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Final report

Project	**Water harvesting and better cropping systems for smallholders of the East India Plateau**
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Contents

The East Indian (or Chota Nagpur) Plateau comprises much of the state of Jharkhand and parts of adjoining West Bengal, Chhattisgarh, Bihar and Orissa. Field operations in this project were mainly on the eastern side of the Plateau, in Purulia District, West Bengal.

Location of main field sites

1 Acknowledgments

The project reported here (LWR/2002/100) was funded by the Government of Australia, the research component through the Australian Centre for International Agricultural Research and its application through AusAID. In-kind support was also provided by the Government of India through the Indian Council for Agricultural Research. Each of the Institutions engaged in the project also provided in-kind support. We particularly acknowledge the farmers and their families who put their trust in us, shared their thoughts, time and labour, and gave us access to their land and water, without which this project would not have been possible.

We also particularly acknowledge the individuals behind the original project concept. Dr Kuhu Chatterjee, ACIAR In-county Manager (SE ASIA), who first revealed her vision for this project in 2003. Dr Tony Fischer, then Program Manager, who backed her judgement despite the difficulties ACIAR envisaged working in a remote and relatively undeveloped area in India, in poor Tribal communities with no long-term culture of agriculture, and with low agricultural productivity and a dismal record of low productivity gains. Mr Deep Joshi, then CEO of PRADAN[1], sought this international collaboration to strengthen the professionalism and approaches of PRADAN.

Successive Program Managers continued to support and encourage the work. Dr Christian Roth, who saw the potential to broaden the scope of the work to include more detailed gender studies; the late Dr Mirko Stauffacher who, with infectious enthusiasm, agreed to extend the term of the project to allow emerging principles to be applied, evaluated and refined; and finally Dr Ian Willett who brought to fruition the idea for an out-scaling phase in the work that was originally seeded and then sustained by Mr Russell Rollason, First Secretary (AusAID) with the Australian High Commission, New Delhi.

The outcomes of this project reflect the dedication and hard work of a large team of people working in a collaborative multi-stakeholder partnership. Some were engaged throughout, whilst others simply visited but shared insights that strengthened the project. Some have been professional staff, others technical; some theorists others practitioners. But all contributed to the richness of the project and its success.

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[1] *Professional Assistance for Development Action*

2 Executive summary

For ACIAR, the opportunity seen at the time of project conception was to lay the foundations for future research to improve livelihoods of some of the poorest people in India in one of the poorest regions on Earth.

Background

The East India Plateau (EIP) is one of the poorest regions of India with little irrigation, frequent drought, and mostly infertile soils. There is a high population of Tribal farmers without a long farming tradition. Mono-cropped rice is by far the major crop, with lowland varieties grown mostly on terraced 'medium uplands' (Fig. 1) rather than traditional lowlands, often resulting in food sufficiency for only 5-6 months. Although productivity and food security are low, the high but variable monsoon rainfall offers opportunities for development based on water harvesting and improved agronomy. Water harvesting refers to a suite of practices designed to collect rainwater in surface storages or recharge groundwater. Watershed development (WSD) based upon water harvesting is the major Indian Government program for improving livelihoods. It is also the centrepiece for integrated natural resource management by PRADAN. Participatory research in two watersheds in Purulia, West Bengal aimed to refine WSD principles for the EIP and develop water-efficient cropping systems with villagers.

Results

PRADAN's approach to WSD was found to be hydrologically sound, increasing storage of water in the landscape in both ponds and in the shallow aquifer, and potentially allowing substantial increases in cropping intensity and diversity. Suggested improvements include taking rainfall variation and risk into account in the watershed plan, and using flexible guidelines for more effective placement and design of structures. Regional sustainability of WSD invokes scaling issues, mainly concerning subsurface outflow at local scale, as this can become surface water fluxes at the regional scale. WSD structures (trenches, bunds, pits, ponds etc.) will reduce the runoff from treated areas, thus reducing wet season peak flows downstream. However, increased recharge leads to an increase in the groundwater storage in receiving areas, and may increase dry season flows, depending on the degree of exploitation of groundwater resources.

Traditional (puddled) rice on medium uplands of the EIP was found to be a surprisingly risky crop. It was shown that water harvesting cannot provide water for 'rescue irrigation' in the worst years, and shorter-duration rice alone cannot address the climate risk. Yet there is adequate water for aerobic, direct-seeded rice (DSR) and other rainfed *kharif* (wet season) crops every year. We conclude that 'drought' is a misperception based on experience with traditional rice. Smallholder food security in future should depend on the adoption of alternatives to traditional rice in the medium uplands – therefore agronomic 'packages' were developed with farmers for DSR, black gram, and vegetables. Residual water after rice is useful for both rainfed and partially-irrigated *Rabi* (dry season) crops – so 'packages' were developed for mustard, wheat and vegetables.

Participatory surveys of traditional rice crops found 10-fold yield variation between fields in the same land class, village and year, mostly explained by nutrition and crop protection. Improved management alone has the potential to at least double average rice yields.

Soil surveys in the two Purulia watersheds and seven others in Jharkhand show soil fertility is so variable within and between watersheds that individual field management needs an approach similar to 'site-specific management'. Surprisingly, phosphorus (P) was potentially deficient for flooded rice in 75% of fields, and rice in experiments often responded to applied P. The need for P-fertiliser will be even greater for aerobic rice and *Rabi* crops, as P is less available in aerobic soil. Wheat and mustard responded strongly to P in experiments. As there is no dependable soil testing service in the EIP, guidelines were developed for participatory assessment of fertility and a P-fertiliser prediction tool was developed. Soil surveys also suggest possible widespread potassium (K) deficiency.

Although WSD has the potential to improve productivity and livelihoods, an unexpected but important conclusion is that even *without* water harvesting, land and water resources can be used much more productively in well-managed climate-responsive cropping systems. These flexible systems respond to opportunities, so they are inherently variable although more productive – families must learn how to use greater production and income in good years to sustain them through poor years. Water harvesting can reduce the variability and further increase production, but cannot ‘drought-proof’ farming.

Monitoring land use change in the Amagara research watershed showed ready village-wide integration of new crops and techniques into farming systems, without subsidies. Case studies documented major improvements in food security, family income, and access to medical care and education, reduced forced migration, and evidence of families re-investing in their natural resources. The participatory, action-learning *process* used was crucial to this success, changing farmer's self-perceptions and perceptions about agriculture as a source of livelihood and fostering the necessary entrepreneurship.

Improved understanding of the role of women led to a modified approach to intervention. It is common in India for women’s self-help groups (SHGs) to be engaged in savings and credit activities but not in agricultural activities, except as a means of reaching male farmers. The engagement developed in this project shifted the focus to building the identity of a woman as a “farmer”, equipping her with knowledge and skills equally with men, helping her to occupy more space in decision-making in the family and to earn respect. The process was shown to transform self-perceptions and elevates status. The role of SHGs need not be confined to micro finance and women's issues, but broadened to women in livelihood generation.

Impacts

PRADAN’s Purulia team has adopted the findings on engagement processes and farming systems technology, in 2011/12 scaling out year-round planning of climate-responsive cropping to 2,700 families, mostly in villages with no formal program of WSD. These families enjoyed averaged increased income of Rs 8,500 although intervention was limited to only four fields per family. The project findings support more effective WSD, but even more importantly they have led to a re-think of the PRADAN (and Government) emphasis on systematic WSD as the initiator of development. A cost-effective alternative may be to start with better use of existing water resources, based on appropriate crop options and improved crop management, followed by WSD to provide more water resources.

This learning has been incorporated into PRADAN’s professional training program (the ‘Development Apprenticeship’). In 2012, 40 new graduates will join 22 teams in East India where project learning has been consolidated in senior staff including Team Leaders.

The partnership with PRADAN was an outstanding success, allowing extensive participatory research to be implemented in farmer's fields, the result being better-focused research and learning for all participants. PRADAN reported enhancements in both their knowledge and processes for engaging with communities, in particular how to include women beyond their role in SHG's to more effectively engage in agricultural development.

The Future

A new project agreed to by ACIAR and AusAID will scale out findings through these 22 teams and address research needs that have emerged, which include: refining the engagement process; continued work at existing research sites to document the outcomes of improved cash incomes for both families and communities and identify the constraints to further intensification of agriculture (labour, water, risk, markets etc.); continued hydrologic investigation linked to farming system development; improving the technology for DSR/aerobic rice including soil management; providing greater choice in vegetables and pulses; and integration of small ruminants into farming systems.

3 Background

The region

The Chota Nagpur or East Indian Plateau (EIP) covers 65,000 km^2, comprising the state of Jharkhand and parts of adjoining West Bengal, Chhattisgarh, Bihar and Orissa (p. iv). Although rich in natural resources it is one of the poorest regions of India, with high population density and mostly subsistence agriculture on small landholdings. Rainfall is high (1,100-1,600 mm, 80% June-Sept) with high runoff and soil erosion, yet with frequent dry spells in the monsoon. Rural livelihoods are based largely on mono-cropped *kharif* rice. Cropping in the post-rainy season is limited by a paucity of irrigation resources (restricted to wealthier farmers) and uncontrolled cattle grazing. Uplands are degraded and make little contribution to overall productivity. Population growth has created pressure to crop more marginal lands, leading to terracing of mid-slopes and uplands to create 'medium uplands' (Fig. 1) that now comprise the major area for rice production.

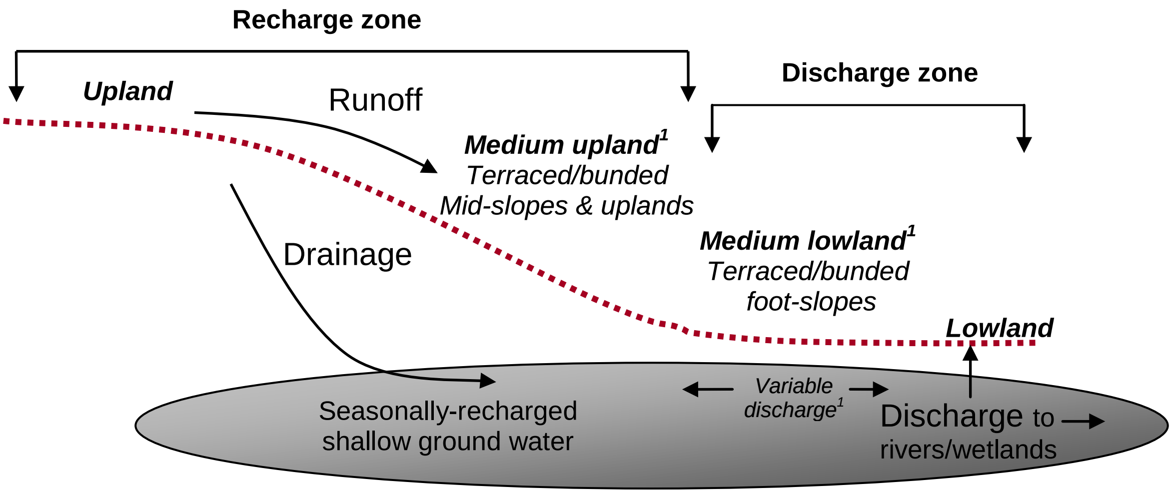

Fig.1. Micro-watershed landscape schematic - *typically up to several km^2 with relief <50m.*

[1]Medium lowlands (upslope from lowlands) are a significant discharge area in wetter years. Upland is locally called 'tanr', medium upland 'baid', medium lowland 'kanali' and lowland 'bohal'.

The problem

Agricultural development in the region lags behind the rest of India partly because of the lack of the irrigation infrastructure that fuelled the 'green revolution'. The area only recently became a priority target for development by the Government, so rural electrification (that elsewhere has driven groundwater exploitation) and other infrastructure development is lagging. It has a high Tribal population that is relatively new to agriculture, and so present a particular challenge to development as they lack the generations of experience that underpinned development in other parts of India. There is a high dependency on government support programs with mixed success.

