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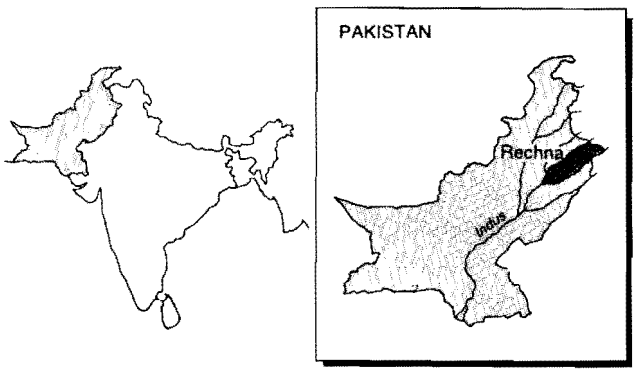


GIS Framework for Salinity Management across Large Irrigation Systems: The Rechna Interfluve in North Central Pakistan

A COMPLEX AND HETEROGENEOUS IRRIGATED DOMAIN

The operational complexities in the use of the spatial information systems primarily derive out of the three-dimensional matrix comprising units in space and time and their qualitative or attributive profiles. An increase along any of these dimensions multiplies the complexity and handling of the respective constituent representations in space. In the context of large area inventories, such as across irrigated landscapes, these considerations become profound due to variations in physiography, cropping pattern, farming practices, and productivity changes over time. One such example could be quoted from the Punjab Province of Pakistan where the regime between the Ravi and Chenab rivers constitutes a bar upland interfluve that is under extensive canal irrigation comprising a total of 2.4 million hectares. Much of the system, irrigated by three major canals offtaking from an equal number of barrages/headworks along the length of the Chenab River, is more than 100 years old and has had a documented history of problems related to high water tables and buildup of soil salinization. The distribution system itself, comprising branch canals and secondary channels, is designed for equity. However, due to a host of physical and social reasons this objective is not globally realized. Incidentally, this aging system has also remained the focus of much of the past public sector investigations and land reclamation efforts; hence, the wealth of information is considerably more than on other parts of the Indus Basin.

INTEGRATION OF SCATTERED INFORMATION THROUGH GIS

Under a mandate from the Government of Pakistan, much of IIMI's past 10 years of research into the management of the irrigation system has remained confined to units comprising the secondary and tertiary level commanded regimes. This was essential to the understanding of the causes underlying emergent constraints to productivity. However, the absence of mechanisms for extrapolation of the results across successively larger geographical locales has prevented consolidated analyses encompassing areas of the size of a canal command or larger. For the Rechna *Doab* (interfluve) in particular, the challenge towards integrated assessment of multi-spatial and temporal data derived from different sources was considerable. Accordingly, the prerequisites of base stratification of public sector archives and IIMI's own data across a consistent reference in space called for an indispensable reliance on a GIS. This would facilitate not only the aggregation, and in many cases spatial resampling of existing mapped data but also the derivation of useful information pertaining to the geographic distribution of the sustainability rankings for crops, surface and profile drainage conditions, and three-dimensional variations in surface topography and groundwater quality.

