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Water markets in Pakistan

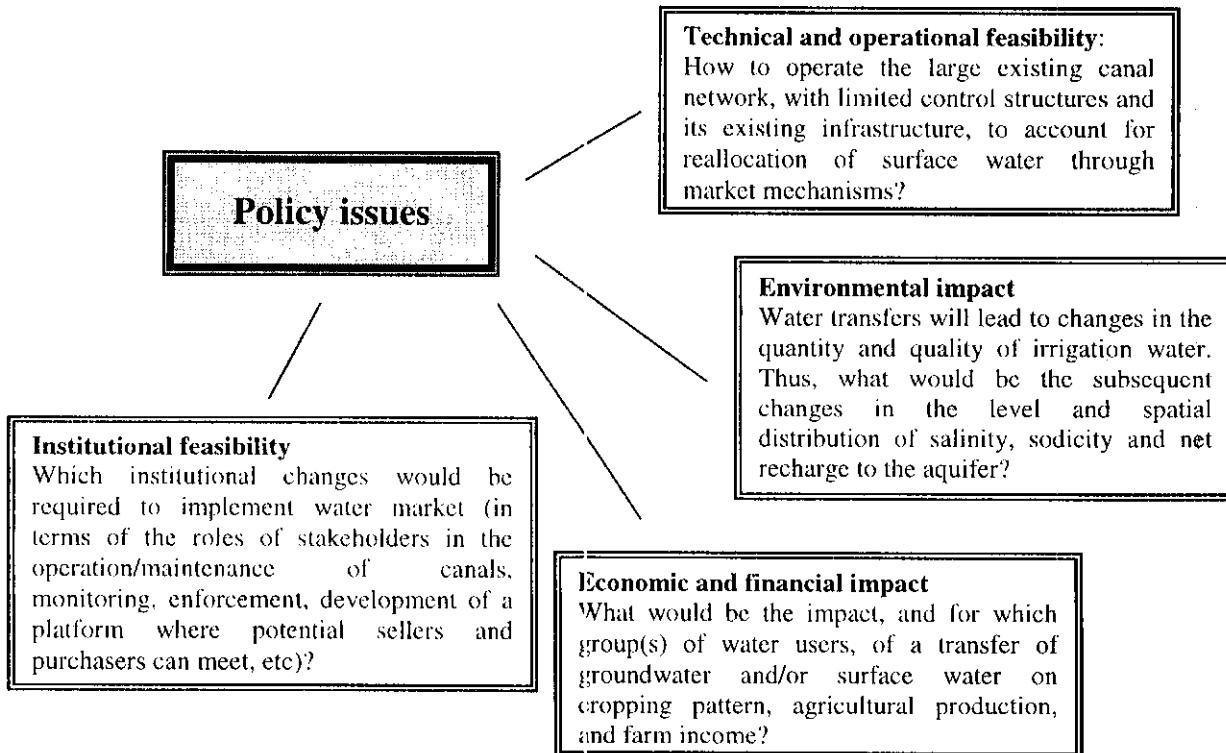
Technical feasibility and potential impact on irrigation system performance



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.



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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.

Existing water markets

Active water markets are functioning within the watercourse command area. Farmers have adapted their warabandi schedule, exchange partial and full canal water turns, sometimes sell or purchase these canal water turns, and participate actively in tubewell water transactions.

Overall, surface water and groundwater transactions allow farmers to more closely match the water supply to crop water requirements. Also, this leads to an improvement in water use efficiency.

Under specific conditions of high canal water supply variability, high seepage losses and poor quality groundwater, active surface water markets have developed with all farmers of a watercourse command area selling or purchasing canal water turns for a week or a season.

Existing tubewell water markets have a significant impact on farm income and account for 40 percent of the aggregated farm income. However, in areas with poor quality groundwater, the purchases negatively impact on the soil salinity and sodicity of water purchasers.

The analysis has emphasized that few gains in aggregated farm income would be obtained by further promoting water transactions within the watercourse command area. Farmers are already managing their water resources efficiently.

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)

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.

