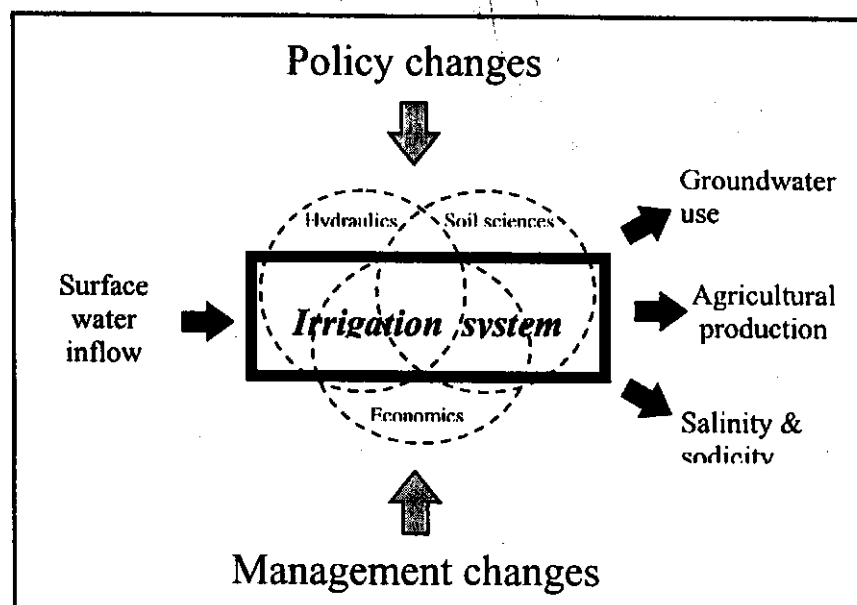


Evaluation of the integrated approach developed in the context of the IIMI-Cemagref collaboration in Pakistan

Lessons from a series of workshops and seminars
for researchers, policy makers and irrigation system managers



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INTRODUCTION

The collaboration between IIMI and Cemagref in Pakistan concentrates on the development, testing and evaluation of methodologies and tools to enhance management and policy decisions in the irrigation sector. Research activities are organized around four themes that combine hydraulics, economics, agronomy, soil sciences and information technologies:

- Decision Support Systems for the operation and maintenance of irrigation canals
- Economic impact of irrigation sector policies
- Use of remote sensing and Geographic Information Systems for the monitoring and evaluation of irrigation system performance
- Development of integrated methodologies to estimate the impact of management and policy changes on irrigation system performance.

As part of the last research theme, an integrated approach has been developed using the Chishtian Sub-division, South-Punjab, as case study. The integrated approach combines hydraulics, economics, agronomy and soil sciences. It considers simultaneously several bio-physical and decisional processes such as surface water allocation and distribution at the main canal and secondary canal levels, farm decisions related to water use and crop choices, salinization and sodification. It uses several complex disciplinary models that, combined with an analysis of the spatial heterogeneity of the main variables, provides a means to quantify the impact of selected interventions on irrigation system performance.

So far, the approach has been applied to the analysis of two management and policy interventions in this irrigation system, i.e. (i) the link between main canal operation and salinity/sodicity, and (ii) the potential impact of water markets on agricultural production and productivity. And more recently, efforts have concentrated on the development of an integrated tool. More simple models have been developed and linked into a common platform. And these models are linked to the information database and a Geographic Information System for spatial display of simulation results.

Past discussions with researchers have shown the need to validate such an integrated approach and model. To do so, two different steps have been proposed. The first one is the ability of the integrated model to reproduce the existing situation. For this, model simulation results for the actual situation are compared with existing information on this situation. The second step considers the usefulness of such approach for taking decisions. Thus, it is important to interact with the different stakeholders of the irrigation system, that may be users of the information produced, or of the integrated approach.

As a result, it was decided to organize a series of workshops and seminars to present the integrated approach and results of its application to a wide audience in Pakistan to partly evaluate what had been produced. At the same time, it was expected that the discussions and comments would help to identify potential follow-up activities as part of the IIMI-Cemagref collaboration or as part of future research projects in Pakistan. These events took place from May 11 to May 16, and involved IIMI and Cemagref researchers.

To disseminate the messages and present results, policy and research briefs were also developed on the following issues: canal operation, salinity and sodicity, water markets, the integrated approach, the integrated model. Copies of these briefs that have been distributed to workshop participants are attached to the present report (see Appendix I).

WORKSHOPS AND SEMINARS

General programme

Date	Audience	Location
11 May	IIMI researchers	IIMI Conference Room, Lahore
12 May	Soil Survey of Pakistan	Soil Survey of Pakistan, Lahore
13 May	National Research Organisations	IIMI Conference Room, Lahore
14 May	Policy makers	Islamabad
14 May	Donors	Islamabad
15 May	IIMI researchers	IIMI Committee Room, Lahore
16 May	Punjab Irrigation Department	Irrigation Department, Old Anarkali, Lahore

IIMI Workshop (11 May, 1998)

Number of participants: 40

The objective of the meeting was to discuss with IIMI research staff the methodology and outputs of the integrated approach applied to the Chishtian Sub-Division. There was a clear interest in the presentations, evidenced by a lively discussion about methodological issues (scale of analysis, selection of processes and actors, possible interventions , ...). This is due to the fact that a number of the researchers present are involved in large scale analyses of irrigation systems and are confronted with some of the same issues that were presented, and to the fact that the methodology of the integrated approach had been presented at the National Conference in November 1996. While stressing that the integrated model developed in Chishtian cannot be applied directly to other systems (in reply to a question to this regard), it was indicated that some elements of the approach can provide a valuable basis for large scale analyses (or integrated approaches) elsewhere. These elements are, amongst others:

- ☐ *Representation*: This is an obligatory element of any integrated approach, comprising the selection of processes, actors, the links between them, and the links with the external environment which will be analysed in the approach. It is important to do the representation *explicitly* and distinguish between physical and decision-making processes.

- ❑ *Information management*: This is one of the more daunting tasks of an integrated approach, as information of different disciplines, for different scales (spatial, temporal) needs to be stored, analysed, and combined (integrated). A well planned, output oriented, information system will need to be developed at the onset of the approach. And GIS plays an important role in the development of the structure of the database.
- ❑ *Integrated model*: It is important to develop a (simplified) integrated model in the early stages of the research, following the representation adopted, in order to ensure that one does not discover at the end of the project that important links or processes have not been taken into account.

Soil Survey of Pakistan Workshop (12 May, 1998)

Number of participants: 30

The Soil Survey of Pakistan is a privileged partner of IIMI in the integrated approach that was applied to the Chishtian Sub-Division. The IIMI-SSP collaboration focused on the identification and mapping of determinant factors causing soil salinity and sodicity. On the basis of this work a salinity and sodicity risk map can be developed, thus providing an effective alternative to the mapping of salinity and sodicity per se. The objective of the workshop was to discuss the findings of the collaborative salinity and sodicity study and to put these findings in the larger perspective of the integrated approach, thus demonstrating that the information collected and analysed can be used for evaluating irrigation management.

There was a clear interest in the findings of the salinity and sodicity studies. This was mainly related to the following issues:

- ❑ The *rapidity* of sodification and its impact on the soil structure at relatively low levels of sodicity (much lower than some of the standards used in the country). It was stressed by the participants that to manage sodicity, chemical amendments were needed in addition to water.
- ❑ *Large area salinity and sodicity surveys*: It was agreed that it is better to conduct a large area survey, by mapping the factors¹ causing salinity and sodicity rather than mapping these phenomena themselves. Thus, a dynamic risk map can be produced based on changes in the various contributing factors, reflecting better the dynamic nature of salinity and sodicity. The participants stressed that this message needed to be conveyed to policy makers, as decisions will be taken shortly on the large area salinity and sodicity survey that will be undertaken for the NDP, and there is a risk that the methodology that was adopted for the 1977-1979 Master Survey will be maintained.

The discussion on the integrated approach was less focused, probably due to the fact that research issues related to integrated water resources management is not an immediate

¹ These factors relate to the soil types, physiography, depth to groundwater table, groundwater quality, canal water supplies, etc.

concern for the Soil Survey of Pakistan. However, there was an interest to discuss the potential use of information generated by the Soil Survey of Pakistan for the management of the system. *We recommend that the Soil Survey of Pakistan be involved in a more action-oriented phase of the integrated approach, where the concepts of the integrated approach discussed here, are implemented to improve irrigation management.*

National Research Organisations Workshop (13 May, 1998)

Number of participants: 30

A large range of national research organisations, working on water-related issues, were present in the workshop. The main interest of the workshop was the fact that most of these organisations are involved in research activities in the FESS area with the intention of evaluating the impact of various management and infrastructural options on salinity and groundwater table behaviour. Coming up with these recommendations is likely going to require an integration of various research components, which explains the interest in the discussion of the developed integrated approach for the Chishtian Sub-Division.

Three groups were formed to discuss specific issues related to the development of integrated approaches. More specifically, the following issues were discussed: (i) potential use of integrated approaches for the analysis of irrigation and drainage systems; (ii) requirements and management of information for large irrigation systems; (iii) how to move from multi-disciplinary research to integrated research. The output of the group discussions is summarized below.

1. Potential use of integrated approaches

A first distinction was made between the users of the integrated approach (i.e. researchers), of the integrated model, and of the information generated by the integrated model (policy makers, managers). The participants emphasised that farmers should be included in the target audience of the information generated by the integrated approach. It was further stressed that this was an iterative process, taking into account the information demand of the users of the information. The outputs of the approach can be used for a *negotiation process* between different actors (policy makers, managers, farmers), who can agree on which interventions are socially acceptable. More specifically, the following points were stressed.

Research institutes and universities should be involved in the development of integrated approaches as they have access to primary information and have the required skills. The potential users of integrated approaches include:

- ☐ Researchers themselves
- ☐ Trainers
- ☐ Operating agencies (managers, policy makers, water user federations)

Integrated approaches should be used to:

- ☐ Improve and refine the functioning of the irrigation system
- ☐ Training and research activities

- ❑ Identify an optimum use of water resources and target interventions towards “poorly functioning” elements of the irrigation system
- ❑ Identify localized problems that require specific interventions

The approach should be applied to analyze specific scenarios. Research results should then be shared and discussed with policy makers, that would provide some feedback leading to further research. The communication and dissemination of results to different government departments is seen as an important element of the approach.

2. Information management for the analysis of large irrigation systems

The actual situation of information collection and storage, as well as the access to this information was viewed to be inadequate by the participants. The result is that a lot of effort goes into collecting data, which can subsequently not be used. It was advocated to coordinate the collection and storage of information, by looking at the end-users of the information, by adopting certain common sampling criteria, and by agreeing on the end products. There was a discussion on whether the databases should remain at the individual institutes (but with explicit links to other databases) or whether a national database should be established. It was agreed that quality control is an important component of information management, including the involvement of the agencies collecting data in the processing and analysis of the data. Training on information management, including the use of GIS, was advocated. More specifically, the following points were stressed:

- ❑ A large amount of information is already collected by different government departments. However, little is known about this information. Thus it would be important to make public what is collected and by whom. The access of information, however, remains difficult. Often, a lengthy process is required to obtain some information. In fact, there is very little collaboration between institutes and organisations that facilitate the sharing of information. It would be important to have specific actions that would make data easily available to a large public.
- ❑ The information obtained from public sources is often of poor quality. One of the reasons explaining this poor quality is the absence of incentives for staff collecting this information, and the lack of knowledge about the use of this information.
- ❑ It would be important to favour the development of well organized monitoring cells in each department. This would allow better structure of information, quality control, etc. GIS/RS and other computer software represent great opportunities that cannot be ignored anymore today in the field of information management
- ❑ In some cases, primary information still needs to be collected (especially farm level data?). In such cases, it is important to document clearly sampling and data collection techniques for use of the information by other users/disciplines.

3. From multi-disciplinary research to integrated research

It was indicated by the participants that the FESS project is a good opportunity to achieve the integration of research. As compared to the activities undertaken in the Chishtian Sub-division, it was clear that more emphasis should be given to the analysis of groundwater in this area. The means required to achieve this integration include an appropriate medium for transferring results to the operational level, small discussion groups interacting on specific issues, an agreed upon set of objectives, activities and calendar and common fora. Some of the constraints mentioned relate to the fact that in the FESS project not only different disciplines need to be integrated, but that the integration needs to be undertaken between a host of research and monitoring organisations. This complicates the integration, as agreements have to be reached about responsibilities, sharing data and information, and common tools and databases. In addition, financial resources are not pooled together (see for example the FESS project) and there is no specified timeframe for integration. More specifically, the following points were stressed.

The different means that would facilitate the development of integrated research activities include:

- A clear identification of common objectives and goals of the integrated research
- A thorough awareness of issues by all participants
- A media to transfer findings of each group to other groups for proper links/aggregation
- Starting integrated from the root level, with an unbiased quality assessment of existing problems
- Interactions between small disciplinary teams that can merge to undertake integration
- Organisation of appropriate forum (conferences, workshops, etc)
- Integration starting from the preparation phase of research activities
- Each group should be able to investigate the basis motivation for integration

The main constraints that people would face are:

- Organisational constraints (lack of willingness to accept what other groups suggest, institutional links)
- Resources that need to be pulled together (financial/human/information), something that is rarely accepted by separate groups/organisations
- Lack of existing solid interactions and common research activities
- Lack of training in the development of integrated approaches
- Lack of training in the use of simulation models

Practical implementation

- FESS will represent an excellent opportunity for research groups to meet, discuss and integrated part of their activities around irrigation and drainage issues.
- Need to develop good communication means between researchers

- ❑ Need to develop specific tools to unify outputs and research results
- ❑ Need to deliver research results within a specific time frame
- ❑ Research results should be communicated to appropriate policy makers for impact of implementation of projects.

The participants were asked to respond to a questionnaire, evaluating the strengths and weaknesses of an integrated approach and identifying opportunities for applying such an approach in on-going or future research activities (FESS, NDP). The compilation of information obtained through these questionnaires is summarized in the following table.

