THE FEASIBILITY OF INTEGRATED CROP MANAGEMENT IN BANGLADESH.

DFID NRSP project R7600

DFID Natural Resources Systems Programme

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The following individuals were directly involved in this project to 'assess the feasibility of integrated crop management (ICM)'.

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Assistance and logistical support was provided by Noel Magor and Ahmad Salahuddin (PETRRA) and facilitation of farmer validation activities were undertaken by Tawheed Rezah Noor (PRA Promoters Forum).

In undertaking this project we drew on the experience of many people, as described in the text. It is not possible to name all those people here. We thank you all for your enthusiasm and willingness to engage in assessing the feasibility of ICM with us.

We have learnt from this process, in the context of this a clear definition of ICM and its feasibility has emerged. The findings of this study will be used by DFID NRSP to define future research on ICM in Bangladesh. Further we hope that the links established in Bangladesh will lay the basis for productive collaboration and synergies in the area of ICM.

In preparing this synthesis we have made inferences based on information gathered during our study. Inevitably there will be information we have missed and differences of interpretation. Thus, we present this document as a discussion paper and invite comments and feedback.

Should you wish to contribute to our ongoing elaboration of ICM and its feasibility contact us at the address below:

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1. INTRODUCTION

1.1 Project outline

The DFID Natural Resource Systems Programme (NRSP) commissioned a project (R7600) to assess the feasibility of introducing integrated crop management (ICM) in irrigated / rainfed lowlands in Bangladesh. The purpose of the project was to assess the feasibility of ICM in terms of the institutional requirements and the opportunities for application of new knowledge.

For this project, it was critical to work closely with organizations in Bangladesh that will be involved over the long term in implementing ICM approaches. Hence the project streamlined its specific activities with on-going activities of the DFID funded project entitled 'Poverty Reduction Through Rice Research Assistance' (PETRRA) and one major NGO in Bangladesh, PROSHIKA. Beyond this interaction the project consulted widely with organisations and individuals involved in ICM, from either an agricultural or an institutional perspective. The project activities are summarised (Appendix 1) and will be reported in detail elsewhere (DFID NRSP Final Technical Report for project, R7600). This report summarises the findings from the research study and presents key recommendations of direct concern to the planned calls by NRSP.

PETRRA initiatives

PETRRA invited scientists whom, it was thought, would be actively engaged in their future research to meet and define a research strategy for ICM and to discuss the requirements of the competitive funding process proposed by PETRRA. Members of this project R7600 participated in the discussions.

A series of stakeholder consultations commissioned by PETRRA have taken place throughout different regions of Bangladesh (reports available from PETRRA, petrra@bdonline.com).

The PETRRA stakeholder consultations are based on a 3-day PRA exercise in a (single, purposively selected) village, followed by 1-day meetings at Thana[1] and District level with officials of several departments and other stakeholders (including NGO and farmer representatives). The aim of the stakeholder consultations is to 'identify the rice related researchable issues that come from the analysis of rice related problems identified by different stakeholders' (PETRRA, 2000). The problems identified in the village, Thana and District meetings are 'framed into researchable issues' by a small workshop of the participant scientists.[2].

[1] / A sub-district governmental administrative land unit used in Bangladesh encompassing several villages

[2] / The village work involves application of a wide range of PRA techniques: village transect, social mapping, resource and land-use mapping, wealth ranking, ranking of crops and sources of income, and problem/solution prioritisation. Consultations are held separately with groups of men and of women, and with groups commanding different levels of resource (small farmers, medium farmers, sharecroppers etc. based on participants' own classification). The focus of the exercise is on those who cultivate some rice, but consultations have also included landless workers.

Project R7600 activities linked with PETRRA
Project R7600 with support from PETRRA undertook further validation and stakeholder consultation at the village level to elaborate issues related to knowledge at the farmers' level. This validation was done at three locations (Rangpur, Comilla and Kustia). Sites were chosen to be representative of major systems within Bangladesh and to complement previous NRSP research (R6751). System characteristics (agro-ecological zone, soil types, physiographic regions and inundation land type) of each location, are shown together with the location of the BRRI regional research stations (Appendix 2).

The aim was to complement the PETRRA stakeholder consultation by exploring farmer perceptions of ICM-related issues using two techniques, scored causal diagrams and participatory farm budgets (Galpin *et al*., 2000 – further developed in this study)[3]. Sites were selected in consultation with PETRRA. Our objective was to cover areas not previously studied by NRSP projects – which represented high potential situations.

Project R7600 – led activities
A half-day 'roundtable' brought together 22 representatives of the various types of organisation involved in agricultural/rural development in Bangladesh, with the objectives of sharing ideas on

- How ICM might be incorporated into their programmes, and
- The implications of ICM for interaction between farmers, researchers and intermediaries.

Discussion focused on the role of intermediaries in general, and the specific tasks of the intermediaries in relation to ICM.

A searchable technology database (see Appendix 4 for description) was constructed after consultation in Bangladesh and with the International Agricultural Centre for knowledge and Information Management (IAC-KIM).

The database was used in this study to assess the validation status of technologies. The database is designed to be compatible with database under development by the Rice Wheat Consortium for the Indo – Gangetic plains.

Project R7600 activities with PROSHIKA
Further insight to the potential implications of ICM to an intermediary organisation (PROSHIKA) was gained from a series of discussion with senior staff and a roundtable discussion held by PROSHIKA to consider the opportunities offered to them by ICM.

1.2 What is ICM

In more developed countries, ICM commonly is defined in terms of a farm management approach. For example the British government defines ICM as "a whole farm approach

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3 / The scored causal diagram is based on the flow chart, with the important modification of a scoring procedure. It helps to examine in detail the causes and effects of problems and to identify the root causes which need to be addressed. The scoring enables the *relative* importance of particular problems and their causes to be analysed. The PB is used for identifying resource-use patters (including e.g. labour and draft power peaks), cash flows and critical seasonal points (for e.g. water availability, pests, diseases).

aiming to provide the basis for efficient and profitable production which is economically viable and environmentally responsible" (MAFF, 1998). The MAFF definition suggests that ICM can be achieved through a combination of crop rotation with the targeted use of crop protection chemicals and fertilisers, cultivation choice, variety selection and improved energy efficiency, together with a positive management plan for landscape and wildlife features.

Other terms, including 'eco-farming' (e.g. Gerber and Hoffman, 1998) and 'agro-ecology' (The Economist, 2000) have been used to describe a similar vision. In more-developed countries, ICM has (inaccurately) being associated by some with integrated pest management (IPM) which focuses on improved plant health through improved soil fertility management and other cultural practices (UNL, 2000) - and even with organic or 'biodynamic' agriculture (De Lisle, 1999).

In this project the MAFF (1998) definition provides the starting point for a working definition of ICM. However, in the context of resource-poor farmers in less developed countries, it was felt that a more appropriate definition of ICM would also include the integration of knowledge and the means of delivery of that knowledge to poor farmers. Further this project recognises that ICM may involve the combination of 'traditional' agricultural practices and the latest technology (ibid).

Box 1 represents simplified versions of the relationships between research, farmers (and other users of research outputs) and those involved in extension under the current situation and as proposed by ICM. Integrated crop management recognises synergies between the perceptions and skills and capabilities of farmers, intermediaries, and scientists. Rather, than positing a linear "technology transfer" model in which scientists' expertise is delivered to farmers via extension staff, ICM implies a collaborative approach that draws on the potential contributions of all stakeholders. ICM also implies that methods and techniques promoted to farmers should recognise the interactions among different livelihood activities. In doing this ICM draws on the concepts of 'user-responsive research' (Castillo, 1998) and 'learning communities' (Fisk *et al*., 1998).

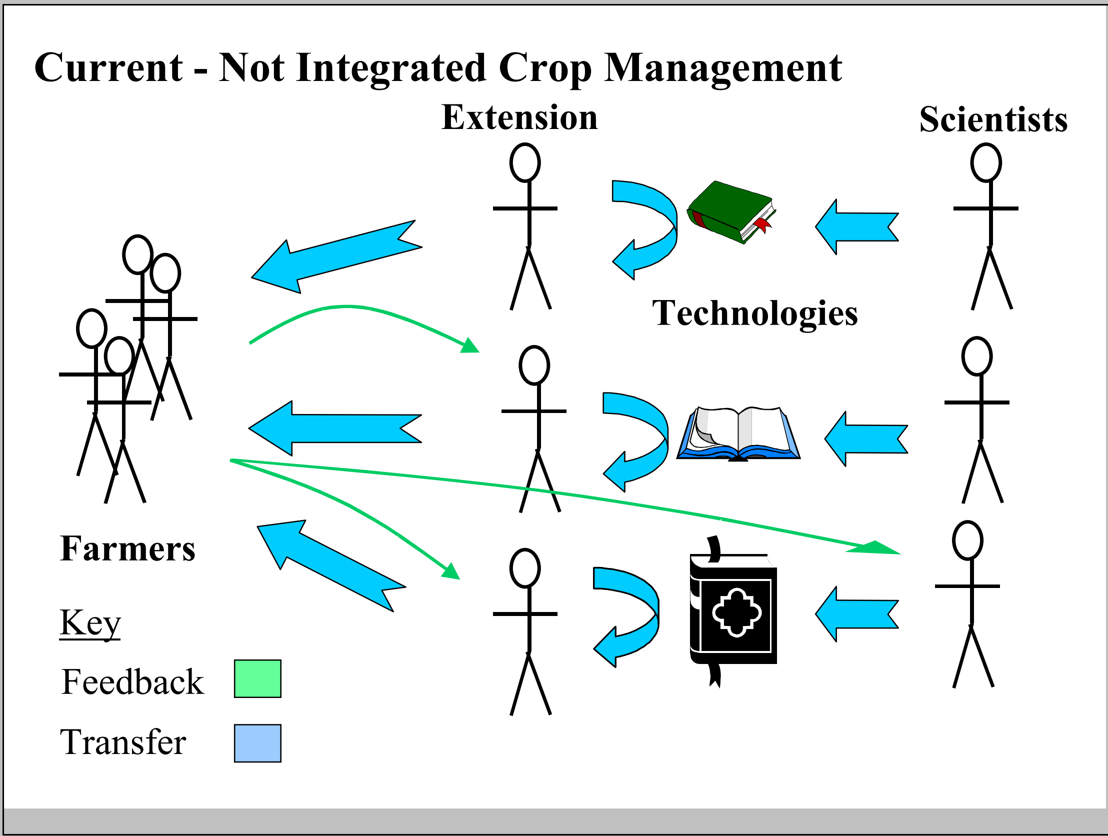
Adoption of ICM should therefore impact on how agricultural research supports rural livelihood systems, and on the approach which extension and other intermediaries take to working with rural people.

