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SUSTAINABLE GROUNDWATER IRRIGATION TECHNOLOGY MANAGEMENT WITHIN AND BETWEEN THE PUBLIC AND PRIVATE SECTORS

Guidelines of good practice, based on the experiences of Bangladesh and Pakistan

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REFERENCE MANUAL

CONCLUSIONS AND RECOMMENDATIONS

Findings of DFID funded research project (R6877) on 'Technology Transfer and Sustainable Rural Development' to develop guidelines of good practice for (a) technology transfer in relation to the full or partial transfer of tubewell irrigation from the public to the private sector, and (b) associated rural development, 1997-1999.

REFERENCE MANUAL - RESEARCH CONCLUSIONS AND RECOMMENDATIONS

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1. INTRODUCTION

This section will consider the main conclusions which have been drawn from the research and make proposals for possible ways of supporting groundwater irrigation as it is transferred from government to the private sector, as it operates in the private sector, and, indeed, some recommendations for priorities within the public sector.

Many of the conclusions which have been drawn from evaluation of groundwater irrigation in the sub-continent are common to each country. However, given the different administrative characteristics of each country, some of the proposals will be country specific.

2. RESEARCH CONCLUSIONS

From the research carried out in support of these guidelines, there are general conclusions which can be drawn about the development of private sector irrigation as well as more specific conclusions relating to the technical, economic and management aspects. The main general conclusions are shown in Box 1 and relate to features about the private sector's abilities in groundwater irrigation, support for the private sector, and motives for transfer to the private sector.

The more specific conclusions relating to the three perspectives from which groundwater irrigation has been looked at are shown in Box 2, for the technical aspects, Box 3 for the economic aspects and Box 4 for the management aspects. The guidelines are seeking to improve groundwater irrigation and, therefore, do focus upon imperfections. However, the great success of the private sector in getting water from the ground into the field is acknowledged and complimented.

Box 1: General conclusions from research for guidelines

1. The private sector has proved itself to be an extremely dynamic and innovative force in the development of groundwater, as shown by the enormous growth in the number of private wells in the last fifteen to twenty years. This has been achieved through initiatives such as:
   - designing and manufacturing cheap copies of imported equipment,
   - modifying technology to suit local conditions,
   - creation of companies to manage larger technologies and command areas,
   - development of second-hand deep tubewell markets.
2. Much of the development of private sector irrigation has come through the initiative of the private sector alone, with little or no direct assistance from outside (except for macro-economic policies such as the removal of duties on imported equipment).
3. There still exists little support for the private sector. The private sector largely operates within a technology and administrative vacuum.
4. Many initiatives to transfer groundwater irrigation from the public to private sector have not been particularly successful in terms of sustainability, either because:
   - the technology was unsuitable for the context or for private sector management,
   - the reason for transfer was not conducive to successful transfer (many wells appear to have been or are being transferred for the purpose of Government disengagement for cost cutting reasons, rather than for positive privatisation reasons of greater flexibility, initiative, profit and development for and through the private sector).
   - subsidies were made available at the point of transfer and many farmers groups appear to have formed for the purpose of getting the subsidy alone.
   - support services for privatised irrigation were generally not in place.
5. There are cases where economic benefits outweigh financial benefits and where economic cost/benefit analyses show positive returns where financial cost/benefit analyses show a loss. This is particularly the case in areas which are 'difficult or depressed'. In these cases, the priority should be given to introduce measures to maximise returns to investment rather than transferring ownership and management. There are examples of successful cost recovery programmes in the public sector which, whilst not greatly contributing to capital costs at least more than cover annual O&M and overhead costs. It is the recurring costs and their drain on national financial resources, rather than the capital costs which are often cited as the main reason/need for disengagement of the public sector from involvement in irrigation.
6. Groundwater irrigation, and its transfer, has often been treated in isolation without due consideration of all irrigated agricultural issues. Irrigated agriculture requires major investment for all concerned, whether it is for a treadle pump for the poorest, or a high horse power submersible pump for the wealthier. It also requires major investment in inputs. However, the output price is highly volatile and unpredictable, making this investment a high risk investment. Issues such as marketing, storage and financial support for groundwater irrigation or often not given appropriate attention.

