THEME-VII

WATER RESOURCES PLANNING DEVELOPMENT & MANAGEMENT

IRRIGATION SYSTEMS MANAGEMENT-NEEDS AND OPPORTUNITIES

V.V.N. Murty, R. Loof* & K. Takeuchi**,*

* Asian Institute of Technology, Thailand
** Food and Agriculture Organization, Bangkok, Thailand

The development of irrigation systems with special reference to the Asian region is briefly reviewed. The scope and benefits of an efficient irrigation system management together with the essential technical components are outlined. These consist of examining the water deliveries, canal operation procedures, forming water users associations, infrastructural development, mitigating environmental hazards etc. The role of computer applications, monitoring and evaluation of irrigation systems, the need for development of interdisciplinary educational programs and irrigation extension services are discussed. Various suggestions for improved irrigation system management are summarized in the form of conclusions and recommendations.

ACTION RESEARCH FOR IRRIGATION MANAGEMENT – A CASE STUDY

R.K. Sinha
Former Engineer-in-Chief, Water Eesources Deptt. Patna, Bihar, India

Action Research in simple terms is research on the performance and efficiency of a live irrigation system in terms of its conceptual design construction, present physical status, agronomic conditions in the command and socio-economic aspects of the beneficiary farmers. The research is used to develop appropriate interventions to rectify the deficiencies observed in the systems, analyse them and search for alternative solutions and prioritize the solutions based on principles of cost and time effectiveness. Action Research is also concerned with implementation of the priority recommendations, monitoring and evaluation of the impact of interventions, and transfer of successful interventions to other similar situation. A case study of Sone Canal System is discussed in this paper.

CAN PROTECTIVE IRRIGATION BE MORE EFFICIENT?

M. Jurriens & W. Wolters***

* International Institute for Land Reclamation and Improvement, Wageningen, The Netherlands.
** Agricultural University,Wageningen, The Netherlands.

In India, numerous irrigation systems have been designed for "protective irrigation". Since developments in the agricultural sector have led to the wish for more productive irrigation, this has resulted in problems of inequitable water distribution and under-utilization of the irrigable area. The paper makes the point that problems now faced are directly related to the difference between actual water demands and available resources. This issue is illustrated with detailed information from the Tungabhadra Left Bank System in Karnataka. First, the initial design is reviewed in terms of irrigation intensities and duties. Subsequently, the essentials of the current situation are depicted and it is shown how the present practices are conflicting with the initial design. In this situation it is often suggested that increasing the irrigation efficiencies would be (part of) the solution to combat water shortage. This is assessed in the second part of the paper.

After a brief review of the efficiency terminology and the problems involved, actual irrigation efficiencies realized for several years are discussed. Results show a wide variation and it is concluded that no definite values can be determined. Very high values point at serious under-irrigation and low values indicate water losses. Results in rabi are generally higher than in kharif, even when not counting rainfall. It is concluded that one should concentrate on identifying possibilities for reducing avoidable losses, based on field information. This is done in the remaining of the paper, distinguishing between kharif and rabi, between various system levels and considering the effects of rainfall.

In the Tungabhadra case the possibilities in the main system seem to be limited and most promising measure would be to apply a canal closure period during the kharif harvesting, when losses are highest. There seems to be some scope for reducing losses at chak and field level. Moreover, losses could be reduced when a more reliable outlet flow could be guaranteed. Although losses during rain can be considerable, a number of practical reasons is given why it is not likely that measures can be found to substantially reduce canal water losses during rainfall

periods. On a number of aspects, the Tungabhadra case may not be representative for all Indian irrigation. But at least one lesson will be more generally valid, namely that it is not realistic to expect, particularly with protective irrigation, that efficiencies could be drastically improved.

RATIONAL APPROACH TO SUSTAINABLE WATER RESOURCES DEVELOPMENT OF NEPAL

Jit Narayan Nayak

Institute of Engineering, Kathmandu, Nepal

The management for the development of water resources system based on the piece-meal planning has been followed till to-date leading to failure and complexities. A rational approach to integrated planning and development with the management in conditions of DEMOCRATIC DECENTRALISM has been proposed. Despite heavy foreign aid, unusual phenomenon (concurrent floods and droughts) and abnormal phenomenon (increasing foreign aid and decreasing real GDP) have harmed national economy to a large extent. The obsolete concept of development should be dispensed with in favour of rational planning preceeding foreign aid for a SUSTAINABLE level of economic growth. Development of water resources of Nepal has to be done in three phases of 10 years each starting with Terai, Mahabharat and Himalayan regions respectively providing foodgrain and water supply sufficiency, surplus electricity with balanced ecology. After 2-3 decades Nepal will develop further independently. A National Research and Design Institute for Water Resources Development (NARDIWARD) has been proposed for the solution of problems (created by unusual and abnormal phenomena) of Nepal and neighbouring countries.

THE OCCURRENCE OF HYDROLOGICAL BARRIERS IN IGNP AREA AND THEIR POSSIBLE HAZARDS IN CANAL IRRIGATION

D.C. Sharma & J.C. Dubey

Ground Water Department, Jodhpur, India

The IGNP Stage-II area is dominantly marked by a vast sandy terrain. It occupies northern and north-western parts of 'Thar Desert'. The heaps of wind blown sand constitute longitudinal, transverse, parabolic, barachan and mixed type sand dunes of varying dimensions. The geological studies in this area have revealed that the aeolian sands have been deposited over different lithological assemblages of Tertiary age. From the study of lithological sections of a large number of boreholes drilled in the area, it has been inferred that the thickness of aeolian sand gradually increases north-wards and towards western parts all along the international border.

Within such a geological framework of area, attempts have been made to interpret the hydrological characteristics of different surface and sub-surface lithounits so as to evaluate the effect of proposed irrigation in the area. For these studies, a large number of shallow drillings have been carried out in flow command as well as in lift command areas. The lithological attributes and hydrogeological properties such as infiltration and hydraulic conductivity tests have revealed that in the entire Stage-II area, hydrological barrier layers occur from almost surface to different depth horizons. It could be ascertained that the first hydrological barrier occurs within aeolian sands at shallow depths. This layer comprises of very fine grained sand cemented with silty and gypseous material and invariably comprises of sporadic sandy concentrations of different sizes showing dendritic growths.

