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Contents

1	Acknowledgments	4
2	Executive summary	5
3	Background.....	7
4	Objectives	10
5	Methodology	13
6	Achievements against activities and outputs/milestones	18
7	Key results and discussion	22
8	Impacts	34
8.1	Scientific impacts – now and in 5 years	34
8.2	Community impacts – now and in 5 years	34
8.3	Communication and dissemination activities	38
9	Conclusions and recommendations	40
9.1	Conclusions.....	40
9.2	Recommendations	40
10	References	41
10.1	References cited in report.....	41
10.2	List of publications produced by project.....	41

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2 Executive summary

The management of water resources is crucial for India's agriculture and the development of water resources has received substantial focus. However, the emphasis has been mainly on the technical side. The development of the necessary institutions required for effective management of the resource has received inadequate attention, and this has led to an emerging water crisis. This project has sought to study and identify key ingredients that can improve institutions and institutional performance in water resource management in India. Drawing upon the theoretical foundation of New Institutional Economics, the project's aim was to help in improving water resource management in India's agriculture by identifying and proposing effective institutional arrangements and policy frameworks.

The generic approach employed in the project was supported and informed by the experience and analysis of the institutional strengths and weaknesses evident in the management of water resources in Australia where substantial efforts and reforms on this have taken place.

The project employed an empirical approach in India and explored the performance of a range of organizational forms across three Indian states – Maharashtra, Gujarat and Andhra Pradesh. The institutional forms covered both surface and groundwater users and included Water User Associations, canal cooperatives, check dam committees, tube well partnerships and tube well cooperatives.

Core findings from the project were as follows:

1. The theoretical contributions of New Institutional Economics, when combined with some of the contributions from the Management Science literature, provide a cogent framework for considering what makes for 'good institutions'.
2. The empirical data supported the view that there was merit in devolving decision making to farmer-based organizations but this required careful staging, design and support.
3. There was evidence of the pervasive influence of the concurrent mechanisms by which authority was devolved to lower order organizations. Good institutions were not created by simply mandating that decision making power now reside with artificially created farmer groups.
4. There was evidence of the need for capacity building within organizations at the bottom of the decision making hierarchy, particularly in the form of effective structures and processes, skilled management and necessary expertise to liaise with higher tiers of governance.
5. Greater effort is required to ensure that the improved performance of low-level organizations is not hindered by the absence of concern and coordination at higher levels in the institutional hierarchy – there is an urgent need for improved synchronization of decision making across the different levels of governance within water resource management in India.

Findings from the work are now available in a manuscript that was developed as part of the project. There were also a range of dissemination activities involving national and state governments, NGOs and representatives of the irrigation sector.

The project has stimulated attention and impact on better institutional design and framework for water resource management in India at several levels. At the local level there has been greater thrust in the devolution of powers for water management to farmer institutions as seen in the formation of project/ watershed based federations of water cooperatives in Gujarat and Maharashtra, and empowering and equipping them to manage the water resources in their respective areas. At the state level, a new act on water resource management institutions has been formulated and passed in Maharashtra state with substantial ongoing impacts on the way water resources are managed in many areas of the state. At the national level, the expertise of those involved in this project was sought by the Government of India to design the institutional structure for the implementation of a massive national program on the interlinking of rivers to better manage surface water in India.

Additional work is required to build on the institutional lessons derived from the project. In this regard the development of a project that considers the institutional milieu of Water Shed Development holds considerable promise.

3 Background

Water resource management is critically important in India because of the growing demand for food and because the incomes and employment of 60-70 per cent of the population depend directly or indirectly on agriculture. Small-sized private farms dominate Indian agriculture and the problem of water management is becoming increasingly serious as development proceeds. Local scarcities are now common and frequent. In the context of the challenges of water resource management in India, standard neo-classical theories have usually little to offer in terms of practical and durable solutions. Determining the right price for water hardly solves the problem since imposing the price and achieving cost recovery are themselves formidable tasks - resolving such issues is primarily an institutional challenge, not a technical one (Reddy 1998).

There are serious problems in the administration of surface water because of the substantial investments required. In addition there are attendant challenges associated with project implementation, maintenance, distribution, and the necessity to account for environmental impacts. There are also non-trivial problem in the management of groundwater, where over-extraction and inadequate recharge is becoming common place. The technical and economic solutions to these problems are typically well-known, but their institutional management in the political economy is becoming very difficult (Parthasarathy 2000; Saleth 1996; Gandhi and Namboodiri 2002).

Researchers indicate that institutional deficiencies are at the root of many water resource management problems in India (Shah 2000) with institutional development lagging well behind reforms in other countries, like Australia. Innovations in institutional arrangements and management structures are a necessary precondition for tackling the problems of water management (Vaidyanathan 1999). It is important to understand past weaknesses and existing arrangements whilst simultaneously searching for institutions that facilitate socially acceptable, efficient, equitable and sustainable use of water.

Irrigation has been amongst the most important strategic factor in the Green Revolution in India. It has played a major part in increasing food production, raising productivity and delivering food security. In the state of Punjab, agricultural productivity grew by around 6 per cent annually between 1960 and 1980 and by the end of the 1980s wheat and rice yields had trebled. Annual per capita income rose from \$US60 in 1980-81 to \$US440 in 1997-98, well above the national average.

However, the successes of the Green Revolution were largely limited to irrigated areas. In addition, poor water management and slowing productivity began to tarnish the image of Punjab as the 'bread basket' by the mid 1980s. Amongst the important factors in this context was the shift from water-prudent crops, such as maize and pulses, to wheat and rice. Ultimately, this resulted in a substantial increase in the demand for groundwater and overexploitation in areas such as north western India has substantially lowered groundwater levels and caused inadequate recharge of the water table. Many adverse environmental consequences such as soil erosion, waterlogging and depletion of local water resources are also now evident.

India is far from a homogenous landscape. In addition to the numerous geographical differences between regions there are strong social and cultural boundaries that have given rise to a range of water management regimes. These include the Warabandi,

Shejpali, Land Class System and Assured Irrigation Area System (Satta). Some of these approaches are supported by government policy, including through law, although often these are not effective. Warabandi has legal sanction in the Northern India Irrigation and Drainage Act of 1873. This law, with amendments, is the basic irrigation law for the northern states of Punjab, Haryana, Rajasthan and Uttar Pradesh. Similarly, Shejpali has legal support in Western India in the Bombay Irrigation Act of 1879. An amended version of this law is the basic irrigation law for the state of Gujarat. The relatively recent Maharashtra Irrigation Act of 1976 continues to recognize Shejpali as the basic approach to irrigation management, although it also authorizes alternatives. Similarly, the satta system is based on the Bengal Irrigation Act of 1876. This act, as amended, is the basic irrigation law for the eastern states of Bihar, West Bengal, and Orissa. There is no comparable law from British time for Southern India (Brewer et. al. 1999, Mitra 1992).

All surface water in India is legally under the control of the state governments. Groundwater, however, is treated in most states as the private property of the person holding the overlying land. Local laws also result in some variations in property rights appertaining to the different types of water. Most states have government agencies concerned specifically with irrigation. These are commonly called irrigation departments or water resource departments and specialize in the construction, operation and maintenance of irrigation systems. Typically such organizations do not attempt to deliver water to each farm but deliver water to outlets serving more than one farmer. Below each outlet, farmers are collectively responsible for both water distribution and maintenance of the distribution system (Brewer et al. 1999).

A major national initiative emerged in 1973, when a coordinated approach to the development of irrigated agriculture was attempted through the creation of Command Area Development Authorities [CAD]. An important objective here was to upgrade the outlet command with suitable on-farm development works so as to allow for the even distribution of water over the entire irrigation command (Singh 1991). Most states created multi-departmental project organizations headed by senior officers of government to implement the CAD program. However, CAD was seen as a government program imposed from the top. There were innumerable cases of farmers wilfully destroying irrigation structures and measuring devices built to facilitate the orderly distribution of water.

In an attempt to improve farmers' acceptance of the CAD, some project administrators argued that farmers should be given more responsibility for irrigation management. Although this received only limited support from administrators initially, some took the opportunity to involve farmers in executing off-farm development works and irrigation management. Farmers receiving water from an outlet point were consulted and Water Users Associations were formed. However, a common experience was that farmers' involvement in water management could not be sustained after construction works had been completed and once a system of water distribution had been introduced. Most irrigation committees established in this manner ultimately became defunct.

The above scenario indicates that water resource management in India is at a turning point. In which direction should it proceed? For over a decade, there has been a growing awareness among irrigation professionals that factors related to the management of irrigation are critically important in determining irrigation performance. These 'management factors' are quite broad and encapsulate things that are somehow different to those issues that reside in the 'technical' domain. Irrigation is not simply a process of design engineering but very much a socio-economic phenomenon. An approach that

delineates the social relationships could provide a much richer interpretation of irrigation performance.

The argument for management change is premised, in part, on the notion that the structure of institutions creates an enduring set of rewards, incentives and penalties that subsequently influence patterns of behaviour. Accordingly, understanding institutions may be at least as critical to uncovering the key to poverty alleviation as the introduction of improved crops or agricultural techniques.