Box 2: Technical conclusions from research for guidelines

A: Within the private sector

1. Much of the success of the private sector has been through simple copying of imported technologies without a thorough understanding of what the technology is doing and the role of each of the components. Comment views expressed are that:

   'if a pump is getting water out of the ground it is doing what it is designed to do'

   'more discharge is only achieved through more input of power'.
2. There are many inadequacies in the design, manufacture, selection, installation and operation of groundwater irrigation technologies throughout the sub-continent. These technologies include all components (well, pump, prime mover and distribution system).
3. These inadequacies result from a lack of basic groundwater and abstraction technology knowledge on the part of most agencies involved in groundwater irrigation, including equipment manufacturers, distributors, misteries, farmers, credit suppliers and NGOs.
4. Much of the knowledge that did exist was in the public sector, for expensive, large technologies, and has been largely lost with the reduction or removal of public sector support for groundwater irrigation.
5. There is a shortage of detailed information on the relative performance of the different technologies and on the suitability of technology matches for different situations.
6. These inadequacies and shortages of information have led to irrigation which is water and fuel inefficient.
7. The efficiency of groundwater irrigation can be improved dramatically, since the inadequacies and lack of information are features which can be improved.
8. The cost of improving these shortcomings is not prohibitive.

B: During transfer to the private sector

1. The transfer of technology has usually been seen as a one-off step. All consequent responsibilities for technology maintenance, repair and replacement is left to the transferees who have little or no experience of these aspects of irrigation management.
2. The technology being transferred has often been under public sector control for many years and showing signs of wear and tear.
3. The support services for groundwater irrigation have often disappeared with the transfer of the technology, without ensuring that some form of support for the transferred technology has been created in the private sector.
4. In addition, no form of practical national, provincial or regional co-ordination has been in place to regulate, oversee or implement policy in groundwater irrigation.

Box 3: Economic conclusions from research for guidelines

A: Within the private sector

Costs

1. Of all the costs involved in groundwater irrigation, those which have the greatest potential for being reduced are for submersible pumps and energy costs.

   Submersible pumps in Bangladesh are still imported but in Pakistan the impellers are made locally and the motors come cheaply from Russia. As a consequence, this technology is cheaper in Pakistan than Bangladesh.

   Energy costs are a high percentage of total costs, often in the region of 85% of operating costs and often more that 50% of capital costs for suction mode technologies. Energy costs comprise two elements - price and volume consumed. Farmers are very much aware of the costs but usually complain about price. Volume consumed is the element which has most potential to be reduced, through relatively simple modifications.

Payment for irrigation

2. Farmers in Bangladesh pay considerably more for groundwater irrigation they do in Pakistan. Yields of basic commodities are also much higher in Bangladesh than Pakistan, though land ownership is much smaller..
3. The most successful systems of payment for groundwater irrigation are on a pay-as-you-use basis, usually hourly. This cuts out the need for (i) large capital cash payments which place great financial burdens on the consumers and increase the risk of defaulting, and (ii) share crop arrangements which are difficult to police, place demands on storage and vary greatly in value depending upon market price.
4. Payment on a pay-as-you-use basis performs well either with cash where single wells are involved or through the use of coupons where one supplier owning many wells sells water to many customers.

Financing irrigation

4. Very little financial support for private sector irrigation is available from the financial institutions. This is mainly because of the dreadful history of outstanding debts and defaulting in irrigated agriculture. This is mainly due to:

   - previous situations where debtors have been absolved of repayment responsibilities for bad debts by government, thus leaving creditors cautious of investing.
   - the high risk of investment, given the volatility of output prices, the relatively high investment for micro-credit, and the unpredictability of weather and its impacts upon production, meaning that income is not guaranteed;
   - the long interval between investment and return. Most investors require weekly repayments but agriculture sees no return until harvest. Long term credit is in very short supply.