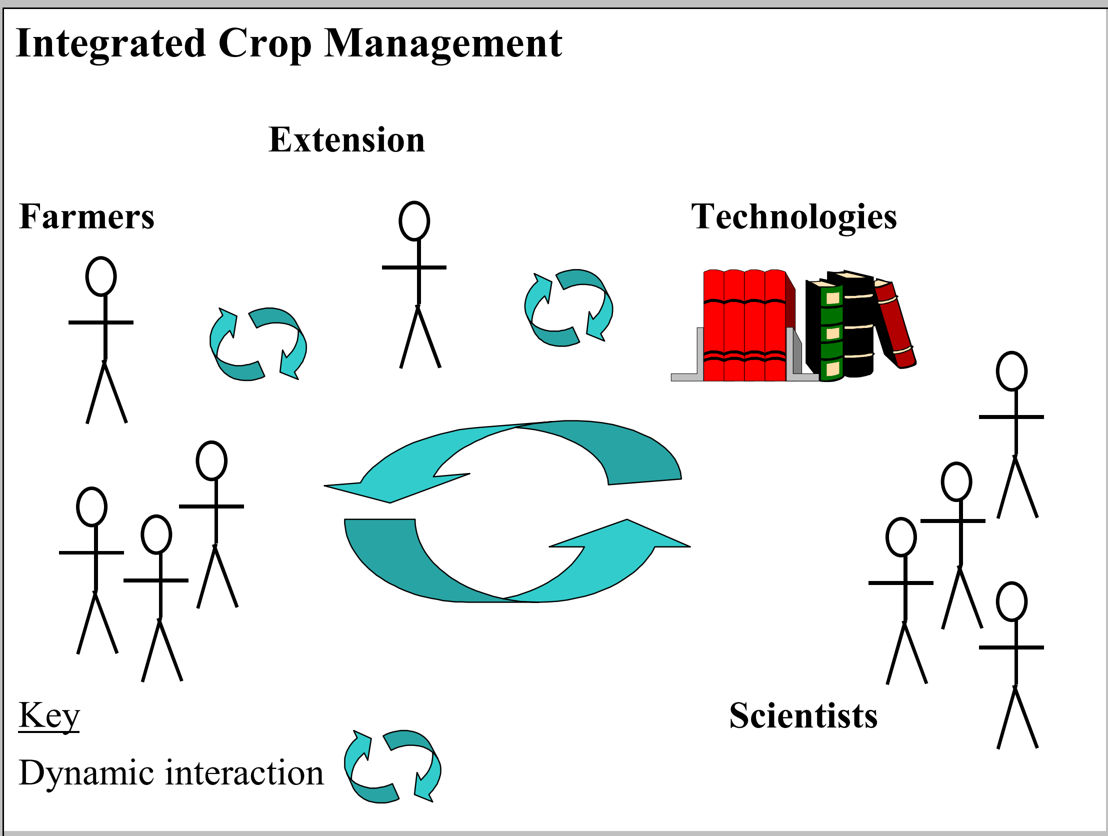
Integrated crop management carries implications for co-management, particularly in the context of intensive cultivation systems where individual farm (and plot) size is very small. The benefits to an individual farmer, or a small number of farmers, from introducing a low-pesticide or low-fertiliser regime may be counteracted if their neighbours continue to use high levels. These high levels may discourage beneficial predators of pests, or continue to depress fish numbers in neighbouring watercourses or (in the case of irrigated rice) in the paddy-field itself (Pretty, 1995).

Given these preliminary observations, two implicit hypotheses have therefore driven this study:

1. *Livelihood gains can be made by resource-poor people through the application of component ICM technologies.*
2. *Many current mechanisms of delivery and access of knowledge prevent farmers from harnessing the potential livelihood benefits from ICM*

Box 1. Schematic representation of current interaction between scientist extensionists and proposed ICM model





1.3 Why consider ICM

The concept of ICM outlined above is broad and relatively inclusive, and hence it might be asked why it is necessary to consider ICM specifically. A key motivator is that farmers, (especially resource-poor farmers) by necessity undertake integrated approaches to crop and indeed farm and livelihood management, recognising inter-relations between their different on-farm and off-farm activities. For example farmers balance trade-offs in the crops they grow, and their field based activities interact with their livestock management and homestead activities.

Intermediary and research organisations consulted in this study recognised the need to involve farmers in research prioritisation and in defining demand for extension products. ICM provides a way to involve farmers in research prioritisation and in the definition of demand for extension products or programmes. Evidence of demand can be seen in examples discussed below.

ICM meets the need, articulated by intermediary and research organisations, for integrated packages and research. Veach (1996) argues that systems research brings biological, economic and social perspectives together. ICM reinforces the aims of systems research and should actively takes on interdisciplinary approaches and seek to provide flexible and pragmatic access to knowledge for a range of clients. Specifically we would now emphasise that the range of clients must pro-actively include the poor and the agents with whom they interact (extension officers, NGP staff etc) on agriculture-related matters.

2. KEY FINDINGS AND RECOMMENDATIONS FROM THE STUDY

2.1 Key findings

This study set out to address the feasibility of implementing integrated crop management in Bangladesh. From this study are several key findings:

A. ICM is happening, but further development will require changes in the way in which scientists and extension workers interact with farmers

Elements of ICM are being undertaken by farmers, researchers and intermediaries in Bangladesh. Focus group interviews with farmers highlighted the extent to which farmers recognise the interactions between these elements in what can be regarded as a livelihood-centred approach to agriculture.

Intermediaries are promoting farming systems such as “rice-fish” systems that may offer synergistic ICM benefits. Further there are ongoing initiatives, such as the Agricultural Technology Transfer Programme (ATTP), to accelerate the testing and adoption of technologies developed by the scientific community.
Researchers are beginning to base their own research planning and prioritisation on an assessment of farmer’s priorities and needs. Further, there is a growing awareness of the need to undertake research together with farmers.

However, our findings suggest that through ICM research and extension activities could be better targeted to meet farmer’s needs.

Research issues:

- Can institutions implement ICM as they are currently structured, relying solely on changes of attitude or are institutional changes also required?
- What are the costs of taking a more integrated approach (time and money costs, loss of focus for scientists, confusion for farmers etc) and do these costs outweigh the benefits?

B. Better use of existing technologies would aid the implementation of an ICM strategy.

The study team identified a large number of farming technologies that have been developed, many of which have not been validated by farmers.

Much of the technical research of relevance to ICM has been discipline-specific and commodity focussed. A consequence of this focus is that synergies that may affect the potential of a particular technology are not necessarily recognised by scientists. Research focussed in this way does not recognise that farmers’ livelihoods involve trade offs at all levels to achieve what they regard as an optimum livelihood strategy at that time.

Innovative approaches to understand the problems farmers encounter are needed. These will enable targeting of existing technologies for evaluation by farmers as well as justification for further technology-oriented research.

Research issues:

- Diagnostic tools need to be developed that enable farmers to understand opportunities to exploit the trade offs between rice production, vegetable crop production and other agricultural activities, in the context of ICM.
- Indicators that point to specific management interventions, that will enhance those attributes of soil quality that are important to livelihoods, are needed.
- How can ICM help in the development of improved strategies to exploit synergies and interactions between nutrient and pest management in rice and other crops?

C. A means is needed for users to access information relating to farmer needs

Prioritisation of both research and extension activities is typically driven by scientists or extension personnel. Yet it is realised by these scientists and extensionists that farmer's needs are also critical to this prioritisation. Thus the application of participatory analysis to diagnose these needs is becoming widespread. However the use of participatory approaches does not guarantee that livelihoods will be well understood, even if they are described. Indeed, there is little evidence of validation of priorities drawn by 'experts' based on these participatory diagnoses.

Moreover, the nature of agriculture in Bangladesh is likely to change. Predicted trends are:

- shift from subsistence farming to production for sale
- greater diversification in the range of agricultural products
- increased levels of production

We anticipate that these shifts will create demand for a more flexible and pragmatic access to knowledge than is achievable through extension messages in which a concept of resource domains drives recommendations.

2.2 Research needs

An 'ICM' decision-support system is needed which aims to strengthen farmers' access to new technologies with the following characteristics:

1. Enables intermediaries to use appropriate methodologies for consultation with rural people
2. Enables the needs and priorities expressed by rural people to inform technology development.
3. Provides access to the 'pool' of information or options for developing farmer-useable technologies, including a means for potential users (intermediaries and end-users) to assess how close particular technical options are to on-farm application.
4. Provides an interface(s) through which users access the information pool, and through which the pool is updated. This interface must enable efficient user access to available information, and also allow experience of users with particular technologies to enter the pool and thus to be available to other users.

3. AGRICULTURE IN BANGLADESH

This section describes some of the trends in Bangladesh agriculture that are particularly pertinent to this study. The section focuses in particular on rice trends, principally because of the key role this staple plays in the livelihoods of resource-poor farmers.

3.1 Trends in rice production

The population of Bangladesh is approximately 121 million and currently growing at an annual rate of 1.8% (Bangladesh Bureau of Statistics, 1997).

Through the 1970s and 80s, the national strategy was to increase rice production through the introduction of high yielding modern (boro) varieties. Where irrigation is available boro varieties which are less photoperiod sensitive than traditional varieties can be grown in the dry season. The amount of land irrigated during the dry season was increased significantly through both flood control and exploitation of groundwater. As a consequence rice cultivation has shifted towards *boro* cultivation at the expense of deepwater (broadcast *aman*) and upland (*aus*) rice (IRRI, 1997).

The strategy was successful: Bangladesh is currently self sufficient in rice (SRDI, 1999). Rice accounts for approximately 80% of the total cropped area in Bangladesh, and 70% of the value added in crop production.

It is recognised by the Bangladesh government (Ministry of Agriculture, 1997) that the strategy described above focussed on wealthier medium and large landholders. This strategy was implemented despite the fact that more than 50% of the rural population were classed as functionally landless owning less than 0.2 ha of land for cultivation (Karim, 1994). These sections of the community tend to rely on other livelihood strategies, such as fishing, which suffered due to the loss of seasonal wetlands that was linked with the intensification of rice production (Barr, 1998).

Our study shows that the trade-offs are also understood by those farmers that specialise in rice production. Farmers that participated in our focus groups reported health and dietary problems that they associate with the reduction of fish in their diet (section 4 below). This appears to reinforce the findings of Barr *et al* (2000) who reported that households with less than 1 ha of land (small and medium farmers) spend up to 6 hours daily fishing during their lean period.

Problems exist in providing a balanced diet, particularly amongst the poor in both rural and urban areas (Hossain & Shahabuddin, 1997). Recognising this demand for more vegetables and fish, Hossain & Shahabuddin (1997) predict that agriculture in Bangladesh will be characterised by a continuing shift from subsistence farming to production for markets, together with diversification in the range of agricultural products and increased levels of production.