4 Objectives

The objectives as originally specified in the project were as follows:

Objective 1:

To develop a framework for comparing institutional issues of:

property rights,

transaction costs,

organizational and socio-political economy,

coequal rights regimes,

issues of land ownership,

water rights and

overdraft problems in managing water resources in India.

The framework will draw heavily on the institutional experiences of Australian water management and attempt to derive lessons for institutional design in India. Close attention will be given to the peculiarities of the Indian setting to determine the extent to which these lessons might be applied.

Output 1:

The resulting background will underpin the accomplishment of subsequent objectives. A succinct and precise measurement framework will then be available to adjudge institutional developments in various Indian contexts.

Objective 2:

To apply the comparative institutional framework, developed in objective one, to the analysis of groundwater use and related institutions. Derive lessons for institutional design.

Output 2:

This part of the study will be conducted primarily in the northern part of Gujarat State, where groundwater problems are acute and group management has been practiced. The output will include case studies of selected areas and groups, and a report from analysis of large-sample primary data collected on institutional issues, extraction economics and over exploitation. The output will offer insights on the effective management of groundwater.

Objective 3:

Study the institutional experience of selected micro-level water management initiatives of small check-dams for groundwater and surface resource management, and their impact on water use efficiency, water saving, access, distribution, adequacy of water, agricultural productivity and farmer incomes. Derive lessons for effective institutional design.

Output 3:

This study will be conducted primarily in Gujarat State where there is scope to examine the recently implemented scheme of check-dams. The output will include several case studies. In addition, analyses of larger-sample primary data collected on the institutional aspects of check-dams and their relationship to effectiveness of water management policy will provide useful insights. Attention will also be given to the relationship between these institutions and those analyzed as part of objective two. The study will include quantitative and qualitative analysis of factors associated with the performance of this water management initiative. Results will enable farmers, development officials, policymakers and others to promote and develop better institutional arrangements for this type of initiative.

Objective 4:

Study water management cooperatives to understand the issues responsible for their effectiveness [or otherwise] in managing water in water scarce areas, and to identify the design features which are critical for the success of cooperatives.

These features are to include institutional rules and systems with information gleaned by examining the experience of established water cooperatives. To derive preliminary lessons for design, operation, and management of effective cooperation in water resource management institutions, including laws and rules.

Output 4: This part of the study will primarily be conducted in Maharashtra State. The output will include detailed case studies of selected irrigation cooperatives to be found in this area. It will focus on institutional framework and arrangements - formal and informal, including by-laws and laws, and the related experience in water management. Analysis of data determining the factors influencing cooperative water use will also occur. This will provide an initial foundation for improving institutional arrangements and enhance policies for water resource management.

Objective 5:

Study the institutional aspects of group action among small farmers in the form of Water User Associations to overcome water distribution and system maintenance problems in surface water command areas. To examine the conditions facilitating / undermining sustainable group action in this context.

Output 5:

This part of the study will be undertaken primarily in the Andhra Pradesh State where a large number of Water User Associations have been recently created. The output will include several case studies of successful and unsuccessful Water User Associations, and a report based on the analysis of larger-sample primary data collected on institutional issues in the creation and management of Water Users Associations and their performance. An analysis of factors that influence the success or otherwise of this type of group action will also be conducted. This will provide exploratory inputs to reform policy to improve group action for water management.

Objective 6:

To strengthen information transfer pathways between Australian resource management bureaucracies and researchers and their Indian counterparts.

Output 6:

The extensive data and knowledge accumulated in accomplishing the preceding objectives will provide a valuable context for enhancing water policy reform. However, without sufficient attention to the transfer of information little on-ground improvement is likely to emerge. Four major workshops are to be held in conjunction with the project so research outcomes can be presented to policy advisers.

5 Methodology

[a] Development of theoretical framework

Without dwelling on the literature too much, it is worth noting that the main premise of New Institutional Economics (NIE) is that the real total cost of an economic activity includes not only transformation costs but also transaction costs. However, transaction costs are often ignored, despite usually being very large, and having the potential to substantially reduce efficiency and effectiveness. In this context, the measure of a 'good institution' is its ability to reduce the costs of an activity.

The project used this background to describe good institutional performance along 5 dimensions. These were:

1 Clear Objectives

Good institutions would have clear objectives and show clarity of purpose. Clear objectives and clarity amongst stakeholders would result in greater congruence, less conflict, and lower transaction cost.

2 Good Interaction

An important feature of good institutions would be good internal interaction among constituents. This would help in reducing transaction costs and obtaining cooperative solutions. Good institutions show good interaction with other institutions so that external transaction costs are also minimized.

3 Adaptiveness

Institutions would typically face variation and change in the internal and external environment. In light of this, successful institutions demonstrate good adaptiveness. Through this process the organization can survive and grow whilst also keeping transaction costs low.

4 Appropriateness of Scale

Good institutions would have appropriateness of scale with respect to their size and scope. If the institution is too large, transaction cost would be too high. On the other hand, if the institution is too small, it would have very little control over its relevant affairs.

5 Compliance Ability

Good institutions would demonstrate the required compliance ability. If the rules and processes of the institutions are not followed by a large section of the participants – i.e. compliance is poor - the institution would in all likelihood cease to be effective and meaningful, and transactions cost would be high.

The project was premised on the view that the existence of these institutional characteristics could be mapped against the performance of particular entities and thus provide useful insights into the relative impact (or combination of impacts) that attend particular institutional features.

However, there are also internal mechanics of organization that can play a major part in subverting institutional/ organizational effectiveness and in this context the study presumed that other attributes should be accounted for as well. More specifically, good governance in organizations/ institutions requires that they address three important rationalities. These are:

1 Technical Rationality

2 Organizational Rationality

3 Political Rationality

Thus, collectively the study focused on eight key conceptual elements – 5 drawn from NIE and 3 drawn from the Management Science literature.

[b] Case Analysis

In order to gain a deeper appreciation of the context, a series of case studies were undertaken. These provided additional insights into the mechanics of water institutions and also gave an appreciation of the feasibility of a wider data collection exercise. A number of state and national agencies were consulted as part of this, to ensure that the data collection exercise was optimised.

The case analyses were undertaken by staff from the Indian Institute of Management (IIM). The output from the case studies were scrutinised by the research team, particularly those from La Trobe University.

Operating in tandem was a case analysis of water laws in several settings. This was undertaken by staff with the University of South Australia.

[c] Empirical Sampling

The outcomes from the case analysis by IIM were then used to develop and test two survey instruments. The purpose of the survey was to capture data on the impacts of differing institutions and the characteristics of those entities. One survey focussed solely on the household level whilst a second was employed to collect data from those individuals heavily involved with the operation of the institution itself.

The study used data collected in the states of Gujarat, Maharashtra and Andhra Pradesh in India. These states all face water scarcity and have attempted to address the situation through various measures, including different institutional innovations. The study sampled a variety of local institutions involved in water resource management. In the state of Gujarat, these included tube well based co-operatives, tube well based partnerships and check dam groups. The tube well co-operatives and partnerships have sought to address two main problems. First, there is a problem pertaining to the high investment requirements and operational costs of deep tube wells which arise as groundwater

progressively recedes. Second, there are problems relating to the distribution of the scarce available water amongst farmers participating in groundwater extraction. By way of contrast, the check dam groups have sought to achieve village-wide rain water harvesting and recharge of wells through the creation of series of check dams.

In Maharashtra there has been a long history underpinning the evolution of farmer irrigation co-operatives to manage the distribution of canal water, and for lifting waters from rivers. These initiatives are the subject of the analysis in that state and sampling was developed around this theme. In Andhra Pradesh there has been a massive government initiative to form Water User Associations (WUAs) across the state to bring a participative approach to the management of canal and village tank (small reservoir) water distribution and maintenance. Accordingly, this government-led initiative has shaped the sampling undertaken in that state.

Based on the information available from the government and academic institutions in each jurisdiction, a set of diverse local water institutions were selected that covered the all of the aforementioned institutional initiatives. The institutions were then studied through detailed institutional questionnaires as well as household questionnaires. In the state of Gujarat, which has largest diversity of water institutions, 19 such entities were covered. In this instance 250 beneficiary farm households were sampled. The sampling distribution is given in Table 1. In the state of Maharashtra 5 canal institutions including river-lift co-operatives were covered and 100 beneficiaries sampled. In the state of Andhra Pradesh 5 WUAs across major, medium and minor irrigation projects were studied. Again a sample of 100 beneficiary households was drawn from this state. The results reported here are thus based on data from 29 differing water institutions in total and was developed using 450 beneficiary households.

The household survey included a variety of questions detailing the respondent profile, landholding, village setting, institutional association and activities, and institutional performance. There was also a series of questions related to institutional structure and function based on the conceptual frameworks of NIE and governance, as discussed above. The survey pertained to the 2004-2005 cropping year.

Sampling Plan: Number of sample households

Sr. No.	Type of Local Water Institution	Gujarat	Maharashtra	Andhra Pradesh	Total
1	Canal co-operatives	50	100	0	150
2	Water users associations	0	0	100	100
3	Tube-well co-operatives	40	0	0	40
4	Tube-well partnerships	60	0	0	60
5	Check-dam groups	100	0	0	100
	Total	250	100	100	450

[c] Empirical Analysis

Several stages were involved in the analysis of the assembled data. First, a statistical overview of farm households and the agro-institutional status of respondents were developed. This was used to buttress the second stage of analysis which explored the key governance and institutional elements embodied in the study in section four. This stage of the analysis was initially undertaken by considering the overall distribution of responses to questions relating to key governance and institutional features.