B: During transfer to the private sector

1. Set terms and conditions have usually been imposed upon individuals and groups encouraged to take over the well, whatever their circumstances. Little or no flexibility has been shown, although this has increased in the more recent transfer projects.
2. Incentives and subsidies have often been provided at the point of transfer. This results in two features:

   (i) farmers' groups form and organise primarily to get the subsidy, and

   (ii) it suggests that the true cost of the technology is beyond the means of the farmers themselves and that maybe they therefore should not be taking over this technology.

Box 4: Management conclusions from research for guidelines

A: Project management

1. Better results are achieved where the project sells water to the farmers as individual customers, whatever the basis of payment.
2. Staff incentive and penalty schemes appear to succeed, but incentives and penalties must be paid and enforced respectively.
3. Continuous training, as in any corporation appears to provide results.
4. Success is more likely where project staff are close to the community, either visiting very frequently or living with or close to the communities concerned.
5. Success is more likely where project staff are kept busy, leaving less time to consider less productive financial issues.
6. Detailed and frequently updated information on the project, the technology and the customers is important, as is analysing the information and acting upon results.
7. Success is very much due to a two way carrying out of duties and responsibilities and must not be compromised whatever the pressure, i.e. suppliers must keep equipment operating, particularly during the peak season, but only in response to payment. If farmers feel that they can get away with non-payment then they will.
8. Success in cost-recovery and profitability is improved if additional features relating to irrigated agriculture are included, such as input supply, credit facilities, marketing facilities and transport to markets. Indeed these additional functions may either make the difference between profit and loss and may be more profitable enterprises than only sale of water.

B: Well management

1. Well management units perform better when kept small - greater numbers of committee members increase confusion and conflict. Creating a seller/buyer management system appears to increase the chances of successful operation, i.e. where the committee are the sellers and the remaining farmers the buyers.
2. A mixture of small, medium and large farmers enables wealthier farmers to dominate at the expense of poorer farmers.
3. Financial commitment should preferably be significant, according to land-holding size and not easy to relinquish. Well owning organisations where it is easy for members to join and leave have a far higher rate of failure than those where it is difficult to join and leave.

C: During transfer to the private sector

1. Changing from a government to a private management system is time-consuming and problematic, especially if previous payment for water has not been enforced. Time should be given for this process and there should be long term back-up post-transfer.
2. A flexible approach appears to be more successful, since no two groups are the same and no two circumstances are the same. Farmers should be consulted about the best way ahead and if ideas are not forthcoming, then a series of ideas should be shared and the farmers given the choice of the way ahead.
3. Addressing all aspects of irrigated agriculture, not just the irrigation technology in isolation, appears to improve performance.
4. Continuing backup and support is often lacking and this decreases of changes of success and sustainability. This should either be provided by the government, or the government should ensure that the private sector is developed to support the projects which have been transferred. Individuals or groups new to well ownership or management should not be left alone to find their way.

3. SUGGESTED PRIORITIES IDENTIFIED THROUGH RESEARCH

The priority action points identified from the research, take the same form as the conclusions, i.e. general, technical, economic and management. Given the different nature of national irrigation management and institutions both common and country specific proposals will be made where appropriate. It is simpler to identify the specific issues relating to technology, economics and management first and then to consider the overall co-ordination and management afterwards, since the overall management function will be a composition of the individual functions.

3.1 Technical priorities

There are clear but different technical priorities for suction mode technologies and for force mode technologies, so these will be dealt with separately.

3.1.1 Suction mode technologies

In all sub-continent countries the technical inefficiencies, and possible improvements of the situation are similar. Regarding the suction mode technologies used within the private sector and being introduced as part of transfer of groundwater irrigation to the private sector, it is commonly understood that there are great water and fuel inefficiencies leading to great wastage of water and fuel and decreased profitability of irrigation. This understanding is based upon a series of small-scale, site specific analyses of pumping equipment. However, the nature and scale of the inefficiencies for the different technologies and products is far from understood. It is strongly recommended that attempts should be made to understand the technical assets in the private sector as a first step, see Box 5.

This information is extremely useful for policy, planning and practical advice, as illustrated by the success and use of the National Minor Irrigation Census carried out by the National Minor Irrigation Development Project (NMIDP) in Bangladesh.

