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Interlinking Rivers of South Asia for Improving the Quality of Life

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ABSTRACT: South Asia (Bangladesh, Bhutan, India, and Nepal) is home to nearly one-fifth of the world's population residing on one-fiftieth of the land area of our Planet Earth. South Asia has the highest population density (400 people/km^2, compared to China's 140 and the USA's 33) in the world. In an evolutionary theory, energy and water combined together create life cycle on earth. Humanity has evolved near the vicinity of water resources. South Asia has vast water resources, and the arable land in this region is 47% of total land area compared to 15% in China and 18% in the US. The land and water resources provide hope for South Asia and future prosperity is possible if both the resources are utilized optimally to enhance the quality of life. A regional, holistic, and inclusive approach has to be adopted to optimize this resource. Interlinking of rivers is one way of optimizing the water resource. However, detailed studies utilizing state-of-the-art technologies such as advanced geodesy/isostasy, satellite remote sensing, and Engineering Geographic Information System (E-GIS) are needed prior to designing and implementing such a project. By coupling the relevant and state-of-the-art technologies and field collected data, including meteorological, hydrological, land use/cover, soil, geologic, and census data, various models such as ecological, evapotranspiration, soil moisture, etc., can be simulated to forecast various options prior to implementing such a project. This research-cum-conceptual presentation will gather in-land historical river linking projects such as in the US, China, Europe, and Egypt to validate the concepts.

Keywords: Water and Land Resources, Geodesy, Isostasy, Remote Sensing, Engineering GIS, Hydrological Modeling, Simulation, Optimal Planning.

BACKGROUND

Artificial or man-made channels for water diversion have been in use for delivery of water for irrigation or water supply or for use as waterways since as early as 4000 BC. The oldest known canals were built in Mesopotamia, Indus Valley, ancient China, Egypt, and in Europe by the Romans. The Grand Canal of China (1794 kilometers) is still the longest canal in the world (Wikipedia). From the 1st to the 18th centuries, the Chinese, the Europeans, the Russians, and the Americans were all building canals for connecting rivers and or oceans for navigation, and other applications. The Russian nationwide canal system connecting the Baltic and Caspian seas via the Neva and Volga rivers was opened in 1718. During the industrial revolution in Europe and the United States, inland canals preceded the rail roads for transport of goods. During the 19th century, the length of canals in the US grew from 160 kilometers to 6,400 kilometers.

Many notable sea canals were built during the 19th century; these are the Suez (1869), the Kiel (1897), and the Panama canals. [Although the concept of a canal near Panama dates back to the early 16th century, the first attempt to construct a canal began in 1880 under French leadership. After this attempt failed and saw 21,900 workers die, the project of building a canal was re-attempted and completed by the United States in the early 1900s, with the canal opening in 1914. The building of the 77 km canal was plagued by problems, including disease and landslides. By the time the canal was completed, a total of 27,500 workers are estimated to have died in the French and American efforts.]

INTRODUCTION

Rivers play a vital role in the lives of more than a billion people living in South Asia. The pressure of human population on the environment in this region is enormous, i.e., more than 20% of the world population lives in less than 2.5% of the total land area of the earth. This region has the most sensitive ecology in the world; i.e., the Himalayas are young and still active. Any abrupt changes in the environment may bring catastrophe in the region. The regional environment may not balance out the population pressure, and the status quo (do nothing) growth of population will increase the poverty further if some new, scientific, and collective project(s) to overcome the situation are

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not implemented soon. Despite all disparities, South Asia has abundant water resources and arable land (2.5% of the Earth's total arable land is in South Asia) to encounter the problem and to prosper economically. This paper is an inventive presentation of River Linking Project(s) for South Asia (RLP-SA). To implement such a regional project(s) the following attributes need to be studied meticulously:

- Dedicated Leadership(s) with Vision
- Needs Analysis
- Political and Legal Aspects
- Planning Aspects
- Economic Aspects
- Social Aspects
- Technological Aspects
- Project Optimization.

The above attribute listings are in the order of priorities to implement accomplish regional project(s). After a brief discussion of the above factors, this paper will move into the "Technological Aspects" of river linking project(s).

Dedicated Leadership(s) with Vision

To implement such a mega project(s), a dedicated and collective leadership has to emerge in the region to successfully implement the project(s) for the benefit of the people living in the region without any discrimination with regard to the size of the country. However, the leadership role should be based on a merit system.

Needs Analysis

This factor is very critical to understand the problem and scope of the project to be implemented.

Political and Legal Aspects

This aspect of the project implementation is the most difficult one and it has to be tackled in a democratic manner to avoid any future squabbles.

Planning Aspects

This is a very important factor for the success of the project. This aspect should include all facets of the project implementation.

Economic Aspects

The project being a regional one and involving many countries, long term economic analyses are essential and consequences should be considered prior to moving to the project implementation. After all, this is the most critical attribute of the project implementation to make it successful and accomplished on time and with desired results.