The second barrier layer is marked by the upper weathered horizons of Tertiary formations. These lithounits comprise of calcareous sandstones, gypseous beds, gritty ferruginous sandstones, reddish shales and variegated clays. These formations occur at near surface in the form of interdunal flats along southern part of main canal, however, they are well exposed at a number of places around Kolayat, Mohangarh, Digga and Ramgarh areas. These lithounits behave as true hydrological barrier, as their hydraulic conductivity is markedly low and percolation of water through them is restricted to a great extent owing to their minerological composition.

The occurence of hydrological barriers within shallow depths in the IGNP Stage-II area is evident, which has gradually caused building up of perched water conditions at a number of places. Such conditions before onset of full irrigation in command area pose a severe challenge to execution of canal irrigation and needs precise delineation of barrier layers so as to design suitable drainage system and to adopt improved irrigation practices.

PHYSICAL AND BIOLOGICAL IMPLICATIONS OF WATER TRANSFER : A CASE STUDY OF CALIFORNIA

Edward A. McBean and Eduardo Bautista

University of California, Davis, USA

With the increasing centralization of population into large metropolitan regions, the availability of water supplies is causing significant concerns for planning. In response, pressures are developing for the transfer of water from one location to another. These situations of water transfer are being incurred in numerous areas of the world, including in the State of California of the United States.

The transfer of water from the northern part of the State to the southern part, particularly to the Metropolitan Los Angeles area with fifteen million people, has been an ongoing activity for decades. However, in 1991, as a measure to deal with critical water shortages induced by six years of drought, additional water supplies were needed. Consequently, the State of California created an Emergency Water Bank. This initiative by the State of California involved purchase of water from willing sellers (mostly from agriculture) and sale to interested buyers (mostly municipalities but also for irrigation needs in the southern part of the State). The initiative created was new to California – in terms of establishing a market for the purchase and sale of water.

Water transfers, particularly as they relate to transfers from rural areas of origin to urban areas, through market transactions offer to provide some of the flexibility required to serve growing water uses without resorting to large scale water development projects that are both economically costly and environmentally damaging. Further, the transfer of water through markets avoids the involvement of large-scale water bureaucracies that take on organizational missions, frequently at the expense of efficiency and public preferences (Reisner, 1986). Arguing against the existence of water transfers are environmentalists concerned with maintaining habitat and stream flows in areas of origin and those who anticipate sacrifices on the part of human communities from which the water is transferred.

In the State of California, more than eighty percent of the 820,000 acrefeet of water purchased by the Water Bank came from agriculture. In addition, the water to be transferred must necessarily pass through the Delta, an area of great importance in terms of environmental habitats and fisheries. Thus, a study was commissioned to examine the impacts of the water transfer on the physical and biological environment. The focus of the paper is on the assessment of the water transfer — how the extensive land-fallowing and increased groundwater pumping occurred in areas that participated in the project. Other short-term physical and environmental impacts occurred indirectly as a result of the transfers, including loss of feeding habitat for migrating waterflow, changes in water quality and flow that could affect fisheries, and increased subsidence in regions where the groundwater pumping increased. The paper briefly describes some of the methodologies used in attempting to isolate out the effects of the water transfer versus the effects as a result of other factors such as drought.

Many observers consider the Emergency Water Bank to have operated effectively, in fact, its success may have changed the terms of the California water debate forever.

INTEGRATED APPROACH TO WATERSHED DEVELOPMENT FOR WATER CONSERVATION AND ARTIFICIAL RECHARGE TO GROUNDWATER - A CASE STUDY OF PUNE DISTRICT, MAHARASHTRA STATE

K.G. Welekar, M.S. Vaidya, & S.B. Khandale

G.S.D.A., Pune, India

Large scale destruction of forest, excessive utilisation of groundwater and heavy application of surface water has damaging effect on the eco-system. The situation becomes more critical in the central part of Maharashtra, which receives scanty rainfall ranging from 400 mm. to 750 mm. and high rates of potential evaporation ranging from 300 cm. to 350 cm. per year. Major part of Pune district falls in the rain-shadow zone of Sahyadri ranges resulting in partial saturation of the aquifer and drinking water shortage.

Pune district is divided into 66-watersheds out of which 10-watersheds fall in the critical category and 15-watersheds fall in the category of deep post monsoon water level. The total area covered is about 3200 sq. km. The critical conditions of the natural resources and deeper groundwater level has laid to the formulation of watershed development project to conserve surface

water and augment the groundwater resources by implementing various projects of afforestation, soil and water conservation. The present paper deals with the various aspects of watershed development by evaluating the total water resources available, utilised and balance left for further development.

Further, an attempt has been made to develop a theoretical model of watershed development by application of multiple statistical methods.

WATER RESOURCES DEVELOPMENT — AN ENVIRONMENTAL APPROACH

S.C. Dhiman

Central Ground Water Board, Chandigarh, India

Natural resources are to be developed by maintaining a complete harmony between developmental activities and environments. Landscape is fast changing with the increasing population pressure. Deforestation and misuse of land has accelerated the erosional processes which in turn affects the potentialities of both land and water resources. In the study area, Pratapgarh Tehsil, Chittor (Rajasthan), a part of TRIBAL BELT, plateau basalts are highly developed for agriculture. Ground Water in the shallow aquifer is the major source of water supply. Prevalence of NARU ROG (Guinea Worms) causes water pollution problems in certain parts and is resulting in serious health hazards, which is affecting the supply of clean drinking water to the widely scattered tribal population.

Based on the detailed studies by both conventional and non-conventional methods, the areas feasible for different ground water harvesting structures have been delineated. To conserve the surface water for conjunctive uses, suitable areas for constructing anicuts, sub surface dykes and stop dams across the stream channels for minor lift irrigation schemes are demarcated. Also, the areas available for further agricultural activities, afforestation and other soil conservation practices are identified. The proposed development of these minor watersheds would result in recharging the depleting aquifers, protecting the degrading environmental conditions and improving overall socio-economical conditions of the TRIBALS.