Needs for integrated approach Usefulness for training (students, professionals) – Dissemination of results regarding understanding of irrigation systems – Evaluation of impact of projects (waterlogging & salinity, farm level policies, irrigation) – To link disciplines – To link researchers and stakeholders – Useful/needed for planning and implementation of development projects	
Past and current experiences with integrated approaches Evaluation of SCARP projects – Collaboration with IIMI in the Chishtian Sub-division (has shown that integration was possible) – Experience from Farming System Research – Inter-organizational studies already undertaken but not necessarily integrated – Involved in multi-disciplinary teaching	
Interest in developing integrated approaches To develop teaching material based on experience – For capacity building of organization – To develop platform for systematic coordination of research activities – To be able to develop research programs for optimal use of water resources – To apply the approach to the analysis of conjunctive use – To use integrated approach as a media between researchers and users of research results – Interest in participating in integrated approach in FESS project	
Strengths To link different systems – To link different disciplines – To gain benefits of holistic approach – Better utilization of water resources – Possibility to formulate pragmatic policies – possibility to solve issues simultaneously and effectively – Efficient means to share experiences – Possibility to look at different scales at the same time – The real situation can be simulated and analyzed – Powerful tool for analysis and communication – Will push agencies/institutes to work together – To gain knowledge from other disciplines	Weaknesses Need interdisciplinary experience that is not always available – Complexity – Lack of end-users in development – Too many actors involved that may make implementation difficult – No drainage and groundwater system in the approach presented – The social aspects are missing – Need leadership qualities to undertake integration – Success only if ownership of the approach by users – Requires skilled people (good tool/model users)
Constraints Lack of an appropriate platform to integrate disciplines and institutes – Need to know basics of other disciplines – Difficulty to integrate different groups and institutes – Lack of coordination and institutional links between disciplines and organisations – Poor political commitment – Time and people required – Funds required for implementation – Availability of proper computer software required – Skills for proper information management – Difficulty to involve end-users	Opportunities Good opportunities in the future – National Drainage Program – To integrate existing information collected by public agencies provides already opportunities for integration – Limited opportunities because limited funds available for this type of research – Limited opportunities today, but successes will lead to more opportunities – Good opportunities if dedicated leadership in organisations – Increasing access to modern technologies – Increasing needs of global approaches

Policy Makers Workshop (14 May, 1998)

Number of participants: 20

The workshop was chaired by Dr. Zafar Altaf, Additional Secretary of the Ministry of Food & Agriculture, who introduced the session by elaborating on the role of research in the improvement of irrigated agriculture in Pakistan. Research should focus on investigating doubts about the present and future functioning of irrigated agriculture in order to provide information to policy makers and other actors about different options and their expected impact. Impediments to a fruitful interaction between researchers and policy makers and other actors (line agencies, government departments, managers) can be found on both sides. On the one hand, the marketing of research results should be enhanced, recognising that written reports may not always be the best means of conveying information. The message needs to be concise, positive and well targeted. On the other hand, there is often a status quo orientation with the actors, a territorial attitude maintaining gaps between the policies and management of water resources, irrigation and agriculture.

There were three presentations on canal operations, salinity and sodicity, and water markets, each followed by a discussion. The results of the (lively) discussions are summarised here:

- ☐ ***Canal Operations:*** The discussion focused on water allocation, mainly related to the factors that should be taken into account when defining this allocation. It was stressed that there is a need to redefine the water allocation in Pakistan, as there have been certain changes in the water availability (e.g. construction of Tarbela, water allocation of agricultural land converted into cities). Agricultural productivity and environmental concerns (not delivering water to certain areas will degrade the resources) were mentioned as being part of the system objectives. A related issue that was discussed was the flexibility of the present irrigation system and the possibility of reallocating canal water. While some answers have been provided by research, mainly at the main canal and distributary level, this is an issue that needs further investigation at the Indus Basin level.
- ☐ ***Salinity and Sodicity:*** The discussion focused on IIMI's recommendation to conduct salinity and sodicity surveys by mapping those factors contributing to salinity and sodicity (soils, depth to groundwater table, groundwater quality, farmers' management). On the basis of this information salinity and sodicity risk maps can be made. In the discussions it was further stressed that new technologies, such as remote sensing, could be helpful in determining the extent of certain factors linked with salinity (e.g. cropping intensities).
- ☐ ***Water Markets:*** The need for regulation of the existing water markets was discussed, especially since the trading of water is not solely motivated by economic reasons, but also depends on social relationships.

Donors Workshop (14 May, 1998)

Number of participants: 12

Three presentations were made to the donors present, similar to those made to the policy makers: canal operations, salinity and sodicity, and water markets. The discussion was not very animated (very few participants took part in the discussions) and there seemed to be a gap between the results presented and the expectations or demand from the side of the donors. This seems to be partly related to the fact that not all of the donors in charge of rural development were present. Whether the decision not to attend is due to a lack of interest in this type of policy brief or to a lack of marketing from IIMI's side needs to be investigated.

The following issues were taken up during the discussions:

- ☐ Address *water distribution* problems through *remodeling of outlets* and not through maintenance. This was a finding that raised some interest and it was suggested that the issue be taken up with the Provincial Irrigation Departments.
- ☐ Large area salinity and sodicity surveys: IIMI's recommendation to conduct salinity and sodicity surveys by mapping the contributing factors rather than salinity and sodicity directly was thought to be important. It was recommended that IIMI take up the matter with WAPDA, particularly in relation to the NDP programme.
- ☐ *Applied research*: If research is to be of interest to donors, it will need to expose itself to the real world and be applied to specific projects or field/system situations. Hence IIMI's recommendation to tie in research activities with development projects to have a continuous exchange between research and implementing agencies.

Irrigation Department Workshop (16 May, 1998)

Number of participants: 30

The session was opened by the Secretary Irrigation & Power (Punjab), who outlined some of the challenges lying ahead of the department, related to the institutional changes such as the transformation into Provincial Irrigation & Drainage Authorities (PIDA), the establishment of Water Boards uniting irrigation officials and farmers, and Water Users Federations (WUF), and related also to new projects such as the National Drainage Plan (NDP). A major challenge is also to manage land and water resources in an integrated manner in order to ensure the sustainability of irrigated agriculture in Pakistan. In addition to the management of the system, the Department will have to prepare for possible extension of the irrigated areas if additional storage is developed. Finally, the Secretary emphasised the importance of research, in contributing to the improvement of the irrigation system performance, giving the example of the Irrigation Research Institute.

There were two presentations, the first one focusing on canal operations and maintenance, while the second one dealt with the use of an integrated approach for irrigation management. A lively discussion ensued focusing on the following topics:

Canal Operations and Maintenance

- ☐ *Remote sensing*: The use of remote sensing for the management of the system, e.g. by determining cropping intensities or salinity levels, was evoked by the participants. IIMI's research in this arena could be of interest to the Department.
- ☐ *Water allocation*: There was a long discussion about the present water allocation rules and the question whether these rules still adequately reflect the present situation with the many changes that have occurred in the system (construction of reservoirs, extension of irrigated areas, ...). The role of research is to determine the technical feasibility of alternative water allocation rules and to evaluate its impact on the water distribution (and subsequently on agricultural production and environmental issues). This should feed into a negotiation process between provinces, policy makers, irrigation officials, farmers and other actors involved, who will define the water allocation rules.
- ☐ *Flexibility*: To answer some of the queries of the participants related to the flexibility of the system, a distinction was made between the technical and socio-political flexibility of the system. While it is technically feasible to reallocate canal water, this may not be possible due to social claims to water.

Integrated Approach

- ☐ *Utility of the integrated approach*: The support that the integrated tool, which was demonstrated, can offer to irrigation managers was discussed. The main interest lies in the systematic way different management options can be assessed prior to implementation.
- ☐ *Salinity*: An interest was expressed in some of the results obtained by IIMI on salinity management (not presented during this workshop). The importance of canal water in dealing with salinity and sodicity was emphasised.
- ☐ *Integrated management*: There was an agreement that farmers' concerns, related to agricultural production and environmental issues such as salinity, have to be included in the management of the irrigation system. However, the participants also indicated the difficulties they experienced in taking farmers' concerns into account due to the diversity of farmers. IIMI emphasised the importance of a negotiation process between Irrigation Department and farmers, supported by tools that quantify some of the discussions.

Finally, some of the participants made valuable remarks about a continuation of the IIMI-PID collaboration:

- ☐ *FESS*: It was advocated to formulate a collaboration focused on the implementation of integrated management in the Fordwah/Eastern Sadiqia area, requiring a close interaction between researchers and irrigation managers. *There is a need to convert research into action.*
- ☐ *Deputation*: It was requested to enable the deputation of more irrigation engineers with IIMI. At present, there is one official of the Punjab Irrigation Department on deputation.

- *Scales*: In addition to working at the division or canal command level, it was advocated to work also at other levels (provincial, regulation, link canals, barrages). IIMI's work on water allocation rules in the Indus Basin was cited as a good example of work at this level.

POTENTIAL USE OF LESSONS FROM INTEGRATED APPROACH TO OTHER IIMI CASE STUDIES

1. Development of an integrated approach in the command area of the Fordwah/Eastern Sadiqia (South) irrigation and drainage project

Discussion with Saeed-ur-Rehman, Mobin-ud-Din Ahmad, Yann Chemin and Samia Ali.

Some general issues

- The research themes are already well defined, and include elements of research studies and of technical assistance to other research institutes. However, the three studies presented are still at a conceptual/data collection/checking phase.
- The biophysical and decisional processes analyzed and the temporal and spatial scales of analysis are different for the three studies. It may be useful to summarize this information in a single table, along with the input, parameters and output of each study.
- There has not been any step to develop a representation of the irrigation system (definition of the system under study, processes investigated, links between these processes, etc). Thus, links between the studies are absent or unclear.
- The research studies undertaken by other research institutes in FESS were not clearly known by IIMI researchers. Thus, the links between these studies and the IIMI researchers studies could not be discussed.
- With the absence of specific integration activities so far, it will be difficult to develop an integrated analysis for FESS within one year.
- It will still be possible to do a proper multi-disciplinary job. This will require that disciplinary studies are finalized within 6-8 months, to leave some time for putting results together.

Thus, a few recommendations:

- To give priority to disciplinary studies and to the quality of the results/output.
- For the final report of each disciplinary study, it will be important to include a section on potential links with other disciplinary studies. These sections will specify the input and output variables of each study, and propose ways to extrapolate the research obtained for sample sites to the overall FESS command area.
- After that, it will be possible to develop an integrated approach as part of the second phase of the FESS project.
- Based on the outcome of the workshop with the PIPD, an integrated approach could be part of a PIPD component of FESS Phase II, with technical assistance

from IIMI. This would provide an unique opportunity to have a real application of the integrated approach and check the usefulness of such approaches for the identification of interventions, negotiations between actors, and finally the implementation of the selected options. However, a strong involvement from PIPD staff from the planning division/Lahore HQ will be required to ensure the feasibility of this effort.

Some more specific issues include

- ❑ Mobin's work: to better specify the time scale selected for the analysis of interventions, to check whether the need to analyse unsaturated zone processes, to investigate the link between potential interventions and the net recharge (the main parameter of the groundwater model that will be modified)
- ❑ Yann and Samia's work: so far, little progress has been made on the methodology itself. Still some primary data has not been processed. The cleaning and organisation of the information is seen as the main constraint today and will require serious efforts. To test the sensitivity of the accuracy of results to the type of ground-truth data collection is probably an interesting issue. It may be necessary to identify the information requirements for the extrapolation of results to the remaining FESS area.
- ❑ Saeed's work: knowing the variability in surface water supplies in irrigation systems, it is important to check whether irrigation water has effectively been supplied in the same way to all the fields monitored. It will then be important to eliminate fields that may not have proper information. The parameters of the production functions that will be obtained, i.e. $\text{Yield} = f(\text{salinity, waterlogging})$, will only be valid for the average irrigation and farming practices that have been selected. In practice, however, a great variability is expected in these variables from one farmer to the other. Thus, the relationships obtained cannot be easily extrapolated and used for other areas or farmers. This is seen as an important limitation in the proposed approach

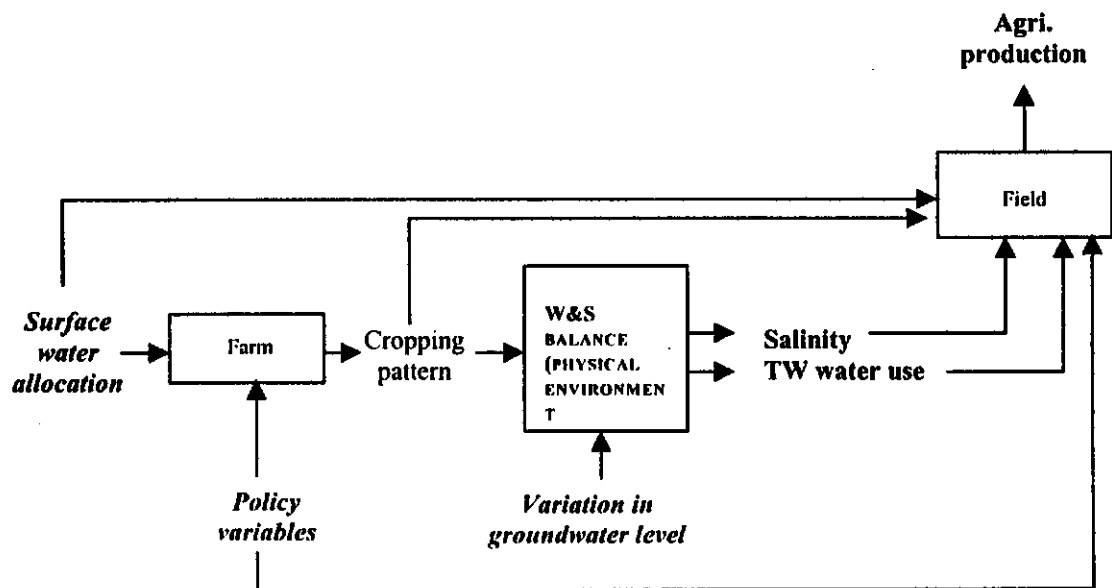
2. Waterlogging and salinity management in Sindh

Discussion with Gauhar Rehman, Waqar Jehangir, M. Aslam and Mr. Hamid

General issues

- ❑ The approach developed to build the suitability map is rather solid.
- ❑ However, the use of such a map for the discussion on appropriate allocation of surface water supplies remains limited and this for several reasons.
 - ❑ The potentiality and constraints of the drainage system are not considered.
 - ❑ The assumption that the cropping pattern is directly related to surface water allocation has not been validated. In fact, a large number of studies show that other parameters influence cropping pattern. Thus, a simple relationship probably does not exist.

a. Development of statistical relationships to estimate the impact of changes in water allocation



In this case, three relationships should be developed for the processes presented in the figure.

- Two statistical relationships
 - Cropping pattern = $f(\text{surface water allocation, policy variables})$
 - Agri. Production = $f(\text{surface water allocation, tubewell water use, salinity, cropping pattern, policy variables})$
- The water and salt balance

The information required/obtained is related to the following variables:

- Intervention variable: Surface water allocation (Based on the discussions we had, I think it will be important for you to better define whether you look at the impact of water allocation, water scheduling (indent) or water distribution)
- Parameters for model calibration: variation in groundwater level, policy variables (possibilities of different policy variables for the cropping pattern and agricultural production relationships)
- Output variables:
 - Cropping pattern
 - Salinity
 - Tubewell water use
 - Agricultural production (yield or gross income, per unit area or per unit of water, etc)

In what has been presented above, it is clear that the variation in groundwater level is to be fixed, thus this cannot be used anymore as an output for policy discussions. Another alternative would be to fix tubewell water use to obtain the impact of changes in surface water allocation on mining of the aquifer. However, this is also not a very satisfactory solution.

Thus it is not possible to obtain at the same time an assessment of the impact of surface water allocation on both tubewell water use and variation in water-table. This is a strong limitations of such approaches. This results, in fact, from the fact that inter-related processes are represented by a succession of independent processes and relationships.

Thus, to develop statistical relationships should not be done.

b. Proposed alternative approach

Using the information already collected, the following could be done.