Social Aspects

This attribute may not appear to be of high priority to some; however, indirectly this is the most critical aspect since the main objective of the project is to eradicate poverty from the region through jobs to the people of the region. This will uplift the standards of societies and living standards of the citizens in the region.

TECHNOLOGICAL ASPECTS

Humanity has been evolving near the vicinity of water resources. About sixty percent of the world population lives along coastal areas according to UN reports. Two thirds of the world's population will live along the coasts by 2030 as reported by The World Bank. The coastal areas of our planet will soon be stressed with over population and environmental degradation unless efficient and environment-friendly planning to cope with this problem is put in place on time. Such a planning can be optimized through an integrated regional energy and water cycle model that is supported by advanced geodesy, satellite remote sensing, and Engineering Geographic Information System (EGIS). By coupling the relevant and state-of-the-art technologies, it is proposed to develop a new integrated and Comprehensive Water Cycle Model (CWCM) that will provide a scientific basis for inter-linking of rivers in South Asia. The model not only will serve the current objectives but it can also be expanded to other studies such as carbon cycle and global climate models. The CWCM will assist towards optimal regional planning of water resources, environment-friendly developments, and emergency preparedness.

Energy and water cycles are intertwined as solar radiation (the vital input of our daily energies) changes the phases of water, as a result of which perpetual global circulation of energy and water cycle takes place. The anthropogenic aggression has been putting stress on the earth's crust and its biosphere to make water as its first victim. Houser (2006) links water and energy to all twelve science application themes such as: Carbon Management, Water Management, Agricultural Competitiveness, Public Health, Homeland Security, Invasive Species, Energy Forecasting, Coastal Management, Ecological Forecasting, Aviation Safety, Disaster Preparedness, and Air Quality.

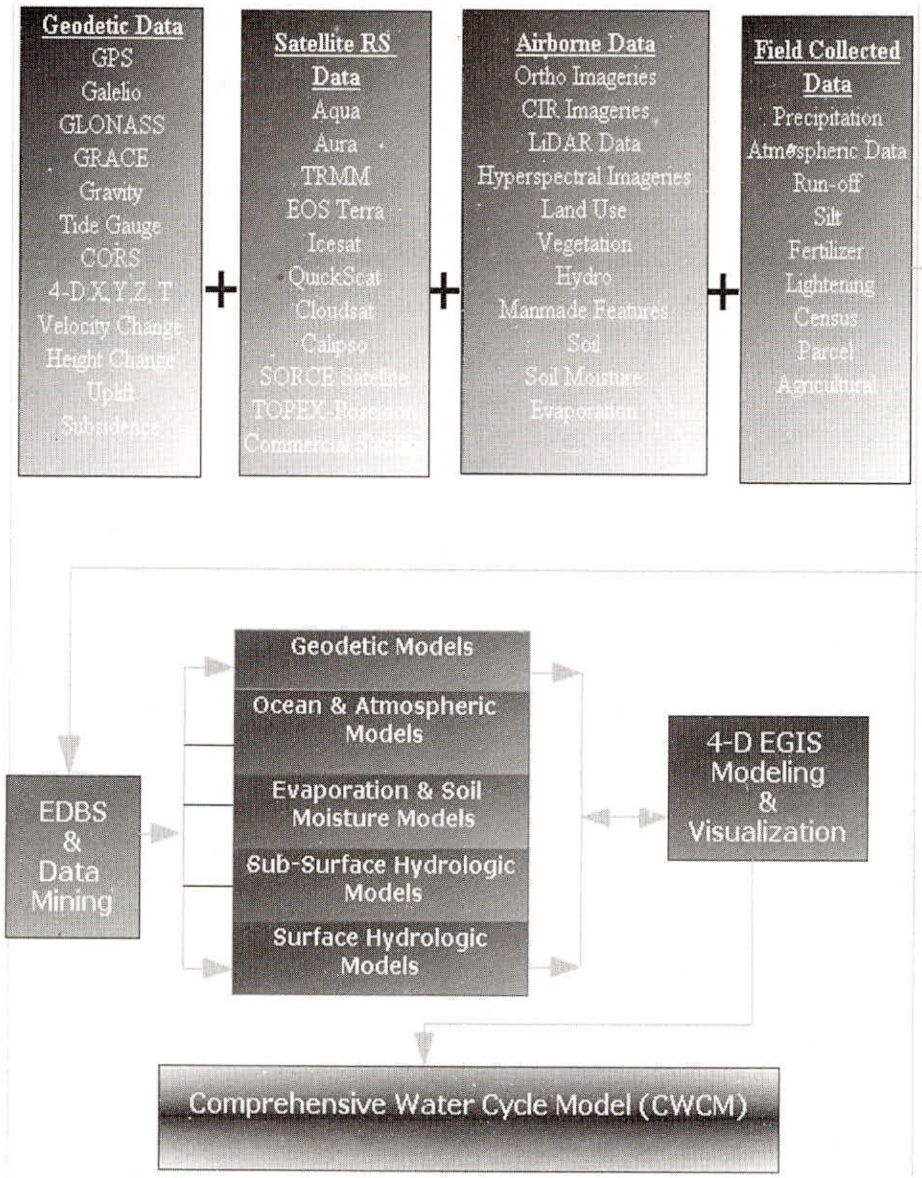

Fig. 1: Comprehensive Water Cycle Model (© B. Acharya)