The third phase of analysis considered the performance of differing institutional arrangements against the national priorities for water management – namely, the extent to which the institutions were dealing with efficiency, scarcity, equity and environmental stewardship considerations.

The fourth step involved the use a bivariate statistical analysis dealing with general considerations, matters relating to governance and concepts directly pertaining to New Institutional Economics (NIE). In simple terms this analysis sought to explore statistically significant relationships between the various components of the data.

The fifth step involved the use of factor analysis to make the data more manageable and to limit the effects of multicollinearity. One of the major problems with multivariate analysis is the potential for multicollinearity between explanatory variables. For example, in production functions, irrigation and fertilizers, even though they are separate determinants of crop production, usually move together in the data – the more the irrigation, more the fertilizer use. Therefore, the multivariate procedure finds it difficult to separate the specific effects of irrigation and fertilizer on production. In the case of water institutions, an active Management Committee may well be associated with Management showing greater expertise, or the presence of a good Secretary and adequate compliance. Thus, the multivariate analysis may find it difficult to separate each of these impacts on performance. This phase allowed us to identify important factors as explanatory variables in their own right.

The sixth stage involved a multivariate analysis centring on the drivers of institutional performance. Here a range of performance indicators were modelled as the dependent variable to ascertain those components of the institutional setting that could meaningfully account for variations in performance. Since the performance indicators are range-bound with values, say from 1 to 4 and 1 to 5, the classical regression assumptions would be violated and an alternative procedure such as a limited dependent variable procedure is required for correct multivariate estimation. The TOBIT model is suitable for the nature of the data and was selected for the econometric estimation.

The TOBIT model is used to study the behaviour of institutional performance with the aim of identifying important determinants. Various measures of institutional performance were used as the dependent variable including the overall rating of institutional performance, and other measures addressing the performance objectives of water delivery, scarcity (efficiency), equity, environmental degradation, financial strength, and development.

These analytical steps were repeated a number of times. In the first instance, the data set was treated as a whole and the six steps were used to identify generic lessons about institutional performance. This analysis was to be the most useful insomuch as there was much more variation within the data to help identify salient influences over institutional performance. Three additional processes were then followed where surface water entities, groundwater entities and entities based on check dams were each examined specifically.

6 Achievements against activities and outputs/milestones

Detailed below are the achievements against milestones specified in the original project. This is followed by a review of the achievements/milestones that pertain to the project extension that commenced in 2007.

Obj No.	activity	outputs/ milestones	completion date	comments
1	Develop a framework for examining property rights, transactions cost, organization and socio-political economy in managing Indian water resources on the basis of Australian and overseas experience.	A measurement framework capable of being employed to evaluate the benefits and costs of alternative water institutions. An analysis tool tailored to the Indian water management context.	December 2004	Completed as per schedule. The framework relied heavily on the contribution of Phil Pagan but also reflected on policy formulation and application processes in Australia. The framework was refined by contributions from IIM which involved incorporating additional insights brought from the Management Science literature.
2	Study the institutional experience of check- dams for groundwater and surface resource management	In depth case studies. Report of the analysis of data on institutional aspects	June 2005 June 2006	Completed as per schedule. The case study reports were interrogated by the research team and used as the basis for the development of a broad based survey instrument. The survey was administered in-person by a team employed by IIM. The data were cleansed and refined by IIM with input from the Australian partners. The modelling of check-dam institutions was not as successful as that undertaken for the sample as a whole. This was due, in part, to the limited

				variability in the data.
3	Study groundwater management cooperatives, their operation and successes and failures	Detailed case studies 2. Report on the analysis of operation and management of groundwater cooperatives	June 2005 June 2006	Completed as per schedule. Again the case study phase proved useful in this part of the work. Survey data covered a wider variety of water institutions (than that considered in the case of check dams) and thus produced more useful empirical findings. However, the metric for success only loosely accounted for environmental impacts of the institution and results need to be interpreted cautiously.
4	Study the functioning of Water Users Associations and their institutional strengths and weaknesses	1. In-depth case studies. 2. Report of the analysis of data on institutional aspects	June 2005 June 2006	Completed as per schedule. Early on the case analysis pointed to different levels of enthusiasm for WUA. This was partially explained by the mechanisms by which WUA had been created in different states. Accordingly, the research team was keen to see if these circumstances proved empirically significant when assessing institutional performance. The upshot was some useful insights about the effectiveness of different approaches to Participatory Management. The results a useful guide to policy makers.
5	To strengthen information transfer pathways between Australian water resource management bureaucracies and researchers, and their	1. Preliminary workshop in Australia 2. Three workshops to widely disseminate findings, two in India	June 2004 May-June 2006	Completed as per schedule. The preliminary workshop was attended by senior representatives from the Indian Ministry. The Australian waters sector and water bureaucracy was also well represented. The final workshop in Australia

Indian counterparts.

had a strong representation for state agencies. These agencies were encouraged by the empirical results to continue to attempt water reform. In addition, the linkages established as part of the workshop have subsequently provided a vehicle for undertaking additional ACIAR work.

The workshops in India comprised both state and national representation. The results from the work stimulated fruitful discussions centring on the role of various tiers of government in policy formulation and institutional design.

The project extension added three additional objectives.

Obj No.	activity	outputs/ milestones	completion date	comments
1	Publication of a book manuscript	Completion of the book manuscript in a timely manner and to a standard that makes the findings of the work accessible to and influential with state policy makers.	Dec 2008	<p>The manuscript is to be published by Earthscan in the UK. The manuscript is presently at copy-edit stage with the publisher and is expected to be released early in 2009.</p> <p>Allowance has been made with the publishers to ensure that a sufficient quantity of gratis copies is available for distribution to state policy makers in India.</p> <p>The manuscript will also be marketed to an international audience by Earthscan.</p>
2	Further dissemination via journal and feature articles targeted at influencing Indian opinion	Conduct of a state-based workshop in India to coincide with the strategic release of	Feb 2008	Initially, this workshop was to have been undertaken as a stand-alone affair. Interest by ACIAR in the development of a project focussed on Watershed Development resulted in the workshop being redesigned to

		published materials.		coincide with the development of this new project. The workshop was held in Hyderabad and attracted interest from officials from the state of Andhra Pradesh, especially from those engaged with the Department of Rural Development.
3	Provision of survey data to other researchers	Access to these data was made available following the final workshop of the original project	July 2006	Completed ahead of schedule

7 Key results and discussion

The key results from this project are described in some detail in the book manuscript. In the interests of parsimony we present the concluding chapter from the manuscript below:

Chapter 16 Institutions and Irrigation in India – Concluding Lessons and the Way Forward

Lin Crase and Vasant Gandhi

[a] Introduction

In this book we have argued that improving the performance of irrigation in India hinges substantially on appropriate institutional design – engineering solutions by themselves are unable to provide the panacea for addressing water resource management in this country. In order to support this argument we have collectively undertaken two main tasks. First, an extensive and rigorous theoretical framework was developed around concepts pertaining to institutional design. Second, the theoretical framework was deployed to gain empirical information about the performance of different irrigation entities in India. An outcome from this approach has been a series of significant policy lessons for how irrigation should be managed in India. Moreover, the study provides important potential implications beyond this setting.

In order to sharpen our focus we initially posed five main questions in chapter 1. Namely:

What theoretical and conceptual insights would be useful for the institutional analysis of water resource management?

What is the magnitude and contour of the extant water resource management in India?

What empirical methods can be harnessed from the theoretical insights offered by New Institutional Economics and related disciplines and how might these assist in guiding policy and institutional reform?

What does empirical analysis tell us about institutional performance?

What lessons might be derived for policy makers?

These questions are now revisited in order to assemble key findings and reflect upon general themes that we hope will resonate with policy makers.

[a] What theoretical and conceptual insights would be useful for the institutional analysis of water resource management?

The theoretical underpinnings of much of this work rests with New Institutional Economics. Core concepts employed include the notion of 'institutions', defined as the set of rules by which human behavior is governed. In some instances throughout this manuscript authors have referred to institutions as organizations that embody those rules. However, the key issue revolves around understanding the defining nature of 'good' institutions or rules, regardless of the extent to which they are ultimately amalgamated into an organizational entity.

The literature on New Institutional Economics provides useful guidance in this regard by specifying with some precision the notion of transaction costs. Here we have opted to employ a fairly broad definition and have conceptualised transaction costs as all costs associated with the creation, use and change of an institution (i.e. a set of informal and/or formal rules) (Pagan chapter 2). The basic premise of good institutional design is that transaction costs should be minimised as this will raise the welfare of those parties involved with exchanging and using resources. However, the intellectual appeal of transaction costs must be necessarily balanced against other constraints. For example, transaction costs are notoriously difficult to measure, as demonstrated by Pagan (chapter 2), and understanding their pervasive form is no simple task. In that regard, it has also been acknowledged that some of the recent thinking in this field has drawn a link between transaction and transformation costs, since the technology of production is, in many cases, inextricably linked to the institutional environment that circumscribes it. Another important refinement has been the conceptual bifurcation between static and dynamic elements. In this context it soon becomes clear that the institutional and technological choices of today have potential costs for the future and any assessment of 'good institutional design' should make allowance for these events.