The nature of these shifts will determine relative prices and profits associated with agriculture. The changes will affect all whose livelihoods depend on agriculture. Impact on the owners of larger areas of land will influence employment opportunities of the landless. Poor farmers, who may own or have access to relatively small areas of land (less than 1 ha in total) participate directly in market driven agriculture and should continue to do so, although their market opportunities may be influenced by what large land owners pursue as profitable agro-enterprises.

3.2 Alternatives to rice production

This study has indicated that the potential returns on alternative cash crops, such as potatoes can be significant (Box 2). However, it is important to recognise that these returns may require significant investment inputs and may be associated with higher risk for farmers. Some farmers have also recognised opportunities for intercrops such as sweet gourd which can be grown at very low cost. Despite this, it seems clear from our focus group work that farmers' recognise rice as their staple food and that they will continue to grow rice to meet this need.

Box 2. Potato and sweet gourd as a subsidiary cash crop

Field work with groups of farmers in Rangpur and Comilla revealed that medium farmers in particular have increasingly grown potato as a cash crop over the past 3-4 years. Both poor and medium[4] farmers stressed that rice is central to their cropping system and that their aim (not usually achieved by poor farmers) is to achieve household self-sufficiency in rice and to generate cash income through sale of a surplus. In the face of the difficulties they meet in maintaining rice-field productivity and in marketing rice for what they regard as a fair price, diversification into potato is seen as attractive.

Potato is planted in the boro season in *addition* to rice, normally in very small plots. The output per unit area of potato is very high, with reported yields equivalent to some 12-14 tonnes per ha - e.g.in Comilla 60 mounds from a plot of 40 decimals (0.16 ha). The price of potato is reported to be around Tk 200 per maund (Tk 5 per kg) in Comilla and TK 350 per maund (Tk 8.75 per kg) in Rangpur. This compares with a price for rice of TK 225-350 per maund (Tk 5.62 - Tk 8.75 per kg) depending on locality and season.

A total output equivalent to some Tk 97,800 per ha for potato was reported at Rangpur). Costs however are also high, with seed alone costing the equivalent of some Tk 19,750 per ha and labour costs estimated as some 3-4 times that required for rice. Although no detailed breakdown of labour input was collected the gross margin for potato is considerably higher than for rice

At Comilla, farmers reported that they earn an extra income from plots in which they plant potato by also growing sweet gourd. According to them, from a *kaani* of land (40 decimals or 0.162 ha) sown to potato they can also get at least 500 gourds. Each gourd sells at Tk 5 which brings an extra income of Tk 2500. The only cash cost is Tk 20 for purchasing gourd seeds. Thus the total output of a *kaani* of land growing potato and sweet gourd was reported to be Tk 14,500 (Tk 89,500 per ha) and the gross margin Tk 6,220 (equivalent to Tk 38,395 per ha).This compares with a reported gross margin for rice of Tk 1,500 to 3,000 (Tk 9,260 to 18,520 ha.),varying between seasons, due to variations of both yield and costs.

Thus potato - for which the market is apparently strong - offers the opportunity for both diversification and for intensification of cultivation in the rice field; an even higher output per unit area is achieved when potato is combined with sweet gourd as an intercrop.

[4] In one District (Kustia) 'focus group' consultations were held with a group of medium farmers, and in the others (Rangpur and Comilla) with groups of both 'medium' and 'poor' farmers. Criteria for defining 'medium' and 'poor' were generated by the farmers themselves (following the practice of the PETRRA stakeholder consultations) as follows:

In Kustia, the medium farmers characterised themselves as having landholdings of 1-7 *bighas* (0.134 - 0.81 ha), and a food deficit of typically 3 months.

In Rangpur, holding sizes are larger, so medium farmers reported holdings of 10 - 15 *douns* (1.0 - 1.5 ha) with no food deficit and poor farmers holdings of 5 - 10 *douns* (0.5 - 1.0 ha) with a food deficit of 2-4 months.

In Comilla medium farmers' holdings were 160 - 280 decimals (0.65 - 1.13 ha), and poor farmers' 40 - 120 decimals (0.16 - 0.49 ha). Medium farmers usually have no food deficit and poor farmers a deficit (length unspecified).

3.3 Trade offs

The trade off between the need to improve national rice production and the effects on other aspects of floodplain livelihoods was discussed earlier (section 3.2). There are concerns that increases in production and improvement of livelihoods may have involved a trade off in terms of long term sustainability of production (Pagiola, 1995, Asaduzzaman, 1995 and Brandon, 1995). The existing evidence on productive sustainability in Asia is somewhat conflicting, for example two, somewhat conflicting, reviews of long-term fertility experiments in Asia have recently been written. Dawe *et al*., (2000) analysed long term yield trends in 47 long-term experiments in rice–rice and rice-wheat systems and argue that yield declines are not very common, particularly yield levels achieved by farmers.
Whereas in examining yields in long term rice – wheat experiments Duxbury *et al*., (2000) showed that rice yields were declining in eight out of eleven experiments whilst wheat yields were more stable with time declining at only three sites.

Farmers are worried about declines in productivity, expressed as returns on inputs. (see Section 4 below). Scientists might attribute these concerns to their interests in soil fertility. However there are contributing factors that are not precisely equivalent to the rundown of fertility on a piece of land e.g., the removal of surface soil from paddies to construct embankments, homesteads or make bricks are common practices. This suggests that:

- Farmers may not perceive a decrease in soil fertility with depth, or this is a strategy to remove soil where fertility has declined to access soil layers below with adequate or even enhanced fertility
- The return from this use of natural capital for construction has greater value than that of fertility or the cost required to replenish soil fertility
- Soils of lower fertility are selected for use as construction materials (although the indicators on which farmers base this decision were not determined)

The concern expressed by farmers with regard to the return on agricultural inputs appears well founded. The agronomic efficiency for nitrogen (N) used by farmers' is generally low for rice. Agronomic efficiency is a measure of the increase in grain yield achieved per unit of fertiliser input. Therefore it provides a way to quantify the observation of farmers. A recent study by the DFID-NRSP project, R6751 found that the yields achieved where only phosphorus (P) and potassium (K) fertilisers were applied ranged from 3-4 t ha^{-1}, indicating relatively good soil N status. Indeed, at recommended N rates, and at rates used by farmers, the yield response to fertiliser N was very low. This was despite very high levels of N in the crop. As a consequence the internal (physiological) efficiency of N was low.

Taken together, these results suggest that factors other than N supply were limiting crop growth. Possibilities (singly or in combination) are imbalances in nutrient supply, inadequate irrigation, poor pest, disease and weed control, low radiation, poor seed quality and poor seedling quality at time of transplanting. However, we did not find any studies undertaken in farmers' fields that investigated these possibilities.

As a consequence of this low efficiency approximately 80% of fertiliser N added was not recovered by the crop and presumably was lost through either nitrate leaching, ammonia volatilisation or denitrification. These losses and lack of grain yield response occur despite the expectation that with efficient and balanced addition of fertiliser a potential grain yield of 8 t ha^{-1} generally attributed to modern tropical rice varieties can be achieved in Asia (Peng *et al*., 1996).

3.4 Summary

In summary, trade offs in agricultural strategies were seen in decisions taken at all levels from policy decisions, such as those to increase national production at the expense of the landless poor, to those decisions made by individual farmers.

A shift from production to market driven agriculture is anticipated. We predict that this shift will create demand for a flexible and pragmatic supply of, and means to access, appropriate information. It is not clear that current extension strategies and support programmes are able to meet this demand.

4. IS ICM HAPPENING IN BANGLADESH?

4.1 Introduction

System approaches to research and extension have been promoted for at least five years as part of a reaction to agriculturally biased (land side) flood control approach of the flood action plan. The study team identified examples of promotion of systems management practices that could be considered to be integrated approaches to crop management, from the perspective of farmers, intermediaries and researchers.

We will look at both technical and communication aspects of ICM drawing on a number of case studies. These case studies are not exhaustive as the purpose of this section is to highlight different approaches and methodologies.

4.2 Agriculture from the farmers' perspective

We used scored causal diagrams as described earlier (section 1.4) with small focus groups of farmers to provide insights into the extent to which farmers themselves take an integrated approach to crop management. This exercise showed a keen awareness on the part of participating farmers of the non-sustainability of parts of their present farming system and of the need for better management of fertility and pest control. The interaction and integrated nature of their livelihoods was clear; however, whether farmers do indeed take an integrated approach cannot be determined from simple exercises asking farmers to prioritise their needs.

Work on the scored causal diagrams started from identifying an end problem, which in all cases was agreed by participants as 'low income from rice production'. (Indeed the facilitator played a role in encouraging this to be accepted as a starting point, so as to achieve some comparability between the five groups.) An example of a scored causal diagram is shown (Box 3) and the responses of the five groups of farmers which constructed scored causal diagrams are summarised (Appendix 3).

All of the groups then identified the same three main 'proximate' causes of low income, namely low price (or 'unfair' price) received for rice, high cost of inputs, and poor yield. An additional cause mentioned in two cases (one poor and one medium group) was the demand made on rice for household consumption, which left relatively little available for sale to raise cash income.

The causes of low price and high cost of inputs were traced to problems with the marketing and supply systems and to inefficiencies/corruption. Lack of farmer storage capacity was mentioned as a reason that rice had to be sold at prices determined by buyers. (A strength of the scored causal diagram is that it allows issues relating to marketing infrastructure etc. to be separated out in problem analysis from agronomic and extension/information related issues which can be addressed at farm level).