Climate change is a function of greenhouse gases, aerosol, and the forces acting on the earth's inner surface and the solar system and its consequences are realized through the water cycle. Prior to implementing the river linking project(s) in South Asia, a comprehensive water and energy cycle study should be performed by integrating geodesy/isostasy (quantify water cycle activities such as sea level changes, land uplifts, subsidences, erosion, etc.), satellite remote sensing (model evaporation process, and visualization of data), and engineering GIS (planning, designing, and implementing of risk management) for water cycle modeling. The water cycle study is a very complex subject as it involves all aspects of the physical sciences. The significance of such a study will be in utilizing data mining technology in creating various water cycle related models, and 4-D EGIS and then integrating them to create local, regional, and global CWCMs. A comprehensive water cycle model is given above (Figure 1):

The above CWCM model was conceptualized by the author in collaboration with other scientists and it is in the development stage.

The following four models should be considered and developed prior to implementing the RLP-SA project(s):

- Geodetic Models
- Ocean & Atmospheric Models
- Evaporation & Soil Moisture Models
- Sub-Surface Hydrologic Models
- Surface Hydrologic Models.

GEODETIC MODELS

The most important aspects of RLP-SA project(s) is the datum configuration, height modernization in the region, and a GPS geodetic network with Continuous Observing Reference Sites (CORS) in the region. The above mentioned geodetic modeling is very critical to optimize the state-of-the-art geospatial technology available today which can achieve a centimeter level precision which is very critical for RLP-SA. (To obtain an accuracy of 10 cm in a 1,000 kilometer long river basin, a 1:10 million accuracy of the GPS Geodetic Network is required and it can be achieved with the satellite configuration available today: GPS, GLONASS, and Galileo).

Various geodetic models can be deployed to study the water cycle in the region, e. g., (a) satellite data can be used to quantify the ice melt in Antarctica and its consequences in the sea level rise in the coastal areas, (b) GRACE satellite and field observed gravity data along with tide gauge data can be used to create a variable geoid model which will predict the rise or drop of water level in the region; it will also be used to correlate mass changes, the portion of the total mass change caused by the movement of water being quantified using gravity data. A combination of GRACE (gravity) with soil moisture, and atmospheric data can be used to isolate changes in groundwater storage, allowing the monitoring of monthly water storage changes in aquifers, (c) Continuous Observing Reference Stations (CORS) and tide gauge stations data can be used to precisely to measure the sea surface water level changes.

OCEAN AND ATMOSPHERIC MODELS

Ocean and Atmospheric Models are critical to understand the water and energy cycle and specially for weather forecasting. There are several models designed by NOAA for the study of the earth's climate, atmosphere and oceans.

EVAPORATION SOIL MOISTURE MODELS

Measuring soil moisture is a critical part of hydrologic modeling and for irrigation of agricultural land. Soil moisture measurements can build a profile of each irrigated field that is invaluable for proper management. The soil moisture models could assist in optimizing irrigation input which is very critical in water management for large areas. Also, it provides information which can be used to minimize water logging. Field data and remote sensing data are combined to create evaporation and soil moisture models.

SUB-SURFACE HYDROLOGIC MODELS

There are several Ground Water Modeling (GWM) packages for ground water studies. The GRACE gravity, remote sensing, and field collected data can be used to create models that will work with 4-D GIS for ground water modeling and forecasting. Abundance and quality of ground water is the governing factor to determine flow and directions of water currents in the aquifers, which eventually lead to open water bodies, springs, or man-made lakes. For an accurate and reliable water balance in space and time, ground water modeling is needed to ascertain the availability of water.

SURFACE HYDROLOGIC MODELS

Space technology can be coupled with 4-D GIS to create a comprehensive surface hydrologic model(s). This type of model can provide water balance on a grid cell basis and provide proper visualization thereof, both on the surface and below the surface. Visual mapping can show flow paths, water storages, and flows in near real time. The modeling tool can assist engineers and planners with proper planning and management of water resources.

PROJECT OPTIMIZATION

The project could be optimized by minimizing cost, maximizing accuracy, and integrating with other development projects such as water navigation, hydro-power generation, surface transportation, electric grids, and implementing land reform programs to eradicate poverty and increase agricultural production. Project can be further optimized by coupling 4-D GIS data with data mining to create a emergency forecasting model.

CONCLUSIONS

Mega project(s) of the nature discussed in this paper can be optimized by utilizing the state-of-the-art geospatial technology which has reached new heights in terms of accuracy and efficiency. A 4-D GIS (XYZT) database created utilizing satellite, airborne, and terrestrial techniques coupled with a data mining model could ensure the success of project(s) of such magnitude and nature.

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