Despite high rainfall, the region is characterized by low cropping intensity and diversity and low water productivity. With little irrigation capacity, the single rice crop per year is drought-prone, partly accounting for low yields although fertiliser and other inputs are limited and apparently poorly managed. There is little mechanisation - seeds and fertilizers are generally hand-broadcast and weeds are mostly removed by hand. The area of irrigated *Rabi* crop is small and there is little rainfed *Rabi* cropping or use of residual soil water following rice. High risk-aversion of poor farmers and the risks inherent in a variable climate, with little irrigation, inhibit investment in development. Agricultural service industries including extension are weak, and marketing is poorly developed.

As a result, most families achieve only 50-60% food grain sufficiency, so forced migration in the non-monsoon is important for off-farm income, but at the cost of social upheaval. The outcome of these forces is widespread malnutrition and low levels of literacy. Perhaps not surprisingly, the region is a strong-hold for Naxalism.

The opportunity

For ACIAR, the opportunity seen at the time of project conception was to lay the foundations for future research to improve livelihoods of some of the poorest people in India in one of the poorest regions on Earth.

Watershed development (WSD) principles suggest the high rainfall should be able to support agriculture that is more intensive, diverse and productive with manageable climate risk, if there is appropriate development of water resources. 'Water harvesting' aims to retain water in the landscape that would otherwise run off. In East India, this water may be stored in surface storages for use either in the monsoon or subsequently, or in shallow (annually-recharged) aquifers (Fig. 1) from which it is later drawn. Both provide local water resources for irrigation, thus creating the opportunity to reduce climate-risk and intensify and diversity cropping, and potentially initiating development. The Government of India has now given priority to development in East India, and WSD generally is a high priority, although the main investment so far has been in the semi-arid tropics. Further research is needed to refine watershed development principles and locally adapt them to the EIP.

The key to food security and improved livelihoods is not to bring more marginal land into cultivation, but to improve productivity from existing areas of cultivation. This means using more water (water harvesting, intensified farming systems), more efficiently (improved agronomy). At present, evapotranspiration of the single rice crop apparently averages only about one-third of average rainfall. With yields being well below the potential there is significant opportunity to improve livelihoods through more efficient use of water, but this requires improved management skills and for the risk of investment in inputs to be reduced, for example through access to water for irrigation.

At ACIAR's request, PRADAN participated as a project partner, allowing the effectiveness of partnering with an NGO to be evaluated and making livelihood improvement the central theme of the project. Not only did this make it possible to engage in a highly participatory way with farmers, but it created the opportunity to research the process of rural development along with the science and technology of improving livelihoods through WSD. Given the scale of change required of farmers, the low level of government or other support for extension, and a history of government programs that encourage dependency, there is also a need to foster independent problem-solving amongst farmers. Having PRADAN as a partner created the opportunity to study how farmers might be helped to change perceptions from one of dependency on others to belief in their capacity to generate decent livelihoods from their own natural resources.

Project Justification

Watershed development in India has been largely restricted until now to the semi-arid tropics, although PRADAN had successfully trialled water harvesting in Jharkhand and West Bengal (Purulia District) prior to project inception. Water harvesting design principles and well-documented demonstrations of success were needed for the East Indian Plateau region.

Water resources need to be matched to a wider set of crop options and new farming systems that make good use of all water resources, without over-use. Groundwater use will be sustainable if it is restricted to the annually-recharged aquifer, but it is also important that WSD not reduce surface flows to the detriment of downstream water users. The potential out-of-catchment impacts resulting from scaling-up needed to be evaluated.

The general aim of the project therefore was to extend watershed development into the higher-rainfall East Indian Plateau in a collaborative project between two Australian

Universities, the Indian NGO PRADAN and ICAR-Research Complex for Eastern Region (ICAR RCER), with its Regional Centre at Ranchi, Jharkhand, taking a participatory approach in partnership with the villagers of Purulia District, West Bengal.

The project addressed principles for the design of WSD interventions, evaluated possible adverse impacts on downstream water-users, and developed crop options and management practices to allow for more intensive and diverse systems.

Effective use of water resources requires vast changes in farming systems, requiring equally vast changes in the farmer's attitudes, knowledge and skills. No extension provider can 'teach' all of this, and so the project partners believed it was important to build capacity in farmers to solve their own problems – to build a capacity to learn. Therefore, the project also considered how to improve the engagement process when initiating the development process.

Following the mid-project review, work on the engagement process was re-focused particularly on women with additional ACIAR funding and a new project objective. Towards the end, AusAID saw the development opportunities arising from the project and contributed funds towards another new objective, to support capacity building in PRADAN as a foundation for further funding following the project.

4 Objectives

1. Develop, validate and promote water harvesting principles
2. Make a preliminary assessment of the applicability and sustainability of water harvesting across the East India Plateau, through hydrologic and geo-hydrologic studies
3. Develop cropping system options and improved agronomy to effectively use harvested water (the scope broadened during the project to include all water resources)
4. Evaluate biophysical and socioeconomic impacts
5. Enhance the capacity of PRADAN (and other like-minded NGO's) to undertake watershed development work (this objective covered technical aspects as well as the processes for engaging with communities for development)
6. Develop guidelines for processes and methodology to effectively incorporate gender sensitivity in projects (added following the mid-project review)
7. To enhance the capacity of PRADAN to scale-out improved water management and cropping practices in disadvantaged villages of the EIP (a later objective funded by AusAID)

5 Methodology

The over-arching systemic methodology

The research team believed that research into rural development needed to be systemic to be effective. A systemic methodology was adopted that included action learning and "Interactive participation" in which "people participate in joint analysis, development of action plans, and formation or strengthening of local institutions" (Pretty 1995).

The process involved interdisciplinary methodologies that sought multiple perspectives and made use of systemic and structured learning processes. A goal was to move farmers towards "self-mobilisation" (Pretty 1995) in which people take initiatives independently of external institutions to change systems - they develop contacts with external institutions for resources and technical advice they need, but retain control over how resources are used. Self-mobilisation can spread if governments and Non-Government Organisations provide an enabling support framework. For PRADAN, the enabling framework is based on the self-help group (SHG), clusters of SHG's and the Federation of SHG's (a regional body). This basic enabling framework was elaborated upon in the project to more fully engage women as farmers (equally with men) and to develop a support system for farmers undertaking development activities.

Villagers participated throughout an action learning cycle (Plan→Do→Observe→Reflect →Revised Plan etc.) that guided the overall project and most activities. Participation in this project had the particular meaning that farmers were genuinely partners with researchers in determining research priorities and interpreting the results. The interpretations may have differed between participants, because each has a different set of objectives as well as current knowledge with which to evaluate and apply the research findings.

As farming systems *research*, elements of this approach included (Cornish 2005):

1. that the research was done on farms with direct involvement of farmers, development professionals and scientists in planning, execution and analysis,
2. that each issue has a well formed research question(s), although stakeholders may ask different questions in the same activity, and
3. that any activity is genuine research and not simply a demonstration.

The approach was designed to strengthen the links between science and practice, improve relevance and adoption, and provide a venue for exploration of a richer set of issues than has traditionally been experienced in research activities.

The biophysical component of the research stressed:

1. Development of a strong conceptual framework (based on Fig.1),
2. Experiments/data collection to:
    a. understand the agro-ecology and
    b. support modelling (that captured a broad range of theory, extended results across sites and years, and allowed risk assessment, and
3. Development of tools/materials for making decisions (for farmers and professionals). The resultant materials are found where relevant in this report.

Project inception workshops were held in villages in April 2006 to clarify issues faced by farmers and seek convergence between broad project objectives and the specific needs of farmers. Based on these workshops, the research team met to consider possible specific research questions and activities, and then met again with villagers to discuss and settle on questions and activities of mutual interest. Following these workshops, the project followed an annual cycle which is illustrated below:

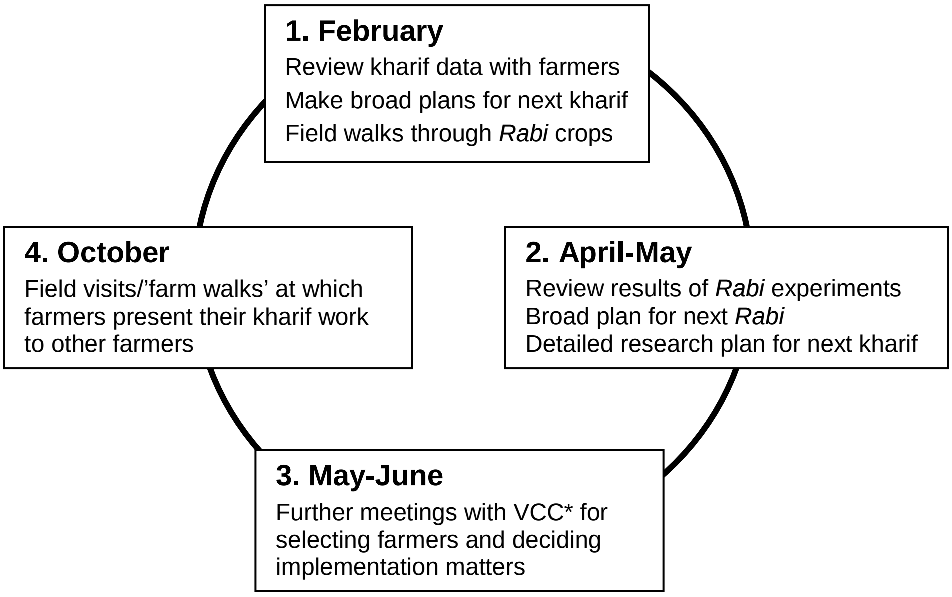

Fig. 2 Meetings for reflection and planning (doing and observing in-between)

Meetings cover more than one part of the action learning cycle, reflecting the annual cycle of kharif and *Rabi* cropping. In the action learning cycle, Plan, Do, Observe and Reflect appear to be separate activities, but these may overlap e.g. reflection of Kharif and planning for the next *Rabi* may occur together.

*The Village Core Committee (VCC) represents all SHG's in a village. It was responsible for project activities.

The Research Strategy

Project activities were in two watersheds in Purulia District, West Bengal (see map p. iv), that take the name of their major village (Pogro and Amagara), plus pilot-scale up-scaling in the wider Purulia district and soil surveys in seven watersheds in Jharkhand.

Amagara (160 families) was where the intervention 'process' and technical aspects of crop management, crop choice and *Rabi* crop irrigation strategies were researched,

Pogro (about 250 families in 3 villages) was an implementation watershed where an enhanced approach to WSD was developed during a pre-intervention period of 3 years of baseline monitoring and hydrologic research, culminating in an intervention plan which could be compared with the plan normally developed by PRADAN. This was implemented in the non-rainy seasons of 2008-09 and 2009-10 and followed by a post intervention period of monitoring, from May 2010 to March 2012. Pogro watershed has within it a hydrologically separate sub watershed used as a 'control', where no interventions were made by the project after the initial monitoring period (some work may have been undertaken by local villagers).

The project was linked to a PRADAN SGSY project. ACIAR supported the Purulia team to extend project learning to 2,700 families and evaluate outcomes.

In June 2011, AusAID agreed to fund a 4-year project to upscale project learning through PRADAN and out-scale the work through 22 Teams that will reach a total of more than 200,000 families. The first tranche of funding for this was attached to the present project, with the aim of adapting the curriculum for PRADAN's in-house one-year training program for new appointees (all of whom are graduates), training of 40 new 'Apprentices' and capacity-building within the leadership of PRADAN. The 40 graduates of the Apprenticeship program will join field teams across the EIP during 2012.

Methods according to key research themes

The project had 6 research themes reflecting areas where attention is required for successful WSD. Together, these address the research objectives. The methods relevant to each theme are covered in the following Sections:

5.1. Resource assessment (various methods including PRADAN's present approach, soil and crop surveys, electro-magnetic induction and hydrologic monitoring)

5.2. Developing social capacity (including effective engagement of women)

5.3. Improving farmer's agronomic knowledge and skill (building human capacity). These were often shared activities with 5.1, 5.2 and 5.4.

5.4. Developing crop options and farming systems (for effective use of resources). This included crop evaluation and fertiliser and irrigation experiments

5.5. Effective and sustainable WSD (hydrology)

5.6. Up-scaling proven processes and technology

Section 7 in the Final Report (Results and Discussion) also follows these themes.

Methods for the Monitoring and Evaluation are in Section 5.7.