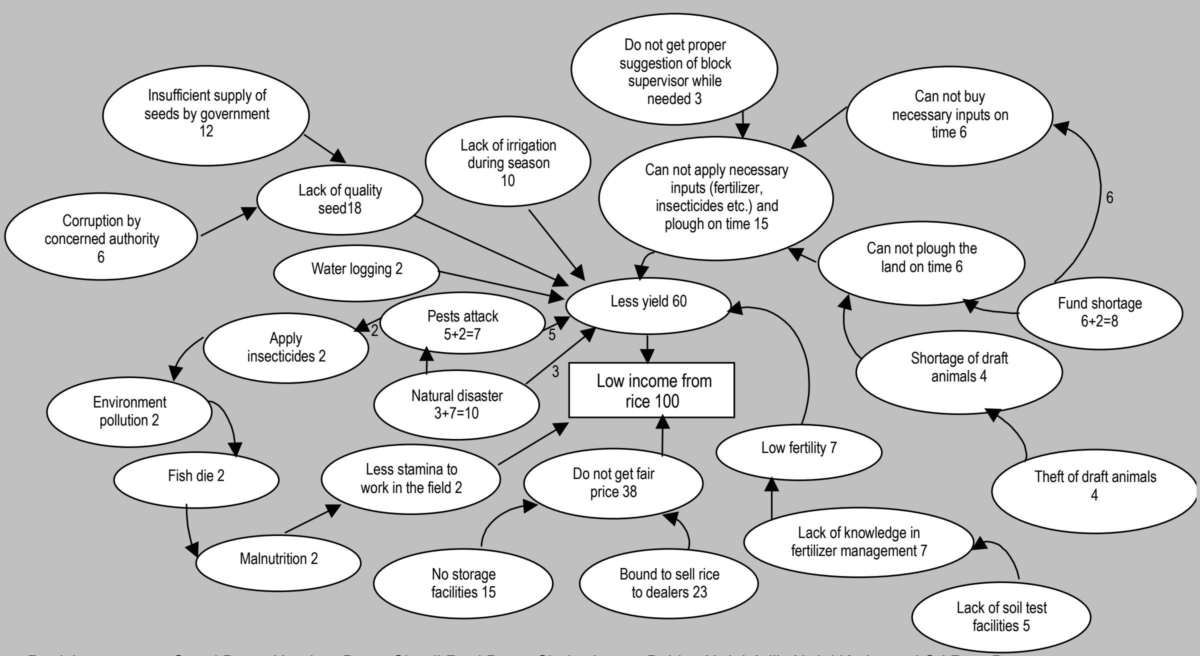
The third main proximate cause of low income, i.e. 'low yield', led to identification of a complex of intermediate and root causes at farm level. 'Low fertility' was traced both to excessive levels of inorganic fertiliser use and to the lack of organic fertiliser - which in turn relates to a relative decline in cattle numbers as more and more land is required for cropping. Interestingly, all groups identified their lack of knowledge as a reason for failing to use inorganic fertiliser efficiently.

All of the groups identified a 'loop' which begins with poor health affecting work efficiency and which traces this in turn to poorer quality diet as fish become less abundant in rice fields and water bodies due to high levels of pesticide and fertiliser use. Some groups also include here the impact on diet of the relative decline in cattle numbers, and also the impact of this decline on fertility since it means that less organic fertiliser is available.

Box 3. Example of a scored causal diagram

VILLAGE: INDROBOTI, THANA: BURICHONG, DISTRICT: COMILLA

GROUP: POOR (motamuti) FARMERS, DATE: 20 JULY 2000



Participants: Gopal Daas, Hemlata Daas, Sheuli Rani Daas, Shah-el-mran Bablu, Abdul Jalil, Abdul Kader and Sri Ram Daas

Facilitator: Tawheed Reza Noor

Some other causes of poor grain yield of rice lead back to root causes which lie in marketing and supply logistics: poor quality of seed, lack of fuel to power irrigation pumps and the lack of credit which would enable timely purchase of inputs. One group mentioned the pollution caused by plastic garbage, which was said to hamper seedling growth (in the period immediately after transplanting).

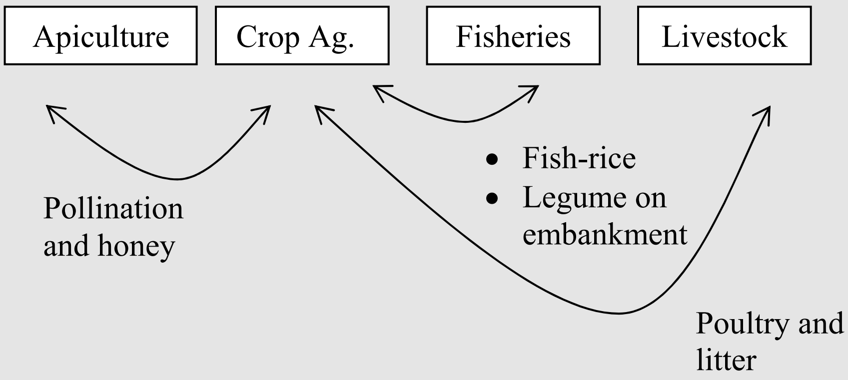
4.2 ICM technologies from the intermediaries' perspective

Several organisations in Bangladesh are undertaking activities that reflect both agronomic and communication elements of ICM. For example PROSHIKA (Box 4) can translate their existing programmes into an example of ICM.

Box 4. Example of integrated crop approach from PROSHIKA perspective:

PROSHIKA has not as yet developed a working definition for ICM, but during consultation in the initial stages of this project, ICM was perceived by PROSHIKA as recognition of the inter-relationships between different crops, livestock, and other on-farm activities.

From a current operational perspective, for PROSHIKA, this integration translates into an integration of different programmes.



Farmer first and farmer field school approaches are used in Bangladesh. The contrasts in how they are implemented can be seen from two examples below Thana cereal technology transfer and identification (TCTTI) project (Box 5) and CARE ICM Farmer field schools (Box 6).

From our intermediary workshop it was very clear that most intermediaries follow the farming systems approach as described by Barr (1998). In general the strategy is to target groups of farmers with sufficient homogeneity that they form a recommendation domain.

The means by which extension activities are prioritised and recommendations are derived varies. The TCTTI project (Box 5) showed a typical example how participatory techniques are being used to prioritise extension activities, in combination with such an approach.

A more conventional approach to the definition of a recommendation domain is taken by the Thana Nirdeshika programme. This programme uses environmental characteristic (land type, flood depth and soil type) to determine crops that can be grown. To achieve site specificity at the Thana level soil samples are taken and analysed.

There appears to be frustration amongst intermediaries that technologies developed by the research community are not reaching farmers. The Agriculture Technology Transfer Programme (ATTP) is an example of a programme that provides resources, through projects, to enable intermediary organisations to validate and promote technologies developed within the research arena. The mechanism used to promote technologies varies from project to project. However, the ATTP project was underpinned by a compilation of technologies from the national research institutes that were judged by scientists to be appropriate for dissemination.

Box 5. Thana cereal technology transfer and identification (TCTTI) project

This project which is supported by the United Nations Development Programme (UNDP) is implemented the Department of Agricultural Extension (DAE) with support of the FAO as executing agency.

The project adopts a 'farmer first' approach for technology transfer designed to enhance the level of farmer participation, including that of females of rural households, in diagnosing the critical areas requiring technology selection and developmental intervention.

The project sees building capacity to create a 'trained cadre of PRA practitioners' as a key step in their project.

Communication mechanisms employed by the project include farmer – researcher – extension workshops and compact frontline demonstrations at the block level. In 1999 the Ministry of Agriculture / Government of Bangladesh (GOB) adopted the TCTTI model of compact demonstrations for extension to a further 80 thanas using GOB resources.

Box 6. CARE ICM Farmer field schools

CARE is an International NGO supported by DFID Bi-lateral funds This programme appears to be a development of farmer field school methods for IPM. A range of communication methods are employed to increase farmers' knowledge, these include teaching basic ecology, using participatory field learning and field schools, using farmers as facilitators, and the farmer 'buddy' system (a trained farmer passes on information to a second farmer).

ICM is investigated by farmers from the LIFE project areas. ICM technologies included the effects of balanced fertiliser, transplanting seedlings (earlier, fewer seedlings per hill and at a wider spacing) and IPM messages to reduce unnecessary use of pesticides (Rahman and Nandeesha, 2000).

Field trials to compare rice production under ICM compared to farmer's practice have been conducted by farmers in thana's within Rajshahi division and Kishoreganj district. The field plots were used to demonstrate to other farmers the benefits of ICM. Generally, farmers found an increase in Aman and Boro rice production of between 4% to 38% from ICM plots compared to 'farmer's practice' plots. The ICM practices were found to give better returns and highlighted problems of monoculture (i.e. rice-rice systems) and how disease can be reduced by introducing diversity into the cropping pattern, for example potato (Rahman and Nandeesha, 2000). Farmers adopted all or some of the ICM technologies.

4.3 ICM technologies from the scientists' perspective

From our literature review we found that generally, scientists focus on an area of crop management and one or two associated problems leading to a fragmentation in research. Consequently there are very few detailed studies that consider interactions or synergies between the various potential components of ICM. Most studies aim at increased yield as the goal, rather than an impact on livelihoods. In addition, problems have resulted from conditions on research stations differing from those on farmers land with most research undertaken on-station, or if on-farm, as researcher managed plots.

An example of what we mean by fragmentation can be drawn from research on green manure legumes. There are seemingly endless papers evaluating the performance in terms of nutrient supply and appropriate management to achieve synchronicity in a crop cycle (Budhar and Palaniappan, 1997; Pillai, 2000).

Other papers address the role of legumes improved nutrient availability through crop rotations. (Singh and Ghosh, 1999; Duxbury, 1999; Hedge, 1998; Mondal and Chettri, 1998). Some literature examines the interaction between green manures and root pathogens

Pathogenic studies include solarisation, relationships between legumes, nematodes and micronutrients, (Duxbury, 2000; Akhtar and Alam, 1993). Few if any seem to draw the strands together – this is ICM.

There are examples where interaction between crop establishment method (rice and wheat), water management, tillage and mulches (Hobbs *et al*., 2000; Tarafdar *et al*., 1999; Thana cereal technology transfer and identification project, 1998; Hobbs *et al*., 1997; Banik *et al*., 1996; Sattar and Bhuiyan, 1994) is considered.

Little of the research reviewed addressed technical aspects of ICM in the context of the socio-economic circumstances that have implications on an individual farmer's decisions. Thus, in reviewing technologies for inclusion in a technology database, whilst we concur that there are many potential technologies in the research domain, we find much less evidence that technologies have been validated by farmers.

5. ICM FROM AN INSTITUTIONAL PERSPECTIVE

Nationally there appears to be a lack of integration, particularly between the agricultural and water management sectors. Within each sector the agenda of those donors and international research organisations supporting agricultural research and extension appears to contribute to the fragmentation of efforts. Donors appear to be driving research agendas (Box 7) and extension approaches (Box 8).

Institutional stakeholders in agriculture in Bangladesh are diverse government ministries, national government research institutes, local universities, local and international NGOs and international research organisations (IROs). Moreover, partnerships are often supported by bi-lateral or multi-lateral development aid.

The local NGOs in Bangladesh are particularly strong. They constitute large national organisations, with infrastructures and resources that match those of government ministries. This situation has arisen, at least in part, owing to the substantial support to national NGOs that has been made available by bi-lateral and multi-lateral donors.

This led to a tension between the national government research institutes and NGOs. During 1997 this was apparent (to the lead author) both in the open discussions held at various conferences and workshops as well as in interviews with individual representative of these organisations. In the subsequent 3 years the situation has changed; it appears that a mutual respect has developed. We have not documented these changes in detail, but elements include the fact that representatives of NGOs have been involved in the government research planning process. Increasingly research projects funded by donors have supported partnerships between NGOs and NARS scientists. Through increased emphasis on use of PRA techniques to identify research priorities, scientists have been encouraged to address the needs of farmers more clearly.