- ❑ Analyzing the existing situation and their dynamics (trends) for the last 10 years. This should allow you to identify different types of canal command areas. For some types, changes in surface water allocation will have a significant role in explaining changes in other performance indicators. For other types, surface water allocation will not explain these changes. Those will be more related to changes in policy variables for example or other constraints that have not been modified (for example tenure status of farmers).
- ❑ Based on this detailed analysis, to choose one canal command area for which surface water allocation had an important impact on performance indicators.
- ❑ For this canal command area, to develop a Indus Basin Model type of model (i.e. combination of LP and water and salt balance) to define the relationship between surface water allocation and the different performance indicators (i.e. cropping pattern, yield, tubewell water use, gross income, salinity recharge).
- ❑ This model will be used to assess the impact of a potential change in allocation on these parameters for a couple of scenarios only.
- ❑ Based on the results of simulation, and using the analysis undertaken in the first step (typology like analysis), to discuss the relevance of results for the remaining canal command areas.

SUMMARY AND CONCLUSION - FOLLOW-UP ACTIVITIES FOR INTEGRATED ANALYSIS OF IRRIGATION SYSTEMS

The approach developed so far has stressed the feasibility of such integrated approaches and tools to analyse policy and management decisions. Also, the workshops with researchers and irrigation system managers have stressed the interest of people to participate in the development of integrated approaches. For follow-up activities, the following elements have been identified.

- Analysis of water allocation within the Indus Basin: methodology developed by Zaigham Habib, will need follow-up activities with tool development, involvement of actors, etc. This would require some funding. Also, it may further strengthen the discussion on generic elements of integrated approaches with the comparison of different scales and approaches (Chishtian, Indus Basin)
- Need to develop a project for development of the integrated approach in a real scale situation. And this effort as part of the overall DSS program that should be limited to canal operation and flow monitoring. The discussions with PIPD and their need to develop a mid-term strategy => they will need such tools and may represent an important partner in this process. To select a given case study for this application, with clear monitoring and evaluation activities of the integrated approach component in itself. FESS Phase II may be the best case, with involvement of planning officers of the PIPD and also input from the various research institutes that have been involved in the FESS project
- National Drainage Program and later on National Irrigation Program: important to make the required dissemination efforts to clearly include an integrated approach component in these programs. In the long term, this may represent the best opportunities to jump from the FESS case to a more general use of integrated approaches for planning of interventions for any projects within the Indus Basin Irrigation System.

APPENDIX I - POLICY BRIEFS

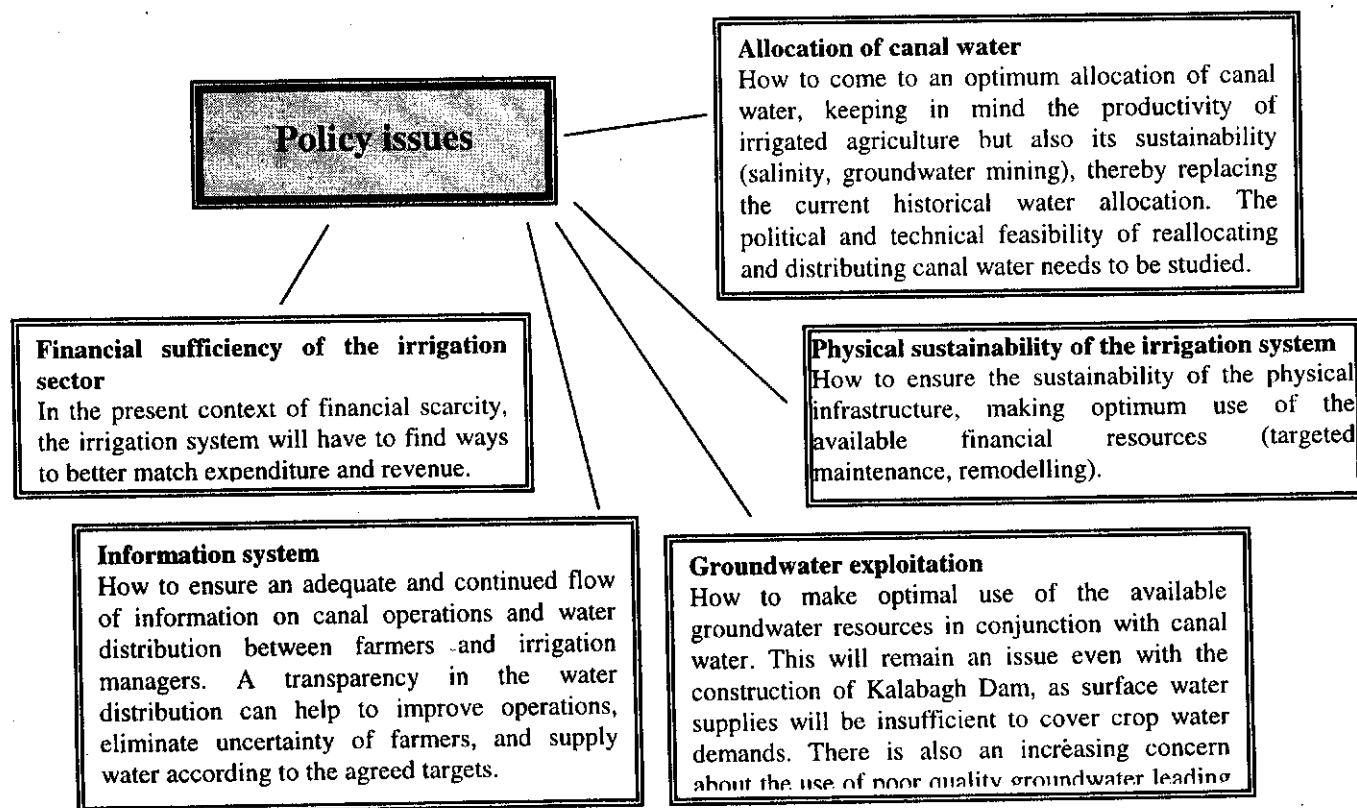
- Canal operation and maintenance in Pakistan**
- Salinity and sodicity in Pakistan**
- Water markets in Pakistan – Technical feasibility and potential impact on irrigation system performance**
- An integrated approach - Assessing the potential impact of policy and management changes on irrigation system performance**

Canal Operations and Maintenance in Pakistan

BACKGROUND

The contiguous Indus Basin irrigation system irrigates an area of about 16 million ha, diverting annually about 128 billion m³ of surface water to 43 canal systems. In addition, at present an estimated 30-40% of the irrigation water at the farm gate is provided by tube wells, necessitated due to the huge increase in cropping intensities (from 75 to 150%). This increase also puts tremendous pressure on the irrigation agency for distributing the scarce canal water. Farmers prefer canal water because it is cheaper than tube well water and it is of better quality. The irrigation sector is, therefore, confronted with the following challenges:

- ❑ Canal water resources are inadequate to cover the demands of farmers.
- ❑ The water distribution is not equitable due to increased competition for scarce water resources.
- ❑ The water allocation to different canal commands (water duty, perennial/non-perennial), based on century old rules, is not equitable and does not account for the present situation where canal and groundwater are used conjunctively.
- ❑ Data measurement, communication and processing of canal operations and maintenance has not evolved since the inception of the Indus Basin irrigation system. New technologies, such as data loggers, telemetry, and decision-support models, have been developed around the world in recent years, offering opportunities for improved management.



RESEARCH RESULTS

Canal operation

It is possible to restore equitability or redirect water to certain specific distributaries (e.g. for reasons of productivity) with the present infrastructure by changing the operational rules. However, there remain certain physical constraints, such as the absence of gates for certain distributaries.

The absence of a proper communication system creates uncertainty in the irrigation system. Gatekeepers operate their structures without knowing what they can expect to arrive from upstream and without knowing the effects of their operations on downstream conditions. In times of peak demand this means that upstream gatekeepers divert too much water, creating shortages downstream. In case of rains, upstream gatekeepers close their gates, resulting in an excess of water at the tail, causing overflow and breaches.

The lack of escapes in the system provokes safety measures of gatekeepers (to avoid breaches), mainly consisting of under-exploiting the physical capacity of the canal. These measures are also provoked by the uncertainty of the gatekeepers about the inflow, which may suddenly increase. The result is that distributaries at the tail of a system receive lower supplies.

It was field tested that an improved communication system, informing gatekeepers of expected perturbations and issuing instructions improved the water distribution considerably.

Canal operations at the main canal level are driven by operational rules such as target discharges, operational order. Actual rules deviate from the official rules to account for system realities (uncertain inflow, lack of communication, discharge variability, farmer pressure), leading to the existing inequity and variability in water distribution.

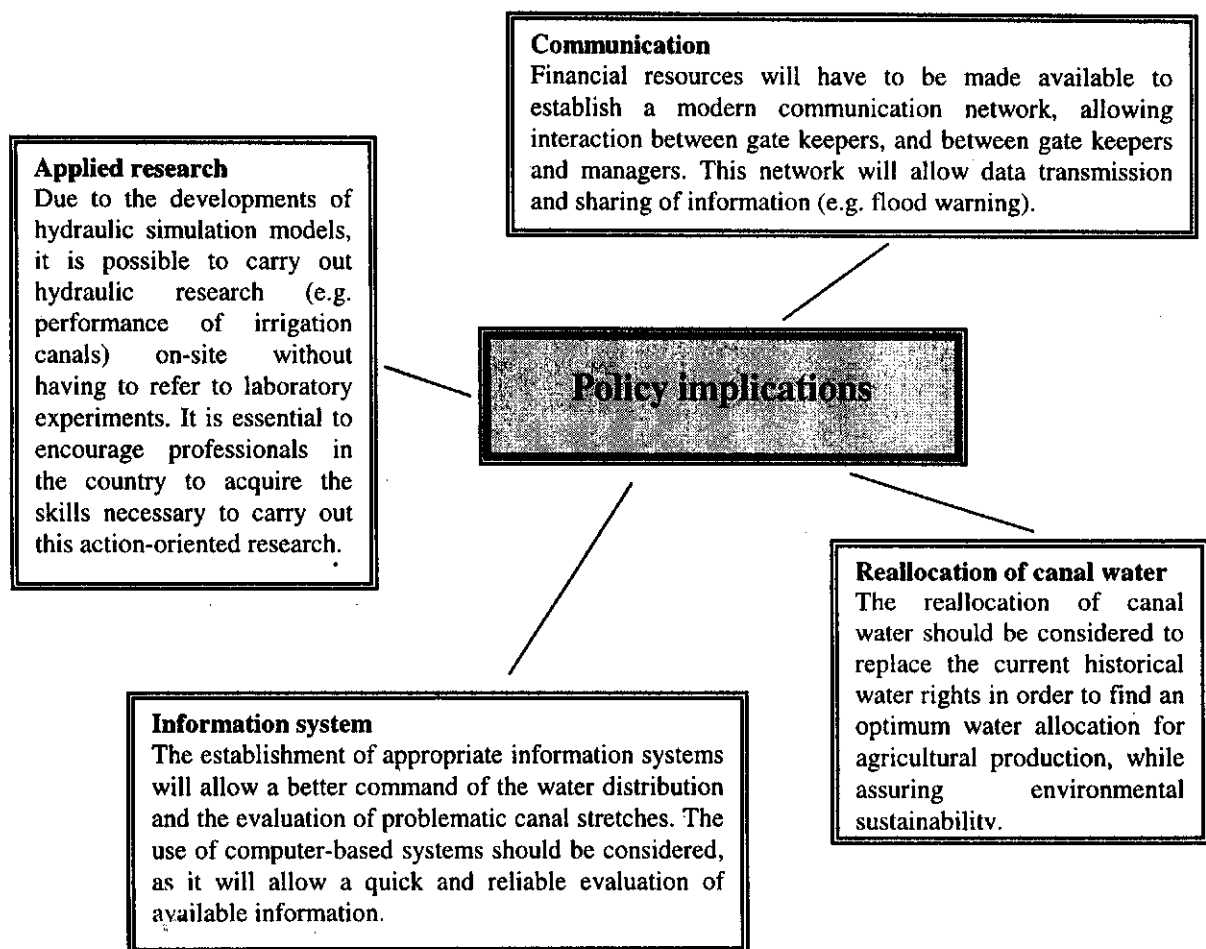
Water distribution

Information on discharges in different parts of the system is only available in handwritten registers. Analysis of existing operational problems is difficult to carry out without a computer-based information system. Such an information system was shown to be able to detect problems in the water distribution.

The characteristics of the outlets (dimensions, setting and type) is the main factor explaining the water distribution in distributary canals. Modifying the outlet characteristics is the most straightforward means of changing the water distribution in a distributary canal, e.g. to restore equity.

The water deliveries to watercourses depends on the regular supply to the distributary it is situated in, governed by main canal operations, and on the physical state of the canal and structures of the distributary.

Maintenance of distributary canals serves mainly to ensure the safety of water conveyance. The effect of canal maintenance on the water distribution is rather limited.



FOLLOW-UP RESEARCH ACTIVITIES

- ❑ Develop an information system suitable for the Pakistani context that can be used by irrigation managers in the field. It can be considered to link these information systems to a provincial database, thus providing a feed-back to the regulation office.
- ❑ Develop on-site methodologies to investigate performance problems related to operations and maintenance, involving simulation models.
- ❑ Investigate the potential impact of a reallocation of canal water on agricultural productivity and on environmental issues (salinity, sodicity, groundwater mining).
- ❑ Develop a decision support system for carrying out maintenance activities to find an optimum mix of interventions related to the performance of the canals.