EXPERIENCE ON IMPLEMENTATION OF SOME SELECTED WATER RESOURCES PROJECTS IN BANGLADESH

S.M. Khalilur Rahman

House of Consultants Ltd., Dhaka, Bangladesh

Bangladesh is one of the least developed countries of the world. It is a land of rivers and flooding is a normal feature in the Bangladeshis's life. At present about 450 completed FCD & I projects exist which cover 40% of the total net cultivable land of the country. Development in the water resources project is mainly dependent on foreign AID which comes either as loan or grant. From the experiences of some selected water sector projects it has been observed that the project implementation period normally extends two to six years, and the project cost increases by an average of 200%-600%. This situation is mainly due to the lack of experience of officials in the area of proper implementation and planning including lack of co-ordination, general inefficiencies & the poor performance of the officials and staff involved in the implementation of the projects.

To assist Government officials in the completion of projects in time, all donors insist on engaging foreign and local consultants. But still the implementation plan can't be maintained due to:

— delay in the allocation and approval of the project proforma (PP).

— delay in the flow of fund and credit effectiveness.

— delay in the initial BWDB staff mobilization.

— delay in the process of appointment of Engineering Consultants for design and monitoring of work.

— delay in the floating of tenders and selection of contractors.

Further, some of the projects had to be rehabilitated prior to completion of works incurring additional expenditure. As a result, the project implementation period is delayed and cost increases due to inflation. People do not get actual benefits from the projects and the projects therefore fail to achieve the target.

LARGE SCALE EXPLOITATION OF WATER RESOURCES: CASE OF THE SOUTHEASTERN ANATOLIA PROJECT IN TURKEY

Nilgun B. Harmancioglu

Dokuz Eylul University, Izmir, Turkey

The planning, construction, and operation of water resources systems are affected by several factors which show inherent stochasticity and/or significant uncertainty. These factors relate especially to the changes in technology and economics, that may cause unexpected changes in the development of these resources. Multipurpose projects, encompassing water power systems in particular, are more sensitive to such changes.

Large scale exploitation of water power is realized by generation of electricity, which can also be obtained from other primary energy resources. Thus, the developments in electricity generation technology, but primarily the changes in economic factors, may significantly affect water power development plans. During the implementation phase, the construction of large hydraulic structures like dams, conduits, and power plants are highly influenced by uncertainties in the related geological characteristics of the environment, with respect to foundation, materials, and water tightness. Even the operation of water resources systems, particularly water power schemes, may be subject to considerable modifications due to unexpected changes in supply, demand and/or economic factors in the broadest sense. Thus, the development of water resources has to be considered as a dynamic phenomenon, and no development plan at any stage can be regarded as a strictly definitive one.

The presented paper demonstrates the dynamic nature of large scale water resources development plans in the case of the Southeastern Antolia Project in Turkey. This project covers the joint development of land and water resources of two large river basins, namely the Lower Euphrates and Western Tigris basins. The first attempts at large scale development of the Euphrates basin date back to 1950's, and since then the project has undergone significant modifications through the years until it was integrated into a broader scheme, called the Southeastern Anatolia Project, together with the development of the Western Tigris basin. The project foresees the generation of 37 billion KWh/y of energy with an installed capacity of 10212 MW, which will double the current hydropower generation in the country. In addition, more than 1.7 million hectares of land will be irrigated by completion of the project.

EXTRACTION OF DRAINED WATERS FROM INSTABLE AREAS FOR MINOR AGRICULTURAL USE

V.A. Copertino, G. Spilotro & G. Vacca

Basilicata University, Potenza, Italy

In countries which are technically and economically more advanced, the main water resources are already well known and have been utilized, by the construction of appropriate waterworks and regulation devices and insertion in more complex water schemes. This has brought about the realization of important distribution and management systems of water resources, generally based on important costly projects.

Water resources of a much lower potential, generally associated with low permeability soils, are of considerable interest especially in many Italian badlands. Their extraction and use are very important for the following reasons:

— these resources are usually associated with unstable areas and in the majority of the cases they are responsible for the instability. So the drainage can be the most important system for the reclamation of these areas.
— although modest, these resources may be of interest for small local agricultural use.
— they may be utilized at a reasonable cost even in extremely peripheral ares, not easily reached by energy supply.

In the paper the characteristics of low permeability aquifer system, the typical geological and geotechnical environments, the climatic context and the evaluation of the specific potential of the associated water resources will be examined and described. The advantages of the improvement of the stability of the slopes in these areas after drainage will be highlighted.

Finally, the usefulness of the exploitation of aeolian energy for the withdrawing of drained waters, a system practised in many countries from ancient times, using new technologies, will be demonstrated. The climatic zone of these areas assures the availability of wind resources for most of the year and particularly during bad weather seasons.

INTENSIVE RAINWATER COLLECTION AND USE TO AUGMENT AVAILABLE WATER SUPPLIES

J. Hari Krishna

University of the Virgin Islands, St. Thomas, USA.

It is becoming a challenge to provide adequate water supplies of good quality in many areas of the world today. The problem is particularly acute in regions having limited water resources and high population densities.

Rainfall, the source of all fresh water supplies, is often overlooked and underutilized for providing the needed water supplies, particularly in urban areas. In the U.S. Virgin Islands and several other Caribbean islands, there are very intensive efforts to collect rainfall and utilize the water for domestic consumption. In fact, the law requires that every building that is constructed in the Virgin Islands should provide a cistern to collect and store rainwater from the rooftop for subsequent use. A minimum cistern capacity of 28.5 literes is required per square meter of roof area. Similar laws are prevalent in other semi-arid Caribbean islands as well.

It is often observed that in regions with large amounts of seasonal rainfall (such as the monsoons), a considerable amount of water runs off from impervious surfaces during high-intensity storms. If this runoff is collected, it will supplement the existing municipal system, for many domestic purposes such as gardening, washing, toilet flushing, etc.

In addition to water conservation, secondary benefits include the development of industries for fabricating small tanks (cisterns) for domestic use, and for manufacturing water filters. It is important to create and awareness amongst the population, to use rainfall as effectively as possible, by collecting the water and minimizing the runoff.

HIMALAYAN HYDROLOGY

Jagdish Bahadur

Deptt. of Science & Technology, New Delhi, India

The Himalayan Environment provides unique opportunity on the earth to Hydrometeorologists, hydrologists and Hydrogeologists for hydrological studies. Himalaya is the world's mightiest water tower, being bestowed with the highest and largest snow and ice reservoirs. The environment in the high mountain region resembles those existing in the polar regions. About 50,000 km^2 of glacier area and on an average 600,000 km^2 of snowcover terrain contributes to meltwater contributions forming the perennial river systems of Indus, Ganga and Brahmputra. The subject of snow and glacier hydrology has yet to find place in all institutions of higher learning and R&D Organisations as we have to develop our understanding based on observations because it is not possible to extrapolate results from other parts of the world.