5.1 Resource assessment

5.1.1 PRADAN's assessment of socio-economic and natural resources

Before undertaking development work in a new area, PRADAN undertakes detailed socio-economic and biophysical assessment on which an intervention plan is based (Fig. 3). Early in the process, PRADAN undertakes capacity building through the development of women's self-help groups (SHG's). PRADAN undertook much of this assessment in Pogro in 2005/06 to quantify benchmarks for establishing impacts later in the project. These assessments were also used to develop PRADAN's usual watershed development plan that could be compared with any plan produced by the project, which intended to inform only the hydrology of the watershed plan and not to inform the socioeconomic considerations. PRADAN's approach is fully described in Appendix 11.1.

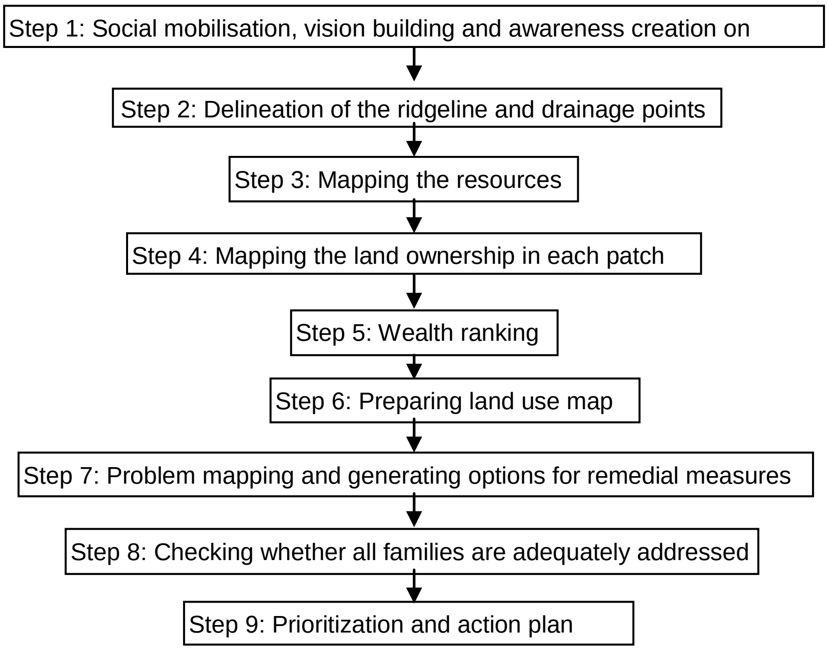

Figure 3. Steps followed by PRADAN in Watershed Planning

5.1.2 Soil surveys and soil profile descriptions

The project sought a deeper understanding of soil and water resources before developing watershed intervention plans or developing agronomic research. Soil assessment also underpinned the aim for this project to scope opportunities for future research in the EIP.

Soil profile description (soil pits) and mapping soil types

Profiles to at least 1m depth were described for 11 sites in Pogro covering the major land classes, and mapped. As well as describing visual attributes and field texture, profiles were analysed for pH and EC, OC, N, P and K, and 1/3 and 15 bar pressure plate values (selected profiles). P-buffering capacity and CEC were requested but not done.

Soil surveys in research watersheds

Classical soil maps do not include all the relevant information for agronomy, and not at a spatial scale required for our agronomic research. So soil surveys were undertaken in conjunction with crop surveys and fertilizer experiments. These were stratified random surveys of at least 10 fields in each land class (uplands, medium uplands etc.). Soil was sampled to 10 cm[2] depth in a 'Z" pattern in a field then bulked and subsampled. It was repeated in Pogro from 2006 to 2008 and in Amagara in 2007 and 2008, as well as on an *ad hoc* basis for each agronomic experiment (for fields not part of the wider survey). An archive of all soils sampled during the project was established at HARP, Ranchi. Double-ring infiltrometer measurements were taken at the soil surface in all landscape positions, and at several depths after removing surface soil (in soil pits) in selected paddy fields.

Soil survey – Jharkhand

To confidently apply the results more widely, a soil survey was undertaken in Jharkhand in 7 watersheds selected for their geographic spread and diverse soil types and land-uses. In each, sampling was stratified to cover the land classes (homestead, uplands, medium uplands etc.), and in each land class 6 fields were chosen at random for sampling. A total of 252 fields were sampled. Analytes were restricted to those that proved most important in Purulia: pH (in water), CEC, OC, available P (Bray, Olsen[3]) and exchangeable K. N was excluded as it depends greatly on current management, but is mostly low anyway. Evaluation of micronutrients was beyond project resources.

5.1.3 Soil water relations

For agronomic work including modelling, it is important to know the water holding characteristics of soil (water retention and release and the depth of extraction). We made laboratory determinations of 'field capacity' (1/3 bar pressure plate) and 'permanent wilting point' (15 bar) for the major land classes in Pogro using samples from soil description pits. Contemporary agronomic approaches also require field determination of the 'upper drained limit' (UDL) and the 'crop lower limit' of extraction (~WP) (CLL).

To determine the UDL, oven-dried water content was determined gravimetrically after rice harvest in a wet year (2007), as soon as practicable after the surface had drained. Values for each field were the mean of 3 holes, sampled using a 75 mm diameter auger designed to operate in wet soils. Sampling increments were 0-10, 10-30, 30-60 and 60-90 cm. Gravimetric values were converted to volumetric water content using bulk density determined from four fields sampled after rice harvest using 10 cm x 6.8 cm bulk density rings at five depths. Values were fitted to exponential regression and interpolated to the depth increments for soil water determination. Bulk density (ρ_B) ranged from ~1.5 g/cm^3 for surface soils to >1.8 g/cm^3 for soils below 80 cm. Assuming a particle density of 2.65 g/cm^3, the total void space ranged from 0.43 v/v (ρ_B 1.5 g/cm^3) to 0.32 v/v (ρ_B 1.8 g/cm^3).

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[2] 0-10 cm rather than the customary 0-15 cm for India, because the soils are only cultivated to that depth

[3] Both tests were included, as soil pH covered the range in which both are commonly used in India i.e. Bray for soils with pH,7 and Olsen for pH>7. Comparison showed little difference over the pH range 4.7-7.7.

Field values obtained for UL at saturation were less than those derived using the pressure-plate at 0.03 MPa. The higher values from the laboratory were inconsistent with the total void space (above), and were presumably an artefact of grinding.

The CLL for rice on medium upland was determined in 2008 when good early and mid-monsoon rainfall preceded early cessation of the monsoon forcing well-grown crops to mature on stored soil water. The sampling procedure was the same as for UL, but different fields were sampled. The field-derived value for CLL was comparable to the value derived from pressure plate determination (15 bar) using soil obtained from pits.

5.1.4 Rice crop surveys (linked to soil surveys)

Crop surveys were seen as a resource assessment tool to identify potential yields and a starting point to understand yield constraints (as well as a vehicle for farmer learning, Section 5.3). The aims, for the resource assessment aspect, were to: (i) evaluate whether baid (medium upland, Fig. 1) is 'poor land' as the farmer's told us (determining achievable potential yields in each land class), (ii) determine the extent to which variation in yield can be related to soil fertility (management constraints are considered in Section 7.3).

Crops and their management were observed along with the soil survey in Pogro (2006-08) and Amagara (2007-08). For each year/village, data were collected from >30 fields for variety, transplanting date/seedling age, fertiliser/compost input, tillage, weeding, weed and pest incidence, anthesis date and crop biomass and yield. Most data were recorded by farmers (after training), including assessments of weed, pest and disease incidence using a simple rating system. Biophysical data were analysed by multiple regression. Observations were made of farmer's responses to the data when shared in a workshop.

5.1.5 Weather monitoring and recording

Two weather stations were installed in the study site: a Stevenson screen in the lowlands area near the Pogro village for recording temperature data, and a manual rain gauge in the village (on the roof of the house of the main data collector). An automatic weather station was co-located with the manual rain gauge, recording minutely values of rainfall, temperature, relative humidity, wind speed and solar radiation. In 2010, standalone rainfall and temperature/relative humidity sensors were added to the station in the village to provide backup for the AWS. The rainfall data was event-based, with each tip of the bucket being recorded. This gives a good measure of the rainfall intensity. Due to the limited memory of the standalone temperature/relative humidity sensor, data was recorded every 15 minutes. Manual measurements of temperature were collected twice daily, with manual rainfall recorded after events.

5.1.6 Shallow groundwater assessment via wells and piezometers

Water fluxes within the Pogro site were monitored at the point scale to understand site hydrology and generate data needed to develop models. The monitoring network is shown below, with hydrological boundaries marked in black and the lowland area in grey.

The western boundary is not fixed as there is a large pond just outside the boundary which can spill into the study catchment. The study site is bounded in the east by a railway embankment with two culverts. Each culvert drains a separate sub-catchment. The smaller sub-catchment (B: northern culvert in the diagram) was used as a reference, with no project driven WSD work carried out within the life of the project. While not a classic "paired catchment" study, sub-catchment B was used to test the ability of models to capture the impact of climate variability, and thereby give a confidence on the detection of the impact of WSD within sub-catchment A.

Monitoring network for the Pogro site

The monitoring network consisted of 14 wells, 4 ponds, 15 piezometers and 2 weather stations. Most of the open wells in the study site were monitored – selection was based on giving as good coverage of the study site as possible. A subset of 4 ponds was selected for monitoring, comprising 2 upland ponds and 2 ponds located closer to the catchment outlets. The piezometer network was focused mainly on the lowland area, with the aim of developing understanding of the subsurface flux through this region. A transect from the upland (Pz 13), through medium upland (Pz 14) to lowland (Pz 4) was also included to investigate the relative behaviour of these regions. The network was mostly installed during Nov. 2005 and completed in early 2006. Manual measurements were made by trained villagers, with data recorded at differing frequencies depending on the expected rate of change - mostly daily in the wet season, down to fortnightly in the dry season.

5.1.7 Gauging runoff at Pogro watershed, including an adjacent 'control'

There are two component discharge volumes: water level (also known as stage height) and a rating curve relating water level to discharge volume. The rating curve is derived from flow velocity measurements and the flow cross section. Staff gauges were installed in both culverts in 2005, with water level manually recorded roughly daily by trained villagers through the wet season. For continuous recording of the flow data at both culverts, weir structures were constructed and water level loggers (pressure sensors, with atmospheric variations removed using a reference sensor located in the Pogro village) were installed in both culverts in 2008 (Photo). As the culverts are a thoroughfare during the dry season, the weirs were designed to have a minimal impact to all forms of traffic. A slight increase in height towards the walls of the culvert increased sensitivity to low flows. A small channel was included in the centre for installing a STARFLOW instrument so a rating curve could be obtained. This was unsuccessful however, and the flow velocities were measured manually using a current meter during the 2011 monsoon.

Culvert B weir designed for adequate gauging of flow with minimum impact on users.

5.1.8 Soil water balance modelling and assessment of risks and opportunities for crop production

Soil water balance modelling was seen as a key tool for water resource assessment, for understanding agronomic responses in our experiments and, more importantly, for understanding the risks and opportunities for rice and alternative crops. Modelling was the main way of assessing cropping potential and for designing new farming systems that could be tested by farmers. The model used was adapted from Cornish and Murray (1989) for the rice-fallow system of East India. The model is described in Appendix 11.2.

5.1.9 Mapping with electro-magnetic induction (EM 31 and EM 38) to evaluate as tools for water resource assessment.

The Methods and Results are reported in Appendix 11.3.

5.2 Developing social capacity

All field-based project activities were designed to provide insight into how the process of engaging with individuals and communities might be improved to foster ‘self-mobilisation’, as described under general project methodology. These insights were used to suggest what changes PRADAN might implement more widely in the way it engages with rural communities to foster livelihood improvement through improved management of natural resources. The methods used in the scaling up are described in Section 5.6.