A MAJOR CONCERN: SALINITY MANAGEMENT

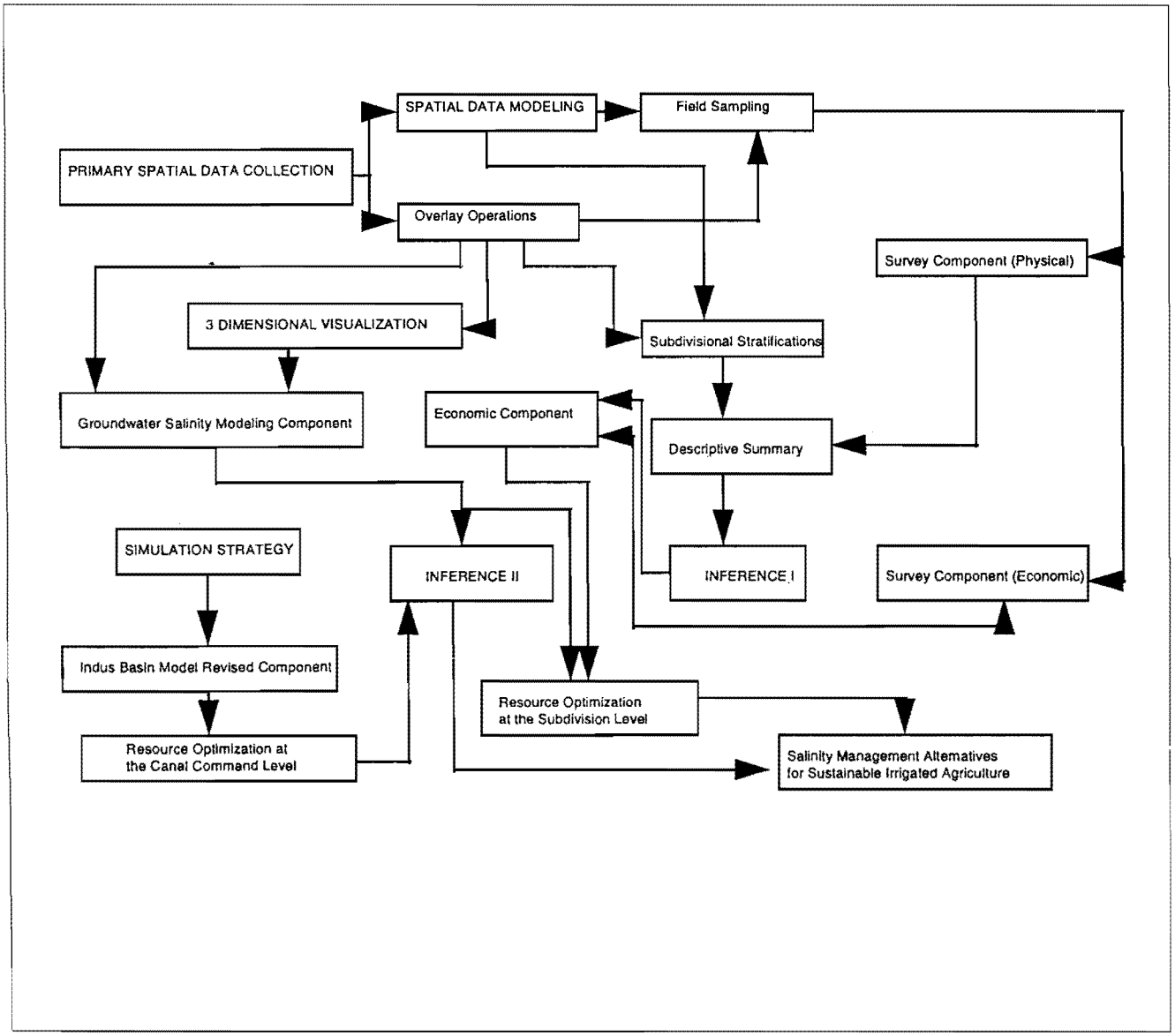
The multidisciplinary study, titled Salinity Management Alternatives for the Rechna Doab, Punjab, Pakistan formed a subcomponent of a larger project, Managing Irrigation for Environmentally Sustainable Agriculture, that has been funded by the Government of the Netherlands for the period 1994-1998. The study, begun in late 1994, was completed in June 1997, and comprises an 8-volume report that follows a

sequential flow of information summarized in the Process Flow Chart given in figure 3. The objective definitions called for an evaluation of the existing physical and economic resource base across the multiple canal commands of the Doab that would facilitate deployment of strategies to combat land degradation. The intent was not to evaluate specific land reclamation strategies, such as the ones effected by the government in the past, but to explore options that are primarily management-oriented and coincident with realistically achievable targets. The ultimate goal of the overall evaluation process is to maintain the best returns at the farm gate.