Salinity and sodicity management in Pakistan

BACKGROUND

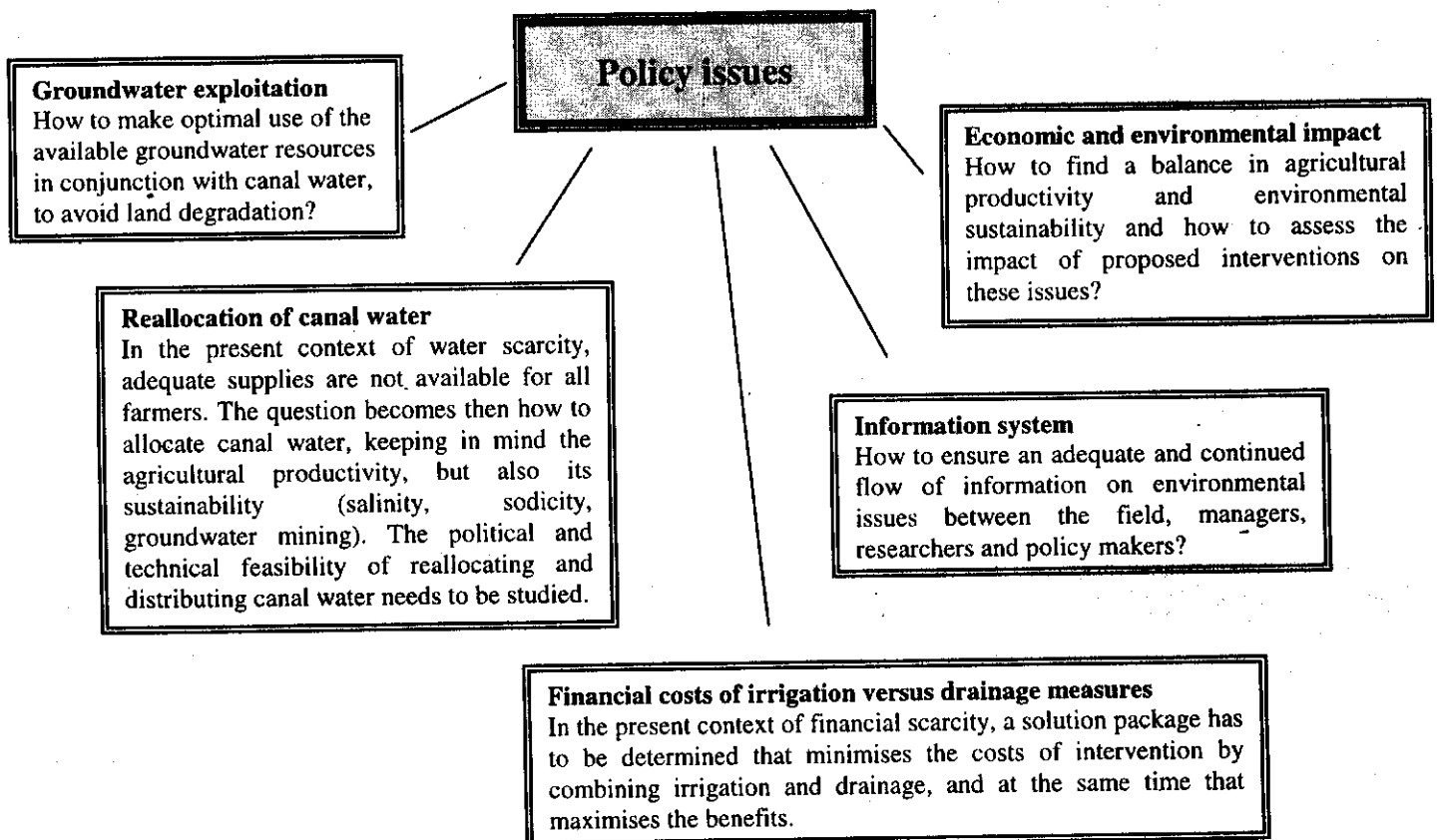
Salinity is traditionally associated with irrigated agriculture in Pakistan. Three main causes can be identified:

- Genetic salinity due to weathering of saline parent material
- Capillary rise of salts due to a rise in groundwater tables
- Use of poor quality groundwater for irrigation

The massive development of private tube wells in Pakistan, estimated to exceed 500,000 at the moment, makes the threat of salinisation through the use of groundwater an important challenge.

Salinity mainly affects the water root uptake of plants and thus the yield of crops. Sodicity degrades the soil structure, impacting on crop yields. WAPDA estimated that 10.7% of the soils in the Indus Basin are saline, 23.6% are saline-sodic, and 3.5% sodic. These figures emphasises the importance of sodicity, in addition to salinity.

Measures that have been taken to control salinity and sodicity have mainly focused on drainage. Recently, the government of Pakistan has encouraged the joint implementation of irrigation and drainage measures (e.g. FESS project). The IIMI-Cemagref research project focused on the identification of irrigation policy and management options that would mitigate salinity and sodicity, thus providing support for the implementation of these options.



RESEARCH RESULTS

Salinity and sodicity are natural phenomena, but are influenced by human interventions. The research, therefore, focused on analysing both bio-physical processes as well as farmer management. In addition, a methodology was developed for large scale salinity and sodicity surveys.

BIO-PHYSICAL PROCESSES

- Irrigation with groundwater rich in sodium and bi-carbonates, leads to the degradation of the soil profile
- Land degradation begins at fairly low levels of sodicity (Exchangeable Sodium Percentage (ESP) of 4) due to the illitic nature of the clay minerals. This corresponds with recent findings in Australia, but is much lower than earlier assumptions, which was based on American research (Richards in 1954 presented a critical limit of ESP 15).
- Sodification occurs rapidly: the first signs of soil degradation (surface crusts, hard soil layers) appear after 1-2 irrigations.
- Salinisation through capillary rise occurs when the groundwater table is at 2 m or less.
- Irrigation water quantity and quality are determinant factors for soil salinity and sodicity.

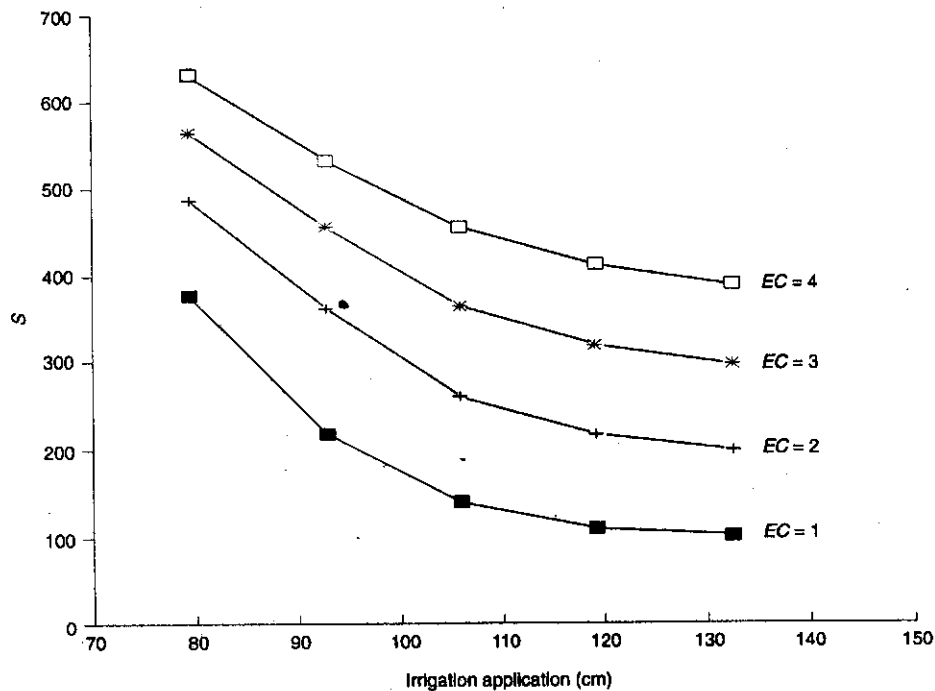


Figure: Irrigation water quantity and quality are determinant factors explaining soil salinity and sodicity. Here the total number of salts, S , in a soil profile (in mg/cm^2) of sandy loam is presented as a function of the water quality (in electrical conductivity, EC in dS/m) and water quantity (in cm).

LARGE AREA SURVEYS

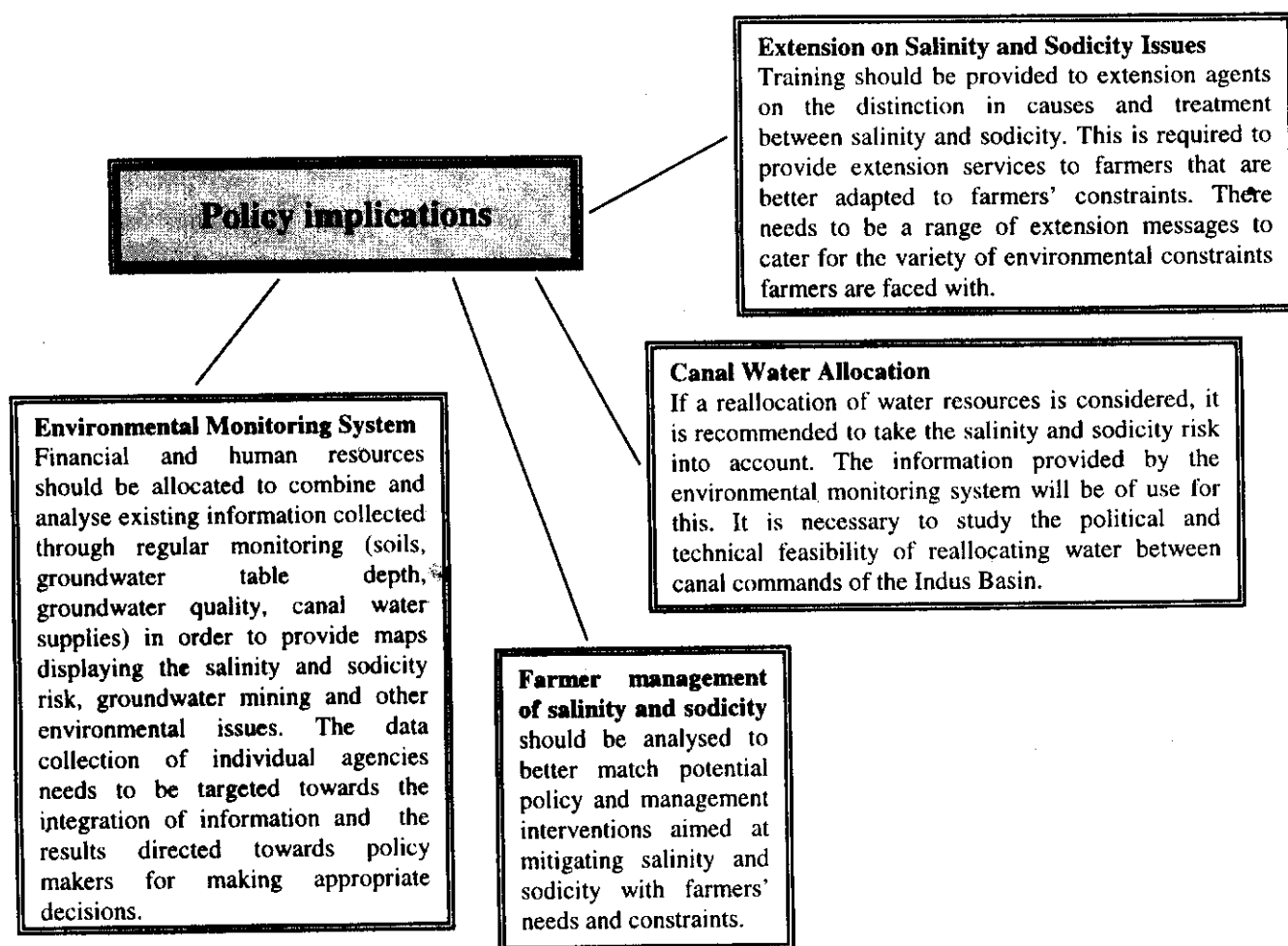
- ❑ The characterisation of the soil salinity and sodicity in an irrigation system must be *dynamic* and must be based on an *understanding of the processes* leading to these phenomena. A map representing the salinity/sodicity status for a given time period is not sufficient to take appropriate policy decisions to mitigate salinity and sodicity. Salinity and sodicity levels are fluctuating and there are multiple causes of these phenomena, which need to be considered to identify policy and management interventions. This was illustrated for a 14,000 ha command area. Supplying extra canal water to areas with high salinity levels was found to be less effective, in terms of mitigating salinity and sodicity, than supplying extra water to areas with poor quality groundwater.
- ❑ A salinity or sodicity risk map for the Indus Basin can be prepared by mapping the soils (soil physical and chemical properties, drainage capabilities), the groundwater quality, the depth to groundwater table and the canal water supply. These were the factors found to determine salinity and sodicity. Most of these data can be obtained from different government agencies.
- ❑ Salinity and sodicity in barren areas can be easily recognised through remote sensing. In cultivated areas this is much more difficult.
- ❑ The influence of farmer and irrigation agency management on salinity and sodicity is considerable. This factor should not be neglected while carrying out a large scale survey. Differences in farmers' objectives and constraints, such as tenancy, may explain certain salinity patterns, but will also require the formulation of different policy and management options.

FARMER MANAGEMENT

- ❑ Farmers have a long experience in dealing with problems of salinity and sodicity. They have a series of management practices to deal with these problems, including water management, crop choice, cultural practices, and biotic and chemical amendments.
- ❑ Modelling results showed that the water management practices of farmers have a considerable impact on salinity and sodicity. This is due to the fact that the irrigation water quantity and quality, generally resulting from a mix of canal and groundwater, are determinant factors for salinity and sodicity.
- ❑ Farmers' salinity and sodicity strategies are related to overall farm strategies (e.g. profit maximisation) and constraints (credit, labour, tenancy) and to their experience in dealing with these issues. Extension messages need to be adapted to these differences in farms.

TOWARDS AN INTEGRATED APPROACH: IRRIGATION AND DRAINAGE POLICY AND MANAGEMENT

- Irrigation management can contribute to the management of salinity and sodicity, by changing the quality and quantity of irrigation water available with farmers. This can help minimising (costly) drainage requirements.
- It is technically feasible to reallocate canal water resources. For an area of 14,000 ha it was shown that in doing this the area threatened by sodicity, could be reduced by 40%.
- Salinity and sodicity are directly managed by farmers. Irrigation and drainage measures should, therefore, aim to increase the capability of farmers to deal with salinity and sodicity. In irrigation management this means that farmers obtain a certain control over the water resources and are free to interchange water turns (e.g. through water markets). In drainage management this means giving farmers the possibility to regulate water levels.
- In order to deal with a highly variable environment (soils, groundwater quality, ..), a large set of policy and management interventions should be considered. To assess the impact of these different interventions in different contexts, it is important to have access to tools that can help in determining the impact on salinity and sodicity.



FOLLOW-UP RESEARCH ACTIVITIES

- ❑ **Analysis:** The analyses of this project determining the origin, causes, and dynamic of salinity and sodicity need to be extended to the entire Indus Basin, thus facilitating the implementation of the Environmental Monitoring System. These analyses should include the determination of the different environmental and human factors influencing salinity and sodicity. These analyses will need to constitute a sustained effort even after implementation of SIS.
- ❑ **Large area surveys:** There is a need to develop a methodology for large area salinity and sodicity surveys. These surveys should focus on the environmental factors leading to salinity and sodicity, thus capturing the dynamics of salinity and sodicity.
- ❑ **Tools:** The use of tools, describing and simulating relationships between environmental factors and salinity and sodicity, should be enhanced to allow for a well functioning Environmental Monitoring System.
- ❑ **Extension messages:** Research results need to be translated into clear messages that extension agents can use in their interactions with farmers. These messages must be adapted to the large variability in environment (groundwater tables, soils, groundwater quality) and farming systems (credit, labour).