Box 5: Priorities for private sector groundwater irrigation technologies asset surveys and technology assessment of technology requirements

- **Carry out asset surveys/inventories of as many locally made pumps and locally made/imported diesel engines as possible. Pump and engine efficiencies, and pump performance curves, should be established. Pump test facilities exist in both Bangladesh and Pakistan.**
- **As part of the asset surveys/inventories, the technical reasons for higher/lower efficiencies should be identified where possible.**
- **Preferred operating conditions and pump/prime mover combinations should be identified for a variety of aquifer conditions (primarily static water level, specific drawdown) and water requirements.**
- **Monitoring of aquifer conditions and dissemination of this information through networks such as dealers or extension services is an important consideration.**
- The surveys should be carried out by an independent body, such as a research organisation, preferably with entirely independent overseas technical assistance or monitoring.

Work on improving standards of equipment cannot properly begin until the information above is available. Without this information, efforts at improvement may be misdirected. Once this information is available the priority should be to work both with the farmers and with equipment manufacturers and dealers. The NMIDP has set up a database of manufacturers and dealers known as the Private Sector Network in Bangladesh and carried out a Knowledge, Attitudes and Practice survey of a sample of dealers. This again is a valuable source of data for policy, planning and implementation. A similar exercise for Pakistan is encouraged.

All parties involved in the support and practice of groundwater irrigation (manufacturers, dealers, NGOs, trainers, misteries, Extension Departments) should then be provided with the results of the asset survey and recommendations for technology combinations for given conditions.

Many of the technical guidelines included in this publication will be strongly resisted by the farmers and the technical support for the farmers (misteries and dealers), because they go against their firmest convictions held ever since the technology was introduced. The priority for these guidelines is demonstration rather than information. Details of these priority and an example of the problems faced are shown in Box 6.

Box 6: Priorities for methods of communicating technical guidelines, asset survey and technical requirements assessment

An example of the problems likely to faced in implementing guidelines

- The strongest example concerns the operating temperatures of diesel engines. Farmers are extremely wary of hot engines and will do all possible to keep the engines cool. Despite the fact that engines are designed to operate at a water cooling temperature of 80-85°C farmers maintain a free flow of water through the engine providing them with water coolant temperatures of 30-40°C. This increases fuel consumption and shortens the life of the engine.
- The Water Resources Research Institute in Pakistan have tried to explain to farmers, on an informal basis, that keeping the engines too cool is in fact damaging the engine and raising costs. They have tried to demonstrate this through showing them car engines, showing the sealed water cooling system and showing the heat of the water. The link between their diesel engines and car engines is not made by the farmers and strong scepticism remains.

Priority for increased success of guideline communication

1. Through the farmers - demand led

- **The priority method for communicating the technical guidelines and the results of the asset survey and technical requirements assessment should be by demonstration, based on the premise that 'seeing is believing'.**
- **Given the history of the spread of private groundwater irrigation and of technologies for the same, only a few farmers and misteries need to be convinced of the benefits of the technical improvements suggested. These should be targeted, convinced and, once they are operating the pump system as it preferably should be, their operating procedures and costs perhaps should be displayed on a board beside their well. Once other farmers see the reduction in costs they will be quick to want to know why. (More detail on this in the economics priorities below).**

2. Through the manufacturers, dealers and misteries - supply led

- **Those manufacturers who perform well in the asset survey and have equipment that is geared to low cost and prolonged operation should be encouraged and supported to advertise and demonstrate, as above (and through dealers and misteries), the technical and financial benefits of their products. Certification of their products would help.**
- **For those manufacturers who do not perform well in the asset survey, the benefits to them of creating and demonstrating more efficient pumping systems (not a big job and not requiring wholesale redesign of their product) should be strongly argued and demonstrated.**

3.1.2 Force mode technoogies

In both Bangladesh and Pakistan there has been considerable criticism of many of the deep tubewell programmes with respect to their environmental impacts and management difficulties. However, in their defence, it should be remembered that:

- these technologies were installed before the major growth of suction mode technologies for groundwater irrigation in both countries. It is the growth of the suction mode technologies, along with population growth and subsequent impacts on land ownership patterns, that has increased the pressure on the manageability of force mode technologies.
- many of these wells are still being used successfully.