We worked with PROSHIKA to examine the implications to their organisation for adopting an ICM approach (Box 9). Concerns were raised that ICM implies a more complex system for delivery of technologies to farmers. Indeed, it was assumed that ICM would require re-organisation to develop a structure with appropriate disciplinary and institutional integration.

Box 7. Bi-lateral donor seeks to develop a research agenda in partnership with NARS and IRO: DFID's project on 'Poverty Elimination Through Rice Research Assistance' (PETRRA)

PETRRA's purpose is the sustainable and equitable enhancement of the productive potential of rice-based farming systems. This supports the (DFID) goal of substantially increased rice production and incomes by 2008 and the super-goal of a 50 percent reduction in rural and urban poverty by 2015.

The project supports research through partnerships between BRRI, Universities, NGOs and other IROs, to develop improved rice production technologies appropriate to Bangladesh. Projects are awarded on a competitive basis.

DFID through PETTRA encourages researchers to take a more integrated approach to looking at rice research and to understand how this research will impact upon the livelihoods of farmers.

Two key elements of the current PETRRA approach are farmer stakeholder visits and intermediary and researcher stakeholder meetings. The purpose of farmer stakeholder visits is to identify farmers' constraints and prioritisation of problems, and to "validate" researcher-proposed priorities. The other stakeholder meetings allow prioritisation by distinct stakeholder groups and validation by these different groups.

This stakeholder consultation and researcher prioritisation process informs research commissioned by PETRRA.

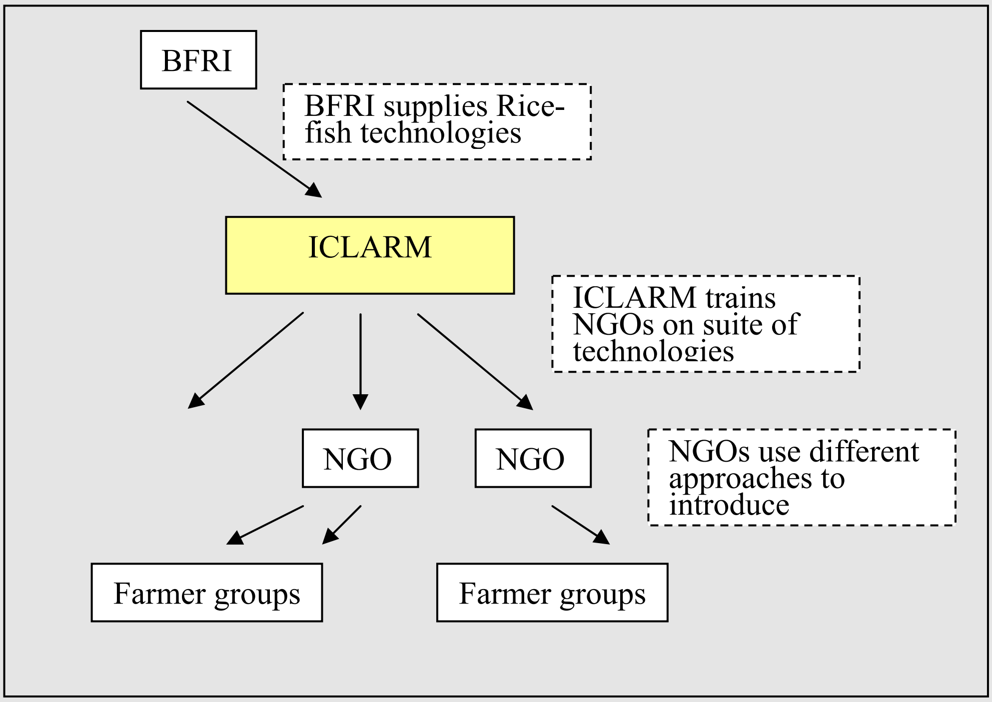
Box 8. IRO seek to mobilise NGO community - ICLARM sustainable aquaculture project

ICLARM is an International research centre that has implemented a “rice-fish” project that targets resource-poor people in Bangladesh. ICLARM has formed partnerships with NGOs to adapt proven technologies that are appropriate for particular situations.

ICLARM recognised that a number of technologies for rice – fish could be disseminated. The source of most of the technologies that ICLARM recommend was the Bangladesh Fish Resource Institute, BFRI.

ICLARM funds NGOs to work with demonstration farmers, specifically training NGO trainers. This training focuses on technologies, and not on the approaches for communicating these technologies to the farmers. ICLARM has however suggested farm days with rallies based on demonstration farmers as a communication mechanism to reach a broader audience.

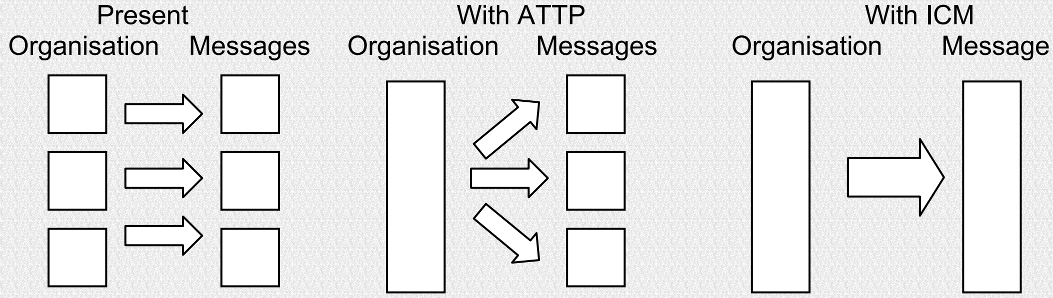
The relationship between BFRI, ICLARM, and the NGOs and farmers



So far ICLARM’s project encompasses 6500 demonstration ponds (USAID has provided additional funding for an additional 6500 demonstration ponds). ICLARM monitors the NGO activities to ensure that the funds are being used appropriately.

Box 9. Analysis of organisational changes required in adopting ICM by PROSHIKA

PROSHIKA perceive the Agriculture Technology Transfer Project (ATTP) as an intermediary step towards ICM in which integration has occurred within PROSHIKA at an organisational level but not in terms of the messages that are given to farmers. ICM was seen by PROSHIKA staff as requiring integration of the delivery mechanism. SWOT analyses were undertaken by PROSHIKA staff to examine each step towards their vision of ICM



Present

STRENGTHS	WEAKNESSES
Integrated program Skilled, multidisciplinary workers Easy communication Less time consuming Ecological agriculture Strong skill development, training cell Exist other related program ADC infra-structure	Feedback – lack of beneficiaries, need based know-how Program overlap Program Staff occupied with other activities Management burden – hard to implement any program properly
OPPORTUNITIES Resource person developed from group member Present where developed infrastructure Grass roots organisation with group federation is strong Popular theatre	**THREATS** Activities (some) not orientated Single program emphasis Existing program threatened

ATTP

STRENGTHS	WEAKNESSES
Skilled and committed person power from different related disciplines. Structural set-up Organised farmers groups Network with partner NGO's far technology dissemination Professional linkage with different agricultural research agencies (domestic and international) Available material support Good integration with different programmes with in PROSHIKA Most of the components are being practised by ATTP	Shortage of person power Shortage of skill person power at the implementation level of partner NGO's Lack of sufficient information regarding ICM Want of logistic supports like vehicles Lack of full time entrusted staff at field level.
OPPORTUNITIES Eagerness of the farmer throughout Bangladesh Available NGO's to implement this project Available sources of necessary information Appropriate technologies Sufficient support at national and international level Scope of required funds Favourable governmental policies	**THREATS** Farmers acceptance yet to be measured Natural hazards and calamities Political unrest Change in Government policies Dependency on donors for funds

ICM

STRENGTHS	WEAKNESSES
Area coverage of PROSHIKA Technical and trained staff Existing physical infrastructure Existing different programs	Lack policy Grass root management systems Lack support material e.g. feed
OPPORTUNITIES Holistic development Co-ordinating farmers and groups through activities Existence of some policy	**THREATS** Government and Donor policies Market policy Natural calamities

6. FEASIBILITY OF ICM

In this section we attempt to draw upon our experience to consider the logistics, the costs, the winners and losers and the caveats of ICM. Further we consider which elements can be influenced (or are changing) and those which we need to work within. This then leads us in the next section to what we see as specific research opportunities.

6.1 Demand for ICM

This study (together with the stakeholder consultation of PETRRA) appears to have confirmed that there is a need for ICM at the farm level. All participating farmers expressed concerns regarding the sustainability of parts of their present farming system and agreement of the need to managing fertility and pest control better. We found that farmers showed a keen awareness of the tradeoffs between their activities and fish production and livestock production. Particularly the value of fish in their diet was clearly recognised. These findings were made despite the fact that the consultation process used in this project targeted farmers involved in rice production and therefore may have under represented those classified as functionally landless.

Farmers have recognised that better production can result from application of 'modern technology' and the need for 'increased knowledge'. Whilst the demand for ICM was not articulated, the integrated nature of their livelihood and the trade offs involved were clear. The farmers consulted in our study recognised the benefits of fertiliser use - as an aspect of modern technology. However the same farmers also expressed concerns regarding negative consequences of fertiliser use namely 'more dependency' (on purchased inputs) and 'decreased fertility'. The loss of grazing land (as a result of more intensive rice cultivation?) was identified as leading to shortage of fodder and to less use of cattle for cultivation. The loss of animal based products for human consumption and lack of organic fertiliser were seen as consequences of reduced livestock numbers. As well as the perceived negative effects of increased levels of inorganic fertiliser, interactions were identified between the various causes (although the links are not made entirely). The farmers interviewed were actively looking for opportunities for diversification, to reduce labour requirements from rice transplanting and for alternative income generating activities.

Thus it seems that farmers do see the benefits from increased access to information and are seeking support to address the integrated nature of their livelihood system.

Intermediary organisations involved in extension articulated a demand to access research findings – particularly for technologies for validation and testing. A large body of technical research already exists. However, an understanding of where and when the technologies are appropriate is not always apparent. There have been a number of initiatives to access this body of knowledge.

The Department of Agricultural Extension has proposed a database that would allow this technical knowledge to be accessed. This project produced used a simple database (see Appendix 4 for description of the project's database) as a tool to collate and search for information on technologies. We see that this could be a key element of implementing an ICM strategy at a national or more localised level.

The intermediary workshop showed that the people involved felt that whilst participatory methods were important to engage intended beneficiaries this should be underpinned by the development of site and domain based recommendations. An alternative model, that some proposed, was that solutions could be generated through participation –i.e. participation was the means to the end.

Despite the current rhetoric, "appropriate" solutions tend to be driven by scientists

- Scientists' own perceptions of the appropriate solutions
- Scientists' needs to develop their own areas of interest
- Perception that farmers are not smart

Thus we see that ICM depends on the ability of different stakeholders to recognise the strengths, weaknesses, and areas of expertise among the different groups and build on the strengths and expertise amongst all stakeholders.