5.2.1 Engaging villagers in all activities (see also 5.3.1)

Villagers were engaged in all activities from project planning through to implementation and interpretation of data, meeting frequently to review and plan (see Fig. 2). Whilst most activities had a ‘technology’ focus (see section 5.3.1) our aim was to also use every activity to challenge farmer’s self-perceptions and at the same time build capacity in the villages to manage the agricultural changes that need to accompany WSD. The most regularly used forum for planning, monitoring and reviewing progress was the SHGs and

VCC[4]. Additionally, at 3-6 month intervals village meetings were held with women and men to make annual plans and share results. The process whereby the farmers learnt to generate knowledge has been fostered throughout project implementation. The process and approach evolved in the course of the project as an outcome of the action-learning methodology and continuous M&E. The engagement of women through SHGs led ultimately to research into how to more effectively engage women in development.

5.2.2 Forming and supporting women's self-help groups (SHG's)

In PRADAN Purulia, SHGs are the primary community organization that the team starts working with in any village. Initiated as savings and credit management groups, SHGs evolve as cohesive and autonomous social units based on trust and mutuality. They remain an important source of microfinance for their members but also provide the platform for area based social and political mobilisation through Federations. They act as springboards for advocacy to secure goals that individuals would not be able to attain on their own. SHGs thus not only enhance the sense of self-efficacy among members but also influence institutions relevant for their wellbeing.

The SHGs also play an important role in acting as a platform for launching livelihood intervention as a group. The Federation[5] has agriculture-livelihood intervention as one of its key programmes, whereby the SHGs play a crucial role. Initially their roles were limited mostly in organising the farmers of their villages and help for each other to make proper choices of crops.

In Pogro and Damrughutu, where there were no functioning SHGs at project inception, designed interventions were made to promote SHGs. This was done mid-project from the learning derived while working with SHGs in Amagara.

5.2.3 Gender studies

It is widely accepted that community participation is incomplete without the participation of women, and widely believed that their participation in activities will lead to their empowerment, thus decreasing the gender gap. PRADAN's approach to farmer mobilisation is predicated upon women's SHGs. This provided an opportunity to extract learning on gender mainstreaming, and it was agreed at the mid-project review that the scope of the project be broadened to study the process and approach adopted in implementing this project. Also an attempt could be made to derive design principles that can foster women's empowerment and mainstreaming. Under the gender studies, research questions were developed that mainly focused on the women's enhanced self-esteem, raised status and role sharing in the family. The main activities planned were-

- Survey questionnaire in a control village
- Timeline Survey through semi-structured interviews
- Focus Group Discussion
- Case Studies
- Structured interviews of women
- Structured interviews of stakeholders (Panchayat member, GP pradhan, banker)
- Attitudinal Scaling on Thurston and Likert Scales.

Because of staffing issues (see Section 6) we later limited the study to completing the timeline survey and attitudinal scaling. Case studies that touched on gender issues were undertaken as part of the M&E.

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[4] *VCC (Village Core Committee) is an executive / functional body formed by the SHG institution (SHG-Cluster-Federation system) at the village level with representative(s) from all SHGs in any particular village. The role of the VCC is in management, to implement the policies / decisions taken by this SHG institution.*

[5] *the third tier collective of 150-250 SHGs from villages in a Block (sub-district).*

5.3 Improving farmer's agronomic knowledge and skills (human capacity)

Activities were undertaken to jointly improve farmer's agronomic knowledge and skills (human capacity) and the research team's knowledge of engagement processes that enhance farmer-learning. Along with acquiring skills and knowledge, it was also thought important that the process of learning should help farmers to change perceptions of their natural resources (e.g. the value of uplands for the right crop) and improved perceptions of themselves as farmers. This 'process knowledge' was used when designing the 'scaling up' (Section 5.6).

5.3.1 Engaging villagers (see also 5.2.1)

Most activities were in common with those described in Section 5.2.1, but with the aim of co-learning about new crop options, fertilizers or irrigation. Every activity was used in some way to build the farmer's knowledge and skill in key areas (and challenge farmer's self-perceptions), as well as provide scientific understanding. We avoided subsidies or other artificial means of engaging farmers in activities (but some inputs were given initially in some cases), whilst explaining risks to farmers requiring them to share the risks as well as the benefits, and designing project activities to elicit shared learning.

5.3.2 Workshops

These were always action-learning activities, sometimes extending over significant time. For example, a fertiliser workshop (described fully in Appendix 11.4) starts with a day of mostly 'hands-on' learning about soils, plants and fertilizers, which is designed to move participants towards participation in the next phase of the workshop which is an in-field fertiliser experiment, and finally to meet for a day to elicit meaning from the extended activity and prompt a decision about future actions to improve the farmer's situation. Farmer learning may be about crop types (legumes/non legumes) and fertilisers, but it has also been about general agronomic skills including line planting (where appropriate), weed management and timeliness.

5.3.3 Specific activities to better understand the adoption process

Some field experiences for farmers were specifically intended to inform the design of a learning approach for farmers that maximised the chance of changing farmer's perceptions about his/her self and about their resources. In these, the actual field treatments were of interest to farmers but of no direct concern to researchers because the research was into the adoption process.

5.3.4 Soil and crop surveys

Crop monitoring and group learning was evaluated as a key learning strategy (or tool) for farmers (and PRADAN). Soil and crop surveys described as resource assessment activities in sections 5.1.2 and 5.1.4 were also used as learning activities for farmers to appreciate the real rather than perceived value of different land classes, understand the concept of achievable potential yield, appreciate the importance of management in achieving higher crop yields, and to help them identify key management factors they can address. After rice harvest, farmers met to share and discuss the results (from activities described in Sections 5.1.2 and 5.1.4), learn from one another and plan future actions.

5.3.5 'Learning cluster'

Six co-located farmers within a single drainage line outside the hydrologic boundary of the Pogro watershed, but within the village, was developed as a focal point for learning and to assist the village and individuals to make the transition from having no water harvesting structures to a developed watershed with improved water availability and many new options for using the water. The learning cluster was intended to help the project team learn how to facilitate the complex change process (details Appendix 11.5).

5.3.6 'Field walks' and 'exposure visits'

Farmers participating in the project, other farmers in the village, and other villages, were invited to these planned learning activities that explicitly included time for reflection and future planning.

5.4 Developing crop options and farming systems

5.4.1 Evaluation of crop options for *kharif* (non-flooded) cropping and *Rabi* cropping (includes P x irrigation experiments for *Rabi* crops)

It was important to verify with farmers that a range of crop options could be grown, with or without water harvesting, to make use of water resources in flexible, climate-responsive cropping systems. Given the limited resources of the project, this 'verification' was given priority over *finalising* production protocols for particular crops. In any case, our underlying philosophy was that farmers are in the best place to adapt production technology to their own circumstances if they have a basic understanding of what is important. The key is to know what is important. As participatory experiments, they also contributed to capacity building for farmers.

A short list of priority crops was determined through dialogue with farmers. None of the crops were new to East India although almost all were new to the production system of the individual farmers. These simple experiments were designed to lay a foundation for later tailoring a 'package of practices' (POP) unique to each village or villager. Any POP used in out-scaling is based on our findings after adaptation to local needs through discussion drawing on local knowledge, farmer's risk aversion etc. and other sources of information. The experiments generally dealt with varieties, fertilizer (N, P) and (for *Rabi* crops) irrigation x P. Some compared row spacing and weed management.

These were randomised complete block experiments (RBC's) designed for analysis of variance (ANOVA), with each farmer's field generally being a block. A variety of experimental approaches was tried so we could develop guidelines to effective participatory *research* that could be employed by other researchers.

Irrigation experiments were designed to provide a starting point for farmers to grow *Rabi* crops (usually for the first time). Our plan was to exploit residual water after rice, relying on early planting and, if necessary, supplemental irrigation. As any *Rabi* crops are usually fully irrigated in the EIP it was necessary to have a range of irrigation treatments from full to partial irrigation, and where practical no irrigation. Irrigation treatments were in factorial combination with P-fertilizer treatments, as we expected an interaction.

All experimental fields were tested for fertility, and minimum crop data included planting dates and plant populations, biomass at maturity and yield (based on either quadrat cuts and or farmer's data for whole fields). All *Rabi* experiments required measurement of soil water near planting and harvest, although the latter proved challenging with hard, dry soils and scarce labour.

5.4.2 Nutrient responses in transplanted rice

This developed as a significant part of a broad enquiry into agronomic constraints and opportunities in the EIP designed to indicate future research directions rather than provide definitive answers. The aims were to better understand nutrient constraints and how to address them, to develop simple, robust procedures for diagnosing nutrient requirements, and to help farmers learn about fertilizers and their effective use.

Experiments were either part of a fertilizer workshop, and/or conjoint with rice crop surveys (Section 5.1.4) to provide farmers with an option for responding when yields were low and plant nutrition was suspected. Fertiliser experiments were simple, but designed for statistical analysis. In all but one case they focused on the major nutrients N, K and especially P. Care was taken when choosing fields to avoid trees and other obvious confounding effects. Individual fields were always blocks (replicates) in the design. On terraced fields with areas of 'cut' and 'fill', treatments were applied such that treatments were equally exposed to both types of land. Amongst the approaches evaluated were:

Paired or matched-fields (for mobile elements like N where paddy fields can't be split). Sets of 3 adjacent paddy fields in 2006 were matched as far as possible, and replicated 10 times across the watershed for analysis by ANOVA. Fields in each set were treated with (i) farmer's normal treatment, (ii) 50 kg/ha N added (iii) 50 kg N + 20 kg P/ha.

Test strips and **split fields** were used as a simple way of detecting deficiency of the nutrients that are immobile once applied to soil e.g. P and K. These experiments were designed for paired t-test analysis. Typically a strip several metres wide would receive a nutrient at a fixed rate above the farmer's rate, that would be the control on both sides of the strip. Small fields could be simply split and treatments assigned at random.

Omission trials, also designed for ANOVA, were used in the 2008 kharif season. In an omission trial all[6] nutrients are supplied to a whole field, except in strips where single nutrients are omitted. This design is more complicated than the split field, but provides information about interactions where more than one nutrient is tested. The results can be used to calculate a nutrient requirement[7].

Replicated dose-response experiments designed for ANOVA. In most cases, a farmer's field comprised a single replication.

5.4.3 Evaluation of farming systems strategy based on earlier-maturing rice

The *Rabi* program was based on the underlying principle that stored (residual) water at the end of the monsoon may be one of the greatest untapped resources in this environment. However, it became apparent early in the project that effective use of water resources would require complex system change. We began participatory experiments with alternative farming systems but abandoned this after two attempts (too hard, limited value), to simply lay the foundations for a farming system by providing farmers with (i) crop **options** that, when integrated into a system, may optimise use of water resources and (ii) the **tools** to help make choices. The approach was underpinned by field experimentation (Sections 5.4.1-3), simulation modelling (Section 5.1.8), developing learning resources, and monitoring land use change over time in Amagara both during and after the field research. The approach assumes that (i) no two fields or farmers are the same so there is little value in comparing set systems and (ii) farmers can best integrate new knowledge into current practices to develop new systems.

We always explained any proposed work to farmers in terms of a farming system e.g. when farmers were asked about work on direct seeded rice or short duration rice, it was always mentioned that the aim was to follow the rice with another crop.

The core hypothesis

"That early maturing rice creates the opportunity for a crop following rice", either irrigated or in some cases rainfed. Early maturity reduces risks of rice failure in poor years and

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[6] In reality, not all nutrients are supplied, only those which some prior knowledge suggests might be deficient. These nutrients then become the subject of the omission trial, in our case P and K.

[7] Based on the increase in the quantity of the nutrient removed, which is calculated from published values for concentrations in grain. Assumptions need to be made about fertiliser efficiency. This is the basis of a P-fertiliser prediction guideline prepared for PRADAN.

provides an opportunity for a second crop in most years. Early maturity can be achieved by cultivar choice, or by direct-seeding rice for earlier planting. The choices made for one crop in a particular season is not independent of choices made previously, or following – so farmers have to think in terms of a system. Along with changing farmer's perceptions of self and his/her resources, the focus has been on developing options for better use of both rainfall and, in particular, harvested water and residual moisture.