On the basis of this literature five generic characteristics were identified as being congruent with good institutions. First, having clear objectives was highlighted as pivotal. This feature was expected to provide clarity of purpose and also articulate the mechanisms for adjustment. Second, good institutional design takes into account the necessity to link between formal and informal rules. Where formal rules are not well aligned with informal rules it was anticipated that cohesion amongst individual members would be weak and the costs of gaining acceptance and compliance would be higher. Third, a generic feature of good institutions was that of adaptability or adaptiveness. Whilst potentially conflicting with the first institutional feature, adaptability implies a structured approach to recognising and dealing with uncertainty. This is particularly relevant when the institutional setting is in natural resources, like water. Fourth, good institutions are characterised by an appropriate scale for dealing with an issue or set of issues. The spatial definition of institutions is particularly important in the context of water where institutional hierarchies are common and hydrological linkages necessarily lead to downstream impacts. Fifth, the ability to bring compliance is another defining feature of good institutions. Maintaining compliance is itself costly, as is the absence of compliance, since lower rates of compliance also reduces the meaningfulness of the institutions. However the burden of those costs will differ substantially and, as a general principle, better compliance rates are consistent with better institutional performance.

In order to refine these generic principles and relate them specifically to irrigation and water resource management, Crase (chapter 3) and Pagan, Crase and Gandhi (chapter 4) set about scrutinising irrigation and water reform in Australia. The intent was to use a setting removed from the pressing social and political milieu of India and yet still allow us to hone our understanding of institutional design in a real life setting. Whilst the Australian setting differs in many ways from India, there are sufficient political and hydrological similarities to draw some higher order messages about institutional design and policy reform generally.

Amongst the most pertinent of these observations relates to the hierarchical nature of decision making and the reality that community preference change over time (see Crase chapter 3). Surface water resources in Australia and India are both vested in the States with Federal governments holding some superordinate control. In the Murray-Darling Basin in Australia the Federal government has sought to expand its influence over

decision making; firstly, through its suasive financial powers and secondly via legislative modifications. These changes highlight that the weight of decision making over water resources can move up and down an institutional hierarchy as priorities change. Importantly, it also serves to remind us that transaction and transformation costs potentially arise at each level of the decision hierarchy and between institutional levels. In the case of modifications to water rules in Australia, Crase (chapter 3) argues that many of the much-heralded early water reforms were consistent with the institutional criteria identified by Pagan (chapter 2), although he expresses some disquiet about recent policy episodes. Nevertheless, these recent policy changes also serve a useful role in helping understand institutional dynamics – in order to achieve good institutional outcomes at the lowest level of water management it is necessary to resolve higher-order dilemmas at the superordinate level. Put simply, it is not enough to simply devolve an intractable problem to a lower order entity because of the perceived costs of dealing with it at a state or national level. If the problem exists at a basin or inter-basin level, then simply asking states or irrigation communities to deliver a solution is hardly adequate. This observation supports Pagan's (chapter 2) claim that attention needs to be given to scale when designing good institutions but also overtly acknowledges that the rights of all water users are invariably attenuated by decisions made at higher levels of governance.

The mechanics of decision making within water agencies located within an institutional hierarchy was specifically dealt with by Pagan, Crase and Gandhi in chapter 4. Reflecting on the reluctance of various bureaucracies to sanction interstate water trade between the Australian Capital Territory and New South Wales, Pagan, Crase and Gandhi demonstrated that the internal machinations of each decision making body are critical in shaping the final outcome. More specifically, how agents within organisations perceive their responsibilities can ultimately influence the course of major policy reforms. On this basis, it was considered important to broaden the generic characteristics of good institutional design in an effort to capture some of the internal dynamics of decision makers. Drawing directly from the Management Science literature, three additional conceptual components were advocated to balance the five generic principles derived from and supported by the New Institutional Economics. More specifically, technical, organisational and political rationality were proffered as useful complementary constructs since these were likely to provide additional insights into the internal mechanics of organisations not specifically captured by those elements emanating from the New Institutional Economics.

In sum, eight conceptual components were seen as being critical to good institutional design and measuring and articulating these was expected to substantially explain institutional performance in irrigation. Five of these elements were directly related to the New Institutional Economics: clear institutional objectives; harmonisation of informal and formal rules; adaptiveness; appropriateness of scale, and; an ability to bring compliance. The remaining three elements related to the internal mechanics of organisations being: technical rationality; organisational rationality, and; political rationality. The challenges was to explore whether these elements were empirically significant in a consequential context and there are few more pressing settings than those that circumscribe irrigated agriculture in one of the most populous nations on earth - India.

[a] What is the magnitude and contour of the extant water resource management in India?

Having delineated a generic framework for adjudging the performance of irrigation institutions it was important to establish the context for any empirical work. This was accomplished over the following four chapters (5-8). Herath (chapter 5) commenced this process by drawing attention to the role of social capital and collective action which are often considered important in developing countries. There are important linkages

between human and natural systems in rural communities in developing countries that are often less obvious in the irrigation landscape of developed nations. Notably, there is an interrelationship between institutional dynamics and the rate of environmental degradation in most developing countries, like India. The presence of weak institutions invariably accelerates degradation and a vicious cycle can result. Herath noted that this is not always the case and there are numerous instances of institutional success that contrast with the many notable failures. He also reviewed the extant empirical work undertaken in South Asia and finds that there is considerable scope for improvement and opportunity to provide greater insights into institutional dynamics.

Substantial institutional change has characterised water resource management in India in recent decades and the key arrangements that attend the status quo were described in considerable detail by Ananda (chapter 6). Ananda concluded that "Indian water institutions portray a complex mosaic of socio-economic, cultural and political realities in concert with numerous environmental challenges". Unravelling this mosaic to uncover the elements of success was therefore likely to prove to be a formidable task. However, the rewards of 'getting things right' are also non-trivial.

Ananda observed that large irrigation schemes that have been historically managed by the state "face continued physical deterioration, siltation of dams, lack of O&M, poor cost recovery and disintegration of institutions". However, irrigation is not confined to large surface water schemes and groundwater has emerged as the most extensive form. Ananda attempted to rationalise the institutional hierarchy for managing water resources in India and observed that a range of local, state and Federal authorities exist within a nested framework. These cover a range of irrigation types including tanks, canals and groundwater entities. The performance of each irrigation type was provisionally assessed against Pagan's (chapter 2) performance framework. Ananda found that, by and large, the groundwater institutions more closely aligned with the generic characteristics of good institutional design than did the other forms of irrigation. Importantly, this was viewed primarily from the perspective of the beneficiaries of these arrangements and did not specifically account for the fact that groundwater extractions in many cases clearly exceed sustainable yields. Moreover, these problems are arguably a manifestation of the inability of superordinate agencies to set reasonable bounds for resource management.

Another important element of Ananda's review of Indian water institutions related to his assessment of Water User Associations and the concept of Participatory Irrigation Management. The origins of Water User Associations vary. In some instance, collective associations have managed water use at a local level for thousands of years. This was also noted by Herath (chapter 5). Ananda contended that these entities "have shown a high resilience to various adverse conditions and managed to survive". By way of contrast, a large number of associations were developed quite recently in response to policy enthusiasm for Participatory Irrigation Management. Often this emanated from the general view that local farmers would do a better job of maintaining infrastructure if they were given a greater say in its use. Interestingly, Ananda summarises the correlation between these two forms of Water User Association (i.e. farmer-induced versus government-induced) and the generic institutional design criteria of Pagan and found marked differences. More specifically, he argued that there was a prima facie case for believing that the farmer-induced associations would perform better than those induced by government decree. This issue was given close attention in the empirical work that followed.

A more detailed analysis of the legal dimensions of water institutions in India was also provided to ground the subsequent empirical work. Upadhyay (chapter 7) offered a synoptic account of water law in India with close attention given to the most prolific form of irrigation – groundwater. Consistent with the observations of Ananda (chapter 6), Upadhyay made note of the general policy enthusiasm for devolving responsibility for water management to local decision makers which he loosely described as “people oriented, decentralized and demand driven water programs”. Importantly, Upadhyay noted that States have retained constitutional power over water resources, although they have tended to endow Panchayats with responsibility for “Water Management”, “Minor Irrigation” and “Watershed Development”. This is consistent with the principles of nested decision making highlighted by others.

Perhaps the thorniest issues raised by Upadhyay relates to the challenge of controlling groundwater extraction. Whilst water resources are generally vested in the States in India, there persists a view that groundwater is an easement attached to overlying land. There is some basis for querying the absolute nature of these arrangements and Upadhyay established a strong case for revisiting these conventions by systematically analysing the course of a ‘model bill’ designed by the Government of India to bring groundwater extractions into check. Notwithstanding these noble attempts, relatively little real progress is evident. Upadhyay traced legal developments in Andhra Pradesh and Maharashtra against this backdrop and found that frequently the rhetoric was not matched by appropriate action. In some instances this was due to a lack of technical expertise but overall he appeared sceptical that ‘uncomfortable’ regulations would ever be invoked, regardless of the perils of unfettered groundwater extraction. The review of the legal arrangements also raised additional questions about the efficacy of devolving responsibility for resource management. Put simply, Upadhyay raised serious doubts about the extent to which groundwater can be adequately managed at a local level when it is so difficult to meaningfully monitor the status of the resource at this scale.