Being highest mountain, it has a strong mechanical effect of a mountain barrier limiting the northward movement of summer monsoon air and southward movement of cold air from Siberian high in winter. As the Indian Himalayas extend from 27°N to 35°N, the lower latitude region have predominant effect of tropical systems while the higher latitude region is largely affected by temperate and arctic systems - thus providing spectrum of climatic variations having enormous influence on the hydrology of the region.

Existing hydrometeorological network in the high mountain region is inadequate to arrive at representative value of area precipitation estimates in different regions. There is need for additional thrust to monitor and integrate the multidisciplinary approach making use of surface, aerial and satellite data for a better understanding of the high terrain and for evaluation of water resources for sustainable development of the region.

CONJUNCTIVE IRRIGATION IN THE HUMID ALLUVIAL PLAINS — IMPERATIVENESS AND ISSUES

T. Prasad

Bihar College of Engineering, Patna, India

Humid alluvial plains are characterised by shallow water table depths and active surface water-groundwater interaction. Due to monsoon climatic seasonality of rainfall occurrences, irrigation is 'sine qua non' for realizing the high agropotentiality of these regions. However, exclusive reliance on the surface water supplies for irrigation in these regions suffers from two vital deficiencies. One is that the river flows — the major source of surface

water supplies for irrigation — themselves have high seasonal skewness and hence are inadequate to satisfy without storages the residual crop water requirements in all the crop seasons, resulting in lower irrigation intensities than what can be sustained by the fertile lands and congenial agroclimate generally obtaining in these regions. Secondly, exclusive surface irrigation causes systematic rise of water table, which leads to waterlogging and possibly salinity over the years in these shallow water table regions. Thus, surface irrigation is likely to prove counter-productive in the long run and is not sustainable over time. Utilization of groundwater for irrigation in the humid alluvial plains is not only feasible and attractive on account of availability of good quality water at relatively low lifts but, in conjunction with surface water, can effectively take care of these two major deficiencies, apart from yielding other benefits like improving the reliability and equity of the system. Thus, conjunctive irrigation is an eminently suitable strategy for irrigation development in the humid alluvial plains. It has to be adopted to ensure productive and sustainable irrigated agriculture.

This imperativeness of conjunctive irrigation, however, has to contend with unresolved problems and issues constraining its implementation. First and foremost is the fact that the technique of planning, designing and operating in irrigation system based on conjunctive use and management of both surface and groundwaters is not yet developed to a point that it can be widely adopted in professional practice. The hydrology and hydraulics of occurrence as well as the technologies of exploitation of the two sources of water have to be integrated to serve the common purpose of satisfying the residual crop water requirements for optimum agricultural performance in a sustainable manner. The dynamics of surface water-groundwater interaction has also to be taken into account in order to ensure this. Moreover, the aspects of economics, management and equity related to the use of the two sources of water for irrigation have also to be integrated in such a manner as to facilitate and promote conjunctive irrigation.

The paper attempts to bring out the imperativeness of conjunction irrigation in the humid alluvial plains and dwells on various issues which constrain the implementation of this strategy inspite of wide recognition and acceptance of the rationale and logic of it.

THE PARTICIPATION OF LANDLESS PEOPLE IN CONSTRUCTION AND MAINTENANCE OF FCDI PROJECTS IN BANGLADESH

S.M. Khalilur Rahman

House of Consultants Ltd., Dhaka, Bangladesh

In Bangladesh during implementation of FCDI projects some people within the project areas become landless due to acquisition of their small pieces of land. In the country two-third of the people are fully or functionally landless. Recently some government and non govt. organizations (NGOs) with assistance of some donor agencies, introduced landless people's participation in earthworks and in the maintenance of some structural works. This will cope with some socio-economic issues like short-term employment, skill development, ensuring fair wages and capital formation with little savings. For successful and effective performance of these issues a model of landless contracting societies (LCS) group has been devised consisting of local landless people. The group is organized for a project and executes the work as a contractor under a contract between the group and the executing agencies with the assistance of technical guidance and supervision from others. From the study of different LCS activities it is found that LCS is a very fruitful options for executing civil works and the quality of work done by LCS have been found to be better than that of contractors. These activities may be implemented widely as some experience has already been accumulated.

CASE STUDY, THE BREACH AT RISHIKANDI IN MEGHNA-DHONAGODA IRRIGATION PROJECT IN BANGLADESH

S.M. Khalilur Rahman

House of Consultants Ltd., Dhaka, Bangladesh

Meghna-Dhonagoda Irrigation Project (MDIP), financed by ADB is one of the most sensitive multi-purpose irrigation project in Bangladesh. The project is located at the confluence of two great rivers, the Ganges and the Meghna, and the area comprising the project is surrounded by the mighty river Meghna and its branch river Dhonagoda. The Project started in 1973-74 (with estimated cost of Tk. 840 million) and officially Completed (actually not completed) in 1987-88 by exceeding the implementation period by three years and with an estimated cost of taka 1466 million.

In 1988 a major flood disaster took place in Bangladesh which caused a maximum damage in the infrastructures of the country. Almost all the FCDI Projects in Bangladesh was affected due to this flood but failure of MDIP was an exception. The embankment was breached at Rishikandi on the Dhonagoda river which caused serious damage to the internal infrastructures including irrigational canals, roads etc. of the project. At the place where the breach occurred a channel was formed of about 2 km in length which was like the Dhonagoda river itself. The bed level of this channel was formed lower than the existing river bed.

There are two main reasons for the failure, a change in design and poor construction. During construction the embankment width was reduced by 1.2 m to save cost. The embankement construction was supposed to have been done by mechanical compaction but this was actually not done. At the same time the embankment was taken across the old river channels consisting of coarse material which provided ready seepage paths. No attempt was made to seal these paths, during construction. As a result breach occurred in this place which caused the damage of the infrastructures and its value is 300 million taka.