GENERATED ALTERNATIVES

The GIS-generated thematic comparisons involving soil salinization, variations in surface texture, and their associative definitions (drainage and crop suitability), quality of groundwater for irrigation, and fluctuations in subsurface water levels together lent credence to the

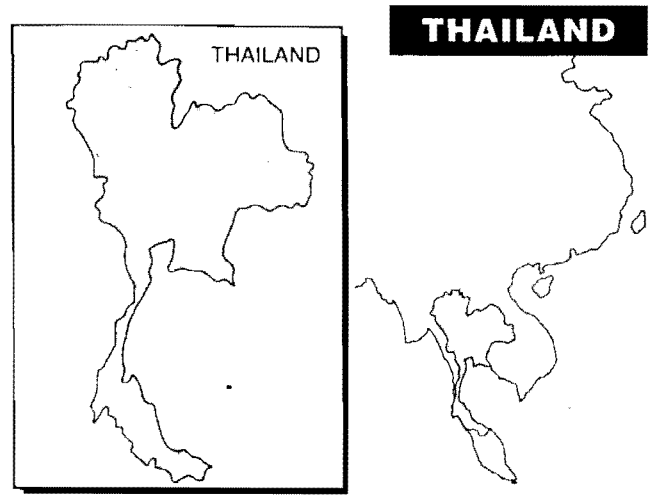
Figure 3.
Process flow chart for the study of Salinity Management Alternatives in the Rechna Doab, Punjab, Pakistan.



selection of sample sights for in situ substantiation of the land degradation trends. Across the sample domain, 164 sites were monitored totaling 15,200 measurements of salinity taken through the EM 38 device. These measurements coincided with 443 farmer interviews recorded on a separate questionnaire. The questionnaire information helped establish the critical parameters for the generation of the production functions specific to the major crops grown in the area. These functions represent the economic slide rule for higher crop yields within their respective definitions of physical constraints that can be geographically accounted for, to arrive at cumulative production potential. Variations to the functional inputs would then constitute partial evaluations leading to the salinity management alternatives.

Towards comparative assessment of the salinity management alternatives at the canal command level for the years 2000 and 2010, the use of the Indus Basin Model has been indispensable. This model was developed by the World Bank for the Government of Pakistan to evaluate the economic costs and benefits of alternative water allocation strategies across the Indus Basin. For the study, the Model has allowed estimation of the productivity, costs, and profits that would be realized, given the options for extensive (land-related) and intensive (input-related) reliance on irrigated agriculture. In arriving at these comparisons, infrastructural adjustments towards augmentation of the irrigation supplies have been forsaken in favor of reallocation strategies. The conclusions are clearly drawn in favor of intensive inputs to irrigated agriculture to redeem the farm-level economies. Recommendations support a farm-level management program together with improvements to the hydraulic performance of the canals and institutional steps for groundwater management. The remediation has to be supported by the renewed commitment to the investigation of the current physical resource base that allows research activities to remain focused on coordinated salinity management.

Gauhar Rehman
Civil Engineer (GIS Specialist)
International Irrigation Management Institute
Pakistan National Program
12 km Multan Road, Thokar Niaz Baig, Lahore 53700, Pakistan
Tel: (92)(42) 5410050-53, Fax: (92)(42) 5410054
E-mail: g.rehman@cgnet.com



NAGA—A GIS-Based Software for the Monitoring and Diagnosis of Irrigation Projects

A large number of computer tools have already been developed with the aim to improve water management or irrigation projects management. Except for a few examples of automated irrigation projects in the most developed countries, their introduction has generally not been very successful. Too heavy data collection, poor data quality, lack of incentive or insufficient skills of the staff, difficulties in enforcing management rules at the lower levels of the scheme, and insufficient hydraulic regulation structures are some of the constraints commonly experienced by these programs.

The NAGA program is deliberately aimed at using existing data without demanding heavier data collection than is usually done. NAGA allows the manager to *visualize* the current situation in his scheme through the use of a GIS interface, and to analyze it by displaying time series of relevant data. In its first version, NAGA is designed to strengthen (or restore) the control upon what can be considered as the minimum and basic requirement of water management: the monitoring of water allocation in the different hydraulic units and the monitoring of the water level in the main canals. In fact, it is assumed that these two functions are a necessary first step in daily monitoring and water management, and that their mastering is a prerequisite to any further improvement. NAGA is, therefore, designed to allow easy and visual assessment of these variables, with little or no change in data collection.