- whilst many wells do face problems and may not be suitable in many contexts, nor may they be the ideal technology for many private water buyers or sellers, the force mode wells represent a considerable technical asset for each nation. At present a significant proportion of this asset is not being used.

The technical priorities for force mode technologies are highlighted in Box 7. The technologies tend to be of a higher technical standard than the suction mode technologies, and performance information is usually available for this technology. Therefore, the priorities relate more to what to do with these major technical assets.

Box 7: Priorities for force mode technologies

- **There is a growing second-hand deep tubewell market in Bangladesh. Individuals or groups close to major population centres or growing valuable crops are interested in purchasing force mode technologies. This is very much in the informal private sector and is restricted by the unclear ownership status of some wells and reluctance of some government officials to release ownership rights of the wells. This market should be looked at and support should be given for private sector purchase of what may otherwise be redundant assets.**
- **Where force mode technologies are being removed and replaced by suction mode technologies as part of transfer to the private sector (as in the case of the Punjab Private Sector Development Project), these need to be, and can be, re-used effectively elsewhere. The assets should not be allowed to deteriorate and become unusable. They may either be used for other projects or the technology could be auctioned. The prime movers in particular can be used for many purposes outside of irrigation as well as for pumping.**

3.2 Economic priorities

The profitability and, hence, sustainability in the private sector, of groundwater irrigation is determined by two factors - the cost of irrigation and the income from irrigated agriculture. There are priorities attached to both these sides of the equation in support of private and privatised groundwater irrigation. In addition, the affordability of groundwater irrigation affects (i) the number of farmers who are able to take advantage of the benefits of irrigated agriculture, and (ii) total agricultural output in countries where food is often in short supply . There are priorities attached to improving the financing of private sector and privatised irrigation.

3.2.1 Costs of groundwater irrigation

The technical priorities for private sector irrigation illustrated in the guidelines and in the priorities above lead to significant savings in total costs. Farmers are interested in getting water to the surface at least cost. They therefore seek equipment at least cost and complain bitterly when the cost of energy increases. However, they can make changes to reduce costs considerably, they just don't know how to yet. Cost streams and cost:benefit ratios can be difficult concepts to grasp when capital is in short supply and each individual season is a priority. Long term financial planning for the average farmer is extremely difficult. However, given the high operating (energy) costs as a proportion of capital costs (operating costs anything from 25% to 95% of capital costs) this concept is almost unnecessary. Rather, just the capital costs and operating costs for technically efficient systems may be demonstrated, see Box 8.

Box 8: Priorities in communicating economic guidelines for private sector tubewells

- **After identifying and/or developing more efficient technology options and operating techniques and selecting farmers willing to use more efficient technologies and operating techniques, boards should be placed near the well to illustrate the technology and operating techniques used, and the capital and recurrent costs incurred. Given the large savings that can be generated by improvements in the technology, farmers would be extremely interested and ideas would spread quickly by word of mouth.**
- **Indeed, the boards need say not much more than:**

  Well cost **Pump cost** **Engine cost**

  Fuel consumption per hour:

  Hours run: **Running cost:**

  These figures alone would suffice, with farmers asking how these improvements were made.
- **These are ideas which should be raised with the larger manufacturers and the manufacturing associations.**

3.2.2 Income from groundwater irrigation

The profitability of groundwater irrigation is also affected enormously by fluctuations in output prices. Farmers usually follow market prices and grow whatever is high in price in the previous season. For example, winter irrigated rice (boro) in Bangladesh has been heavily produced this year in response to the high prices following the heavy monsoon and flooding of 1998. As a consequence, rice prices

at harvest time for boro are almost half of what they were at the start of the season and many farmers are currently making losses on irrigated agriculture. The farmers face additional problems in that they must sell at harvest because many have debts to pay, and even if they do not have large debts (or are able to reschedule debts) most farmers do not have storage facilities available. The 'middle men' are able to buy cheaply, store and sell as and when the price rises.

Priorities for increasing income from groundwater irrigated agriculture are summarised in Box 9.