HYDROLOGICAL IMPACTS OF PATHAKHALI-KONAI FLOOD CONTROL, DRAINAGE, AND IRRIGATION PROJECT: A CASE STUDY

M Mozzammel Hoque & Syed Mohib Uddin Ahmed

Bangladesh University of Engineering and Technology
Dhaka, Bangladesh

The topography, rainfall, and the river regime of Bangladesh are ideal for agriculture. But due to its location Bangladesh is subject to frequent floods which seriously affect the agricultural development. The Flood Control, Drainage, and Irrigation (FCDI) project has been considered as one of the alternatives to achieve a break through in agricultural development. Since its inception, the Bangladesh Water Development Board (BWDB) has completed 437 FCDI projects upto 1990. The implemented projects have shown positive impacts on over all economy of the country, however, in many cases the adverse impacts have been observed. In the present paper the hydrological impacts of the Pathakhali-Konai project have been presented. The specific impacts on groundwater conditions, surface water conditions, erosion and deposition, and flooding and drainage conditions have been evaluated. In general, a rising trend in groundwater during monsoon has been observed whereas during winter an in significant variation has been found. The annual maximum discharge of the Bangshi river, the only surface water source of the project, shows virtually neither increasing nor decreasing trend upto 1979; but from 1979 to 1990, the results show a significant trend. It has been found that the project has accelerated the sand deposition resulting in increased rainage congestion. Study reveals that there is an increased erosion and deposition during post project period in the river Bangshi at the vicinity of the project area.

HYDROLOGIC DESIGN OF CIVIL WORKS: DISCONTINUOUS BANK REVETMENT

Dhali Abdul Qaium or D.A. Qaium

Bangladesh Water Development Board,. Bangladesh

Bank Revetment work is one of the river training works intended to protect the river bank from erosion by sliding/scouring/caving. A continuous revetment work is done for the eroding reach of river to save the soil by placing revetment (C.C. blocks/boulders) on the slope and bed. Apron is built on the bed to take care of the anticipated scour depth. Thickness of the revetment on slope is computed by empirical formula based on design discharge, properties and shape/size of the revetment. Anticipated scour depth, design discharge are the main factors controlling the volume of the revetment on Apron.

Drawing an analogy between the spurs and continuous bank revetment work, a discontinuous bank revetment work may be designed. Spurs are constructed in series to protect the eroding bank with a spacing of 2.00 to 2.50 times the projected length of the spurs; the projected length and the spacing of the spur is calculated using empirical formula. The thickness and the volume of revetment at apron of the discontinuous bank revetment is calculated following the same empirical formula for continuous one and the spacing between the revetment is determined using the procedure of computing the spacing of spur.

Theoretically, a discontinuous bank revetment work will serve the purpose of bank protection work; experiment on it (discontinuous bank revetment) was carried out on concave eroding bank of the Khowai, a flashy river of the North-estern part of Bangladesh.

The work was done in 1988 using locally available boulders. Performance of this discontinuous bank revetment work is nice. The work withstood several severe floods of 1991 but no damage occurred on the revetment or no erosion is observed either on bank or in bed.

Discontinuous bank revetment work is technically sound one. Economically it is cost effective; cost of discontinuous bank revetment work is about 60% of the cost of continuous one. Experimental work on discontinuous bank revetment on flashy river carrying huge sediment load having a maximum observed discharge of 750 cumecs indicates good result.

PLANNING CONSIDERATIONS FOR WATER RESOURCES DEVELOPMENT IN HAOR AREAS OF BANGLADESH

G.M. Akram Hossian & Ainun Nishat

Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh

A haor is a bowl shaped depression which are flooded every year during monsoon. It remains under water for several months of the year and as it drains out in post-monsoon, some water bodies are left in the deeper parts which are perennial in nature locally called beels (natural very shallow lake). This paper gives an outline of the planning considerations for the development of haor areas located in the northeastern and north-central regions of Bangladesh. The haor area is generally subdivided into three major areas which have similar characteristics in terms of morphology and hydrology: the piedmont area (area around the hill foot), the flood plain and the deeply flooded area. For each of these areas, the actual situation of the hydrology, morphology, fishery, agronomy, socio-economy and water resources has been discussed; and the impact of flood control projects on these disciplines is investigated.

The paper also analyses the impacts of existing flood control schemes as well as those presently under implementation. Based on the findings, development strategies for the near future has been prepared. The technical feasibility of the projected flood control drainage and irrigation schemes has been considered, and at the same time social and environmental impacts and institutional development of the schemes has been given due attention.

The main crop grown in the area is Boro or dry season rice. Damage to Boro crops due to early pre-monsoon flash floods just before the harvest is common in the haor areas. To prevent damage to the rice grown in the fertile lands of the haor area protection against this early flash flood is essential. Present day planning of water resources development projects aim at either full flood protection for the year round rice cultivation or construction of submersible embankments for protection of Boro rice. It has been established that projects with submersible embankment offer a higher rate of economic return compared to full flood protection projects. Submersible embankments with adequate number of water regulating structures coupled with the development of fishery and navigation is the recommended mode of development based on technical, economic, social and environmental considerations.

LOCAL LEVEL PLANNING OF SMALL WATER RESOURCE SCHEMES IN A DEVELOPING COUNTRY

Ainun Nishat, Jahir Uddin Chowdhury, M. Mirjahan & M. Rezaur Rahman

Bangladesh University of Engineering and Technology, Dhaka, Bangladesh

The Government of Bangladesh is pursuing a policy of decentralization to strengthen the implementation mechanism of the institutions at grass root level. The government is now giving responsibilities to local level institutions for planning an implementation of small scale water resources schemes. The objective of this work was to produce a planning guideline with the expressed intention to reach those who are legally vested with the authority to select water resource development schemes. As such, the contents, formulation and structure of the methodology reflect the objective planning environment at the local level in Bangladesh. The methodology strives to strike a balance between the desired level of comprehensiveness and available human and institutional planning resources in Bangladesh.

INTEGRATED WATER RESOURCES PLANNING

A. Rajamany

College of Engineering, Thiruvananthapuram, Kerala, India

Water is an integral part of man's environment. The quality of his life is controlled by the extent to which

it is abundant or scarce, clean or polluted, beneficial or destructive. Rapid development of human civilization and advances of scientific and technological developments are changing the face of our planet giving rise to fundamental transformation of the environment in which water resources play a significant role.