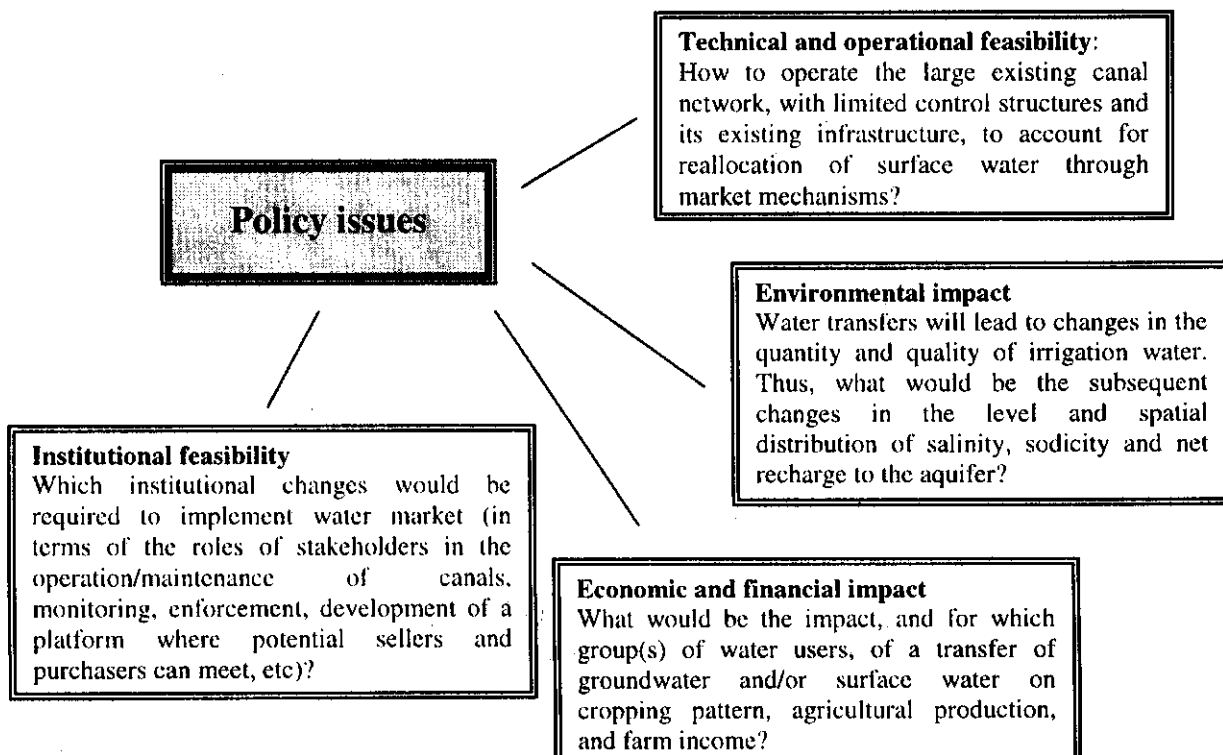
Water markets in Pakistan

Technical feasibility and potential impact on irrigation system performance

BACKGROUND

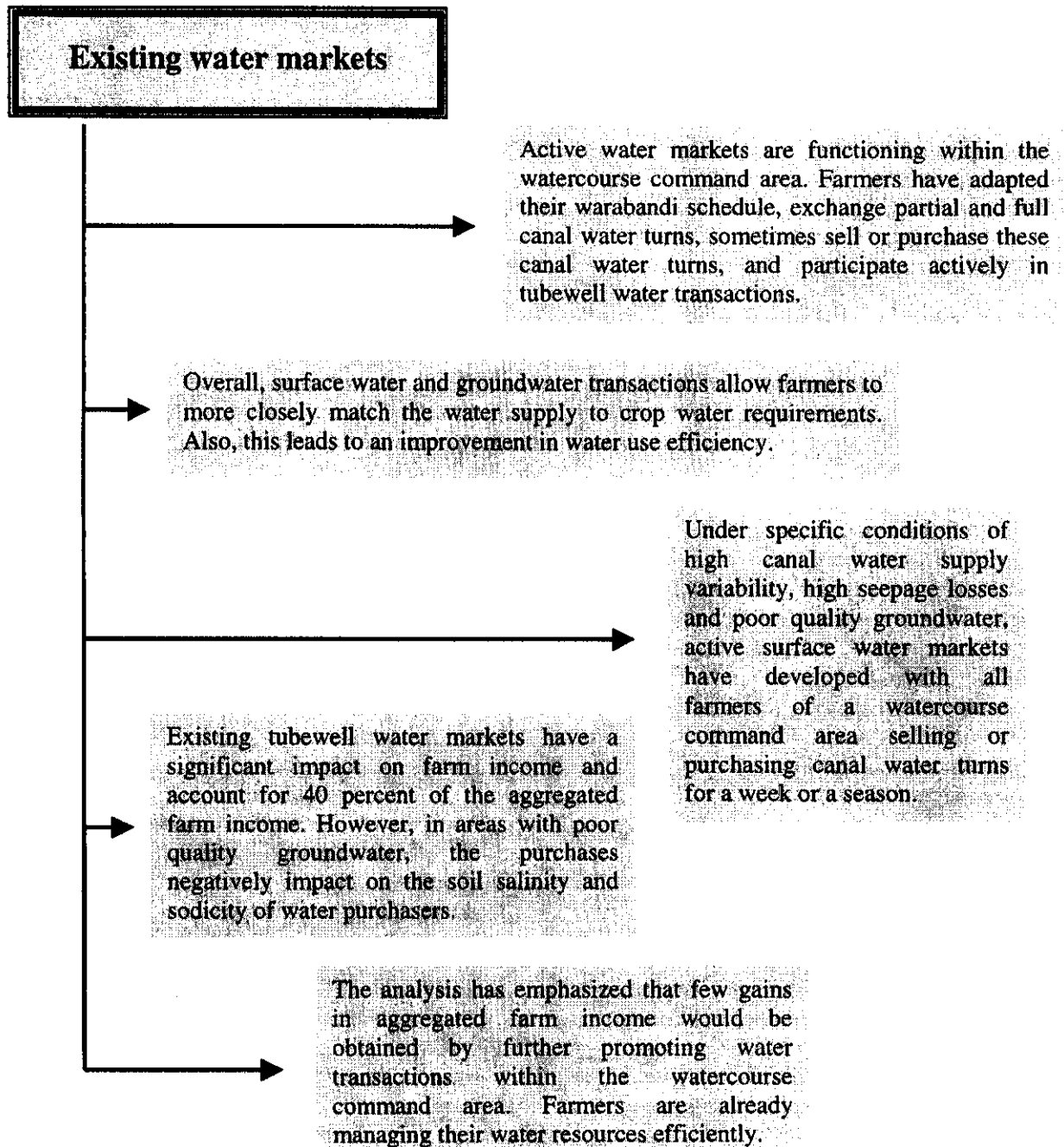
To address productivity and sustainability issues in irrigation systems of Pakistan, and to reduce the financial deficit of the irrigation sector, policy and management changes have been proposed and are currently being implemented. These changes include a shift towards a greater autonomy of irrigation agencies, and the transfer of part of the management responsibilities to water users.

Also, based on experiences elsewhere, to promote water market development has been proposed to improve agricultural production and productivity. Although the term water markets is used to characterize a wide range of situations, it generally means the sale/purchase of water rights or volumes of water from one user/group of user to another user/group of user. As little is known regarding the potential feasibility of such markets in Pakistan and their expected impact on agricultural production, farm income and on the environment, a specific research study has been initiated as part of the collaboration between IIMI and Cemagref.



RESEARCH RESULTS

Research activities have concentrated on the Chishtian Sub-division of the Fordwah Branch Irrigation System, South-Punjab. The emphasis of these activities has been first on describing the existing situation in terms of allocation, distribution and use of groundwater and surface water. Then, simulation models have been used to assess the potential for reallocation of surface water between tertiary units and between secondary units.



Potential surface water markets

Technical and operational feasibility

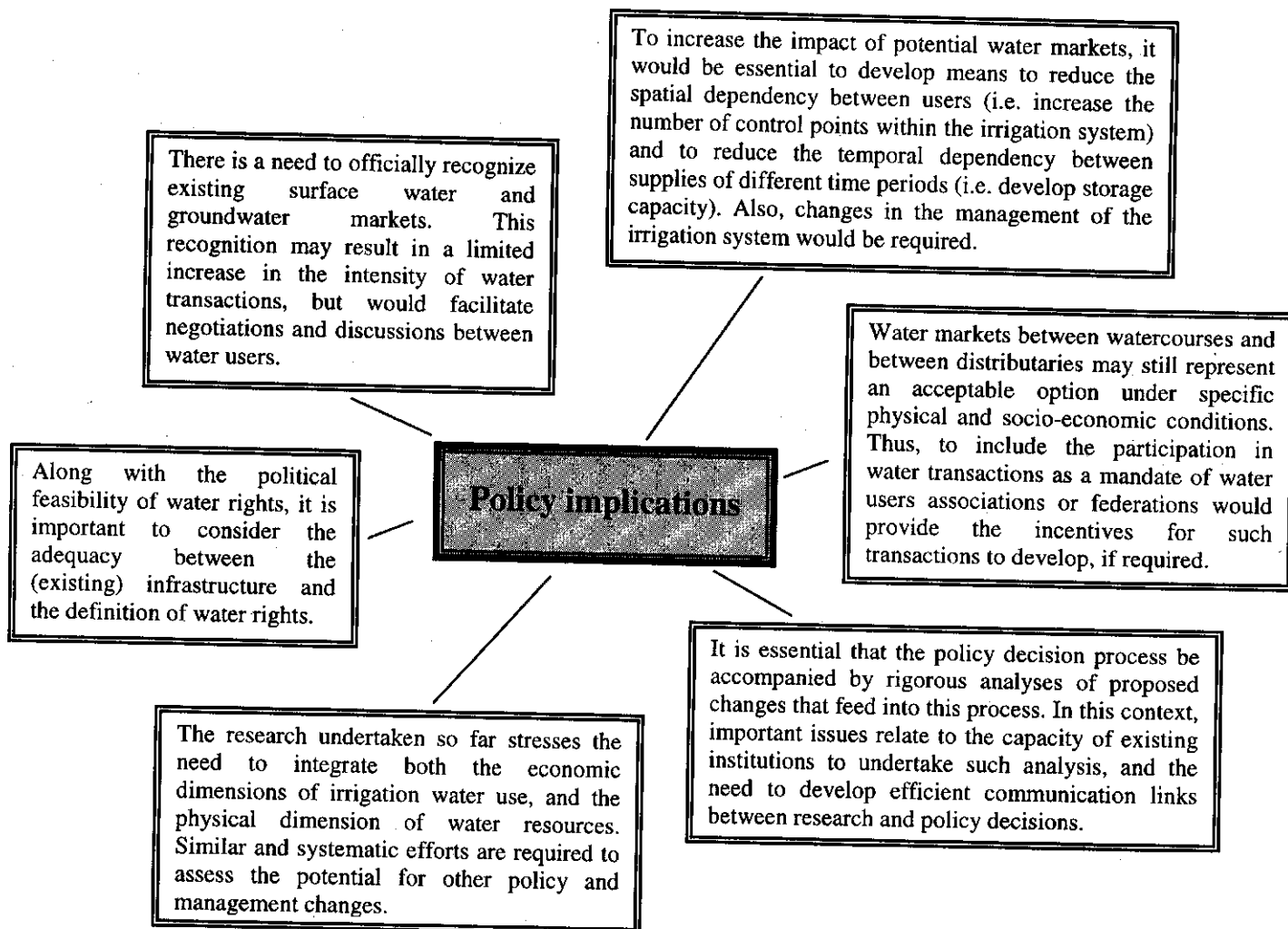
- ❑ To allow for reallocation of surface water between watercourses would require gates at the head of the watercourses, or regular changes in the watercourse outlet dimensions (every 1-3 years for example). Frequent changes in outlet dimensions already take place in various secondary canals, emphasizing that the regular modification of outlet dimensions can be considered as an option for reallocating surface water.
- ❑ The transfers of surface water between watercourses negatively impacts on supplies of watercourses located between watercourses participating in the transactions. Required compensations in supplies may be difficult to implement.
- ❑ The capacity of primary and secondary canals would not represent a constraint for the transfer of surface water between secondary canals. However, the supply to secondary canals should remain above 70% of their design. This limits the potential for any given secondary canal to sell surface water to other canals.
- ❑ Clearly, transfers between tertiary units and between secondary canals would require significant changes in the information required for managing the irrigation system and monitoring water transfers.

Impact

- ❑ With the current physical network, the development of surface water markets between tertiary units and between secondary units would yield limited impact in terms of changes in aggregated farm income (+2-5% only).
- ❑ The main impact would be a change in groundwater use, farmers with good quality groundwater and cheaper tubewell water selling their canal water to other farmers and compensating surface water sales by increasing tubewell pumpage. This may increase the pressure over good quality groundwater resources.
- ❑ To increase the impact of potential surface water markets, it would be essential to develop means to reduce the spatial dependency between users (i.e. control points within the irrigation system) and to reduce the temporal dependency between supplies of different months (i.e. develop storage capacity).
- ❑ Also, surface water transactions are expected to yield to greater benefits in areas with large differences between the gross income obtained from different crops.

Institutional requirements

- ❑ The definition of water rights is far from being a simple technical issue and has strong political components. For example, from which initial rights to start: the official (equitable) allocation that has little chance to be accepted, or the actual (inequitable) allocation with more chances to be accepted?
- ❑ With the present physical infrastructure, water rights could be defined as volumes at the main canal, share of the flow at the head of tertiary units, and time duration within the watercourse command area.
- ❑ Water users associations and federations could play an important role in the implementation of water markets. Their involvement would reduce information costs, facilitate the allocation of purchased water between different users/groups of users, and also improve the enforcement of water rights.



FOLLOW-UP RESEARCH ACTIVITIES

- Based on discussions with policy makers of these initial results, additional water market scenarios will be tested. Such scenarios may include the combination of surface water transactions at different scales of the irrigation system, or the combination of surface water and groundwater transactions.
- Further analysis is required to validate the research results for a larger range of physical and socio-economic environments.
- Using a similar approach, a new research activity has recently been initiated by IIIM and Cemagref to analyze the potential for reallocation of surface water between canal command areas.

An integrated approach

Assessing the potential impact of policy and management changes on irrigation system performance

BACKGROUND

While irrigation sector policies and projects have long been based on purely technical interventions, there is a growing recognition for the need to identify appropriate combinations of technical, institutional and economic changes that would improve the productivity and sustainability of the irrigation sector. The identification of appropriate interventions requires a *multi-disciplinary and integrated analysis of the complexity of irrigation systems*, and this for several reasons:

- ❑ The stakeholders of the irrigation system (policy makers, managers, and water users) have different objectives such as equity, sustainability, and productivity. These objectives are to be considered jointly in the search for improvements. The tradeoffs between objectives should be emphasized.
- ❑ Proposed policy and management changes are likely to influence, directly or indirectly, several inter-linked decisional and biophysical processes. Thus, these processes are to be investigated simultaneously.
- ❑ With the increased involvement of water users in the management of the irrigation system, interactions between the different actors and their decisions are reinforced. A simple juxtaposition of disciplinary studies cannot assess the impact of potential improvement on these interrelated decisions and on irrigation system performance.
- ❑ The impact of policy and management changes will vary within irrigation systems, as a result of the spatial heterogeneity of the physical and socio-economic environment. This spatial heterogeneity is to be considered for the different processes investigated.

As part of the IIMI-Cemagref collaboration, a study was proposed for developing an *integrated approach to assess the potential impact of policy and management changes on irrigation system performance*. This study has been implemented in the Chishtian Sub-division of the Fardwah Branch Irrigation System, South-Punjab.

The integrated approach developed under this collaboration has been applied to the analysis of two management and policy interventions: (i) modifying main system management to mitigate salinity/sodicity problems; and, (ii) developing surface water market to improve agricultural production and productivity.

INTEGRATED MANAGEMENT, INTEGRATED APPROACH, INTEGRATED MODELS?

- ❑ *Integrated management* aims at the implementation of interventions that have been *first negotiated* among actors. Information technologies, conflict resolution and negotiations, institutional and legal arrangements between actors are the main elements of an integrated management framework. The use of an integrated approach may facilitate communication among actors.
- ❑ *The integrated approach* aims at the development of a *shared understanding and knowledge* between actors (and among researchers) concerning sub-systems, interactions and processes to take into account in the diagnosis and the evolution of the irrigation system. Sometimes integrated models are developed from this shared understanding in order to support policy decisions.
- ❑ Individual process-based *models* are linked in an *integrated model* to *simulate* overall consequences of various « what-if » scenarios of interventions on the output of the system.