Box 9: Priorities for increasing groundwater irrigated agriculture income

- **Fluctuations in output prices need to be controlled more effectively by Governments through their intervention price setting. Market prices often follow these prices, though at a slightly higher level.**
- **Opportunities, advice and finance for crop storage should be looked at closely by Extension Services and NGOs involved in agriculture in general and irrigated agriculture in particular.**
- **Credit arrangements need to allow scope for farmers to delay repayment until sale at greater profit, through longer credit payback periods.**

3.2.3 Financing groundwater irrigation

There are two main aspects of finance for groundwater irrigation, relating to the private sector and the public sector. These guidelines do not attempt to advocate which sector particular developments of new groundwater irrigation projects should occur in, or whether transfer is preferable or not. They just seek to give guidance on issues at the point of transfer and advice on good practice following transfer. However, it should not be the case that the private sector should be seen as the panacea for failings within the public sector, particularly in those 'difficult and depressed' areas where economic returns outweigh financial returns. Therefore, certain priorities for the public sector, identified during the research, will also be included.

Private sector

As described in the economics guidelines, the outstanding debts linked to irrigated agriculture, particularly in Bangladesh, are considerable, and reflect general shortcomings in finance for groundwater irrigation thus far. The private banks

have had their fingers burned badly in the past and are reluctant to get heavily involved again. The priorities for financing groundwater irrigation are summarised in Box 10 and relate mainly to types and processes of financing.

Box 10: Priorities for financing private sector groundwater irrigation

- **Procedures for credit application from banks need to be examined and simplified.**
- **NGO credit needs to be closely supervised and flexible and extended repayment terms developed which suit the farmer more.**
- **Institutions loaning money for groundwater irrigation can improve the quality of irrigation equipment by only providing loans for approved technology and overseeing correct installation, indeed by appointing or recruiting their own technicians.**
- **More attention should be given by lending agencies to the farmers' overall needs rather than simply loaning for equipment.**
- **Capital generating schemes such as rotating savings and credit associations (ROSCAs) popular in urban areas and other sectors should be further investigated as a potential source of financing, particularly NGOs who are well placed to manage them.**

Public sector

In areas where economic returns to capital investment are available then the financing of operation and maintenance of publicly run wells through effective cost recovery is a major priority. Methods of increasing income and reducing 'leakage' of money from the cost recovery system have been proposed in the economic guidelines. A further priority for investigation is that of taking staff salaries off the central government revenue budget and making the project/project staff wholly responsible for covering their salaries through project revenue collection. This could be further enhanced by incentive and penalty schemes, including the removal of guaranteed employment status and creating employment packages closer in nature to those of the private sector.

3.3 Management priorities

Management priorities relate both to project management (in current status or during transfer of ownership and/or management) and to individual well management.

3.3.1 Project management

Suggested priorities in project management relate to direct management of water

supply and to support for groundwater irrigated agriculture as a whole, see Box 11.

Box 11: Priorities for groundwater irrigation project management

Direct management of water supply

- **There are many cases, particularly in publicly run projects, where revenues are paid by the individual farmers but there is considerable leakage of money between farmer payment and project receipt. Ways of reducing leakage in the cost-recovery system are a priority. The most successful projects are where each irrigator is an individual customer with an individual contract with the supplier (project).**
- **Conflict and refusal to pay is often as a consequence of poor performance in water supply. Projects should consider their responsibilities for this and make it a priority. It is surely entirely reasonable that customers should refuse to pay for poor service.**
- **Management of staff and farmers' organisations in both of the above is a priority. It is the staff in the field who are largely responsible for the successful carrying out of both the above and they need project support, incentives and discipline where necessary.**
- **Projects should also look at the type of staff they have and they recruit. Government projects are traditionally staffed by engineers but much of the engineering function in these projects has gone. For many engineers the management and support function of on-going projects is unchallenging and unsatisfying and motivation is a major problem.**

Management of support for groundwater irrigation

- **Projects should look for ways in which added value can be derived from irrigated agriculture through supply of quality inputs, training, storage and marketing.**
- **Projects should consider functions such as monitoring and storage, processing and reporting of data.**