The hypothesis was based on the following **key assumptions**

i. Short duration improves rice yields in dry years but may reduce yields in good years.

ii. Producing a second or even third crop will give greater system productivity than a single rice crop, even if rice yields are sometimes reduced.

iii. From i and ii, we need to know the effects of rice duration on the yield of both rice and any subsequent crop.

iv. Short season varieties may sometimes leave more water in the soil at harvest, or at least allow a second crop to benefit from the period when soils are near saturation

v. In most (but not all) situations, it is assumed that a second crop will use significant residual water, i.e. crops will not be fully irrigated (some will not be irrigated at all)

vi. The amount of residual water depends on landscape position (greater soil depth lower in landscape, in the lowest positions there may be lateral flow through soil).

vii. There are no soil physical or chemical impediments to second crops using the residual water (e.g. compact soil/poor structure, low pH and high Al)

5.5 Effective and sustainable watershed development - hydrologic considerations

This requires developing water harvesting capacity and linking water supplies from all sources to crop options and farming systems (for efficient water use).

5.5.1 Developing models that capture the function of water harvesting structures.

Based on data collected during the project coupled with field observations, a suite of models was developed for individual water harvesting structures commonly used by PRADAN, as well as more generally applied techniques. These include:

1. 30x40 plots (hillslope plots 30x40 feet with low bunds to intercept and direct runoff to a pit in the corner, for irrigation and/or to recharge local groundwater).
2. 5% pits that are 5% of the area of a field, designed to capture local runoff for use in irrigation.
3. Ponds (i.e. dams) and recharge pits (pits designed to capture runoff to recharge local groundwater)
4. Seepage pits (pits in lowland or drainage lines, designed to give access to shallow groundwater – pits are emptied for irrigation and refill by seepage.

These models were used to assess the impact of such structures on the fluxes and storage of water at a plot scale, and formed the basis of the guidelines that were generated for designing WSD intervention plans. These models also laid the foundation for the micro-catchment scale hydrological modelling work that was undertaken towards the end of the project.

5.5.2 Evaluating/improving PRADAN's intervention plan for Pogro

While data collection was taking place, PRADAN followed their existing practices for developing WSD plans (but delayed to allow adequate observations of pre-intervention conditions). This included mapping the resources and developing an outline of what could be done within the catchment. Once sufficient observations were made at Pogro and Amagara, understanding of the hydrological response of the study sites was used to evaluate existing practices to identify what works well and where improvements could be made. Coupled with simple observation techniques (e.g. using test holes to explore potential shallow groundwater resources), this knowledge was used to develop guidelines for developing WSD plans. The final WSD plan for Pogro was then developed by PRADAN based on the guidelines. Feedback from the PRADAN staff was used to assess the effectiveness of the guidelines, and adjust the guidelines where necessary.

5.5.3 Developing and applying models to evaluate the potential out-of-catchment impacts as WSD is scaled up over larger areas of the EIP

Evaluating the impact of wide-scale WSD in the East India Plateau (EIP) on stream flow requires modelling catchment response at a ~1,000 km^2 scale. To achieve this, hydrological modelling was conducted at 3 scales using a range of approaches. At the micro-catchment scale (Pogro study site), observations of discharge through the culverts were used to develop, calibrate and test model structures (see Appendix 11.6). The starting point for these structures was the IHACRES rainfall-stream flow model (Jakeman *et al.* 1990), using the catchment moisture deficit (CMD) version (Jakeman and Croke, 2004). At the meso-catchment scale (of the order of 100 km^2), daily data for 5 catchments in the Damodar Valley (where the Pogro study site is located) were used to test model performance. Finally, at the catchment or basin scale (of the order of 10,000 km^2), data for sites in the Brahmani basin were used to test the model performance, as well as methods for estimating the areal rainfall and unit hydrograph.

Application of the model to the EIP uses long-term (1971 to 2005) gridded climate data from the Indian Meteorological Department, applied on a semi-distributed version of the model developed at the Pogro study site. The modelled flows were compared with observed flows at the gauged sites used in the model testing phase.

5.6 Up-scaling project learning

5.6.1 Applying project learning in PRADAN's Purulia team

Late in the project PRADAN applied, evaluated and refined emerging principles relevant to (a) the process of engagement and (b) climate-responsive cropping, in more than half the villages in which the Purulia team works. The opportunity to engage in improving cropping systems was taken to almost 5,000 families in 2010-11 and 2011-12, of which almost 3,000 responded. This work required PRADAN to train professional staff in the new technologies and processes and develop a management system for the program (through SHG's supported by PRADAN professionals). It was necessary to (i) train villagers to provide technical support (Community Service Providers or CSP's[8]), (ii) help women to take a different view of themselves and adopt a more central role in agricultural planning, (iii) conduct workshops with families to develop cropping plans with the potential for some cropping activity from the pre-kharif period through to the *Rabi*, and (iv) to assist farmers to procure inputs. Design of the activity took account of the following principles:

- The need to make best use of resources in rainfed conditions, developing the potential for year-round cropping for each family

[8] *CSP's are recruited by PRADAN from the community and given curriculum-based training to provide technical support ('extension hands for the professional'). For our project, additional training was provided.*

- The need for the process to be independent of watershed development, thereby making it accessible to a far larger numbers of families
- Need for development based on understanding by farmers of soil & water (rainfall, residual water, irrigation) and its potential to generate sustainable livelihoods
- The need for a streamlined process for PRADAN to reach scale (thousands of families) with less professional intensity than we used in Amagara
- The need to restrict each family to a maximum of 5 fields (typically representing all land classes owned by the family) on which to learn these innovations, to avoid over-committing both professionals and farmers
- Need for cropping plans to consider human and draft power as well as water
- Opportunity to use CSP's with special training to support up-scaling
- That costs, including payments to CSP, need to be at least partly covered by a 'subscription' of Rs 30 paid by each family to participate (it is not a free service)
- The central focus on the SHG and in particular on women in agriculture
- The need to capture the opportunity to make the development self-sustaining by using community institutions to support the process.

Objectives

1. To develop and evaluate systems and processes to upscale project findings.
2. Through this, to impact on the livelihoods of 5,000 families (the target was to increase annual cash income per family of at least Rs.10,000 – this is in addition to any increase in food crop production (rice).

The Research Questions

i. Do women come to enjoy equal engagement in decision-making, and ensure good implementation of plans, as a result of the condensed process of engagement?
ii. Has the condensed process still led to changed perceptions of self and resources?
iii. Can the crop options in various land classes be replicated elsewhere despite differences in soil type, access to water resources etc.?
iv. Do land use, cropping intensity and diversity change?
v. Do farmers use pesticides effectively/ safely?
vi. Do villagers quickly learn new technology and apply it effectively?
vii. Do villagers develop a capacity for independent problem-solving?

Data collection in the up-scaling was designed to address these questions, although not all could be answered in the time-frame of the project. A shortage of resources also constrained data collection, so priority was given to items iii and iv.

Activities in 2010-11

Development of a new process for the Purulia team:

- Brainstorming of state agriculture unit - sharing and synthesizing best practices and learning's on engagement processes, adopting system approach, new technologies and systems for up-scaling
- Design training module: Workshop of professional staff on the above
- Design training module: Workshop with SHG Federation leaders and Agriculture Management Committee (AMC) – women as farmers and project leaders
- Technical training of AMC and CSP's
- Preparation and development of information, education and communication material, planning formats, agriculture inputs indenting formats
- On-field planning demonstration with SHG member's families for professional staff

- Planning by staff with SHG member's families in their work domain

Implementation in 2010-11 (a drought year)

Implementation steps are summarised below, and detailed in Appendix 11.7

Activity	Place	Main actor	Co-actor[1]
Agriculture Planning (5 fields/family)	SHG	PRADAN	AMC/SP
Indent generation and money collection	SHG	SP	AMC
Estimation of materials for machan and disbursement	Office	Stock keeper	SP
Input procurement	Market/Co-operative	SP	Not applicable
Store inputs in village stock center	Stock center at village	SP	AMC
Input distribution from stock centre and entry in pass book & stock register	Stock centre at village	Farmer	SP
Regular field visit and assistance	Village	SP	AMC/PRADAN
AMC+ SP Field visit and meeting weekly	Village	SP/AMC	PRADAN
AMC+ SP meeting	Office	SP/AMC	PRADAN

Data

This included the number of participating families, the area sown to each of the crops included in the program and income data for a 25% sample of the participating families.

Implementation in 2011-12

Evaluation of the up-scaling in 2010-11 led to refinements in 2011-12 including new activities to ensure deeper engagement of women (as farmers) and the use of a newly-developed planning 'tool' (shown below) to help farmers understand the water resources available for each of their fields (throughout the year) and to make choices of suitable crops from a range of possibilities offered including options for 'drought' (as experienced in 2010-11). This enabled more dynamic year-round planning of suitable crops. The planning process followed three phases:

1. AMCs were taken through the exercise to have an understanding of the program. Facilitated by PRADAN professional using, amongst other resources the 'cropping systems planning tool' (see photos below)
2. Second phase orientation with the Cluster leaders, facilitated by PRADAN.
3. Cluster leaders took charge and executed planning in their respective SHG falling under their Cluster, with a minimal supervision from the AMC and help from SP

Training AMC and Cluster leaders using a 'planning tool' to match crops to land and water resources

Cluster leader and SP conducting planning meeting in village

'Demonstration' plots were established in 2011-12 for farmer 'exposure' (10/SHG cluster).

5.6.2 Up-scaling in PRADAN and out-scaling to East India Plateau

This was the capacity building phase of out-scaling funded by AusAID. Its application will be in a new project. The present phase was intended to identify the technology and processes to be out-scaled through PRADAN, include this learning in PRADAN's in-house training program (the Development Apprenticeship), train 40 Apprentices under the revised curriculum and develop capacity for senior PRADAN staff and team leaders to ensure receptive ground for the new Apprentices.

5.7 Monitoring and evaluation

A specific criticism of watershed development projects in India has been the poor monitoring and evaluation (Kerr *et al*., 2002). Therefore, M&E was elevated to the status of a project objective (Objective 4).

Although the intention of the project was to lay the foundations for future research to improve livelihoods through WSD and better agronomy, it was also the intention of the research team to improve the lives of participating farmers and generate both useful technical knowledge and an improved development process that could be up-scaled through PRADAN and out-scaled to villages across the EIP. This was the rationale for using a participatory research process. In keeping with these intentions, a participatory M & E approach based on the LogFrame was made integral to all activities.

The M&E framework was developed at a workshop in Toowoomba in August-September 2006, and indicators drafted at a workshop in Ranchi in May 2007 (Appendix 11.8). The framework recognises that project activities were designed to provide outputs (e.g. trial results and training materials) that would contribute directly to achieving specific 'lower-order' outcomes (e.g. new, relevant biophysical knowledge, and the skills and other capacities required to apply the knowledge). These outcomes were designed to feed into 'higher-order' outcomes including changes in farmer practices and improved collaboration between agencies engaged in development. Ultimately, these outcomes were designed to make a sustained, positive impact on the quality of life of villagers.

Indicators at each level in the framework were subsequently refined to arrive at a short list of useful, quantifiable and measurable indicators suited to the project budget (Table pp. 27-28). Indicators were designed to track changes at the different levels at an appropriate time-frame. The methods used to track these changes included baseline socioeconomic surveys near project inception, linear studies of land use (change) over time (cropping intensity and diversity), focus group discussions, family case studies, individual interviews, and documentation of various events to track the engagement process.