6.2 Organisational

As recognised in section 5, nationally there is a lack of integration, particularly between the agricultural and water management sectors. The agenda of those donors and international research organisations supporting agricultural research and extension appears to exacerbate fragmentation of efforts. Donors have a lot of say in the research agendas of individual projects and programmes. This may limit the scope for innovation in some situations as these stakeholders seek to promote their own particular agenda and approach. By participating in projects supported by a range of donors, GOB and national NGOs are able to evaluate the alternative approaches proposed by various donors. Whilst this may be regarded as an advantage, from our experience it seems to lead to a dilution of effort and some confusion.

It is possible to bypass the problem in the development and testing of specific technologies related to ICM by identifying an appropriate research partner or partners. However if a relatively targeted research input (such as is supported by NRSP) is to achieve impact, then the strategy to achieve uptake of the outputs of this research by target institutions must be clear. This especially applies to achieving the uptake of the decision support tools that we propose as a component of ICM (refer Section 7).

Given the fragmentation apparent in Bangladesh and transaction times involved in developing partnerships we would suggest developing strong partnerships with organisations that have sufficient resources to pilot test ICM.

In the PROSHIKA case study (Box 9) it was felt that ICM implies a more complex delivery system (of technologies to farmers). Further, it was assumed that within PROSHIKA, ICM would require an integrating structure. This assumption must be verified. At a research level an interdisciplinary approach is essential for the reasons outlined in section 4.3 above. However, within an organisation, non-integrated arrangements may have distinct management advantages that might be lost if a more integrated approach to these intermediary organisations were proposed.

It is notable that we found no evidence of the evaluation/assessment of the costs and benefits either of research or extension models being used. Discussion with FAO staff (pers comm, Dr H Nabhan, 2000) suggest that the FAO are in the process of assessing the costs associated with farmer field school programmes.

7. SPECIFIC RESEARCH OPPORTUNITIES FOR ICM

7.1 Specific options within the current cropping systems

We have suggested that current rice yields that farmers achieve are lower than would be expected given the level of N application. There is evidence from plant N status that N uptake is not the limiting factor. In addition, only about 20% of N added as fertiliser to rice crops is taken up by the current crop, implying significant losses of N or immobilisation.

PETRRA has identified that farmers and extensionists increasingly recognise nutrient deficiencies as a constraint to sustainable crop production in intensive rice-based cropping systems in both favourable and unfavourable eco-systems. The nutrient deficiencies may arise from unbalanced use of N, P, and K fertilisers and failure to address deficiencies of other nutrients such as zinc, sulphur, and boron. However, we found evidence that agronomic factors other than balanced nutrition may determine levels of production.

Considerable knowledge of agronomic management, including nutrient management of crops exists. This knowledge is packaged, generally on the basis of agro-ecological zone. However, the optimal management for a given crop in a given season can vary across small distances within an agro-ecological zone. Hence, in the context of the trade-offs discussed earlier there is a need to develop simple guidelines and tools (including leaf color charts, pamphlets, diagrams, etc) to enable other farmers to modify recommendations to suit their own needs.

Further we suggest that in order to convince farmers of the benefit of engaging in a participatory process, it is important to find simple means to demonstrate the potential gains if these constraints are overcome. As an example of what we mean, a farmer may be considering diversification as a means to increase cash income based on a presumption of a certain rice grain yield. If it became apparent that this yield could be increased by 30%, then the farmer’s decision as to what area to grow for potato might be affected.

Thus we have identified gaps or opportunities where ICM might be appropriate as follows:

1. To provide tools that enable farmers to understand the opportunities to exploit the trade offs between rice and vegetable crop production (and other agricultural activities) in the context of ICM.
2. To provide appropriate improved methods for crop variety selection and establishment (to achieve timeliness, market value etc.) for rice and non rice crops to enable these trade offs to be well judged.
3. To provide indicators that point to specific management interventions that will enhance attributes of soil quality that are important to livelihoods (i.e., that farmers readily perceive as improving their productivity through such ways as returns to labour, returns to outlays on inputs, impact on what they view as major hindrances to productivity). Some examples of soil quality and possible indicators are:
    - the workability of soil (soil structure and consistency)
    - the presence of a relatively shallow hardpan (resistance to penetration of a probe at shallow depth in the soil profile)
    - soil salinity (changes in soil structure due to flocculation)
    - degrees of acidity (characteristics of soil profile – uncultivated versus cultivated)
    - soil nutrient status (crop performance in unfertilised or omission plots).
4. To develop strategies to exploit synergies/interactions between nutrient and pest management in rice and other crops

7.2 Options for ICM – Delivery

Delivery of renewable natural resource (RNR) information and technology is increasingly seen in an 'active' rather than a 'passive' sense, i.e. as routes through which users of RNR search for potentially useful information and technology, often using multiple sources and channels in 'information-seeking strategies' (Garforth and Usher, 1997). These complement the long-standing recognition that farmers are active experimenters (e.g. Chambers, 1983, Richards, 1985).

Investigation of farmers' information systems (e.g. Rolls *et al*, 1995; Lawrence, 1996) has been to identify a complex of intermediate users of RNR research outputs. These include researchers in national systems (NARS) through to public sector and voluntary organisations working with rural people, and including private sector actors such as traders and input suppliers.

Participatory approaches have long been used to facilitate understanding (on the part of biophysical scientists, social and economic scientists and intermediaries such as extensionists) of rural livelihood systems and of the constraints to change (e.g. Chambers *et al*., 1989). These tools alone, without attention to the contribution of the differing areas of expertise of those who use them, do not guarantee that livelihoods will be well understood.

The use of participatory approaches is now extended to include approaches to working with rural people in a process of developing useable, farmer-validated technologies (Van Veldhuizen, *et al*., 1997) – and for assessing the likely impact of changes in the farming system on income and livelihood (Galpin *et al*., 2000).

At issue is how to improve access to new knowledge, including technologies, practices and other needed information, as a basis for assisting the decisions that farmers make on their livelihood and farm management strategies. Central to ICM is the process by which end-users and intermediaries interact to access and adapt research outputs, and position this with other information that bears upon profitability of farming, with intermediaries playing a crucial role the process.

A decision-support system which aims to strengthen farmers' access to information on new technologies and practices would, it is suggested, need to strengthen the process outlined in the above paragraph and in the sketch (Box 1, page 4) at the following points:

- To provide diagnostic tools that enable farmers to understand the opportunities to exploit the trade offs between rice production and vegetable crop production (and other agricultural activities).
- To provide appropriate improved methods for crop variety selection and establishment (to achieve timeliness, market value etc.) in rice and non-rice crops to enable these trade offs to be well judged.
- To identify indicators that point to specific management interventions that enhance aspects of soil quality important to livelihoods.
- To develop strategies to exploit synergies/interactions between nutrient and pest management in rice and other crops

We further suggest that, as a support to the DSS, a database of technologies is needed, in which criteria for assessing the proximity to the end-user and possible constraints to adoption, are defined. The decision support system envisaged will combine an appropriate user interface with the databases to provide:

1. An accessible information pool of technical options, consisting of a database structured to indicate the level of validation by farmers of individual technical options. This structure will identify whether technologies are used by farmers in-country, are not adopted by farmers, are successfully used by farmers in another region/country, or are still being developed and tested. (Reasons for non-adoption will be identified where possible – including economic/infrastructural as well as technical reasons.)
2. A robust ‘interface’, pre-tested and validated, that enables users to access the database and provides information relating to farmer needs The interface should be appropriate to:
    a) existing patterns of transfer of knowledge and information.
    b) skills of farmers/ intermediaries in relation to information and communication technologies (ICTs), including literacy skills.
    c) (rapidly changing) availability/ accessibility of ICTs

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Appendix 1. Project logframe DFID NRSP project R7600

NARRATIVE SUMMARY	Objective Verifiable Indicators	Means of Verification	Risks, Assumptions & Conditions
Goal			
Benefits for poor people in target countries generated by application of new knowledge to natural resources management in high potential systems	By 2005 evidence of application of research products to benefit target communities by achieving one or more of; -sustainable production increase -less variable production -improved employment (numbers, income, quality) -Improved access by poor people to RNR Output	DFID Commissioned reviews. Reports of in-country institutions Monitoring against baseline data collated by the programme Local and international statistical data	Adoption of strategies changes behaviour in the private sector. Enabling environment exists. Budgets and programmes of target institutions are sufficient and well managed Climatic conditions are favourable
Purpose			
Mechanisms to assist poor farmers to improve their livelihoods through better agronomic management	By aman season (June) 2000 PETTRA initiates projects on soil fertility / ICM with support from NRSP research projects By July 2000 Collaborating NGOs commit staff time and support facilities to a longer term ICM project	PETRRA documentation and workplans for 2000 PETRRA calls for research Filed correspondence, aide memoirs of meetings between NRSP and NGO	Target institutions are willing to invest resources in the uptake and application of research products

Outputs			
1. Strategy for ICM research including modalities for involving stakeholders agreed by PETRRA and NRSP	By April 2000 meeting between PETRRA and NRSP held and strategy for collaboration agreed	Records of meeting in trip report and PETRRA files	Common research strategy can be achieved that meets the objectives of both PETRRA and NRSP
	Discussion day on soil fertility and crop management held in March 2000	Project final technical and trip reports PETRRA documentation of discussion such as reports to DFID	Stakeholders agree to participate in discussion day. Political unrest and strikes do not disrupt schedule.
	By June 2000 PETRRA and NRSP strategy	PETRRA and NRSP calls for research proposals	PETRRA project continues to be funded by DFID, NRSP priorities and predict resource allocation do not change.
2. Modalities for implementation of ICM by PROSHIKA resolved	Meeting held with President and Director by April 2000	PROSHIKA project records	PROSHIKAs commitment to ICM is a pre-condition.
	By June 2000 PROSHIKA document ICM strategy	Formation of ICM task group by and records of PROSHIKA	PROSHIKA staff maintains commitment to ICM and are able to resolve any philosophical difficulties.
3. Feasibility of technical and process related options for implementation of ICM assessed and validated.	By June 2000 at least 3 village workshops held to elicit farmer priorities for ICM	For each study site PETRRA report NRSP and PETRRA documentation	Political unrest and strike do not disrupt schedule. Villagers participate and identify need for support on ICM and related issues.
	By July 2000 joint definition of ICM and criteria for its feasibility established by farmers, intermediary stakeholders and scientists	NRSP and PETRRA documentation Records of workshops	Common definition meeting various viewpoints and needs is possible.
	By July 2000 information on feasible ICM options for implementation in Bangladesh	NRSP project documentation ICM database	
	By July 2000 database installed at PROSHIKA	PROSHIKA documentation Records of RWC	Database structure can be designed to meets requirements of PROSHIKA.