The status of groundwater in India was also given attention by Gandhi and Namboodiri (chapter 8). Utilizable groundwater resources reportedly stand at about 432 cu km in India whilst surface water resources amount to 690 cu km. Notwithstanding their magnitude, the highly variable nature of these water resources in temporal and spatial terms makes management problematic. Water resource management is critical for India due to skewed rainfall, growing food demand, and the large dependence on agriculture for livelihoods. The historical response to these circumstances has been active government sponsorship of irrigated agriculture. British rule left India with over 20 million hectares of irrigated land by the time of independence, almost half being major and medium surface water irrigation schemes. Enthusiasm for irrigation development continued after independence and by 1985 more than three times this irrigation potential had been created in the form of major, medium and minor projects. However, serious concerns about unsatisfactory management, delivery and utilization of water at the farm level have emerged.

Gandhi and Namboodiri (chapter 8) bemoaned the growing gap between the potential created for irrigation and the area actually irrigated. Amongst the more notable trends in irrigation in India in recent times is the expansion of groundwater extraction. Whereas technical solutions are known and implemented, serious institutional deficiencies exist. A large number of analysts have argued that that water resource management in India is heading for a crisis unless policies and institutions are radically transformed. The major challenge for India is to design institutions which can deliver on the efficient use of the scarce resource, offer equity in its benefits, reduced environmental harm, and achieve financial viability.

[a] What empirical methods can be harnessed from the theoretical insights offered by New Institutional Economics and related disciplines and how might these assist in guiding policy and institutional reform?

The ambition of this project was to establish the extent to which the characteristics of good institutional design impacted on irrigation performance in India. This investigation commenced in earnest with the work reported by Gandhi, Crase and Roy in chapter 9. The setting for this empirical component was the states of Gujarat, Maharashtra and Andhra Pradesh – all water scarce jurisdictions with differing institutional responses to the problems at hand. In addition, the empirical work was based on a variety of irrigation entities covering surface water, groundwater and rainwater irrigation. This approach was adopted to allow for comparisons across jurisdictions and across resource types.

The data set that underpinned this work comprised household surveys of farmers where respondents provided extensive details on their productive activities and their perceptions of institutional performance. The latter proved particularly vexing, inasmuch as performance has many dimensions, ranging from strictly short term productive considerations to broader notions of equity and long term environmental sustainability. Nevertheless, the sample of 450 respondents provided the basis for undertaking some useful empirical tests.

In this preliminary stage a bivariate approach was employed which involved scrutiny of potential relationships using the familiar Analysis of Variance (ANOVA) framework. The need to address technical rationality, organizational rationality and political rationality emerged as important determinants of institutional performance. The importance of the Secretary and the Staff being active, and the necessity to have well trained personnel with the right expertise indicates the importance of addressing technical rationality. In addition, the Management Committee being active and have the necessary skills supports the view that it is critically important to address coordination and organizational rationality. The importance of the general body along with the elected Chairman being active indicates that, without adequately addressing political rationality, the water institutions cannot be successful. The results indicate that successful institutional design extends beyond leadership - what is required is the correct institutional design with the required structure, active processes and effective systems.

Given the richness and extent of the data set, an additional series of factor analyses and cleansing techniques were required to establish meaningful measures for the theoretical constructs developed in earlier chapters. Importantly, seven key factors were evident and these are repeated here for convenience:

****Factor 1: Managing committee (active), Secretary (active), Management has expertise, Management has authority to adapt rules, Compliance is sufficient**

****Factor 2: Organization created by government (negative), Rules of organization determined by government (negative), Objectives are clear, Clear mechanism for changing rules, Scale is appropriate, Organization uses its powers**

**Factor 3: Good interaction between members of the institution, Good interaction between management and members

**Factor 4: General body active, Institution regularly plans and pursues objectives

**Factor 5: Higher level issues are appropriately addressed by higher level institutions

**Factor 6: Good leadership to facilitate

**Factor 7: Management has the expertise

Subsequently, a process was adopted to test the veracity of important relationships against the dimensions of institutional success. This second stage involved multivariate analysis and, in this case, raised particular empirical challenges. The first of these problems arose from the categorical nature of much of the data. After several pre-tests it was clear that the cognitive burden on respondents could only feasibly be contained by using a categorical format for some questions. Consequently, the data collected for this exercise were not always continuous, and respondents provided information in an ordered format – e.g. rating performance from 1-5. Accordingly, assumptions that accompany conventional regression techniques would be violated were empirical analysis of these data to proceed along the lines of standard linear regression. To account for this the multivariate approach adopted a Tobit framework capable of dealing with this constraint.

A second major challenge related to dealing with multicollinearity in the empirical models. Given that good institutions probably embody more than one attribute from the theoretical framework, it might be expected that explanatory variables would be correlated. The development of factors went some way to dealing with this problem but it is not possible to completely account for multicollinearity within these data.

Given these constraints, perhaps the most meaningful insights were derived from the analysis of the data set as whole, and this was reported by Gandhi, Crase and Roy (chapter 9). The comprehensive data set has the advantage of including greater variability and, by including the maximum observations, increases the potential for establishing statistically significant relationships. The bivariate analysis revealed important relationships in the data but the deployment of the multivariate Tobit technique offers more poignant lessons. Regardless of whether performance was specified in efficiency, equity or environmental terms, there was clear evidence that the theoretical attributes developed in earlier chapters were influential in determining success across jurisdictions and irrigation types. The new institutional economics fundamental were found to be very important, particularly in indicating ways of reducing transaction costs and promoting cooperative solutions. The results showed that the problems of institutional failure in water resource institutions in India can be overcome in many cases through the implementation of cogent features of institutional design emerging from new institutional economics. In addition, the necessity to incorporate components suggested by management theories of good governance is also clear in this research. Successful institutions invariably embody these features.

[a]What does empirical analysis tell us about institutional performance?

To shed additional light on institutional performance an empirical analysis was undertaken for each of the irrigation types – surface water, groundwater and rainwater (check dams).

[b]Surface water

Namboodiri and Gandhi (chapter 10) considered the performance of surface water institutions along similar lines to those applied to the data set as a whole. The bivariate analysis revealed that the performance of canal cooperatives was general superior to that of Water User Associations. This was consistent with Ananda's (chapter 6) prediction that the government-induced nature of some Water User Associations would limit their overall success. Other general findings in the context of surface water were that tail end users rated institutional performance somewhat lower than their upstream neighbours and stronger social cohesion in a village was positively and significantly associated with better performance.

The multivariate analysis offered additional insights particularly as it allowed for the specification of performance in different ways. When modelled against overall performance, important internal elements of the organisation proved positive and significant. These included having an active general membership body and a capable and energetic management committee. In addition, the capacity to undertake systematic planning and having a strong compliance culture were conducive to better overall performance. By way of contrast, overall performance was rated lower when the entity was created by government, again supporting the view by Ananda that such arrangements can prove to be sub-optimal.

Denoting performance primarily along economic lines, for instance, by gauging the extent to which prices are used to reflect scarcity, provides alternative insights. Here the experience of staff members, capable leadership, strong compliance and sound interaction between members were shown to be significant drivers. In the context of enhanced operation and maintenance activities, New Institutional variables like clarity of objectives and structured planning to facilitate adjustment were shown to be significant as were several concepts from the Management Science perspective – particularly, the presence of experienced and capable staff able to deal with technical rationality. Poignantly, the model of maintenance activities also reveals that the role of higher order decision making bodies remains significant – when superordinate bodies deal appropriately with pressing issues then subordinate agents function more effectively.

Testing for performance along environmental and financial sustainability lines produced results that were broadly consistent with earlier models. The role of the internal decision mechanisms, personified in the capabilities of office bearers and managers, good interaction between members and experienced staff proved to be positive influences. Similar observations could be made about the wider welfare effects on the village community, with the presence of capable staff members and regular planning proving important. Planning processes were also shown to be significant promoters of better financial performance as was the necessity to have higher-order decision entities dealing with systemic or basin-wide problems.

[b]Groundwater

Groundwater now forms the largest single source of irrigation in India and this has largely resulted from the widespread use of tubewells and the simultaneous expansion of the electricity grid to the rural population. Several institutional forms can be found in the context of groundwater, including large formal institutions arising from the devolution of state controlled wells. However, the majority of the groundwater is extracted from private tubewells, tubewell partnerships and relatively informal tubewell cooperatives.

In order to better understand the functioning of groundwater organisations Gandhi and Roy (chapter 11) analysed the data drawn from irrigation farmers in northern Gujarat. One of the distinguishing characteristics of Gujarat irrigation is its heavy reliance on groundwater, which constitutes over 80 per cent of the irrigated area in the state. Given the limited variation in institutional types in this context it was anticipated that the empirical analysis would not produce the same level of clarity as that offered by the earlier investigations (i.e. the analyses of the whole data set and surface water irrigation). Nevertheless, there was clear evidence, even in this more limited context, that elements of the New Institutional Economics and management theory of governance played important roles.