Log Frame – the M&E framework, indicators and methods for data collection

Level of evaluation	Description	Key indicators	Formative (F) or Summative (S)[1]	Method[2]
IMPACT on villagers	Improved quality of life based on increased farm income	• Cropping intensity • Crop diversity • farm income • migration • education	F F F S S	LT, US LT, US BS, LT , US FGD, CS, I FGD
IMPACT on natural resources	1. Some runoff (quick-flow) converted to slow-flow. Balance stored in ponds, soil, shallow groundwater 2. Erosion 3. Fertilizer used according to need (esp. P)	1. Runoff (less = good) Shallow groundwater (more = good) End of base-flow (early=bad) 2. Turbidity of discharge Area remediated uplands 3. Fertilizer use	S S S S	1. Measure and model (Pogro) 2. Not done FGD, I

Log Frame – the M&E framework, indicators and methods for data collection (continued)

Higher-order OUTCOMES	Improved development practices 1. Farmer practice improved 2. Effective collaboration • With farmers in project • Women effectively engaged[3] • Between agencies	Number of farmers who: • Crop to water resources • grow wider range of crops • Use line sowing • Use proper amt. fertilizer • Use good weed control • Use good plant protection # participating in activities # joint activities	F F S S S S S	LT, US LT, US I, FGD I, FGD I, FGD I, FGD PRADAN accounts Project documents U/S
Lower order OUTCOMES	Improved agency & community knowledge, attitudes, skills 1. Agency capacity Knowledge in key biophysical areas - applies to scientists and PRADAN although knowledge to one may be information to another, and knowledge may be 'packaged' differently depending on who generates or uses it. 2. Knowledge of development processes and skills to apply[3.] Note 1 and 2 comprise agency capacity 3. Improved farmer capacity – changing attitudes, improving knowledge and gaining skills to apply it 4. Social capacity - SHG's & other institutions	Reports/papers synthesising knowledge of WSD principles, integrated land & water management (crop choice & water assessment for climate responsive cropping systems) soil fertility, plant protection Reports synthesising gender and development process Capacity building workshops held in key areas (weed management, assessing soil fertility, the learning process, climate-responsive cropping) Principles mainstreamed into PRADAN programs • Numbers participating in trials and other training • Numbers participating in Purulia up-scaling • Number effective SHG's • Effective institutions	F, S F, S F, S S F F, S F, S	Annual reports PRADAN FGD Workshop reports, Apprenticeship curriculum[4], new ACIAR project Project reports, gender/process studies, U/S
OUTPUTS that enable change (Contributes to knowledge and changed practices but is not knowledge in itself)	1. Trial results -key questions answered (on hydrology, climate/water resources, crop options, farming systems, soil fertility/fertilizer requirements) 2. Tools developed to apply knowledge for professionals (e.g. models) & villagers (learning aids) 3. Workshops/training material 4. RD&E process refined 5. Information improving women's engagement[3]	1. Results summarised & interpreted for application 2. Tools/learning aids developed for water & fertility assessment 3. Modules documented 4. Findings documented, end of project workshop 5. Findings documented	F F F F F	Project reports, publications
ACTIVITIES	1. Agencies meet commitments to project 2. Research trials completed Includes gender[3] + M&E activity 3. Village communities engaged in participatory way	1. Staff time in project met 2. Trials etc. successfully carried out as planned 3. Workshops & community-based activities planned & carried out as required	F	Project meetings (monthly and biannually) and project Annual Reports

1. Formative assessments occurred throughout the project and informed project management. Summative assessment was at the end and provides an overall evaluation
2. Methods: LT, Linear tracking of land use in Amagara; BS baseline survey at project commencement; FGD, focus group discussions in Pogro, Amagara; CS, family case studies Amagara; I, interviews; U/S, up-scaling M&E
3. Added after mid project review and funding for more detailed gender/process studies
4. Added following AusAID funding for up-scaling

M&E activities helped individual self-reflection, to track the progress of the project as a whole, to do mid-term corrections (as required), and also to design new interventions as per the need of the project. Results of agronomic trials were discussed and analysed with staff and farmers at least twice a year. Trial results and the analyses were discussed and validated with the field level experiences of the farmers after each season (*kharif*, *Rabi*). At the project level, the data were evaluated in staff meetings at least twice in a year. The PRADAN team also took stock of the progress at monthly team meeting.

Section 7 (Results and Discussion) reports on M&E only in relation to higher-level project outcomes and impact, largely to support statements of project impact made in Section 8.

6 Achievements against activities and outputs/milestones

Objective 1: To develop, validate and promote water harvesting principles

No	Activity	Outputs/ Milestones	Completion (scheduled and achieved)	Comments
1.1	Soil & landscape assessment	Soil types mapped Seasonal EM maps Land-use map Benchmark PRADAN WSD plan	October 2007 Completed 2/yr August '06 Aug '07	Included a P review requested by Dr Roth
1.2	EMI evaluation	Evaluation report	Oct '07(draft) (was due '09)	Final measurements Dec 07 and evaluation report drafted
1.3	Collect local historical gauging & climate data	Historical data accessed and digitised	Due March '07 Completed 2012 with gridded climate data	Hard copy of local hydrologic data and some climate data have been digitised. But the main climate record has come from recently released gridded data
1.4	Instrumentation: weather, hydrologic	Instrumentation completed	July '06. Data collection continued until Feb 2012 (when completed)	Loss of equipment through theft & interference was a persistent problem despite security arrangements. Most piezometer, well and pond data were collected manually by trained villagers. Low rainfall in 2010 resulted in only 1 small runoff event. Instruments failed but manual depth readings taken (no velocity data for rating the culverts).
1.5	Watershed plan - Interventions	1. Plan for Pogro 2. Finish Amagara 3. Implementations in Pogro completed	Feb/Mar '08 May '06 May '10	Completed on dates indicated
1.6	Develop water harvesting principles	1. Draft principles 2. Technical report 3. Decision support ('thumb rules')	Jan '08 Due Jan '10 Jan '09	Completed, sent to partners (Mar 08) To evaluate 'thumb rules'. Ongoing. Guidelines presented to PRADAN staff in a workshop in Feb 2010.

PC = partner country, A = Australia

Objective 2: To make a preliminary assessment of the applicability and sustainability of water harvesting across the East India Plateau, through hydrologic and geo-hydrologic studies

No	Activity	Outputs/ Milestones	Completion (scheduled and achieved)	Comments
2.1	Modelling Workshop	Report: conceptual framework	April 2007	
2.2	Collect regional hydrology & climate data	Historical data accessed and digitised	Due Mar '07 Completed mid 2009	Additional (grid) climate data obtained
2.3	Model parameterisation & validation	Models validated	Due March '08 Achieved in stages	Intervention-scale model March 2009, Basin scale model end 2010, Catchment scale, Pogro July 2012
2.4	Model applications	Reports: 1. 'Thumb rules' 2. Upscaling	Mar '10, then June '11 post extension	Two journal paper accepted and three conference papers completed

PC = partner country, A = Australia

Objective 3: To develop cropping system options and improved agronomy to effectively use harvested water

No	Activity	Outputs/ Milestones	Completion (scheduled and achieved)	Comments
3.1	Farmer-initiated *kharif* trials	Annual experiment plan / report end-of-season evaluation Report: lessons on methodology	Ongoing Year 5 (following extension)	Minor part of project addressed issues important to farmers but outside scope of project. Farmers guided but given no resources. Any research related to process. 'Vegetable experience' is the best example (data lost when PRADAN computer failed). Lessons applied in upscaling, not otherwise documented
3.2	'On-farm' research to include crop and soil monitoring (also part of soil assessment, 1.1)	Annual experiment plan / report end-of-season evaluation Report on 'Issues arising from monitoring' Extension material Synthesis report Peer reviewed papers	Ongoing Jan all years April '11 Due June '11 Due June '11 (end of project)	Addresses 'shared' research questions, with farmers. All work statistically designed & analysed. Catchment-wide survey of soil fertility, crop management and rice yield fundamental. Extension material - guide to soil assessment, and 'tool' for assessing P-fertiliser need prepared April '09, plus workshop materials for fertilisers, water management and pesticide use. All used in out-scaling
3.3	Researcher-initiated New in extension	Annual experiment plan / report end-of-season evaluation Papers published Extension reports Wider soil testing on EIP	Experiments have ceased Feb '11 Apr '11 Due Sept'10 Ach. Jan 2012	Irrigation x P experiments completed in Amagara. Conf. paper published on overall constraints and opportunities on EIP, journal papers in prep. In project extension to test wider applicability of findings on soil fertility.

Objective 4: To evaluate biophysical and socioeconomic impacts

No	Activity	Outputs/ Milestones	Completion (scheduled and achieved)	Comments
4.1	Workshop on project evaluation	Framework and indicators	Sept '06	Revised April '07. The team needed to find the optimum between evaluating every activity (risking loss of interest) and evaluating too little
4.2	1. Monitoring 2. Reporting	Activity reports Annual report	1. Ongoing 2. Annually at time of annual report (completed only in 2006)	Baseline data collected in Pogro. Formalised evaluation of changes in PRADAN (March '08). Linear study of land use and crop diversity in Amagara and Pogro, case studies of impact on families done in 2008 and updated in 20128 Focus groups (8) Documentation of project activities and impacts improved since September 07, but annual summary has proven difficult
4.3	Write evaluation report	Report for project reporting complete	Due April '11 post extension	Included in project final report
4.4	Gender and Process	Conceptualise program Appoint staff	April 08. Achieved June 2008	A new component added at ACIAR's request, to extend aspects of the M and E and introduce a gender component (Objective 6). The RA resigned after a year and we were unable to recruit a replacement or even get assistance with data from the RA who resigned

4.5	Develop 'process' principles for WSD	Paper written on 'process'	Due Apr '10	Paper not written as the SRA left. But principles learnt underpin PRADAN's up-scaling to 5,000 families in 2010 and strengthened in 2011. Out-scaling (Objective 7) focuses on improving cropping systems using available water resources and is not limited to new water made available by WSD
4.6 New	Workshop	M&E framework and indicators	May 2012 Achieved May	New for Variation 7 (up-scaling). Used to monitor Implementation phase in years 2 and 4 if AusAID provide further funding; also provides research data on engagement process and its impact

Objective 5: To enhance the capacity of PRADAN and staff (and other like-minded NGO's) to undertake watershed development work

Expanded with Variation 7 – see new Objective 7

No	Activity	Outputs/ Milestones	Completion	Comments
5.1	Workshop. See 4.1	Report	Dec '06	Held in Australia
5.2	Workshop on soil & landscape assessment	Workshop evaluation report	Feb '09 Deferred to near end of project . Held in April 2012	Scheduled year 1 of project but deferred until local project experience can be reported. Again deferred from Feb 09 because of travel restrictions to India, but a 'pilot' workshop was held with the PRDAN Jharkhand team in April '09. A workshop on soil fertility in Jharkhand was held in Ranchi in Feb 2011. The main activity in April 2012 focused on climate-resilient cropping systems
5.3	Workshop on integrated weed management	Workshop evaluation report	Held Sept '07	Originally integrated pest management but changed to weeds to reflect the greater need of project participants especially PRADAN
5.4	Workshop on 'Designing Village – Scale Watershed Development'	Workshop evaluation report	Due Feb '10 Deferred to end of project (following the extension). Achieved in stages from May 2010	The Purulia team developed a program to improve livelihoods that has been implemented and evaluated since 2010/11. This involved workshop training for PRADAN professionals. This program can apply to any village PRADAN works in; the focus is on better use of resources (including water) and is not necessarily dependant on water harvesting.
5.5	Enhance social and technical capacity of villagers	Evaluation report of individual activities	Aug '07 (Pogro) and Ongoing	Added during first year to make this objective more explicit as it underlies every project activity

Objective 6: Develop guidelines for processes and methodology to effectively incorporate gender sensitivity in projects.