Activities			
1.1 Participation by UK representatives in PETRRA discussion on ICM	By March 31 2000 at least 2 UK collaborators and local stakeholders meet to discuss ICM	PETRRA documentation and project report	Political unrest and unforseen natural disasters may delay or prevent achievement of activities. Partners are able to make contracted input
1.2 Discussions with PETRRA concerning links between NRSP and PETRRA	By April 2000 at least 2 UK collaborators hold meetings with PETRRA project manager and staff	PETRRA and NRSP documentation	
2.1 Meeting with President and Director PROSHIKA to establish PROSHIKAs requirements of ICM	By April 2000 meetings held between at least 2 UK collaborators and PROSHIKA staff	*Project report* PROSHIKAs records	
2.2 1 day workshop with PROSHIKA staff to identify modalities for implementation of ICM	By May 2000 workshop held by PROSHIKA with input from UK expertise (at least 2) and task force formed by PROSHIKA	Project report PROSHIKAs records	
3.1 PETRRA Stakeholder consultation at village level	By June 2000 Stakeholder meetings held.	PETRRA documentation Project report	
3.2 Identify, make contact with, and interview representatives of key institutions involved in ICM in Bangladesh	By July 2000 records of interviews are available	Project report	
3.3 Identify relevant documentation and supplementary literature sources	By July 2000 literature searches and documentation are available	Project reports and records records of literature searches and exercises to gather documents	
3.4 PETRRA / NRSP consultation with intermediary stakeholders	By June 2000 Stakeholder workshops held		
3.5 Design of ICM database structure	By june 2000 prototype ICM database compatible with WISARD and INTERDEV project available	Project reports and records	
3.6 Compile relevant literature emphasising, technical and process related options for implementation of ICM	By July 2000 inventory of options encoded as MS Access database	Project report Database available	

Appendix 2. System Characterisation for Bangladesh

This information was derived from the following report:-

FAO 1988 Land Resources Appraisal of Bangladesh for Agricultural Development. Report 2. Agroecological Regions of Bangladesh. BGD/81/035Technical Report 2. FAO, Rome.

Further details can also be seen on the FAO's agro-ecological zoning (AEZ) methodology website:-

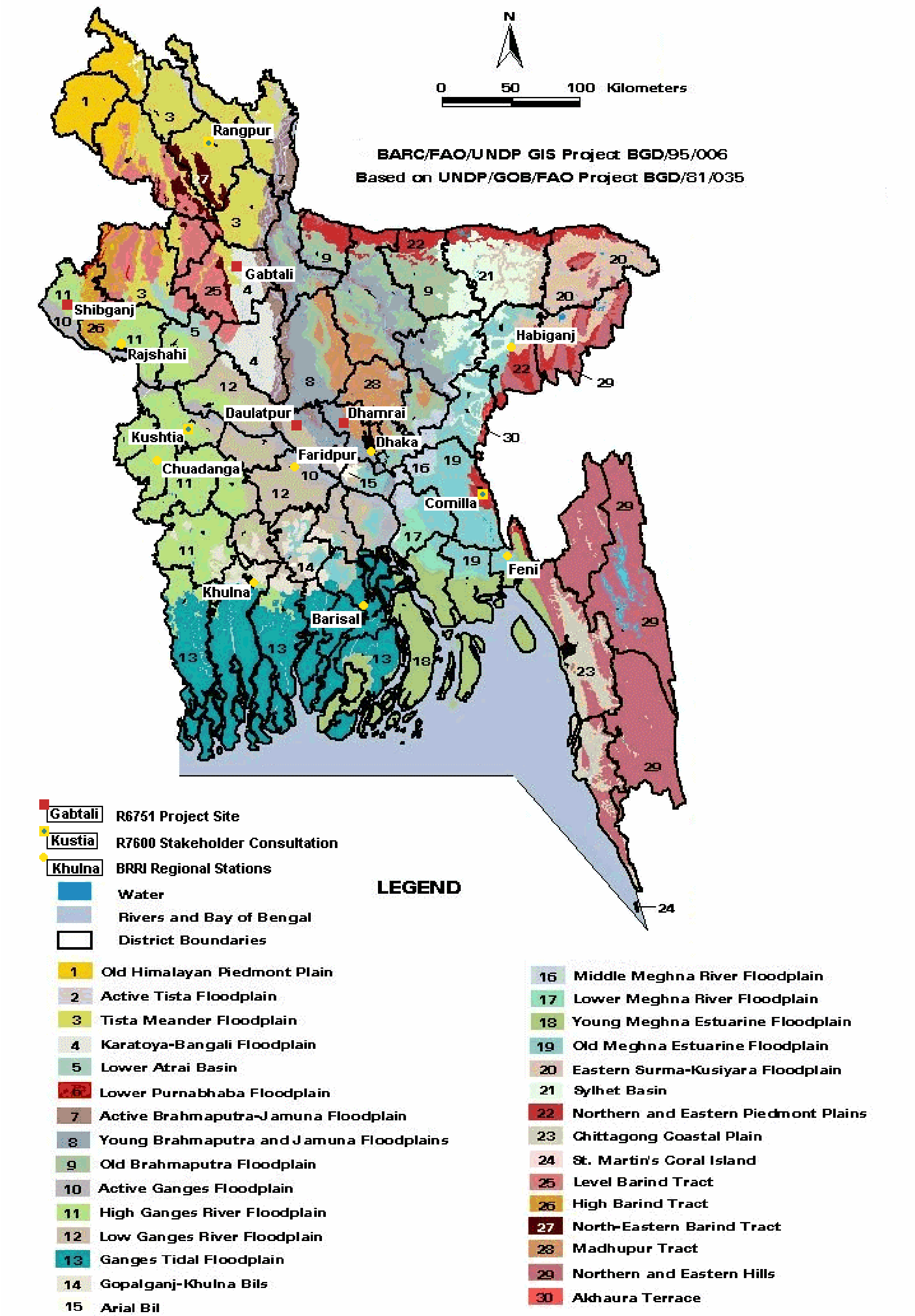
http://www.fao.org/waicent/faoinfo/agricult/agl/agll/aez.htm

Maps contained:-

1. **Agro-Ecological Zones of Bangladesh**
2. **General Soil Types of Bangladesh**
3. **Physiographic Regions of Bangladesh**
4. **Inundation Land Types in Bangladesh**