The bivariate approach that was used in the other settings again showed the necessity for good internal decision mechanisms with the activity level of the chairman, the managing committee and secretary all proving to be significantly and positively correlated to institutional performance. Similar support was found in the multivariate models. Modelling the overall success of the entity indicated that technical rationality, delivered via good management practices, was paramount in this regard. The model developed around maintenance activities also illustrated the importance of technical elements where the role of the secretary was significant. In this model the capacity to undertake planning significantly improved performance, as it did in the model designed to scrutinise the impact on the overall welfare of the village community. Welfare in the village was also likely to be enhanced when the groundwater organisations had better management expertise.

Notwithstanding these findings, there is an important cautionary note that applies to local groundwater organisations in this setting. Groundwater cooperatives and partnerships are usually held together by strong individual incentives to maximise the benefits that accrue to the members of those entities. For example, tubewell partnerships in the study region often emerged as a direct response to the failure of shallow wells and the necessity for individual farmers to pool resources to extract water from greater depths. Arguably, the very success of these institutions on some fronts spell disaster on others. On the one hand the skilled management to extract water from greater depths and the ingenious institutional arrangements to support these endeavours needs to be considered in the context of the long term sustainability of extractions. It is somewhat ironic that stronger institutional performance in this case may simply accelerate the depletion of scarce resources and worsen the long term outcome.

This issue assumes even greater importance when combined with the earlier insights offered by Upadhyay (chapter 7). Recall that Upadhyay expresses some reservation about the apparent enthusiasm amongst policy makers for devolving responsibility for compliance and monitoring of groundwater extraction to local authorities. Throughout this manuscript we have sought to expose the folly of this simplistic approach to decision making. Moreover, we have emphasised the necessity for policy makers to reflect on the principles of good institutional design suggested by New Institutional Economics and organisational theories drawn from Management Science. In the context of groundwater,

having superordinate bodies dealing with problems suited to the scale of their operation, like basin-wide over-extraction, would seem to hold much more promise than an approach that simply shifts the problem and costs to local authorities. This was considered in greater detail by Ananda, Crase and Keeton (chapter 15) but remains one of the most significant challenges for water management in India.

[b]Rainwater institutions - Check dams

At a practical level many local institutions in India have produced marked and useful impacts on water resource management. Arguably, one such initiative is the check dam movement which was described in some detail by Gandhi and Sharma (chapter 12). Check dams have arisen as a localised effort to enhance groundwater recharge and usually centre on the development of a structure (or series of structures) designed to retard runoff during the wetter months of the year. The upshot has been improved groundwater recharge in many villages, particularly in Gujarat where the movement has attracted greatest attention.

The institutions required to accompany these initiatives are relatively uncomplicated compared to those that attend on-going work, as would occur with a canal cooperative, for example. Nevertheless, some degree of organisation and rule-setting is required to bring even singular check dam projects to fruition. For instance, as a minimum the village community needs to establish mechanisms for planning, financing and construction.

In the interests of completeness a similar empirical analysis to that used to scrutinise other water sources was applied to these entities. The objective was to establish the veracity of the conceptual framework in this setting. Overall, the performance of check dam organisations was rated quite highly by those impacted and the bivariate and multivariate results point to the importance of several constructs. More specifically, Gandhi and Sharma observe that "overall, appropriate scale, clarity of objectives, good interaction, and having Management with the ability to adapt rules and bringing compliance appear to be major determinants of success".

There is one caveat that needs to be added to these results. Check dams, by definition, positively impact on the hydrology in a local area. However, it may not always be possible to modify local hydrology without impacting on others. Thus, what is missing from the analysis of check dams is an understanding and appreciation of their overall impact on hydrology and other potential water users. Again, this points to the necessity for superordinate bodies to develop and maintain an adequate understanding of the wider impacts of water use at a local scale – not because such entities will do a better job of micro-managing water, but because broad scale issues are more appropriately dealt with by institutions with jurisdictions that match that scale.

[a]What lessons might be derived for policy makers?

Having developed a robust theoretical framework and tested its empirical significance in a range of settings, it is now important to reflect on what this means for policy formulation. Clearly, we have already introduced several elements of this but three specific areas of interest were given attention in chapters 13-15.

Firstly, Herath (chapter 13) considered the relevance of the mechanisms for devolving responsibility for irrigation to farmers and farmer groups. He did so by recounting the

events of irrigation management transfer (IMT) and the associated development of Water User Associations, which were also subjected to scrutiny as part of the empirical analysis by Namoodirir and Gandhi (chapter 10). Poignantly, Herath finds that "IMT has shown some positive achievements but there is scope for considerable improvement". This is supported by the earlier empirical work which found substantial variations in the performance of surface water entities and specifically tied this to elements of the conceptual framework, like having clear objectives or having capable Management able to facilitate decision making. Herath further contends that, all too often, the results from establishing Water User Associations fall short because the reforms that occur "are often in the interest of local elites and others extracting sizeable economic rents. These events created weak WUAs with poor skills and knowledge to enhance administrative, managerial, and financial capacities of participants".

Combined with the empirical work on surface water organisations there is a resounding message for policy makers. It is not enough to simply absolve higher-order agencies of responsibility for surface water management on the grounds that local communities possess inherent qualities that lead to a better job. Clearly defined rights must accompany this devolution else cost and blame shifting between levels of the decision hierarchy will become the norm.

A similar message emerged from chapter 14 where Ananda, Crase and Keeton considered the conundrums that arise from the dispersion of information and varying capacities to make decisions. In this instance, the theoretical literature on decentralised decision making offered some useful guidance but, as Ananda, Crase and Keeton pointed out, this same literature runs the risk of treating decision making processes as a 'black box'. Rather, what is required is a more detailed appreciation of decision making itself. By focussing on the bifurcation between routine and non-routine decisions, it quickly becomes evident that the structure of the decision making hierarchy and the capacity at different levels of that hierarchy are important components of the institutional design landscape.

Useful insights are available from the institutional literature and these were summarised in chapter 14. However, one message continues to resonate from this review – the imperative to match scale and recognise linkages. This has several components. First, it is necessary to match the scale of human activity with the scale of natural systems. This should not be taken to imply that all socio-political boundaries need to be realigned with natural hydrology or ecosystems. Rather, what is required are low-cost mechanisms for dealing with hydrological or ecosystem spillover effects when jurisdictions are founded on different criteria. Second, it is important to have in place institutions that recognise that variations in scale usually attend water-related decisions and this requires differing responses. For instance, in many cases check dams may have trivial downstream effects and the benefits and costs of these structures will be largely internalised by the communities that develop them. This will be the case where water evaporates quickly or enters a saline sink if not first intercepted. However, in other instances check dams (or other watershed development works) may have a wider impact on the availability of water resources to other users. These differing impacts demand differing institutional responses and at different scales. Moreover, failing to understand these nuances will lead to sub-optimal outcomes; either uncompensated spillover effects will persist or users' rights will be unnecessarily attenuated thereby stifling local initiative. Thirdly, there needs to be an acknowledgement that the scale of knowledge must at least approximate the scale of decision making. This theme has arisen several times throughout this manuscript and needs little more elucidation, other than to emphasise that decentralised decision making counts for nought when the subordinate decision maker lacks knowledge or capacity.

Finally, it is important not to overlook institutional linkages. The property rights literature makes it quite clear that rights are not exclusive in the sense that stronger rights for some implies less say in decisions by others. For example, stronger rights for farmers or farmer groups must intrinsically be associated with less say on the part of the state. Ironically however, this also requires greater effort by the state to ensure that lower order rights are validated and respected. In simple terms, it is not a matter of state-management versus community or individual management; regardless of which entity is assigned authority, this can only operate effectively as long as other groups consciously chose to embrace institutions that recognise that authority.

In concluding this manuscript an effort was made to move to the most pressing justification for this work. As Gandhi and Bhamoriya (chapter 15) observe, national estimates place the number of poor people in India at over 300 million, with almost three quarters of these living in rural areas and being heavily dependent on agriculture for their livelihood. The rationale for investing resources in improving irrigation institutions hinges on the fact that increased productivity in agriculture has been shown to substantially reduce poverty in India and the productivity of agriculture is inextricably linked to irrigation. In simple terms, irrigation development is closely and negatively linked to poverty levels across states in India.

A systematic process of overcoming institutional deficiencies holds great promise in the fight against poverty. However, it is also important to include equity considerations in the institutional design criteria so as to maximize its benefits. Gandhi and Bhamoriya (chapter 15) argued that there should be a purposeful inclusion of equity considerations into the laws, rules, structures and processes of water institutions. The data analysed in this volume and other studies in this field find substantial variation in the extent to which equity is dealt with in local water institutions in India. Poignantly, there is strong evidence that where equity considerations are deliberately addressed, the overall impacts on equity and poverty alleviation are significantly better.

As we have shown the returns from improved institutional design can be substantial. The empirical work reported in this manuscript indicates that attention to the detail of institutions is critical, but this need not require substantive calls on the public purse. Changing institutions is not costless but nor does it require large foreign reserves or sophisticated transfers of capital. Any yet the rudiments of good institutional design are not always evident in irrigation in India. Hopefully, the lessons we have identified can be combined with adequate motivation and political resolve to address these issues whilst there remains scope to avert a crisis.