The integrated approach may be applied at various scales (a field, a farm, an irrigated scheme, and a river basin) with different disciplines (hydrology, hydraulics, economy, agronomy, soil science, and social sciences,...) according to the issue considered.

An integrated approach: improving the fit between the analysis of irrigation/drainage systems and policy and management issues?

A restoration of the **equity in canal water supply** is often advocated for the management of the canal network. An integrated approach can provide information on the impact of restoring equity on the aggregated agricultural production of a given canal command area, and on its sustainability in terms of salinity and net recharge to the aquifer.

The search for the most **cost-effective combination of irrigation and drainage interventions** to improve the sustainability of irrigated agriculture requires an (optimum) balance between agricultural production and environmental sustainability. This can be done more effectively using an integrated approach.

The combination of economics and hydraulics has stressed that the existing physical infrastructure and canal operational rules would limit the economic **impact of potential transfers of surface water through market mechanisms** between tertiary units and between secondary units.

Because of the pressure on water resources, it is more and more difficult to **allocate extra surface water supplies to tackle salinity and sodicity issues (reclamation shoots)**. Using the integrated approach developed by IIMI and Cemagref, it was shown that the reallocation of surface water from watercourses with ample supplies to watercourses with sodicity risk would significantly mitigate sodicity risk of the latter without reducing the cropping intensity of the former.

THE INTEGRATED APPROACH

The main objective of the integrated approach is to test the impact of policy and management interventions on the surface water supply and groundwater use, agricultural production and farm income, and environmental phenomena such as salinity, sodicity and net recharge to the aquifer. These interventions include changes in surface water allocation, remodeling of outlets, maintenance of secondary canals, lining of watercourses, changes in water prices, development of water markets, or changes in prices of agricultural products.

The main elements of the integrated approach

Building a common representation of the irrigation system requires an agreement on the actors considered, the main decisional and biophysical processes that impact on irrigation system performance, and on the influences of the external environment on these processes.

The main decisional and bio-physical processes investigated include surface water allocation and distribution at different scales of the irrigation system, the impact of surface water supply on groundwater use, agricultural production and farm income, and the link between water supply (quality, quantity) and soil salinity/sodicity.

Investigating the spatial diversity of the main variables that influence the selected processes is required to understand the functioning of the irrigation system and link disciplinary studies. The information pertaining to physical and socio-economic variables is obtained from primary and secondary sources for the entire area. The information is stored and structured in a **spatial database** developed under a Geographic Information System (GIS) that also provides a means to display the results of model simulations for different scenarios.

The development and use of simulation models for the different disciplinary studies (hydraulics, economics, soil sciences) provide means to quantify the impact of interventions. The initial analysis of management and policy changes has been undertaken by linking these disciplinary models. Further efforts have concentrated on building an integrated model, *Integis*, that provides a common platform for the disciplinary models and links these models to the databases of the Geographic Information System (GIS).

Validation/evaluation of the integrated approach. The sensitivity analysis of the main parameters and the capability to predict the actual irrigation system performance and its spatial distribution are important elements of the validation/evaluation framework of the integrated approach. Also, the usefulness of the results obtained is assessed by potential users of the integrated approach.

THREE ISSUES RELATED TO THE DEVELOPMENT AND USE OF INTEGRATED APPROACHES

How to use the integrated approach?

- ❑ The main purpose of the integrated approach is not to identify the optimum policy and management change that would improve irrigation system performance. It provides information that feeds into the policy decision process through an iterative exchange between policy makers and researchers.
- ❑ Overall, the use of integrated approaches is expected to facilitate policy decisions and negotiations between the different stakeholders involved in irrigation management.
- ❑ Precautions are required with the use of the results obtained from simulations with integrated models. More than providing accurate predictions of impact, the results obtained from simulations will show trends, stress the interrelationships between processes, and provide a better understanding of the irrigation system analyzed.

Communication

- ❑ Enhanced communication between researchers is an essential element of an integrated approach. The integration of disciplines means, for each discipline, a good understanding of other disciplines and the integration of elements from other disciplines in disciplinary studies.
- ❑ To promote the development of multi-disciplinary research proposals is a first step towards the integration of disciplines. However, systematic efforts are required to effectively integrate disciplines and researchers, and avoid disciplinary results that are only combined at the end of research activities. This can be better achieved with the development of a common representation of the irrigation system and of joint databases.
- ❑ Enhanced communication is also required between researchers and policy makers or irrigation managers. More specifically, it is important that researchers investigate performance indicators of interest for policy makers. Also, the interaction with the different stakeholders is required for researchers to identify potential policy and management changes to be analyzed. Finally, the results of the integrated approach, both in terms of the understanding of the existing irrigation system and of the potential impact of management and policy changes, need to be communicated and shared with stakeholders.
- ❑ The integrated tool and the maps obtained from the Geographic Information System are important means that will strengthen the communications between researchers, policy makers and irrigation managers.

Information management

- ❑ With the development of integrated approaches, information and its management become an increasingly crucial issue. The quality of information clearly conditions the potential of such approaches to provide useful and consistent results.
- ❑ The construction of a common database plays a significant role in integrating disciplines and researchers. The development of such a database means identifying variables that will be required for each discipline at different spatial and temporal scales, and also variables that will link disciplines.
- ❑ The databases produced in the context of integrated approaches should be made accessible to other researchers and to users. An important step in the development of these databases is to analyse the information requirements of users (policy makers, irrigation managers, etc).
- ❑ The management of information requires specific skills that are not always available within research teams. Examples of such skills include database management, information technologies, and Geographic Information Systems (GIS). To strengthen research teams in these skills (new staff, training) is seen as a key to success for developing/applying an integrated approach that will provide suitable information to support policy decisions.

APPENDIX II - RESEARCH ISSUES AND METHODOLOGIES

- Canal operation and maintenance in Pakistan**
- Salinity and sodicity in Pakistan**
- Water markets in Pakistan – Technical feasibility and potential impact on irrigation system performance**
- An integrated approach - Assessing the potential impact of policy and management changes on irrigation system performance**

RESEARCH METHODOLOGY

- ❑ Physical and chemical processes leading to salinity and sodicity were studied at the field level by employing deterministic models that are based on physical laws that have been proven to govern these processes. These deterministic models (separate models for salinity and sodicity) were calibrated and validated for the existing situation.
- ❑ Once calibrated and validated the models were used to carry out sensitivity analyses in order to quantify the relative impact of the different physical factors that cause salinity and sodicity, showing the importance of the quantity and quality of irrigation water. Another important finding was the dynamic of salinity and sodicity, depending on the irrigation regime, the climate, and the soils.
- ❑ Land degradation as a function of the sodicity level was quantified through physical measurements of the soil structure, providing evidence of soil degradation at ESP levels as low as 4. In addition, this process was found to be rapid with signs of soil degradation appearing after 2-3 irrigations.
- ❑ The models were also used to evaluate the impact of farmers' management on salinity and sodicity in order to determine whether farmers could contain salinity and sodicity if more canal water would be made available to them. The physical model describing salinisation is easier to use than the geo-chemical model describing sodification. The latter model incorporates both physical and chemical processes, complexifying the studied relationships.
- ❑ *Farmers' salinity and sodicity management* was studied in the larger context of the farming systems to understand their constraints in managing salinity and sodicity in order to formulate matching policy and management interventions.
- ❑ The results of the salinity and sodicity analyses were combined with studies of the canal irrigation system in order to assess the technical feasibility of reallocating canal water through simulation models in order to mitigate salinity and sodicity.
- ❑ *Large-scale surveys* were undertaken for the entire study area (70,000 ha) through different means: remote sensing, visual observations (in collaboration with Directorate for Land Reclamation), and a Soils/Hydrological survey (in collaboration with the Soil Survey of Pakistan). The strengths and weaknesses of these approaches could thus be established.
- ❑ The information collected was stored in a *GIS*, combining soils and physiography data with information on groundwater table depth and groundwater quality. This provides a good means for analysing the salinity and sodicity risk and providing opportunities for discussing these analyses with researchers, managers, and policy makers. The data collected provide an interesting scope for continued efforts in this field.

Canal operations and maintenance in Pakistan

RESEARCH ISSUES

- ❑ At the main canal level, the water distribution is governed by gate operations, while at the distributary level, it depends on the state of the canal and the (outlet) structures. Analysing the water distribution will, therefore, need to be carried out differently at both levels.
- ❑ The water distribution, both at the main as well as the distributary canal level, depends on a number of physical and human factors (operations, maintenance). By developing a model, each of these factors can be analysed separately, by varying this factor and keeping all other factors constant (sensitivity analysis).
- ❑ The actual operational rules (target discharges, rotational order) deviate from the official operational rules, reflecting the system realities. To capture these actual operational rules, it is important to study the actual water distribution and relate this to canal hydraulics and to operations of the irrigation agency.
- ❑ It is important to identify the main parameters influencing canal water distribution, as these parameters will offer opportunities to irrigation managers to intervene in the water distribution. Such a 'sensitivity analysis' is typically an exercise that can be undertaken through modelling.
- ❑ The technical feasibility of reallocating or redistributing canal water is not clearly understood. The flexibility of the canal system (physical constraints of canals and structures) to deal with this need to be investigated.
- ❑ Information management is an essential part of canal operations, including exchanges between the field and the irrigation manager. In order to determine the scope for improvement in the information system, it is necessary to analyse the existing management and evaluate its impact on canal operations and performance.
- ❑ The impact of canal water allocation and distribution on agricultural production and on environmental sustainability is presently not known. In order to quantify this impact, these relationships need to be quantified. Thus, the impact of the often-invoked restoration of equitability can be evaluated.

RESEARCH METHODOLOGY

- ❑ The actual water distribution at the main and distributary canal level was studied through a daily monitoring. The information collected emphasized the discrepancy between official and actual operations.
- ❑ Canal structures were calibrated through measuring exercises. Most of this was accomplished through training programmes in collaboration with the Punjab Irrigation & Power Department.
- ❑ Canal hydraulics were studied with the help of a hydraulic unsteady state simulation model, based on the St. Venant equations.
- ❑ Decisions and interventions of irrigation managers and gatekeepers were captured in a regulation module, which was then linked to the hydraulic model to quantify their impact on the water distribution.
- ❑ Once the combined model was calibrated and validated, a sensitivity analysis was carried out, comparing different parameters for their impact on the water distribution. A sensitive parameter is of interest, as it offers opportunities to managers to improve the performance of a canal. An insensitive parameter is of interest for the modeller, as we can relax the input requirements, thus minimising the data collection efforts.
- ❑ Once the sensitive parameters were identified, scenarios were formulated for improved water distribution patterns. These scenarios included modifying operational rules at the main canal level, and modifying outlet characteristics at the distributary level. The combined model was run to quantify the impact of these scenarios on the water distribution.
- ❑ The hydraulic model at the distributary level was also used to test various maintenance options, such as desiltation, lining and remodelling of outlets, and assess their impact on the water distribution to ungated outlets.
- ❑ The combined model was linked to models of farmer' strategies and to models capturing processes of salinity and sodicity, thus developing an integrated tool. Thus, the impact of a reallocation and redistribution of canal water on agricultural production and on salinity and sodicity could be established.
- ❑ The integrated tool combines the different (deterministic) disciplinary models and it is time-consuming to simulate different scenarios. The integrated tool was, therefore, linearised and simplified, while remaining within the established limits of accuracy. This implies that the developed simplified version is easier to use, facilitates communication between researchers, managers and policy makers. When transferring the tool to different areas, a re-articulation of the tool will be required, using the different disciplinary models.

Salinity and sodicity management in Pakistan

RESEARCH ISSUES

- ❑ *Salinisation and sodification* are two distinct processes with different causes and requiring different policy and management interventions. These processes, therefore, need to be analysed separately.
- ❑ Salinity is traditionally associated with irrigated agriculture due to weathering of saline parent material and capillary rise of salts due to a rise in groundwater tables. A more recent threat is posed by *the use of poor quality groundwater* for irrigation. The recent deployment of more than 500,000 private tube wells in Pakistan makes this threat an important research issue. The use of groundwater in conjunction with canal water should, therefore, be studied for its impact on salinity and sodicity.
- ❑ Due to the *spatial heterogeneity* in environmental factors (depth to groundwater table, soils, groundwater quality, canal water allocation) and the *diversity in farmers* (objectives, resources, constraints), special attention needs to be given to formulating research that captures this diversity.
- ❑ Different policy and management options can be considered to address salinity and sodicity. To evaluate the effectiveness of these options, *tools* need to be developed to quantify the impact of these options on salinity and sodicity.
- ❑ Salinity and sodicity exhibit *dynamic properties*, related to climate, hydrology and soils. Capturing the salinity and sodicity at a given time does not have much value. Instead, the factors explaining the state and the dynamic of salinity and sodicity should be determined.
- ❑ *Canal water* is singled out by farmers as the most important factor for salinity and sodicity control. The feasibility of reallocating and redistributing canal water should be investigated.
- ❑ *Assessing salinity and sodicity for large areas* is not an easy task given the dynamics of these phenomena and the fact that the determination of salinity and sodicity levels is rather cumbersome, involving laboratory analyses. A methodology for a large scale survey needs to be developed to take these problems into account.

Water markets in Pakistan

Technical feasibility and potential impact on irrigation system performance

The terms *water markets* cover a large range of situations. It is used to characterize short-term/long-term transfers of water rights or volumes of water, groundwater or surface water, within the irrigation sector or between different uses (agriculture, cities, and industry). Water markets have been described under a large range of socio-economic and hydrological conditions, in countries such as the United-States, Chile, India, Bangladesh, Australia.... and also Pakistan.

RESEARCH ISSUES

- ❑ The reallocation of irrigation water through market mechanisms is expected to take place from water users that value water at a low price to water users that value water at a high price. It is essential to estimate the potential demand for, and supply of, irrigation water of different water users/groups of users to assess the potential for a market-based reallocation of irrigation water.
- ❑ With an initial allocation of surface water, each water user can be either a potential seller or a potential purchaser of surface water. Farmer's participation in water transactions will depend on the characteristics of the surrounding environment and on the potential demand/supply of other water users. Thus, the understanding of farmer's participation in water transactions requires information on the farmer itself, and also on its surrounding environment.
- ❑ The market-based reallocation of irrigation water will only take place if users/groups of users attach different values to water (i.e. *differences in the marginal value product of water*). Differences in such values are explained by a different access to water, land, and labour resources, along with different farm objectives and production strategies. Thus, to investigate the potential for water market development requires an analysis of the diversity of farming systems and production strategies.
- ❑ If surface water is reallocated through market mechanisms, it will be done through the existing canal network. These canals have a given capacity, with a limited number of control structures that provide means to modify the water supply at given points. The analysis of water markets should identify the physical constraints that are imposed on water transfers as a result of the existing infrastructure and operational rules.
- ❑ Along secondary canals, and as a result also of the absence of control structures, negative side-effects are expected on water supplies of tertiary units that do not participate in water transfers. Such indirect influences, or *externalities*, may limit the feasibility of surface water markets along secondary canals.
- ❑ Decisions in terms of cropping pattern and farming practices will be directly related to farmer's participation in water markets. Overall, water markets are expected to increase agricultural production and productivity.
- ❑ The reallocation of surface water will lead to a modification of the ratio between tubewell water and canal water. As both waters are of different quality, water market development may result in changes in the level and spatial distribution of soil salinity and sodicity. Also, farmers' participation in water markets will increase water supply flexibility and allow farmers to better deal with salinity and sodicity.