No	Activity	Outputs/ Milestones	Completion	Comments
6.1	Sub-project implementation	Conceptualise program Appoint staff Reviews year 1, 2 Paper written on gender roles in tribal communities Paper on family-wise planning and intervention	April 08 June 08 March 2009 (not completed End of project	Achieved SRA appointed on schedule resigned after a year. After multiple searches for candidates and an appointment who quit (security concerns) the gender research activity was scaled back and effort (and funds) put into actually mainstreaming findings into Purulia team programs Papers not written but learning has been incorporated into PRADAN's Purulia team programs.
6.2	Questionnaire in control village (Feb) Timeline Survey - semi-structured interviews July Collection of Case Studies (April)	Report on Questionnaire Analysis of timeline Survey with explanations Documentation of case Studies	Report due May 09 Due August Due July '09	When SRA left, the study was shortened to one village which has been completed
6.3	Focus Group with families in Gokulnagar, Amagara and a control village (Apr) Interview PRADAN/ others in area - Apr Case studies May Workshop (May 09) at Pogro	Synthesis of data from FGDs, Documentation of interviews Document case studies/outcomes Document w'shop, summary of out-comes/principles	Due June '09 Due June '09 July '09 June '09	FGD completed (Gokulnagar &control village dropped). Only one case study completed due to staff problems, but FGD in the M&E touched on gender issues. Training module has been developed for project out-scaling.
6.4	Interviews with women (May) Focus groups with families (June) Structured interviews - women (August) Structured interviews - other stakeholders (Sept)	Summary reports and analysis	Due July Due Aug '09 Due Oct. 09 Due Dec '09	Changed to be done in FGD with VCC, completed as part of the M&E. Completed in two phases as a part of attitudinal scaling. Stakeholder meeting held only with the Panchayat in Amagara as the SRA resigned could not be replaced
6.5	Overall	Documented principles and guidelines for engaging women in development	June 2011 (following project extension)	Completed June 2011 for up-scaling and included in this report

Objective 7: To expand the capacity of PRADAN to scale-out improved water management and cropping practices in disadvantaged villages of the EIP

This objective has been added for Variation 7 (funded by AusAID)

No.	Activity	Outputs/ Milestone	Completion	Comments
7.1	Appoint project co-ordinator (UWS)	Appointed	July 2011 Achieved July2011)	Dr Gavin Ramsay was appointed

7.2	Workshop to scope out capacity building for senior staff and modules for Apprenticeship	Plan for capacity building in senior staff (PD/TI) Plan to develop Apprenticeship	July 2011 Held August 2011	
7.3	Recruit first batch of Apprentices	Recruits commence (By the end of year 1 recruit 80 and expect 40 to complete)	June 1 2011, August 1 and November 1 as scheduled	
7.4	Develop and implement capacity building for senior staff	Training completed (but with ongoing capacity building also)	January 2012 Achieved May 2012	• Innovations workshop held with 12 senior PRADAN staff in Delhi, 3-5 Nov, 2011 to determine innovations from the project as well as across other PRADAN Projects and developed processes for dissemination of the learning and further action where required. • Based on the identified Innovations from above workshop an Innovative business support workshop was held with 13 professionals to help them to further their innovations and develop prototype. • Workshop to disseminate the learning from the Innovation Workshop across PRADAN Also training of trainers for building Community Service Providers on Integrated natural resources management for 20 executives
7.5	Enhance Apprenticeship curriculum	Modules drafted for technical and process subjects	October 2011 Ongoing as at May 2012	• Technical learning from the project has already been incorporated into the Foundation Course programs of the Development Apprenticeship program. • The FC curriculum for INRM is based on experiential learning process, which is reinforced by experiencing the impact of Action learning cycle practiced in the ACIAR project. • The revised INRM module has also been implemented with two batches of DAs in presence of Gavin Ramsay. Strengthening teams and Field Guides in relevant curriculum areas, through INRM thematic training June- July
7.6	Apprentices trained	Minimum 40 successful completions	June-November 2012	As at May 31, 2012 a total 78 DAs are on board - 23 should successfully complete and graduate as Executive by June 2012 and 30 more in September, 2012. Of these a total of 40 apprentices are expected to be from in East India.

7 Key results and discussion

7.1 Resource assessment

7.1.1 PRADAN's assessment of socio-economic and soil and water resources - the intervention plan

Physical and socio-economic resource assessments are part of PRADAN's 9-step process for planning WSD (Fig. 3). By project design, PRADAN did not undertake any significant work on SHG development in Pogro (Step 1, Fig. 3) until late 2008, to minimise impacts on Pogro that were not due to intervention through WSD and related agricultural development. The delay inadvertently reduced the capacity of villagers to respond to project activities (discussed later), but had no impact on mapping of the physical resources (Fig. 4, note delineation of ridges and drainage lines, and land classes). The Pogro VCC was reconstituted in 2008 to engage more women and nearby hamlets prior to finalising and implementing the WSD plan. At this stage, wealth ranking (Step 5) was undertaken and the remaining steps leading to the final implementation plan (Stage 9).

Figure 4. PRADAN's resource map, Pogro (Nov., 2005) - Step 3 of planning WSD

Application of guidelines to evaluate/improve the PRADAN's intervention plan

The 'final' PRADAN intervention plan (Stage 9 of the planning process) was checked against WSD guidelines developed in the project and further negotiations were undertaken with villagers. One change arising from using these guidelines was that previously PRADAN made the area of ponds 5% of the command area[9], but project guidelines helped to size ponds relative to land classes. The guidelines were also used to determine the shape, size and orientation of structures. Provision was made to trap most of the sub-surface flow, keeping the length of the 'hapa' (pond) across the direction of water flow. Guidelines to the upper limit of water that can captured from seepage within sub-catchments and the catchment overall was also used, to minimise the risk of installing more pits, or attempting to irrigate a greater area, than seepage can sustain (we called this the "20% rule"[10]). The map showing interventions in the action plan following enhancement using guidelines developed in the project is shown in Fig.5.

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[9] The irrigable area to be supported by a structure

[10] 20% of the rainfall detained by all of the WSD structures is available for irrigation from seepage pits

Figure 5 Intervention map on transparent sheet overlaying the resource map (Stage 9)

7.1.2 Soil profile descriptions (Pogro), and soil surveys in Pogro, Amagara and across Jharkhand

Overall, the soils were found to be low in organic matter, acid and infertile, as expected, but with little evidence for the popular view that lowland is the most fertile. Considerable variability mostly could not be predicted from either lithology or land class. This variability is not to be confused with the variation in soil 'types' reported in generalized maps of soils and soil fertility (e.g. Soil Survey of India) that have little predictive value.

Profile descriptions - Pogro

The general geology is granite-gneiss (quartzite). Features of soils are outlined in Table 1.

Table 1. General Features of main land classes from the soil profile descriptions

Parameter	Tanr[11] (upland)	Baid (medium upland)	Kanali (medium lowland	Bohal (lowland)
Land capability class	IV	II & III	II	II
Land irrigation class	IV	IV	III	II
Rock outcrop	√	√	√	√
Lithologic discontinuity	Nil	Nil	Nil	√
Slope	3-5%	1-3%	1-3%	<1%
Surface drainage	Good	Good to Moderate	Moderate	Poor
Erosion[12]	Severe to moderate	Moderate	Moderate to slight	Very Slight

Because of extensive cutting and filling and other major earthworks the soils are, strictly speaking, Anthroposols. However, with time, the constructed soils develop profile characteristics that allow classification and mapping (Fig. 6), mostly as Alfisols and Inseptisols. These descriptions allow for soil classification which is necessary for

[11] 'Bari', homestead land (may receive manure, compost); 'gora', cultivated but non-terraced upland; 'tanr', uncultivated upland; 'baid', medium upland, terraced and bunded uplands for rice; 'bohal', the most secure rice land, found in valley floors and terraced drainage lines; 'kanali' or medium lowland found between bohal and baid. These farmer terms reflect the hydrology and security of water including for any second crop.

[12] Classification as per soil survey norms but misleading as it refers to unconstructed landscapes. After paddy construction fields are sites of net sediment deposition, although erosion through gully formation may occur.

publication in journals, and they may assist other agronomists and soil scientists to assess the applicability of our work to their situation (soils).

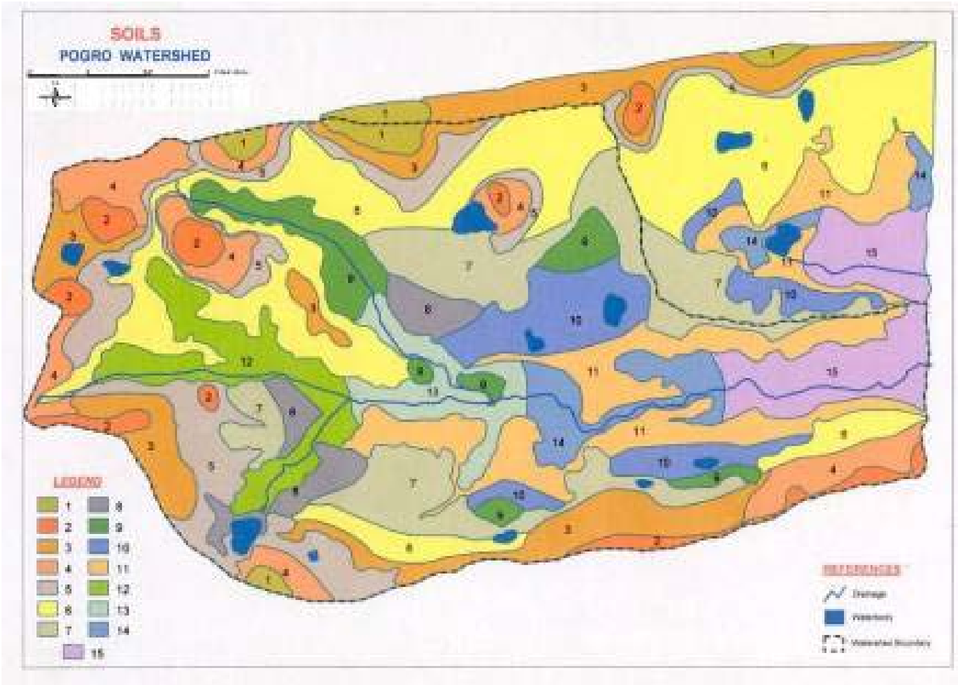


Figure 6. Soil map, Pogro

Soil surveys – Pogro and Amagara

Example data are given in Table 2 and full data in Appendix 11.9. OC was low overall, with few sites exceeding 1%. Mineral N varied, which may reflect residual N after rice.

Table 2. Example soil fertility data - Pogro 2006

	Min N (kg/ha)	OC (%)	Available P[1] (Bray) (mg/kg)	Exch. K (mg/kg)	Soil pH (1:5 water)	Soil $EC_{1;5\ water}$ (mS/cm)
			Baid			
Average	**137**	**0.61**	**6.3**	**93**	**5.5**	**0.06**
Max	198	1.38	24.2	253	6.7	0.12
Min	85	0.30	0.0[2]	30	4.7	0.03
			Kanali			
Average	**139**	**0.64**	**4.2**	**107**	**6.0**	**0.05**
Max	207	1.03	16.1	175	7.0	0.11
Min	91	0.42	1.5	53.6	5.1	0.02
			Bohal			
Average	**106**	**0.73**	**3.5**	**79**	**7.2**	**0.11**
Max	150	1.20	5.9	124	8.3	0.19
Min	67	0.44	1.1	44	5.9	0.05

1. P and K are concentrations, in keeping with international practice (in India it is usually mass/area)
2. Zero means below limit of detection

Available P in most fields at both watersheds was marginal to deficient, even for rice. Literature suggests that Bray-P is deficient if <3 mg/kg or marginal <9 mg/kg, and the Pogro means were 3.5-6.3 mg/kg depending on land class. P was generally higher at Amagara than Pogro, although often <9 mg/kg. Rice internationally is often said to be unresponsive to P-fertilizer because soil P is more available under anoxic (reduced) conditions. Our data suggest, however, that responses to P-fertilizer in rice are likely in our research watersheds. The very low P status also suggests that P-fertilizer will be mandatory for non-flooded crops (aerobic soil), especially *Rabi* crops where drier conditions will exacerbate P-deficiency. Crop surveys (Section 7.1.4) show that P application in the research watersheds is generally low and restricted to DAP (apart from FYM/compost), and is mostly used for vegetables and maize (also on rice in Amagara).

For K, with 100 mg/kg as a threshold, many sites are marginal to deficient in K. Lowlands appear to be the most deficient in P and K. If so, this may reflect both nutrient removal as well as progressive terracing of medium uplands that prevents sediment eroded from uplands reaching the lowlands and replenishing the nutrients removed by rice.

With respect to soil pH, almost all surface soils were slightly to moderately acid. Soil pit descriptions reveal pH trended to neutral/alkaline at depth (generally neutral by 50 cm). A typical pH profile for medium upland is shown in Fig. 7a. Soils were also less acid lower in the landscape (pH_{water} >7.2 throughout the profile in lowlands). Soils were generally less acid than expected from the literature, but the data are supported by widespread occurrence of annual legumes (Fig. 7b) that are not adapted to very acid soils. Whilst generally inconspicuous, these legumes grew vigorously where P had been applied in areas protected from grazing, suggesting they could play a bigger role on the N economy of the landscape if soil P were increased.