8 Impacts

8.1 Scientific impacts – now and in 5 years

A range of worthwhile papers have been published in scholarly journals. Some are detailed in subsequent sections of this report. In addition, the findings from this work were reported at the Australian Agricultural and Resource Economics Society in 2005, 2006 and 2007. The work was also presented at the International Conference of Agricultural Economics in 2007. In each instance useful feedback was received to improve the analytical techniques.

Whilst acknowledging that publication in its own right does not assure impact, the continuing interest in institutional issues in the context of water is testament to the contribution of this (and related) work in the field. This interest shows no signs of abating and it is expected that the body of work generated by this project will become a major reference for policy analysts in the future.

The work has also extended some of the initial thinking in Institutional Economics. In particular, the insights brought by Pagan provided an elegant means of combining the consideration of transaction and transformation costs. The recognition of the roles of hierarchies and how this further complicates a composite assessment of transaction and transformation costs was another notable achievement. Finally, the integration of theoretical component of Management Science with the New Institutional Economics literature represents another notable contribution on the theoretical front.

At a practical level, the novelty of the empirical work should not be overlooked. The development of suitable scales for enumerating complex constructs is a valuable contribution. The development and refinement of scales in this area is relatively underdeveloped and the results from this work will guide others who follow.

8.2 Community impacts – now and in 5 years

The following comments are taken from the Reviewer's report at the conclusion of the project proper. They succinctly summarise the impacts of the project and are consistent with the views of the project team. The comments cover all three dimensions – economic, social and environmental.

"Adoption of the results of socioeconomic research is problematic. Usually, policy research is undertaken because of ongoing problems that have either escaped official attention or more often are the outcome of political differences between interested parties that has resulted in an administrative stalemate. It takes a long time for negative reactions to be overcome whenever the status quo is being challenged. While adoption of socioeconomic research is difficult to achieve the rewards are correspondingly larger. Once inertia is overcome, rapid progress and substantial benefits can follow. In many cases the 'benefit' of socioeconomic research is the cost that is avoided if the status quo persists. The stakes are high in India if over allocation of water is not tackled at some time in the near future.

In federations a difficult issue is to resolve conflicts between different levels of government over financial and other responsibilities. The constitutional situation can be ambiguous and/or compromised because financial power (ability to raise taxation) does not match the formal division of responsibilities. In any federation, and especially one with such large units as India, competition in ideas and policies can be a fruitful vehicle for reform. In a situation of uncertainty, experimentation rather than the search for 'national consistency' should be encouraged. This supports the argument for directing policy extension efforts at state officials, some of whom may be more receptive to new ideas. If policy innovations are successful in one state, others including the central government may follow.

All governments find it difficult to concede that policy problems may be of their own making, including problems lingering on from decisions taken in the distant past. Thus, lack of acceptance is not always a good criterion on which to judge the quality of research on economic policy or its potential benefits. The harsh fact is that steps towards water reform are easy to initiate but it is difficult to maintain momentum in the face of vested interests".

8.2.1 Economic impacts

Following the exposure of farmers, government officials and NGOs to the activities and findings of the project, the governments in all the three states have become more cooperative with the WUAs. A better institutional interface has developed between the government, WUAs and farmers. This has led to better management of activities in the interest of the farmers, greater devolution of responsibilities, and also better recovery of the water rates.

The WUAs in the Dharoi project area in Mehsana district of Gujarat and the Waghad project area in the Nasik district of Maharashtra have formed Federations to come together in taking on higher level responsibilities and activities for better managing the water resource. Through this the farmers in Waghad have got water entitlements from the government, and now the budgeting of the water and its distribution is managed entirely by the farmers themselves. An entitlement of 40 percent of the water in the Waghad Reservoir has been given to the Federation of 24 WUAs on 15 October 2008. Mr. Sanjay Belsare who attended the project workshop in Ahmedabad is now the Executive Engineer of the Nasik Irrigation Circle in this region in Maharashtra and is having a big impact.

While the WUAs manage the water at the village level there was a need for a coordinating and managing institution across the WUAs. The federations have been formed to fulfil these functions and have started to move in that direction slowly. The canal is a hydraulic system with riparian linkages and downstream villages are affected by almost every significant activity that takes place in the upstream villages. This requires a coordination institution essential for the water rights and water management by the farmers. Functions that link up more than one village or WUA across the flow of the canal are referred to the Federation. These include the cleaning and rehabilitation or repair of main canals, clearing encroachment on the canals and the distribution system, policing unauthorised lifting of water from the canal directly, lobbying for the water entitlement for the irrigation sector as also each WUA, lobbying for the necessary implementation of laws and amendments and adaptations where needed for the better functioning of the WUAs.

The federation of the 27 WUAs on one bank of the Dharoi Reservoir in Gujarat has been active in policing and removing encroachments as well as attempting to reduce losses from the system to the minimum. As the mandate of each WUA is limited to a few villages they are unable to be of much help in this regard. Also the weak capacity of some WUA results in the encroachments persisting. The federation took up the issue with the

irrigation department and decided to force an anti-encroachment cum inspection drive to remove the encroachments and also to inspect the full length of the canal for prospective problems. The federation also arranged for patrolling along the length of the canal during the days of water flow to ensure that water reaches a maximum area possible.

In Maharashtra, a federation of 24 WUAs of the Waghad Project has been formed. The members were chosen from the WUAs itself and the federation was formed on good principles of institution building by having a clear separate mandate that does not overlap with that of the WUAs. The federation has been able to get the water entitlement of 40 % water from the Waghad reservoir from the government. Now it is the federation which plans the distribution of water. As the Waghad project has been transformed from a seasonal to a perennial irrigation system, the federation helps the farmers in better allocation and distribution of water amongst the various WUAs. The water budgeting and redistribution of water 'saved' from the 'rabi' season into the 'summer' season are all done by the federation. The federation has spearheaded the efforts to remove encroachments and rebuild the canal system to international standards. The federation also decided to build a road along the entire distributory and minor length in the villages to facilitate patrolling and therefore check on encroachments. The federation has also been critical in inspecting and keeping a check on the activities and procurements in order to assure quality during the same. The federation and its board of directors have taken the lead in their efforts for establishing a producer company towards branded exports of the agricultural produce.

Many WUAs have started new activities aimed at improving irrigation efficiency, increasing irrigated area and improving agriculture. In a few villages such as Inddore in Maharashtra, the WUA has become the central platform for cooperation amongst the farmers for development. This has led to the creation of a dairy cooperative society and a planned setting up a commercial complex in the village with essential shops including a medicine shop.

Democratic elections have taken place in the WUAs in Andhra Pradesh. During this, the WUAs have linked up with the mainstream politics of the state and have gained recognition as important and powerful institutions in the villages. This has helped them to gain more influence. There was a shortage of water in the Godavari basin in the current year, and given this new influence, the government officials have worked closely with the newly elected WUA presidents and committees on better water management. The wastage of water has been reduced and the irrigation efficiency has been increased from the river to the canal to the fields to make up for the shortage, Measures such as building of cross-bunds and retaining walls across the fields, conjunctive use of the water, lifting of water from the river downstream to upstream canals, and implementation of a rotation system for the first time in the history of the system. The command area along every canal, distributory and minor have been divided into parts and the distribution on a rotation basis has been implemented so that at least some quantity is assured to all farmers - some for all rather than all for some.

In Maharashtra, there is a shift to crops which bring more return per unit of water used. The cropping pattern has changed from seasonal cereals (short duration commercial) to long duration commercial crops, to perennial commercial crops to export crops. There is a move towards institutional innovation to develop and register a producer company of the farmers.

Rules regarding different hourly rates of water application in different seasons is a significant new development indicating that the institution is treating water as scarce economic good. This is found even in lift irrigation schemes of Maharashtra in the Ozar region. The rates may not vary across crops but priority for irrigation is kept different for different crops. This is also seen in Gujarat. The implementation is done by the canal

operators during distribution and these rules have contributed substantially to the success of these WUAs.

Unique design solutions are also being developed by some institutions. Inddore village WUA hired a consultant who designed a simple masonry device which assures equal distribution of water to each farmer and this greatly reduced the conflicts among farmers.

8.2.2 Social impacts

According to the World Bank, three out of four poor people in the developing countries of the world live in the rural areas and most directly or indirectly depend on agriculture for their livelihoods. As a general premise then, more dynamic and inclusive agriculture can dramatically reduce rural poverty and hunger. Rapid growth in agriculture has been largely responsible for the decline in rural poverty in many countries. The most direct impact of irrigation on agriculture growth is through increased productivity of land. Irrigation is reported to raise yields by one third to one half as compared to yields in rainfed areas. Irrigation is also widely acknowledged as bringing stability to agriculture as it protects the farmer from the seasonality and vagaries of weather, at least to some degree. Thus, it follows that improvements in irrigation through better institutions, as described in economic impacts above, would have a direct impact on agricultural growth and poverty alleviation.

In the WUA villages of the Dharoi command area in North Gujarat, the landless, most of whom are among the poorest, have gained from increased employment on farms as well as off farms. Some of the landless have bought cattle and are able to maintain cattle as the fodder availability has improved substantially with better management of the canal waters. A similar trend is seen in Maharashtra.