But water can no longer be taken for granted. It is a limited and valuable resource. Scarcity of water, food, fibre and energy, floods and droughts, poverty, pollution and population are major impediments in the progress of the country. Water Resources projects can play a vital role to minimise these hazards. But environmental problems appears to be a major bottleneck in the promotion of Water Resources Project. It is necessary to absorb new concepts, processes and devices in Science, Engineering and Technology for the planned development of the nation.

Integrated water resources planning aims at the optimal development of water and its use most beneficially under appropriate priorities consistent with the requirements of the region. This will take into account. Planning of Water Resources strictly "basin wise" for a hydrological unit as a whole and preservation of quality of environment and ecological balance to the maximum extent possible. The paper has been prepared with special reference to India.

WATER CONSERVATION IN DROUGHT PRONE AREAS

R.S. Varshney

Retired Director General, ICID, New Delhi

Aspirations for higher standards of living and the steady increase in World population have continuously increased the demand for food, fibre, raw materials, energy, and other services. This has led to increase in demand for water in almost all sectors of life. With the increase in the proporation of utilization of the total available water resources, the risks of water shortages increase rapidly. This increase in shortage has been accentuated by uneven distribution of rainfall in tropical countries, where most of the rain water is available only during four months of the year and storage capacity for water is extremely low. It is therefore necessary to conserve water by storing and by using various water conservation techniques such as interbasin water transfer, rain water harvesting, conjunctive use of surface and groundwater, proper management of irrigation schemes, recycling of waste water, reuse of water, reducing absorption, evaporation and conveyance losses, reducing transpiration losses from plants, breeding crop spices which are particularly suited for drought affected areas, proper scheduling of irrigation water and crops, optimum utilisation of available water resources, developing ground water storage etc. The methods have been discussed with special reference to Indian conditions. Role played by National Institute of Hydrology, Roorkee in collecting and disseminating the information and knowledge in this field and research carried and by N.I.H. have been highlighted.

STATUS OF MULTIPURPOSE WATER RESOURCES PROJECTS IN U.P.

H.S. Badarinath

University of Roorkee, Roorkee, India

Rivers Ganga and Yamuna held in veneration by countless people are the sources of hydropower and irrigation. A number of multipurpose schemes have been executed and few are currently in progress. The demand of the growing population in terms of food and energy is assuming a challenge to planners and engineers. The hydropower potential of UP is tremendous but the limitations are the financial resources required to implement them.

This paper discusses some of the schemes proposed and their present status. Some innovations carried out on some of the schemes already executed have been included to indicate a direction to researchers and designers to make further improvements in their methodology to effect greater economy.

AUGMENTATION, CONSERVATION AND DEVELOPMENT OF GROUND WATER FOR SUSTAINABLE OPTIMUM FOOD GRAIN PRODUCTION IN BUNDELKHAND REGION

Dhaneshwar Rai & Bharat Singh

Ground Water Department, Lucknow, U.P., India

Bundelkhand is an area of rocky basements composed of granite complex, with thin blanket of alluvium. Rocks are structurally deformed, with dissected physiography and dendrtic rainage pattern. In five districts: Banda, Hamirpur, Jalaun, Jhansi, Lalitpur, the reported area is 29,60,174 ha, and net sown area 18,64,800 ha. The net

irrigated area is 4,49,100 ha. out of which by Canals-2,64,00 ha. STW 28,800 ha, PTW/Wells/PS 17,400 ha. and others 1,38,500 ha. Climate is tropical, with dry hot summer with maximum temperature 48°C and chilled cold winter minimum to 1.0°C. High evaporation rates, cause quick drying of surface water reservoirs. Normal annual rainfall is 870 mm., estimating 25633 MCM out of which ground water recharge is 4159 MCM (16%). The utilizable ground water for irrigation is 3527 MCM against which net ground water draft is 1044 MCM. Aquifers are of limited storage capacity, restricted to weathered, fractured, fissured and unconsolidated sandy formations. Much ground water seepages waste through leakages. There is acute shortage of irrigation water, causes poor crop yield: Paddy 0.88 tonnes and wheat 1.54 tonnes per hectare. For sustainable optimum food grain production and crop yield, the role of ground water is unchallenging. Its augmentation and conservation can be made easily by the construction of check dams, bundhies, tanks, ponds, sub-surface dykes and leakage cealing at suitable sites. Artificial recharge and rain water harvesting can be accelerated creating artificial porosity by blasting. Ground water development can be made easily constructing wells, tubewells at feasible sites. In the micro-basins, Conjurtive use of surface water can optimise cropping intensity. This paper deals with physiography and drainage, climate, soils, geology, water resources, agriculture, and methodology of augmentation, conservation and development of ground water.

MORPHOMETRIC ANALYSIS IN PART OF MUSSOORIE SYNCLINE

C.S. Agarwal & B. Chakraborty

Ground Water Department, Lucknow, India

With the advent of Remote Sensing via satellites specially the IRS-IA, LISS-I imagery providing a synoptic overview of our Earth, a powerful new tool in regional terrain analysis for natural resources is now available to earth scientists. Many significant earth features identificable on IRS-A, LISS-II images help to update regional surveys.

The study reported herein deals with morphometric analysis in parts of Musoorie using satellite remote sensing. It is observed that the area is composed of permeable formations having lack of geological control on the drainage pattern of the area.

STUDY AND DEVELOPMENT OF DROUGHT ASSESSMENT TECHNIQUES

T.K. Ghosh & G.K. Tripathy

Indian Institute of Technology, Bombay, India.

This paper examines the drought in the arid-semiarid region of Gulbarga district of Karnataka State, India. The statistical property of precipitation (1970-1986 period) has been analysed to determine the drought at 30 day, 60 day, 90 day and 120 day period. A prediction model has been constructed to determine the amount of water available before a drought period. The measure of drought is evaluated through the analysis of normalised deviation.

The digital analysis of satellite data determines the mean, variance and the index (PC1/PC2) for May 22, 1984 and May 1, 1985. The large values of variance and PC1/PC2 are indicated in May 1, 1985 scene. The sharp increase of variance and PC1/PC2 is the indicative of drought year.