Agro-Ecological Zones of Bangladesh

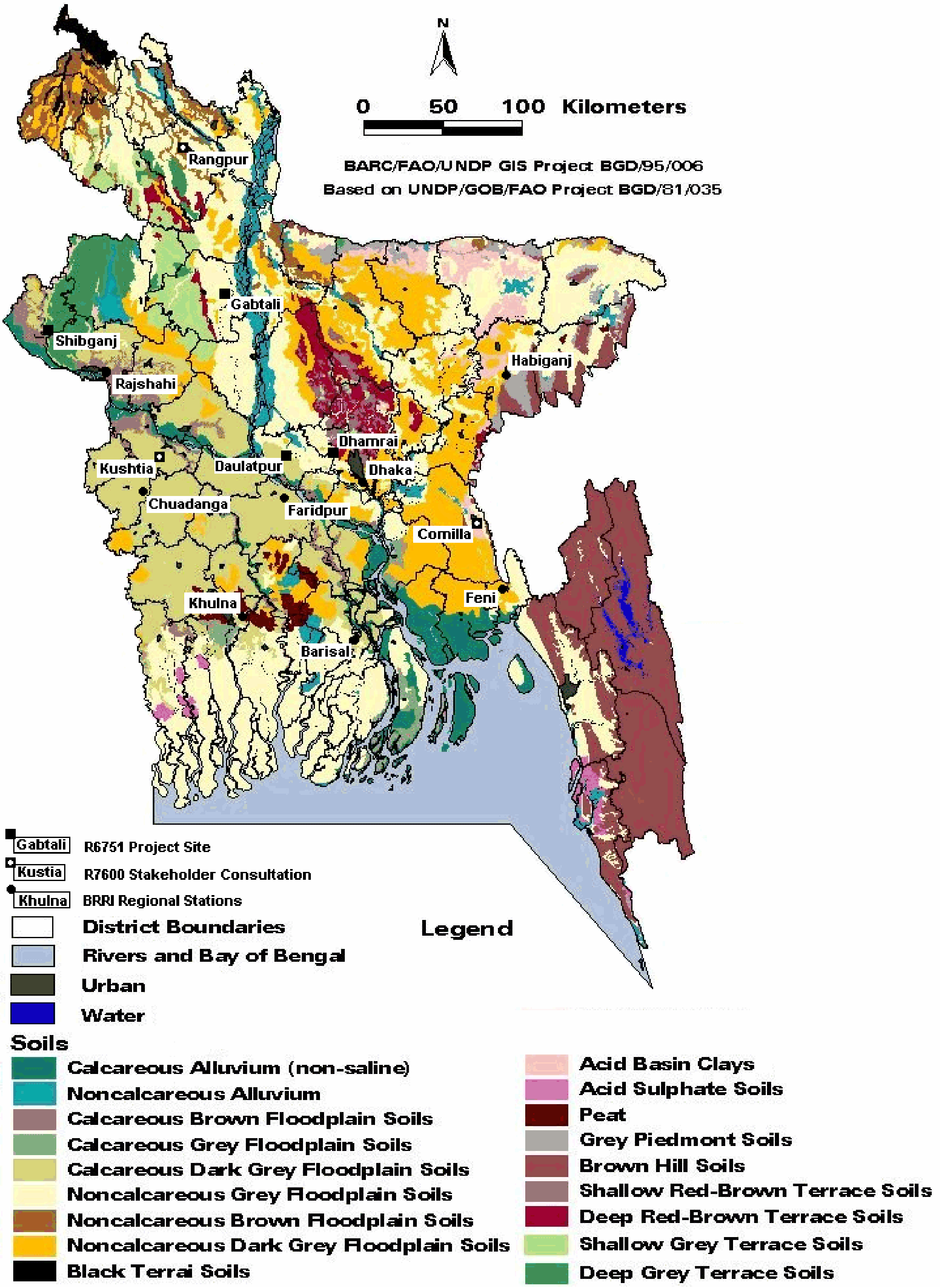
National Land Area 138,507 km^2



Source: http://www.fao.org/waicent/faoinfo/agricult/agl/agll/aez.htm

General Soil Types of Bangladesh

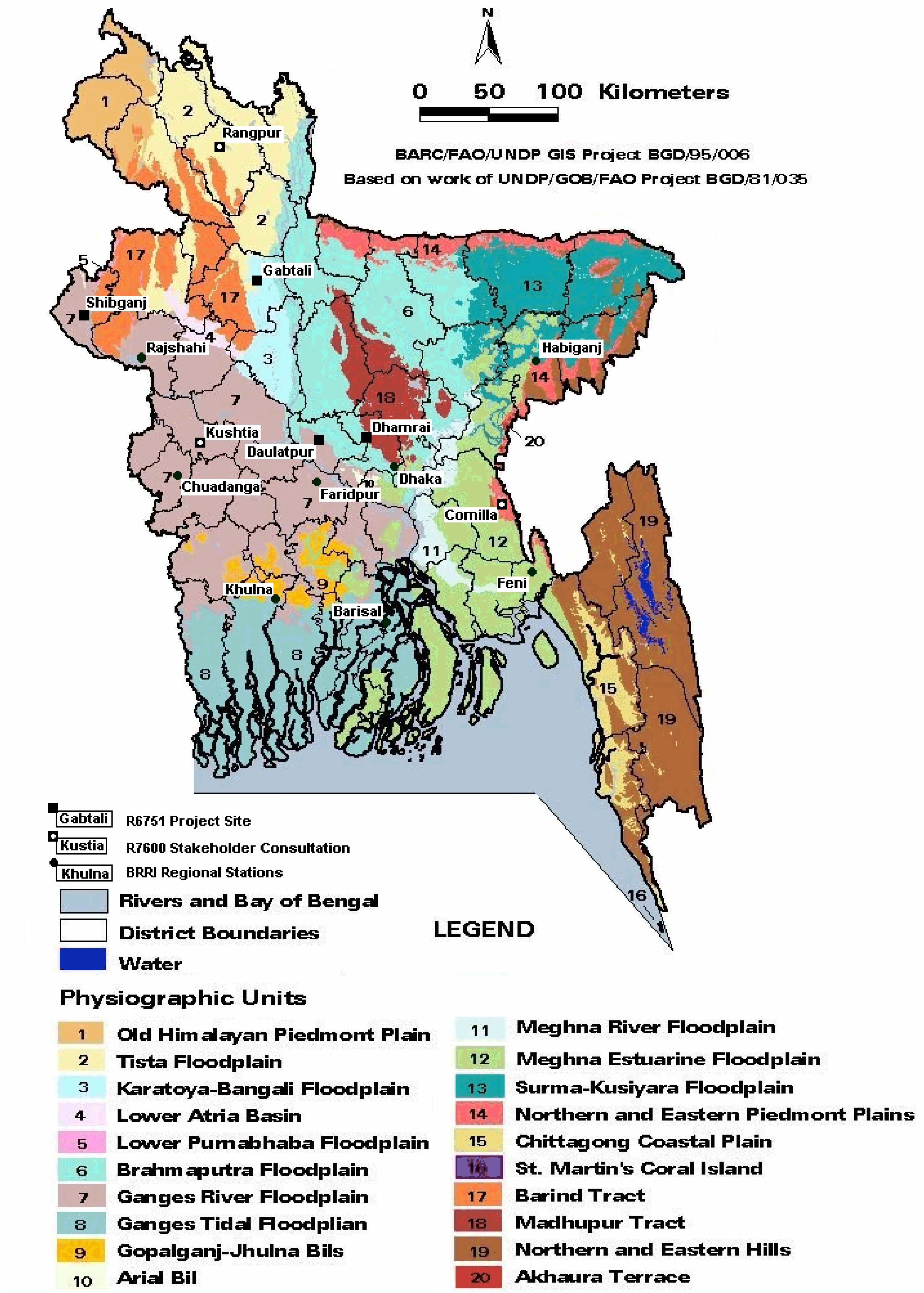
National Land Area 138,507 km^2



http://www.fao.org/waicent/faoinfo/agricult/agl/agll/aez.htm

Physiographic Regions of Bangladesh

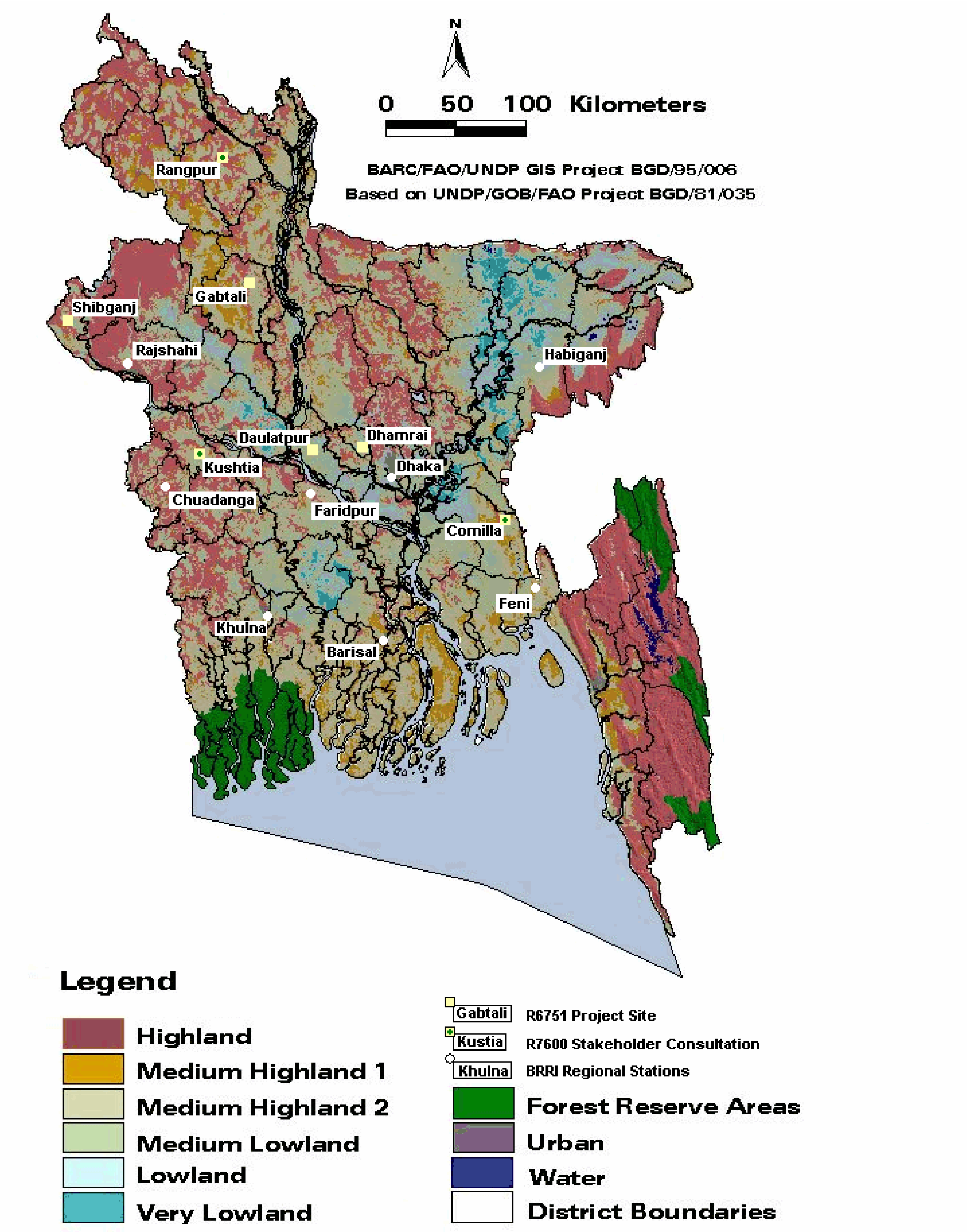
National Land Area 138,507 km^2



http://www.fao.org/waicent/faoinfo/agricult/agl/agll/aez.htm

Inundation Land Type in Bangladesh

National Land Area 138,507 km^2



Source: http://www.fao.org/waicent/faoinfo/agricult/agl/agll/aez.htm

Appendix 3. Summary of proximate, intermediate and root causes of low income in rice components identified by 5 groups of medium and small farmers in Kustia, Rangpur and Comilla ***Number of dots in each cell record No. of observations (max =5)***

'Proximate' cause	Intermediate causes				Root causes	
Low price of rice •••••	Bound to sell to agents •••••				Lack of storage •••	Corruption ••
High cost of inputs (inc. water) ••••	Poor supply •				Corruption •••	Low water table (for irrigation) •
Less rice available for sale ••					Household consumption needs ••	Crop damage •
Poor yield •••••	Low fertility •••••	Poor knowledge of fertiliser use •••••	Excessive use of chemical fertiliser ••••		Lack of extension guidance •••	
		Lack of organic fertiliser •••	Few cattle –also linked to nutrition •••	Lack of pasture ••	Demand for crop land ••	High crop production needed for livelihood •••
	Poor quality seed •••				Lack of effective supply by govt •••	Corruption •
	Cannot buy inputs on time •••				Scarce funds •••	Lack of timely& accessible credit ••
	Waterlogging •					
	Lack of new HYVs •					
	Shortage of irrigation water ••••	Scarcity of diesel & power •••			Corruption ••	High price of equipment •
	Poor health / work efficiency ••••	Shortage of protein ••••	Fewer fish ••••	High fertiliser & pesticide use ••••	Pest attack •••	
	Plastic garbage pollution •				Increased use of plastic packaging	
	Cannot plough land timely ••	Lack of draft power ••	Few cattle (see above)		Theft of cattle ••	

Appendix 4. Description of Integrated Crop Management Database

The ICM database to be produced by project R7600 contains information on integrated crop management technologies in rice based cropping systems. Technologies are drawn principally from Bangladesh and the surrounding region (the Indo Gangetic Plains).

The database categorises information using 4 broad technology groups:

1. Commodity
2. Production or cropping system
3. Practice/ Technique
4. Equipment

Each technology entered in the database receives a validation level according to the following list;

1. Validated in country (by farmers), pre-requisites for large scale implementation are understood and in place.
2. Validated in country (by farmers), but where specific logistical factors currently limit uptake.
3. Validated (by farmers) in region under similar environmental conditions.
4. Non validated i.e. developed/ tested under research conditions but not yet validated.

The database is not linear in structure. Users may search using the technology group and / or validation level combined with a number of pre-defined keywords/ categories. At each stage free keyword searches are also available.

The pre-defined keyword categories include.

- Species, Variety
- AEZ
- Equipment types
- Land type
- Technical steps in production process

Within these categories further levels are defined, for example:

- Technical steps in production process: Soil tillage
Soil conditioning
Nutrient management
Irrigation
Plant and crop establishment
Weeding
Pest & disease control
Crop maintenance
Harvesting
Post harvesting
Other

Basic information describing the technology is stored in the database if available. This includes:

- Owner / source of technology and country address
- Short technology description.
- Location where technology has been validated / used (AEZ)
- Person who entered the information
- Date of entry
- Date of modification
- Supporting communication material
- Supporting diagnostic tools