The social fabric is reported to have improved in the WUA villages. The villagers report that conflict resolution has improved in the villages after the formation of the institutions. They also reported that the relationships in the village are more inclusive and smooth due to the role played by the institutions. In Maharashtra, a new leadership has been created with the water user associations. In association with an NGO called the Samaj Parivartan Kendra, the villagers have developed a new ethic of keeping bad party politics out of the domain of irrigation management. This reflects a clear institutional understanding of the fundamental importance of water for life and livelihood. The WUAs in Maharashtra now have an informal rule that the secretaries of WUAs would be from landless families, preferably graduates with some computer skills. The canal inspectors would be educated with some experience of farming so that they can make sensible adjustments to the water schedules so as to manage it with fairness and efficiency. They also try to have some directors on the managing committee who are below 50 years of age so that the younger generation is represented, fresh ideas are contributed, and they gain experience for future leadership.

The WUAs in the Waghad project of Ozar, Maharashtra have active women members and also managing committee directors of all castes. They also have a representative system based on localities. This has ensured equity and the consideration of various interests in the functioning of the institution. For example, Parvatabai is the current woman chairperson of the Mahatma Phule WUA in Ozar and she is one of the pioneering village leaders in the establishment of the WUAs.

8.2.3 Environmental impacts

Various initiatives described in the economic impacts section, especially those leading to more efficient use of water have environmental benefits through conserving water and preventing harmful effects of overuse, waste and flooding. The formation of the federations has also led to the realization of a total view of the water resource in the area including ground water, therefore the need for controlling overexploitation and making a more efficient and equitable use of the water.

The WUA in the village Pimpalnare in Maharashtra is attempting to reduce the electricity consumption in water pumping by harness wind power. It has a good location with high hills right besides the village. The WUA has contacted the company Suzlon energy for this and is trying to work out how to handle the costs.

8.3 Communication and dissemination activities

The project proper culminated in several important dissemination activities. Two workshops were initially conducted in India – one in Ahmedabad and another in Delhi. The workshops in India comprised representatives from the federal Government, State governments, Farmer Representatives, Canal Co-operative delegates, Australian Government agencies (e.g. DAFF), Co-operative Research Institutes, Universities and NGOs. A summary list was provided in the project review documentation. In addition to these workshops numerous publications were produced and other conferences have been used to disseminate results.

The extension of the project provided additional dissemination opportunities.

Vasant Gandhi was appointed a member of "Task Force on Irrigation" of the Planning Commission of India in 2008, formed on the direction of the Prime Minister. As a part of the Task Force, he participated in many high level meetings with senior government official and irrigation experts, and had many opportunities to share the findings of the project.

The Project Reviewer for the initial phase made the following observations about the publications emanating from this work:

"The number of publication arising from the project is too large to list in its entirety. This selection indicates the breadth of topics covered and publication outlets.

Gandhi, Vasant P. and Shingi, P.M. 2004, 'Designing a Suitable Institutional Organizational Structure for Implementing the Programme on Interlinking of Rivers', Task Force on Interlinking of Rivers, Ministry of Water Resources, Government of India, Delhi.

Gandhi, Vasant P. and N.V. Namboodiri, 2008, "Evaluation of Participatory Irrigation Management in India: Study of Andhra Pradesh, Gujarat and Maharashtra", Centre for Management in Agriculture, Indian Institute of Management, Ahmedabad.

Gandhi, Vasant, Lin Crase, and Gamini Herath, 2007 "Determinants of Institutional Success for Water in India: Results from a Study across Three States", Paper presented

at the 51st Annual Conference of the Australian Agricultural and Resource Economics Society (AARES), February 13-16, 2007, Queenstown, New Zealand.

Gandhi, Vasant, Lin Crase, and Gamini Herath, 2006, "Comparing Indian Irrigation Institutions: What Determines Institutional Behaviour and Performance? Preliminary Empirical Observations", Paper presented at the 50th Annual Conference of the Australian Agricultural and Resource Economics Society (AARES), February 8-10, 2006, Sydney, Australia

Herath, G. and Mokhtarul, W. 2005, 'Institutional Economics Approach to Irrigation Management: the Case of Developing Asia, COE/JAPA Joint International Conference, Kobe.

McKay, J. and Halanaik, D. 2003, 'New Directions and National Leadership in Developing Water Policies in Federations: India and Australia', 11th World Water Congress of the International Water Resources Association, Madrid.

Pagan, P. and Crase, L. 2005. 'Property Rights Effects on the Adaptive Management of Australian Water Resources', *Australasian Journal of Environmental Management*, 12 (2), 77-88.

Task Force on Irrigation - Sub Group, 2008 "Report on Raising Financial Resources for Irrigation Projects", National Bank for Agriculture and Rural Development, Mumbai, September 2008.

Task Force on Irrigation - Sub Group, 2008, "Report on Efficient Utilization of Existing Irrigation Facilities", Ministry of Water Resources, Government of India, New Delhi, December 2008.

Other notable publications include:

Keremane G and McKay 2006 'Self created rules and conflict Management Processes; The case of Water users' Associations on Waghad Canal in Maharashtra, India', *Water Resources Development*, 22 (4), 543-559.

It goes without saying that the most substantial publication from the work is the book manuscript itself:

Crise, L. & Gandhi, V. (ed.) 2009. *Reforming Institutions in Water Resource Management: Policy and Performance for Sustainable Development*, Earthscan Publishing, London

9 Conclusions and recommendations

At the time of inception, this project represented somewhat of a deviation from the form of research conventionally sponsored by ACIAR. Institutional economics, although well established in other settings, had not always been readily embraced as a means of considering and dealing with agricultural poverty and hardship. However, as this project has demonstrated, institutions are at least as important as engineering structures or new technologies when it comes to irrigation.

9.1 Conclusions

The project highlights the need for addressing institutional deficiencies in irrigation in India. In particular, the findings highlight the fact that, without attention to the detail of institutions, the impacts of water reform are substantially weakened. In this regard it is important to assist policy makers and advisers to consider these issues as they attempt to modify the rules by which water use is governed. The observed differences between successful and less successful institutions, and the specific identification of the underlying causal features suggests that it is possible to improve and develop successful water institutions in most settings.

9.2 Recommendations

Detailed analysis of specific instances of water institutions should follow. This would allow for the refinement of the theoretical and empirical techniques developed here but importantly, it would also allow for a more sophisticated analysis of institutional interactions. For example, an analysis focussing on the interrelationships that attend national programs like Watershed Development could provide a substantial boost to Indian agriculture and the well-being of those who rely on it.

10 References

10.1 References cited in report

Covered in the forthcoming book:

Cruse, L. & Gandhi, V. (ed.) 2009. *Reforming Institutions in Water Resource Management: Policy and Performance for Sustainable Development*, Earthscan Publishing, London

10.2 List of publications produced by project

The major piece of work emanating from the project is:

Cruse, L. & Gandhi, V. (ed.) 2009. *Reforming Institutions in Water Resource Management: Policy and Performance for Sustainable Development*, Earthscan Publishing, London

In addition, a range of journal articles have been informed by and informed the project some of these were noted earlier but a more extensive list appears below:

Ananda, J., Cruse, L. & Pagan, P.G. 2006 "A Preliminary Assessment of Water Institutions in India: An Institutional Design Perspective", *Review of Policy Research*, Vol. 23, No. 4, pp. 927-953

Cruse, L. (ed.) 2008. *Water Policy in Australia: The Impact of Change and Uncertainty, Resources for the Future*, Washington

Cruse, L. & O'Keefe, S. 2009, "The Paradox of National Water Savings", *Agenda* (forthcoming)

Cruse, L., O'Keefe, S. & Dollery, B. 2008. "Can Urban Water Markets Work? Some Concerns", *Agenda*, Vol. 15, No. 3, pp. 73-82

Cruse, L., Dollery, B. & Byrnes, J. 2008. "An Inter-Sectoral Comparison of Australian Water Reforms", *Water Policy*, Vol. 10, pp. 43-56

Cruse, L., Byrnes, J. & Dollery, B. 2007. "The Political Economy of Urban-Rural Water Trade", *Public Policy*, Vol. 2, No. 2, pp. 130-140

Cruse, L. & Dollery, B. 2006, "Water Rights: A Comparison of the Impacts of Urban and Irrigation Reforms in Australia", *Australian Journal of Agricultural and Resource Economics*, Vol. 50, No. 3, pp. 451-462

Cruse, L. & Dollery, B. 2005, "The Inter-Sectoral Implications of 'Securing Our Water Future Together'", *International Journal of Environmental, Cultural, Economic and Social Sustainability*, Vol. 1, No. 5, pp. 13-22

Cruse, L. Dollery, B. & Wallis, J. 2005, "Conceptualising Community Consultation in Public Policy Formulation: The Case of the Living Murray Debate in the Murray-Darling Basin of Australia", *Australian Journal of Political Science*, Vol. 40, No 2, pp. 221-237

Pagan, P. & Cruse, L. 2005, "Property Right Effects on the Adaptive Management of Australian Water Resources", *Australasian Journal of Environmental Management*, Vol. 12, No. 2. pp. 77-88

Cruse, L., Pagan, P. & Dollery, B. 2004, "Water Markets as a Vehicle for Reforming Water Resource Allocation in the Murray-Darling Basin", *Water Resources Research*, Vol. 40, pp. 1-10

Gandhi, Vasant P. "Rural Infrastructure and Growth: Rapporteur's Report", *Indian Journal of Agricultural Economics*, Vol.61, No.3, July-Sept, 2006.