RESEARCH METHODOLOGY

Research activities developed under the IIMI-Cemagref collaboration have investigated the research issues described above at various scales of the irrigation system. The main focus of research activities has been first on the analysis of the functioning and impact of existing water markets (i.e. the irrigation system today), then on the analysis of the potential for surface water reallocation through market mechanisms between tertiary units and between secondary units. The methodology developed by IIMI and Cemagref or *integrated approach* includes:

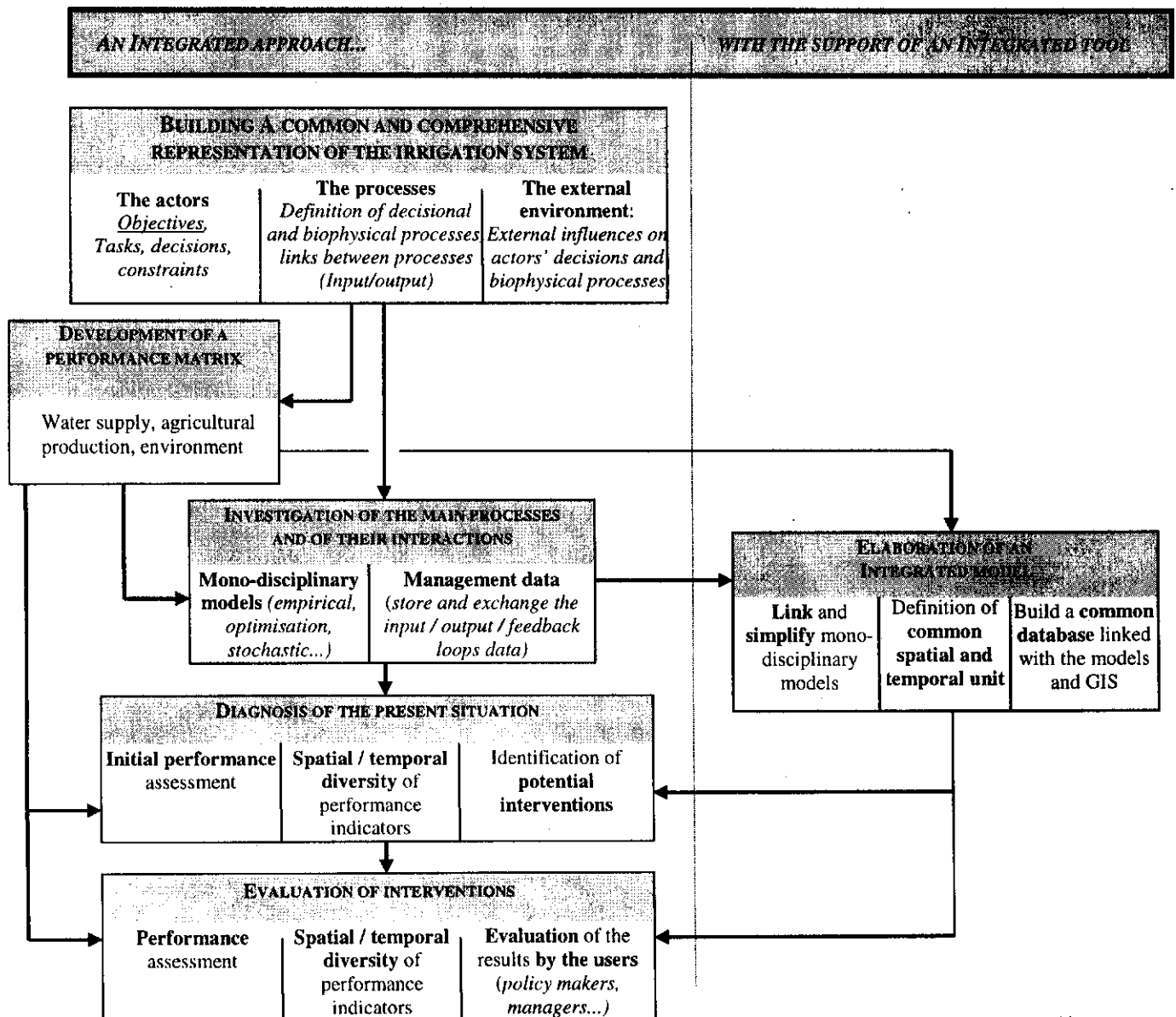
- ❑ **A detailed monitoring and analysis of current allocation and distribution of irrigation water.** Monitoring activities have been undertaken in the command areas of selected tertiary units. The information collected is the basis for understanding existing water markets.
- ❑ **The classification of farmers and tertiary units** into a limited number of groups. Based on the characteristics of the farm population and on the physical environment, these classifications provide a better understanding of farmer's objectives, strategies and constraints in the context of their participation in existing and potential water markets. The classifications are also used to limit the number of situations for which simulation models are to be calibrated and validated (see below). And they provide a means to extrapolate research results to large areas.
- ❑ **The development, calibration and validation of linear programming economic models.** These models link surface water supplies (in terms of quantity and variability) to farmer's decisions in terms of crop choices and groundwater use. The final output of these models includes the monthly tubewell water use, the cropping pattern, and the farm gross income. These models are developed for each farm group. Farm group models are then aggregated at the scale of the watercourse command area.
- ❑ **The economic models are used to estimate the impact of existing water markets on the agricultural production and farm income.** To do so, the results of simulation for two scenarios (i.e. with and without water markets) are compared.
- ❑ **The economic models are linked to hydraulic simulation models** to account for the physical dimensions of water resources, and to integrate constraints on water allocation and distribution that exist within the irrigation system.
- ❑ **The economic models linked to hydraulic models are used to develop relationships between the quantity of surface water received and the marginal value product of water.** Such relationships are developed at the scale of the farm, tertiary unit and secondary unit. The confrontation between these relationships provides a means to assess the potential for surface water reallocation through market mechanisms.
- ❑ **The economic models aggregated at the scale of the tertiary unit are linked to salt-and-water-balance models and solute transport models.** With these models combined, it is possible to assess the impact of water transfers on the physical environment in terms of the net recharge to the aquifer, salinity and sodicity.

So far, the methodology developed for the entire command area of the Chishtian Sub-division (67,000 hectares, 520 watercourses, 10,000 farmers) has been applied and tested for the command area of two major distributaries (aggregated command area of 30,000 hectares).

An integrated approach to assess the potential impact of policy and management changes on irrigation system performance

The demand for the development of integrated approaches is expected to increase. Looking at larger systems such as river basin, combining sustainability and productivity issues, a higher competition over water resources are driving forces for the development of policies that integrate different uses and actors. Integrated approaches may be applied at various scales (a farm, an irrigated scheme, and a river basin) with different disciplines (hydrology, hydraulics, economics, agronomy, social sciences, etc) to tackle a wide range of interventions and issues. Whatever the issues investigated and the scale of analysis, some methodological issues are common. The development of an integrated approach results in a wide range of methodological issues. This note summarizes some of the experiences obtained by IIMI and Cemagref in Pakistan.

A FRAMEWORK FOR INTEGRATED APPROACHES



METHODOLOGICAL ISSUES AND IMPLEMENTATION CONSTRAINTS

- ❑ The development of an integrated approach requires good disciplinary studies. Both the integrated approach and disciplinary studies are complementary, and should be developed in an iterative process. The integration of disciplines, however, is required at the early stages of a research project.
- ❑ A good communication between the different researchers involved in the development of integrated approaches is required for its implementation. This can be enhanced through the development of a common platform such as an integrated model or Geographic Information System.
- ❑ The implementation of the integrated approach requires interactions between researchers and the different stakeholders of irrigation systems (farmers, policy makers, and irrigation managers). This will help identifying important processes that take place within the irrigation system, define the performance indicators that will be computed, and facilitate the dissemination of the results to these stakeholders.
- ❑ Some biophysical and decisional processes are neglected in an integrated approach to keep the level a complexity of the approach manageable. The approach developed, thus, has its limitations in the type of intervention that can be tested and the accuracy of the output obtained from model simulations.
- ❑ The computational time required to run simulation models also imposes constraints with regards to the level of complexity that can be considered for the integrated approach.
- ❑ As a result of the accuracy issues in model predictions and the complexity of irrigation systems, the validation of the integrated approach is built around two elements: (i) the accuracy of predictions for the actual situation; (ii) the evaluation of the usefulness of the information provided by the integrated approach to take (better) policy decisions. The latter element clearly requires interactions with policy makers and irrigation managers.
- ❑ The experience has shown that it is easier to link biophysical models, while it is more difficult to integrate social and institutional aspects. As a result, it is not possible to directly assess the potential impact of institutional changes, unless a clear relationship between these institutional changes and modifications in the processes considered can be established.
- ❑ The collection of information to account for the spatial diversity of the processes investigated remains an important issue for large-scale irrigation systems. Often, the required information is not available, accessible, or of adequate quality. This, in turn, will affect the quality of the output obtained through the integrated approach. The availability of information needs to be considered at the early stages of the approach, as it will influence the level of complexity that can be considered.
- ❑ As users of the information and integrated approach are often different from those that have collected the information, it is important to document the information process from the source to the database. This will provide a useful means for users to assess the quality of the information and also the quality of the output of the integrated approach.

APPENDIX III - LEAFLET OF PRESENTATION OF THE TOOL INTEGIS

INTEGIS

A tool for an integrated analysis of irrigation system management

As part of the collaboration between the International Irrigation Management Institute (IIMI) and Cemagref in Pakistan, research activities have concentrated on the development of an integrated approach to assess the impact of management and policy changes on irrigation system performance. In the context of these activities, an integrated computer tool, *Integis*, is developed to assess the impact of policy and management changes on canal water supply, groundwater use, soil degradation, agriculture production and farm income.

Integis is still in its development phase for one irrigation system, the Chishtian Sub-division. But it has already been partly tested to analyze the link between main canal operation and salinity/sodicity, and to assess the functioning and impact of potential water markets. Its output in terms of cropping intensity has been compared to existing values obtained from satellite imagery and has shown satisfactory results.

Integis facilitates the understanding of the complexity of irrigation systems and of the numerous impacts of given interventions. It complements more detailed disciplinary studies, and provides means to understand the links between these studies. Its spatial output provides a powerful communication means for sharing the output of simulations with other researchers, line agency staff and policy makers.



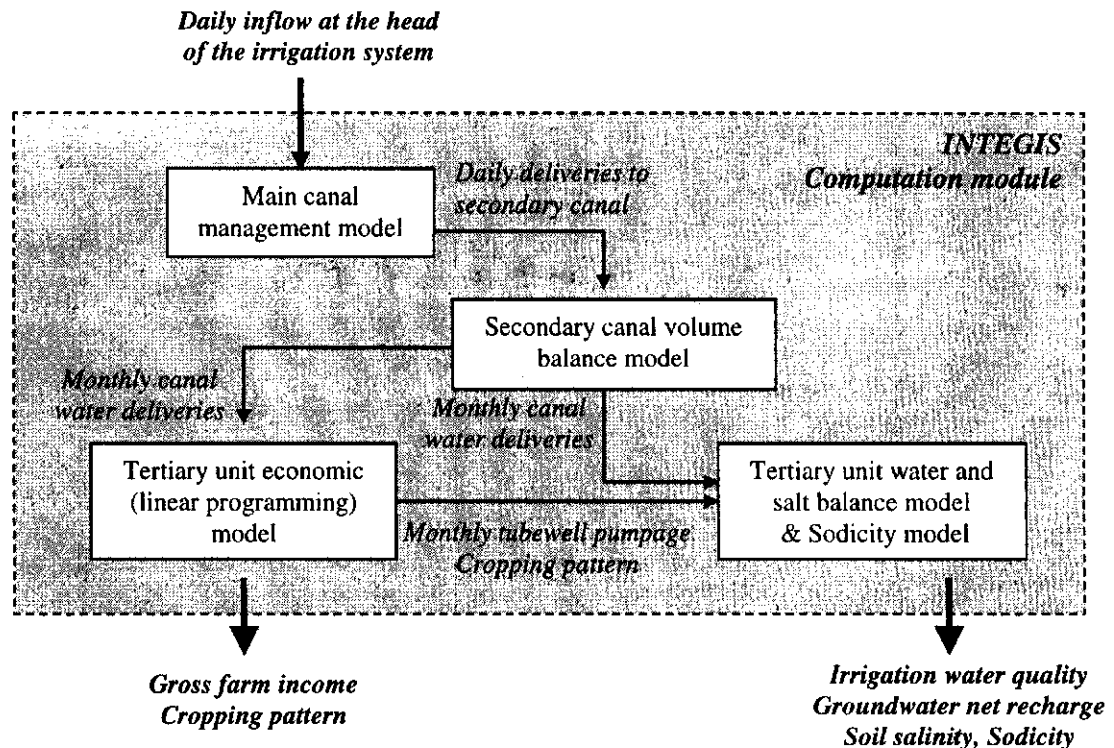
The general *Integis* interface presents some background information on the research collaboration, the integrated approach, and the Chishtian Sub-division, along with the user's guide of the computer tool. It provides access to two operational components of *Integis*:

- The **computation module** built on a MATLAB platform, with a user friendly interface to formalize scenarios and access to the input database.
- The **display module**, mainly based on a customization of the ArcView software to analyse the performance of the scenarios investigated complemented by a summary performance table.

The general interface provides also access to a tool box that contains more complex simulation models that have been developed and applied for more detailed analyses of the bio-physical and decisional processes investigated.

Computation module

The computation module is an interfaced combination of 4 models developed under the MATLAB software. The daily inflow entering the system is distributed to secondary canals through a **water main canal management model**, based on allocation rules and hydraulic constraints. Then, a **volume balance model** shares secondary canals deliveries between tertiary units. The monthly deliveries to these tertiary units are used as input for **economic (linear programming) models** that aggregate farm responses at the watercourse scale. The output of the economic models include the cropping pattern and intensity, farm gross income, and also the monthly tubewell pumpage for farms having different socio-economic characteristics. The cropping pattern and tubewell pumpage information is finally used as input of a **water and salt balance model** and a **sodicity model** (empirical equation). These models compute the average irrigation water quality, soil salinity, sodicity and groundwater net recharge.



Input data requirement

- **Hydraulic/canal management:** main canal allocation rules, main canal hydraulic constraints, tertiary outlets characteristics (dimensions, discharge rating curve), seepage losses.
- **Socio-economic:** characteristics of farm population for tertiary units, water-yield relationships for main crops, input/output prices, water (surface/tubewell) prices.
- **Physical environment:** spatial distribution of soil types, groundwater (tubewell water) quality and water-table depth.

Investigating policy and management

Integis offers the possibility to test and compare a wide range of interventions or scenarios. Those include changes in the main canal operation, remodelling of outlets or lining of watercourses, or policy changes such as changes in tubewell water prices or input/output prices (still under implementation).