Management of transfer of groundwater irrigation

- **The role and use of subsidies at the point of transfer should be seriously examined and the motives of farmers in the formation of groups to receive the technology closely scrutinised.**
- **Potential transferees should be surveyed and consulted, perhaps through rapid or participatory rural appraisal, to understand the motives and mechanisms in their community. This is something which has begun to be addressed by some of the newer irrigation projects. If transfer is for disengagement reasons, then this issue is not important, but if transfer is about positive development of the sector under the private sector, then the transferees need to be understood, consulted and respect for their wishes accounted for.**
- **The support for transferred projects should continue well beyond the point of transfer if the projects are to be successful. 'Second generation' problems often occur and support is vital for sustainability.**

for details. Regarding direct management of water supply there are two main suggested priorities: (i) management for maximising returns from provision of irrigation water, and (ii) and management for providing reliable irrigation water. These are not new priorities but the research for the guidelines has reinforced the need for these issues to be examined and addressed. There are projects which do succeed in managing these issues (see management guidelines) and much that can be learned from them.

3.3.2 Well management

The most successfully operated wells surveyed during the research were those where no group were in power (i.e. where farmers and water suppliers had individual contracts) or where a small but powerful farmers' organisation group acted as seller and the remaining farmers acted as buyer. These systems were not perfect but performance was improved on those wells with large committees where there was greater scope for conflict and lack of co-operation. Farmers, like most people, are not particularly communal in practice, even if holding communal beliefs in theory and tighter, clearly defined management systems and seller/buyer roles appear to result in more successfully managed wells. Examining this further is seen as a well management priority.

In areas where groundwater irrigation is carried out as supplementary to surface water irrigation, using the same large conveyance system often results in a reinforcement of the management and distribution problems (particularly of head/tail canal conflicts) encountered in the larger irrigation system. One way of potentially overcoming this is to consider separating the groundwater irrigation conveyance system from the surface water system and hence redefining the groundwater irrigation command area. It is recognised that this is a controversial and problematic concept in Pakistan but, nevertheless, one that should be considered.

3.4 Overall priorities

In neither Bangladesh nor Pakistan does a co-ordinating agency exist. There are many functions currently carried out by individual organisations but there is no agency which keeps abreast of all issues and co-ordinates support for groundwater irrigation, whether in the public or private sector. The private sector has

developed largely in isolation with little regulation, overseeing or support. Possible solutions to, and structures for, this for Bangladesh and Pakistan are laid out below. These are only suggestions designed to promote thought and debate about this important issue.

The main functions to be carried out in support of groundwater irrigation are:

- implementation
  - project management
  - design, manufacture, installation, distribution, repair and maintenance
- monitoring
  - groundwater levels and quality
  - technology use, developments and performance
  - energy supply, use and pricing
  - input/output performance and prices
- regulation
  - control of groundwater irrigation in areas with water resource problems, both quantity and quality
- research
  - technical/social/economic
- dissemination
  - provision of regular information on results of monitoring and research to public and private sector
- training
  - technical/social/economic
- finance
  - credit delivery and recovery
- policy advice
  - to government, international funding agencies and private sector

Much of this is currently being carried out in both Bangladesh and Pakistan but more needs to be done and the work needs to be co-ordinated since much of the work is done in isolation. It became clear during the research for the guidelines, that many organisations involved in groundwater irrigation had little idea of what was being done elsewhere in the country or of the wider issues in the field in which they were working.

The prime function of such an agency in either country would be to monitor, inform and advise, and it would not necessarily have any regulatory powers but would make recommendations for policy or regulation to the relevant authorities. Separating out to individual organisations (public or private) the technical, economic and management functions for the priorities listed and agreed upon would seem to be appropriate.

3.4.1 Bangladesh

In Bangladesh the main functions listed above are currently being carried out

principally by the public and private sector institutions shown below in Box 12. There are gaps in the delivery of functions, particularly research, monitoring and demonstration of technology developments, monitoring of energy and all agricultural input and output issues. There is also no agency which co-ordinates and disseminates the information coming from these functions. There is a clear need for co-ordination and for gaps in support for groundwater irrigation to be filled.

