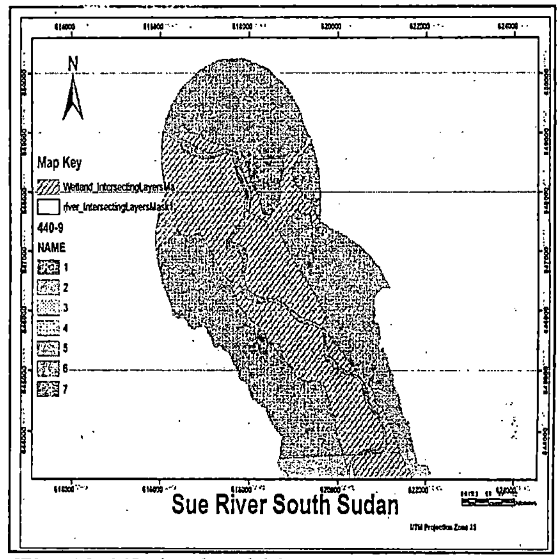

Fig. 13: Wetlands within zone one of the study area

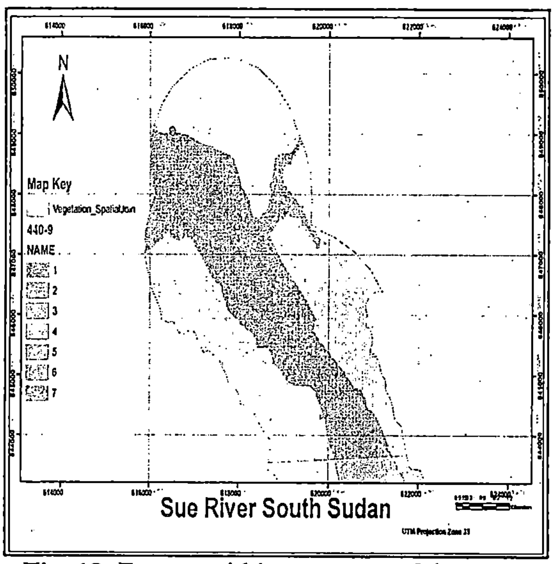

Fig. 12: Forests within zone one of the study area

Table 1: Wetland areas in the study area

Area Type	Area (m^2)	Zone No.
Wet Land	2294804	6
Wet Land	111758.6	6
Wet Land	880372.7	6
Wet Land	3936917	6
Wet Land	265483.6	6
Wet Land	2860761	6

8. CONCLUSIONS

Direct field measurements are one of the most accurate methods for precise information but the disadvantage of this method is the high cost and time consumption especially when a large area has to be surveyed. Sometimes, it could not be achieved for some other reasons such as wetland, unsecured sites, etc, as the case of Sue river basin. Integration system between direct field measurements, RS, and GIS techniques was found to be useful in such kind of sites, as it accelerate very much the data collection process with accepted accuracy.

This system practically proved to be successful in surveying the basin of the Sue River and all of the needed information in the study area such as houses locations, roads, crops and forests, etc. The data was analyzed and presented in a form of digital contour maps, tables and figures that satisfy the required information with accepted accuracy.

9. REFERENCES

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NOTATION:

The following symbols are used in this paper:

DEM	: Digital Elevation Model,
DGPS	: Differentially Global Positioning System,
GIS	: Geographic Information System,
GPS	: Global Positioning System,
NASA	: National Aeronautics and Space Administration,
RS	: Remote Sensing, and
STRM	: NASA Shuttle Radar Topographic Mission.