Users can select different scales of analysis: the entire Chistian Sub-division, any of the 14 secondary canals, or a selected tertiary unit. The possible scenarios that can be tested vary according to the scale of analysis. For each scenario, changes in selected input data are required. Such changes are directly specified by the user from the *Integis* interface.

Scale of analysis			
Management and policy changes	Chistian Sub-division	Selected secondary canal	Selected tertiary unit
Inflow at the head of the main canal	X		
Main canal allocation rules	X		
Inflow at the head of the secondary canal		X	
Modification of outlet dimensions	X	X	X
Tertiary unit seepage losses	X	X	X
Tubewell water prices	X	X	X

Examples of policy and management changes that can be analyzed with Integis

Rules

File name : rules

Modify :

Priority order

Daulat 4131

Shahar Farid 3312

Fordwah 1243

Azim 2424

Rotation duration (days) 4

Target discharges

Daulat 5.5 S. Farid 4.2

Mohar 0.8 Masood 0.8

3L 0.4 Soda 1.9

Phogen 0.7 5L 0.15

Kemgahr 1.1 Fordwah 5.3

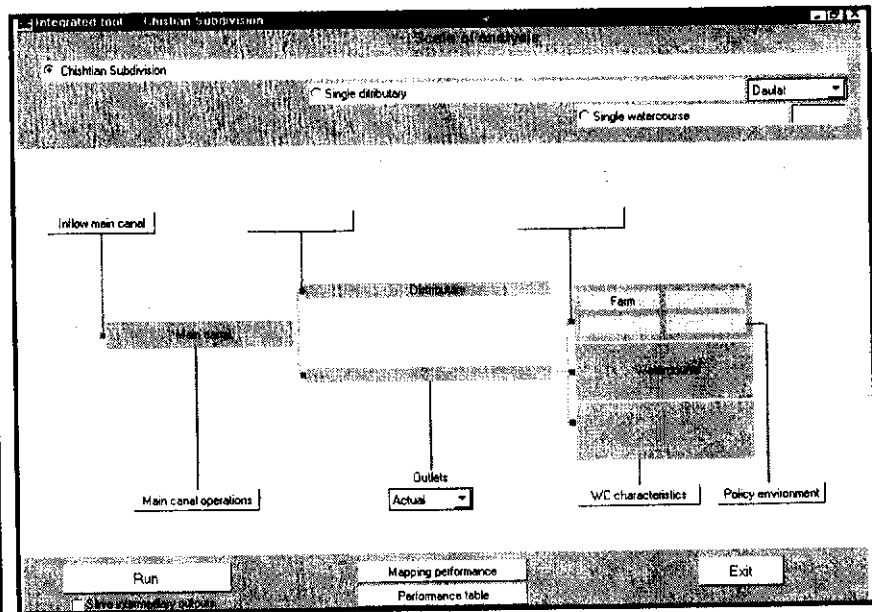
4L 0.4 Mahmud 0.45

Jagir 0.85 Azim 5.3

Save as :

OK Cancel

Main canal management model dialog box: users can specify the rotational schedule (priority order, duration) and the target discharge of each secondary canal.



The interface of the computation module

Display module

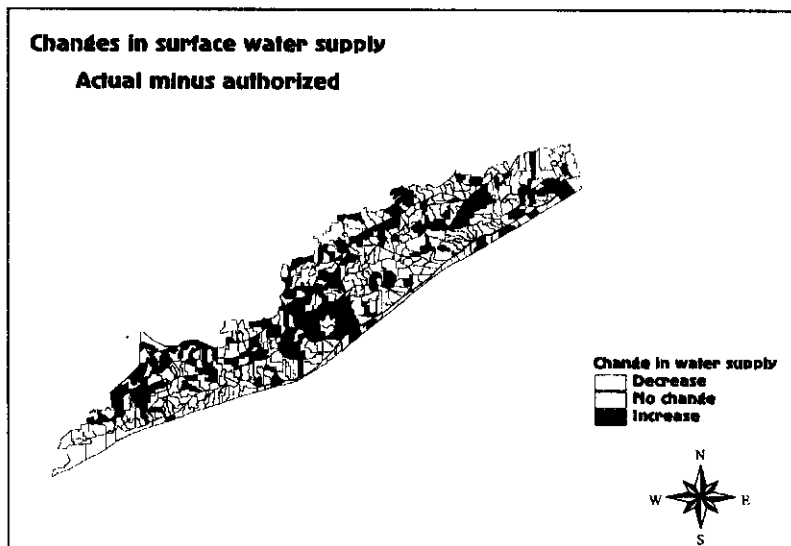
Two options are offered to display the results of simulation of the selected scenarios.

- A summary table provides aggregated performance indicators for the entire Chishtian Sub-division directly from the computation interface.
- Performance indicators can be presented in a map format (under the ArcView software) to investigate their spatial distribution. The spatial analysis provides useful information on areas that have suffered/benefited the most from a given scenario. This information can then be used to identify alternative scenarios that will be tested with *Integis*, or to specify accompanying targeted interventions that will mitigate the negative impact on suffering areas of the irrigation system.

Performance indicators

- **Water supply**
 - Canal water supply adequacy
 - Tubewell water use
 - Equity in surface water deliveries
- **Agricultural production**
 - Cropping pattern
 - Seasonal cropping intensities
 - Farm gross income
- **Environment**
 - Area affected by salinity
 - Area affected by sodicity
 - Irrigation water quality
 - Groundwater net recharge

Changes in surface water supply
Actual minus authorized



The present map compares the existing and authorized canal water supplies at the scale of the tertiary unit. The information presented is obtained through simulations with *INTEGIS*. It is displayed in a map format using the ArcView software. Such maps are powerful means to present and discuss simulation results with a wide range of stakeholders involved in the management of irrigation systems.

For more information, please contact

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or

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APPENDIX IV - AGENDA OF WORKSHOPS

11 May 1998 - SEMINAR AT IIMI-PAKISTAN

- ✓ Participants: IIMI Pakistan Research Staff
- ✓ Duration: 2 hours
- ✓ Location: IIMI Conference Room, Multan Road

	Recitation from the Holy Quran
14:00 -14:10	Opening Remarks – The Need for Large Area Analysis Prof. Gaylord V. Skogerboe
14:10 -14:25	Research Activities of the Integrated Management of Irrigation System Unit at Cemagref Patrice Garin
14:25 -14:45	The Integrated Approach Developed in the Chishtian Sub-division – Main Components Marcel Kuper/Pierre Strosser
14:45 - 15:00	The Integrated Tool Frederic Labbe
15:00 - 15:25	Demonstration of the Integrated tool Frederic Labbe
15:25 - 15:55	General discussion – integrated approaches/tools Animator Prof. Gaylord V. Skogerboe
15:55 – 16:00	Closure

12 May 1998 - WORKSHOP AT SOIL SURVEY OF PAKISTAN

- ✓ Participants (25): SSoP Researchers/Field staff
- ✓ Duration: 3 hours
- ✓ Location: SSoP office, Multan Road

	Recitation from the Holy Quran
10:00-10:05	Opening Remarks Director General of SSoP
10:05-10:20	Introduction to Workshop and General Presentation IIMI-Cemagref Patrice Garin
10:20-10:50	Lessons from Analysis of Salinity/Sodicity Issues Marcel Kuper
10:50-11:20	Discussion Chariman SSoP person
11:20-11:30	Demonstration of UNSATCHEM by Dr. M. Aslam Demonstration SWAP Software by Asad Sarwar Qureshi
11:30-11:40	Tea Break
11:40-11:55	Soils and Irrigation Resource Analysis in the Chishtian Sub-division SSoP staff
11:55-12:10	The Integrated Approach Pierre Strosser
12:10-12:25	The Integrated Tool Frederic Labbe

- 12:25-13:00 Discussion – Changes for the Analysis of Soil/Salinity Risk/Assessment?
Evaluation of the Integrated Approach
Chairman: Dr. G. Saeed Khan
- 13:00-13:05 Concluding Remarks
Dr. G. Saeed Khan

13 May 1998 - SEMINAR WITH RESEARCH INSTITUTES

- ✓ Participants: 30
- ✓ Duration: Half a day
- ✓ Location: IIMI-Pakistan Conference Room

- 08:40-09:00 Registration
- 09:00-09:05 Recitation from the Holy Quran
- 09:05-09:15 Introduction of Seminar
Prof. Gaylord V. Skogerboe
- 09:15 – 09:20 IIMI-Cemagref Collaboration
Patrice Garin
- 09:20-10:10 Presentation of the Integrated Approach and demonstration of the Integrated Tool
- 10:10-10:30 Questions and discussion
- 10:30-10:45 Tea Break
- 10:45-10:55 Presentation of Research Issues
- 10:55-11:45 Working Groups
- ✓ use of Integrated Approach
 - ✓ Information Management for Large Area Analysis
 - ✓ From Multi-disciplinary to Integrated Research
- 11:45-12:00 Restitution of Results of Working Groups
- 12:00-12:35 General Discussion
- 12:35-12:45 Concluding Remarks

14 May 1998 - BRIEFING WITH POLICY MAKERS

- ✓ Duration: 2 hours
- ✓ Location: Hotel Holiday Inn, Islamabad

- Recitation from the Holy Quran
- 10:30-10:40 Introduction to Policy Brief
Dr. Zafar Altaf, Additional Secretary Incharge, Ministry of Food & Agriculture
- 10:40-10:45 Format of the Policy Brief
Prof. Gaylord V. Skogerboe
- 10:45-11:50 Presentation on three issues
Main canal operation and maintenance
Salinity and sodicity issues
Water markets
- 11:50-12:20 Discussion - From research to policy making and implementation: need for integrated approach, linking research and policy making
Chairman Prof. Gaylord V. Skogerboe
- 12:20-12:30 Concluding Remarks
Dr. Zafar Altaf

14 May 1998 - SEMINAR WITH DONORS

- ✓ Duration: 2 hours
- ✓ Location: Hotel Holiday Inn, Islamabad

	Recitation from the Holy Quran
14:00-14:10	Introduction of Seminar Prof. Gaylord V. Skogerboe
14:10-14:20	IIMI-Cemagref Collaboration in Pakistan Patrice Garin, Cemagref
14:20-14:50	Selected Research Findings Canal Operation Salinity and Sodicity Management Water Markets
14:50-15:00	General Discussion
15:00-15:50	Linking Research Activities and Policy Decisions Integrated analysis of irrigation systems Developing links between research and policy making Strengthening research on irrigation management
15:50-16:00	Concluding Remarks Prof. Gaylord V. Skogerboe

15 May 1998 - Group Discussion at IIMI-PAKISTAN

08:30 – 10:30	Group Discussion with the researchers involved in FESS Area Studies
10:30-11:00	Preparation for next discussion
11:00 – 13:00	Discussion with Sindh Salinity Group
13:00 – 14:30	Lunch Break
14:30 – 15:00	Preparation for next Discussion
15:00 – 16:00	Discussion with the group involved in Water Allocation Studies
16:00 – 16:15	Tea Break
16:15 – 18:00	Continuation of Discussion with Water Allocation Group

16 May 1998 - WORKSHOP AT THE PUNJAB IRRIGATION AND POWER DEPARTMENT

- ✓ Participants: 25
- ✓ Duration: 2 hours
- ✓ Location: Committee Room No. 2, I&P Deptt., Lahore

	Recitation from the Holy Quran
012:00-12:05	Opening Remarks Secretary, Irrigation and Power
12:05-12:10	Introduction to Workshop Prof. Gaylord V. Skogerboe
12:10-12:20	General Presentation IIMI-Cemagref Collaboration Patrice Garin
12:20-12:45	Lessons from Analysis of Canal Operation and Maintenance Marcel Kuper
12:45-13:00	Discussion Animator PIPD staff

- 13:00-13:15 **Looking at Agricultural Production and Sustainability – Towards an Integrated Analysis of Irrigation Systems**
Pierre Strosser
- 13:15-13:30 **Presentation of the Integrated Tool**
Frederic Labbe
- 13:30-13:50 **Discussion – Towards an Evaluation of the Integrated Approach**
Animator Prof. Gaylord V. Skogerboe
- 13:50-14:00 **Concluding Remarks**
Secretary, Irrigation and Power Department

APPENDIX V - LIST OF WORKSHOP PARTICIPANTS

May 11, 1998

CEMAGREF

- 1 Patrice Garin
Cemagrf, Montpillier
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Cemagrf, Montpillier
France
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Cemagrf, Montpillier
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- 4 Fredric Labbe
Cemagrf, Montpillier
France

IIMI-Pakistan

- 5 Prof. Gaylord V. Skogerboe
Director
IIMI-Pakistan
- 6 Adbul Hakeem Khan
SFRE
IIMI-Pakistan
- 7 Ghulam Nabi
Water Engineer
IIMI-Pakistan
- 8 Muhammad Mazhar Saeed
International Student
IIMI-Pakistan
- 9 Saeed ur Rehman
Agricultural Economist
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- 10 Asaad Sarwar Qureshi
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- 11 Muhammad Badruddin
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- 12 Zafar Iqbal Mirza
Irrigation Agronomist
IIMI-Pakistan

- 13 Yoshiyuki Shinogi
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- 14 Dr. Muhammad Aslam
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- 15 Zubair Tahir
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- 16 Dr. Muhammad Asghar Cheema
Social Scientist
IIMI-Pakistan
- 17 Abdul Rehman
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- 18 Syed Daniyal haider
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- 19 Ineke M. Kalwij
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- 20 Dr. Waqar A. Jehangir
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- 21 Mushtaq Khan
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IIMI-Pakistan
- 22 Dr. S. A. Prathapar
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IIMI-Pakistan
- 23 Mobin ud Din Ahmed
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- 24 Raza-ru-Rehman Abbasi
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- 25 Mehmood ul Hassan
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- 27 Robina Wahaj
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- 29 **Samia Ali**
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- 30 **Gauhar Rehman**
Civil Engineer
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- 31 **Yann Chemin**
Junior Researcher
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- 32 **Shahid Sarwar**
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- 33 **Abdul Hameed**
Soil Data Analyst
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- 34 **Jevoen Alberts**
Surface Irrigation Project JR
IIMI-Pakistan

LIST OF PARTICIPANTS (SOIL SURVEY OF PAKISTAN)

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Multan Road, Lahore
- 3 Muhammad Farooq
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- 14 Ali Ahmed Sabir
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- 15 M. Fahim Dar
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Multan Road, Lahore
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- 17 Niaz Ali
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Government of Pakistan
Multan Road, Lahore
- 18 A. Hameed Sial
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11:00 – 13:00 Researchers involved in the Sindh Salinity Management Study

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14:30 – 17:30 Researchers invloved in the Water Allocation Study

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APPENDIX VI - QUESTIONNAIRE FOR RESEARCHERS

Development of an integrated approach to assess the potential impact of policy and management changes on irrigation system performance

Name :
Organisation :
Position :

HOW WOULD YOU DESCRIBE THE NEEDS FOR INTEGRATED APPROACHES FOR YOUR OWN WORK/ORGANISATION?

What are your past and current experiences with integrated approaches (different disciplines involved, activities that are developed to integrate disciplines, involvement of stakeholders)

What would be your interest in develop integrated-like approaches in your own activities?

Integrated approaches: what are their

- ☐ Strengths
- ☐ Weaknesses
- ☐ Constraints
- ☐ Opportunities