The agency would not necessarily be large, since much of the practical work in support of the functions is already carried out but it would need (i) locally based staff to monitor and collect data from the field, and (ii) highly skilled management staff, staff skilled in the art and methods of communication and an understanding of irrigated agriculture and associated technology, and database managers. This could be an autonomous government agency, a publicly funded private/independent agency or an agency managed by an advisory board comprising members from institutions for each of the functions. Of the existing institutions which could possibly take on the role on their own, the best placed would be the Irrigation Wing in DAE, the Rural Development Academy at Bogra (since they already have links with many of the institutions involved and are involved in research and training) or WARPO.

Box 12: Institutions performing support functions for groundwater irrigation in Bangladesh

• implementation	- project management	BMDA, BWDB, GKF
	- design, manufacture, installation, distribution, repair and maintenance	Private sector either independent or contracted under public projects
• monitoring	- groundwater levels and quality	BWDB, DPHE
	- technology use, developments and performance	NMIDP, RDA
	- energy supply, use and pricing	-
	- input/output performance and prices	-
• research	- technical/social/economic	RDA, BARD, BARI, BRRI, BARC, BIDS
• dissemination	- provide regular information on results of monitoring and research to public and private sector	NEMIP, NMIDP (to a limited extent and on a finite basis)
• training	- technical/social/economic	Irrigation Wing, DAE, RDA, BARD, GKF, Proshika, RDRS, BRAC
• finance	- public sector funding	MoA, Planning Commission
	- credit delivery and recovery	Banks, NGOs

• policy advice	- to government, international funding agencies and private sector	National Water Management Plan (through WARPO)	

However, the f unctions cut across existing Government Departments and responsibilities and for any Government agency to take control would be complex and likely to cause problems. An independent agency would be preferable. Much criticism was made of NMIDP but the project did a great deal of useful research and data collection, linking with other organisations, and with a clear mandate a similar, though permanent, agency could be best placed to perform this function. Such an agency should perhaps start small, with a few clear priorities, and be allowed to grow as and when appropriate.

The issues of co-ordination and dissemination are somewhat eased by networks which have already been created in several sectors, for example, the national association of NGOs, the Bogra Metal Engineers and Entrepreneurs Group, the trade associations set up under NMIDP, and the National Association of Small and Cottage Industries of Bangladesh.

As for several of the individual technical, economic and management priorities, some of these are being, and could perhaps further be, addressed by (i) existing projects, such as the National Water Management Plan and the North East Minor Irrigation Project, (ii) relatively small internationally funded projects with technical assistance.

3.4.2 Pakistan

Despite the greatly different context of groundwater irrigation, and administration of irrigation in general, in Pakistan, the pattern of supply and lack of supply of functions is fairly similar, as shown in Box 13 below. In addition, as with Bangladesh, there is no overall agency to create a well-informed, co-ordinated groundwater irrigation sector.

As with Bangladesh there is a need for an agency to develop, oversee and co-ordinate the functions and institutions set above on a national and provincial basis. This again is probably best as some kind of autonomous/independent agency which does not fall under any one ministerial department but which draws information from, and disseminates information to, all relevant departments and private sector agencies. The Water Resources Research Institute is one such agency. They are

already involved, both informally and formally, in working with many of the agencies listed above and in many of the activities highlighted in the guidelines.

Box 13: Institutions performing support functions for groundwater irrigation in Pakistan

• implementation	- project management	PIDs, OFWM, PPSGDP, PATA, NDP
	- design, manufacture, installation, distribution, repair and maintenance	Private sector either independent or contracted under public projects
• monitoring	- groundwater levels and quality	SMO
	- technology use, developments and performance	-
	- energy supply, use and pricing	Enercon
	- input/output performance and prices	-
• research	- technical/social/economic	IWMI, WRRI, RRI, IWASRI, PARC
• dissemination	- provide regular information on results of monitoring and research to public and private sector	OFWM, IWASRI, WRRI
• training	- technical/social/economic	AED, projects, research institutes
• finance	- public sector funding	
	- credit delivery and recovery	Banks, NGOs (esp. NRSP, AKRSP)
• policy advice	- to government, international funding agencies and private sector	Research institutes