Potential surface water markets

Technical and operational feasibility

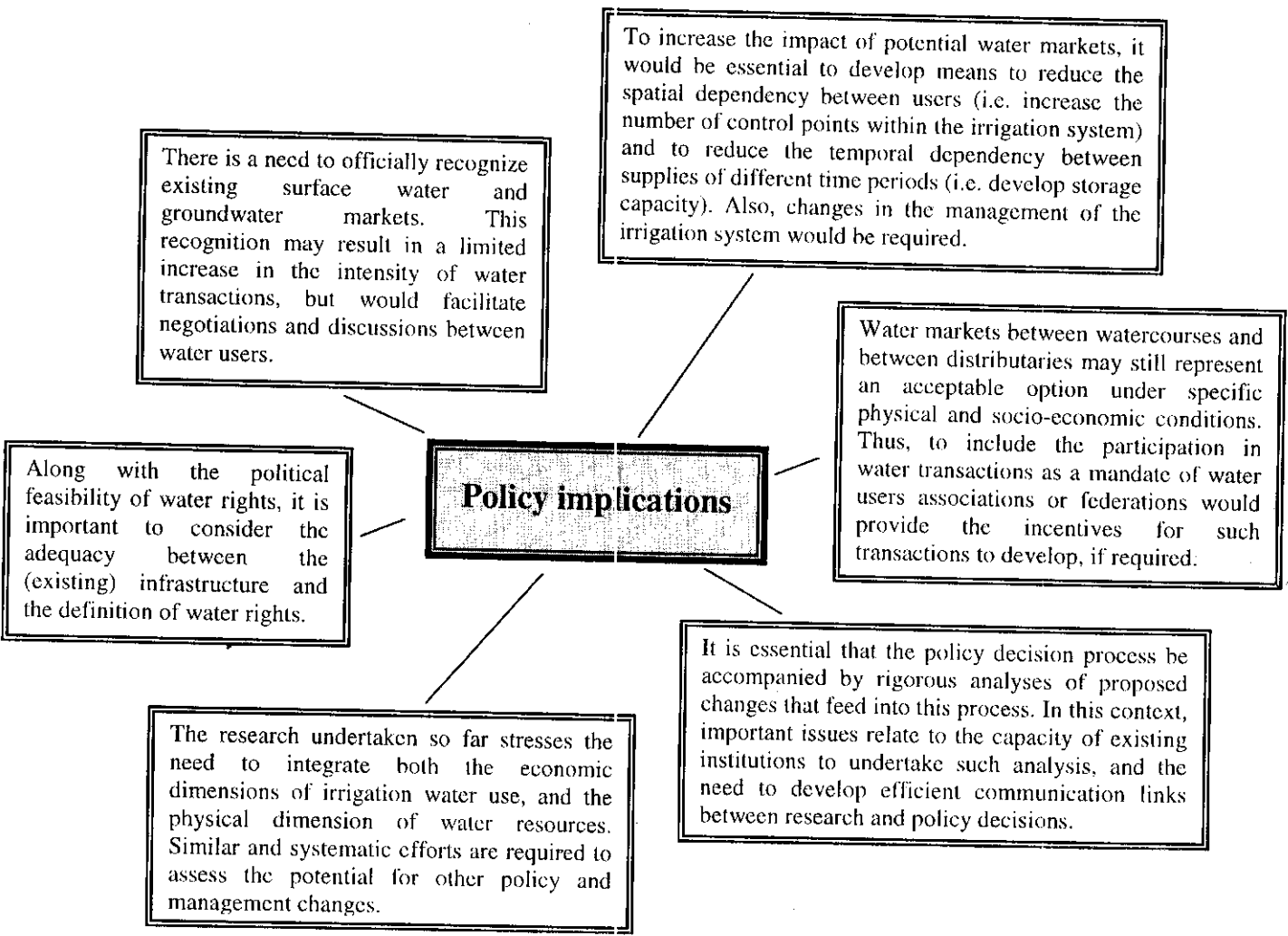
- To allow for reallocation of surface water between watercourses would require gates at the head of the watercourses, or regular changes in the watercourse outlet dimensions (every 1-3 years for example). Frequent changes in outlet dimensions already take place in various secondary canals, emphasizing 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 IIMI and Cemagref to analyze the potential for reallocation of surface water between canal command areas.