MEETING WATER REQUIREMENTS OF LUDHIANA BY MANAGING STORM WATER RUNOFF

J.P. Singh

Punjab Agricultural University, Ludhiana, India

The need for conserving of our water resources was never felt so severely before as today. Saving of every drop of water has become necessary at it is becoming a scarce resource and demand for it, by industry, agriculture, human has increased. So, every effort need be made to stop this scarce resource being lost or polluted. The present state of the art is that we are largely depending upon ground waters for our various needs, causing its pollution and scarcity. Therefore, the need of the present hour is to plan, manage, and design of storm water control methods and the management of both storm water quantity and quality. Ludhiana is at present the largest district of Punjab with a population of 20 lakh. Through this paper, its is seen that the average annual storm water run off of Ludhiana, if managed by detention/retention facilities is quite sufficient to fulfill all the water requirements of the town. By doing so, the water resources can be augmented and all kind of water shortages can be relieved in Ludhiana.

OPTIMAL DESIGN AND OPERATION OF A MULTI - PURPOSE RESERVOIR BY STOCHASTIC METHODS

A.B. Dariane

Dept. of Civil Engineering, Tehran, Iran

Optimal design and operation of a multipurpose reservoir is investigated through stochastic modeling. Chance constraint Linear Decision Rules (LDR's) along with Standard Operating Policy (SOP) and a Yield Model are used to find monthly operating policies and estimate reservoir capacity required to meet the demands. A simulation model is developed to evaluate the performance of these approaches.

15-Khordad reservoir which is under construction at this time with a total capacity of 200 mcm is chosen as a case study. It is located in south of Tehran in Iran, and is planned to meet part of municipal water demand of City of Ghom. Several studies indicate that LDR's, and in particular S-type rule, over-estimate reservoir capacity required to meet a certain demand with a certain reliability level. Application of LDR's to the case study showed a lower capacity with the same reliability level than what was estimated using simulation methods by the consulting firm. In design of 15-Khordad reservoir no flood control capacity was assumed. For city of Ghom being downstream from the reservoir and in danger of flood, it is suggested that part of the capacity to be allocated for flood control purposes, with minor loss in reliability to meet the firm demand.

15-Khordad reservoir is constructed for multiple purposes of meeting municipal and agricultural water demand, with the priority to meet the municipal need of City of Ghom with the highest possible reliability. In multipurpose operation of the reservoir a Multi-Yield Model (MYM) gives better results than any of LDR's. Using an SOP approach resulted in meeting the firm yield (municipal) during lower demand periods (winter months) while facing with serious deficits in summer months. On the other hand, due to uncertainties in using statistical methods in evaluating the inflows, some adjustments are needed to ensure that the MYM would give the desired results.

AN AUTOMATIC ELECTRONIC INFILTROMETER

Bhishm Kumar

National Institute of Hydrology, Roorkee,U.P. India

Infiltration characteristics are the primary requirement to assess runoff potential, to plan cropping pattern, irrigation practices and management. An infiltrometer consisting of two cylindrical rings with a water level measuring device is a very simple equipment which is used to study the infiltration characteristics of soils.

Several types of infiltrometers have been developed in past for infiltration rate studies in situ as well in laboratory. Infiltrometers starting from simple ring type to automatic with constant head device have been reported in the literature. However, most of these have the problems of maintaining constant head accurately and acquiring data automatically. In some cases, the complete set up is so sophisticated that its transportation from laboratory to the field is very difficult and very skilled persons are required to conduct the field experiments throughout the experimental period.

Keeping in view all these practical problems, the author, in collaboration with a local private firm has developed a microprocessor based automatic electronic infiltrometer. The data logger part of this equipment has ben designed using 8085 microprocessor chip. The memory module has been used to store the infiltration rate data and maximum of 1000 readings of 'water level' with time can be stored. The data logger can be programmed to store the data for any interval starting from 1 minute to 99 minutes. The capacitance type water level sensor has been used to sense the drop in water level with an accuracy of 1 mm.

The constant head is also maintained using electronic device which consists two sets of electrodes. The water is supplied into the double ring type infiltrometer from two separate G.I. containers. The solenoid valves, an electrical device, have been fitted, with each water container. As the water level drops in the infiltrometer rings, the electrodes which remain initially in close connection, due to in contact with top water layer, become open, and the electronic circuit becomes operational in order to provide power to the solenoid valve. Thus the system is completely automatic for storing the infiltration data with time.

The technical and operational aspects of the microprocessor based automatic infiltrometer have been discussed in this paper.

A NEW TECHNIQUE FOR CALIBRATION OF NEUTRON-MOISTURE PROBE

Bhishm Kumar, Rm. P. Nachiappan & Rajan Vatsa
National Institute of Hydrology, Roorkee, U.P., India

The neutron moisture probe is used for the study of soil moisture movement and recharge to ground water. But, the calibration of the probe using gravimetric technique, does not result the required accuracy. Actually, the measurement of dry density at the deeper depths is the main source of error in the calibration of probe using gravimetric technique.

The authors have reported, a new technique which is very easy, accurate and the probe can be calibrated even in situ with the required accuracy. In this technique, known amount of water (equivalent to some ponded height of water) is applied at the surface having a boundary to prevent the loss of water due to surface run-off and also sub-surface run-off upto some extent. The infiltrated water is accounted for by taking the observations of change in volumetric moisture content by neutron probe and a graph is plotted between the observed change in volumetric moisture content and depth. The integration of this moisture content gives the total water infiltrated into the soil-system in terms of ponded heights (cm) which can be determined just by estimating the area of the curve. This total infiltrated water should be equal to the water applied at the surface owing to the fact that loss of supplied water due to evaporation will be negligible due to very short duration between the supply of water and water absorbed in the soil-system after complete infiltration including the possible sub-surface flow loss of infiltrated water. The comparison of the applied water at the ground surface and observed water in the soil-system using neutron probe provides calibration factor.

The details of the experimental work carried out in the campus of National Institute of Hydrology, Roorkee, U.P., India for the calibration of neutron soil moisture probe using gravimetric technique and the said new technique are reported in this paper.

A NEW AUTOMATIC RAINFALL SENSOR

Bhishm Kumar, V.C. Goyal & Sandeep Gupta
National Institute of Hydrology, Roorkee, U.P., India

Rainfall is an important parameter of hydrologic cycle. But, as its distribution on earth is unequal in space and time, therefore, universal equipment (rainguage) has been designed so far to measure the rainfall in any part of the world with the required accuracy.

Several types of raingauge/rainfall sensors have been developed in past for the measurement of precipitation. Precipitation can be measureed as simply as possible by using an open container and the vertical sides of the container can be calibrated depending upon the 'open catch area' to determine the amount of precipitation. Raingauges as simple as funnel type to tipping bucket type, including weighing type with programmable electronic devices, have been reported in the literature. But, none of the models is suitable to be used in different possible conditions of rainfall. However, tipping bucket type raingauges are now mostly used, but, the size of tipping bucket is to be designed according to the place and pattern of the rainfall occurs.

Since the size and shape of the exposure affect the 'precipitation catch by a gauge, it is therefore, desirable to use a standard gauge so that observations from different gauges could be comparable. Like most of other countries, India follows the raingauge as standard with 203.4 mm and 128.6 mm as open catch diameters of the raingauges for low and high intensity rainfall measurement.

Keeping in view the above referred problems associated with the present rainguage models, the authors under a project financed by Ministry of Agriculture, Govt. of India, have developed an automatic rainfall sensor based on dual mechanism i.e. weighing and tipping bucket. The rainfall sensor consists of an outer container with open catch area of 203.4 mm (as per Indian standard) and an inner container to collect the rainfall with tipping bucket fitted at its top and weighing mechanism (load cell) alongwith solenoid valve fitted at its bottom.

The precipitation will be collected in the inner container through top funnel and tipping bucket and its weight

will be sensed by the load cell. Abnormally the signal of change in weight will be fed to a data logger which will convert and store the rainfall in mm at the desired interval. The solenoid valve will be activated by the signal received from the data logger with respect to the maximum possible rain which can be drained out from the container. The tipping bucket data will be only used when during the rainfall, the water will have to be drained from the container. Thus there will be no loss of the precipitation data which is the major fault associated with the siphon type (Indian/Imported) and weighing type (Imported) raingauges and this rainfall sensor can be used at any place irrespective of any rainfall pattern as it can measure low intensity rainfall as wells as high intensity rainfall. The sensitivity of the sensor is 0.1 mm.

This paper deals with the design and operational aspects of the automatic rainfall sensor based on the dual mechanism.

WATER RESOURCE PLANNING, DEVELOPMENT AND MANAGEMENT IN WEST BENGAL

*R. N. De**

Central Design Office, I&W Dte, Calcutta, India

In this paper the author has presented the planning, development and management of the vital water resources in West Bengal. The problem on the food sector as a result of partition and various water resource projects taken up to mitigate the situation has been indicated. Considerable detailing has been made on the position of drinking water in the state which has been accorded highest priority in the National Water Policy document.

The need for accelerating the activities of CADA in the State has been stressed. The experiences of the author to manage irrigation water during critical years of low rainfall has been elucidated.

In conclusion the author staates the need for detailed investigation for a water resource project, necessity of project bench mark and post project evaluation study which are not common now including upgradation of existing HO stations with present day know how have been discussed in details. The author clearly informs the role and necessity of NGOs in the State.

The paper is dedicated to my beloved Proessor Satish Chandra who has always been a driving force in my life.

EFFECTIVE GROUNDWATER MANAGEMENT FOR THE DEVELOPING WORLD

J. Balek

ENEX, Prague, Czech Republic

In special conditions of arid, semi-arid and wet and dry regions, ground water is one of the most important natural resources. In semi-humid and humid parts of the tropics ground water also plays an important role since many surface resources are intermittent or polluted and infected and thus local supply needs, cattle watering, irrigation and even industry depend on ground water sources.

An effective ground water management becomes one of the prerequisite conditions of the sustainable development in the developing countries. In addition, a proper ground water management is an efficient tool in the restoration and conservation of the environment.

Effective management and development of ground water resources and restoration of the damages done to the ground water resources and aquifers in many developing countries are important and challenging tasks for applied research and technology.

HYDROLOGICAL DESIGN OF LOW DAMS IN KANDI AREA (MIRZAPUR DAM)

Ram Chand, P.S. Narula & S.N. Goel

Kandi Area Development Project, Chandigarh, Punjab, India

Construction of low dams over hill torrents/choes has been envisaged for flood control and irrigation purposes in the Kandi area in Punjab, India which is intercepted by various choes (rivulets/hill torrents). The dams are designed as per available rainfall data runoff and sediment data and considering the flood absorption of SPF plus 25 years frequency flood. The conventional

concrete spillway has been eliminated. An emergency escape has been provided for routing the Maximum Probable Flood.

Daily rainfall data for the past 30 years as observed at sites as well as of adjoining rain gauge station at Chandigarh has been processed for adopting a suitable conversion factor. Daily runoff data for past 30 years has been processed and complete synthetically from rainfall v/s runoff plots. An average runoff factor has been worked out. A sediment rating curve has been plotted for monsoon period while sediment flow has been considered to reduce in view of soil conservation and afforestation measures adopted in the catchment area of the dam. The design flood worked out as per latest techniques such as synthetic hydrograph, improvised method as per Handbook of Hydrology, GOI, CWC. Short term method and rational method have been evaluated and adopted. It has been planned to store most of the flood water (SPF plus 25 years frequency flood) above NCL and slowly route these floods through irrigation outlet. In addtion to it a provision for unregulated emergency escape for routing Maximum Probable Flood has been made. This system has eliminated the provision of conventional concrete spillway.

The above has been discussed in detail, in this paper.

CONCEPT OF CRITICAL PIPES IN THE DESIGN OF PIPE NETWORKS

G. Prince Arulraj & H. Suresh Rao

Indian Institute of Technology, Madras, India

The analysis and design of pipe networks play an important role in the planning and management of water supply systems. The hydraulically well-designed networks give the maximum values for the nodal heads of the system under a set of given input conditions. In any network a few pipes can be identified as "critical" pipes. A critical pipe of a given network can be defined as the one whose parameters such as Hazen-Williams C. and diameter play an important role in altering the nodal heads at all points in the network.

This paper explains the concept of critical pipes for the design of networks and explains the method of identification of critical pipes. Analysis of the effect of changes in the C values and diameters for the critical pipes is also presented. Few sample networks are analysed and for each network, critical pipes are identified. Once the critical pipes are identified the variation of nodal heads at all points are studied when the above mentioned parameters are changed. Based on the studies guide lines are also presented for the design of pipe networks and to improve the hydraulic efficiency, without significantly increasing the total cost of the system.