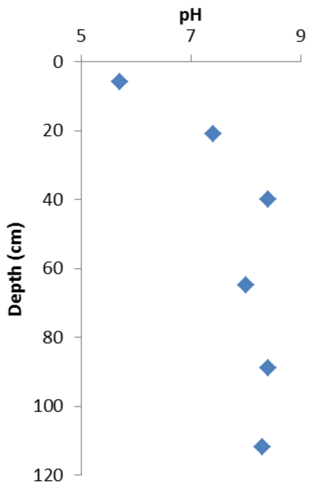


Figure 7a. Soil pH profile

Figure 7b. Annual legumes are widespread indicating soil surface pH is not as low as expected.

Further *acidification* caused by product removal, N-leaching and the use of ammonium-based fertilizer will be a bigger problem than acid soils *per se*. Acidification will progressively acidify *subsoils* and become a greater problem for remediation than surface soil acidity that liming can correct. It is important to remove ammonium fertilizer (e.g. DAP) from these systems by using superphosphate and urea where P and N are both required, and to minimise N leaching. Research is needed to manage N in this high rainfall environment, to meet crop requirements efficiently without excess N that can leach.

pH was particularly low at some medium upland sites (to pH 4.7) and remained acid to greater depths than elsewhere, raising concerns about subsoil acidity (even without further acidification) and its effect on Al or Fe toxicity for rice. Subsoil acidity may lead to reduced root growth and increased drought sensitivity. This requires further investigation.

The most outstanding feature of the Pogro and Amagara data is the very great variability *between fields* within land classes for almost all variables, most importantly for P (but also N and K). Variability *within* land class is greater than the difference *between* land classes, suggesting that any farmer perceptions of land quality are based largely on water and its reliability (i.e. soil water holding capacity as well as contributions from lateral inflow [seepage] in lowlands). From crop management data collected at the time of the soil survey (Section 7.1.4), much of this variation in rice fields was associated with the use of FYM and compost or the choice of fertilizer used to supply N – most farmers use urea (no P) but some use compound fertilizers that contain P (farmers seemed unaware of this difference). Presumably site history also affects the present fertility although this might not be immediately apparent – both the 'cut' area of a recently levelled field and a lowland field with a long cropping history may be poor on all counts, but for different reasons.

EC was generally low but salt efflorescence was observed in some lower landscape positions. Some sodic subsoils (i.e. high pH and EC) were observed low in the landscape.

Infiltration rate was measured independently of the profile descriptions and soil survey. It was mostly high in the uplands (10-25 mm hr^{-1}) but low in medium uplands, even below the puddled layer (<1 mm hr^{-1}).

Jharkhand soil survey, 2010 – a survey of 252 farmer's fields

To scale up the application of Purulia findings, a soil survey was undertaken in Jharkhand in 2010. Full data are reported in Appendix 11.10, by watershed and land class. Summaries of pH, P and K data are reported here as cumulative distribution functions over all fields, to show percentage of fields above or below nominated thresholds.

Expectations of low pH were confirmed with median pH 5.4, although notably <15% of fields had pH <5.0 and >20% of samples had pH >6.0 (Fig. 8). As in Purulia, the uplands were more acid trending to neutral-alkaline in lowlands (Appendix 11.10), and there were some differences between watersheds e.g. Khunti was relatively more acid.

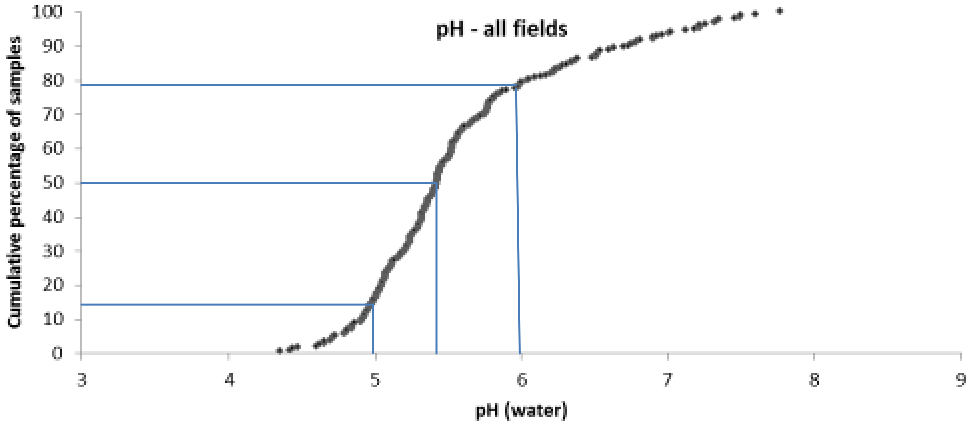


Figure 8. Surface soil pH (0-10 cm) – Jharkhand soil survey, all sites

P data for the Olsen test are given in Fig. 9. (Bray gave similar results over the pH range 4.7-7.7; b=1.0, r^2= 0.7.) P ranged from not detectable to >50 mg/kg, with a median of <3 mg/kg which is extremely low. 75% of fields were judged potentially responsive to P-fertilizer based on a synthesis of published critical concentrations of soil P for rice (Fig. 9). P was >10 mg/kg in 10% of fields, which is moderately high even for non-rice crops.

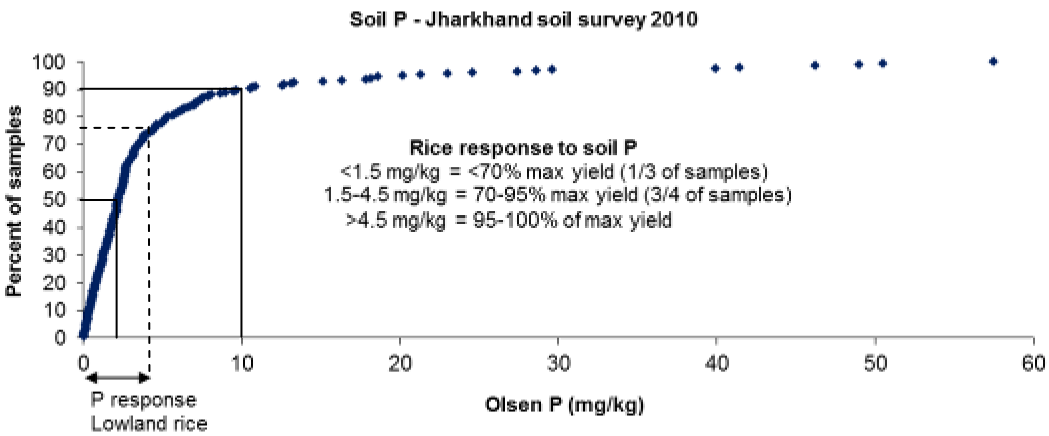


Figure 9. Available soil P (0-10 cm) – Jharkhand soil survey, all sites (n=252)

Values in rice fields (median 2.5 mg P/kg) were close to non-rice fields (2.1 mg P/kg), although lowlands, with the longest cropping history, tended to be lowest in P (Appendix 11.10). Any differences due to land class were masked by differences between watersheds or differences between fields within land classes within watersheds.

These results not only confirm that soil P is low, but show (i) how critically low it is, even for rice and (ii) that it may, in fact, also be quite high. Soil P cannot be predicted from either lithology or land class (Appendix 11.10). We can expect widespread moderate deficiency in rice and acute deficiency in other crops in the absence of adequate P-fertilizer, but it will be important to make field-specific recommendations.

Potassium concentrations also varied widely between fields, from <30 to >400 mg K/kg (Fig. 10), i.e. from potentially acutely deficient to abundant. The median concentration was slightly lower in rice fields (61 mg/kg) than non-rice fields (68 mg/kg), but the 90th percentile values were much higher for non-rice fields (205 mg/kg) than rice fields (110 mg/kg) which, together with the detailed data in Appendix 11.10, suggests that K has been depleted from lowlands with a long history of rice production but increased in homestead areas that receive FYM/compost or ash.

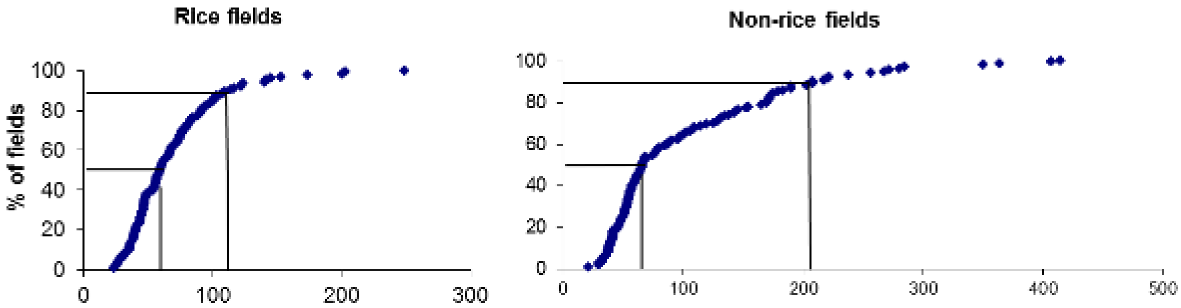


Figure 10. Exchangeable potassium, rice and non-rice fields, Jharkhand 2010

For both P and K, variation between fields within land classes was as great in Jharkhand as in the research watersheds in Purulia. We conclude it is impossible to predict available P from soil type or land class because of this variation. History and current management have a much bigger bearing on current P than the parent material a soil is formed from or its position in the landscape. It follows that broad recommendations or 'prescriptions' will lead to gross under- and over-fertilization. Field-specific management is needed.

7.1.3 Soil water relations

The results of comprehensive sampling for soil water are summarised in Fig. 11, which gives cardinal values for soils in the important medium uplands. (Note values are for soil and ponded water not actual crop water use.) The values were used to interpret agronomic experiments and most importantly to parameterise a soil water balance model used in the project.

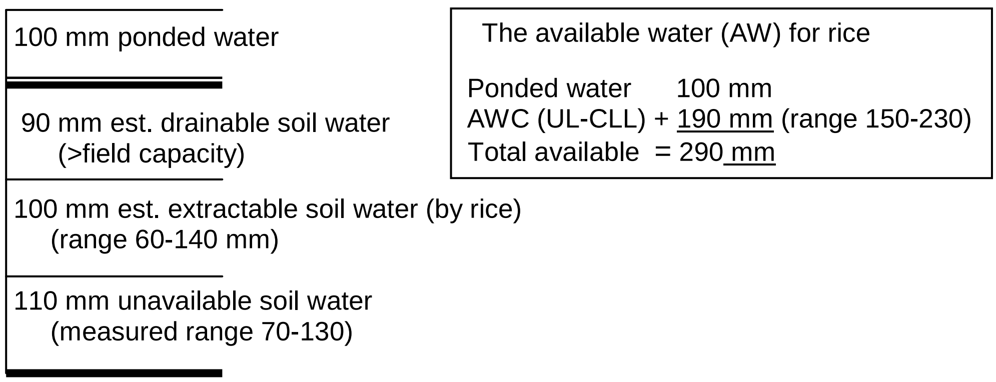


Figure 11. Components of soil water (+ ponded water) used for modelling

7.1.4 Rice crop surveys (resource assessment)

These were carried out for three years in Pogro and two in Amagara. Yield for Pogro in 2006 is shown in Fig.12 as an example. Farmers say baid is poor land, but there was no difference between baid (medium upland), kanali and bohal (3.95, 4.23 and 3.8 t/ha, P>0.05), despite faltering rain early in the monsoon that delayed transplanting in some baid fields. In all land classes, yields varied hugely depending on soil fertility (Section 7.1.4) and management (Section 7.3). Presumably any low yields in baid related to delayed planting or poor management, whereas in lowland it related only to management.

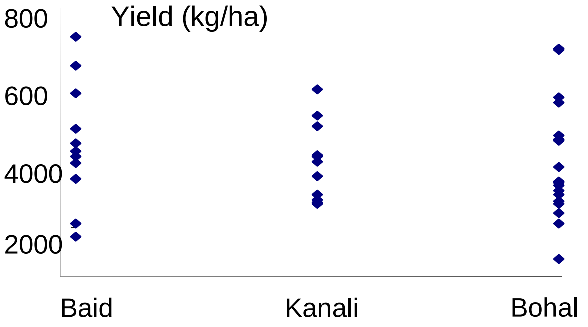
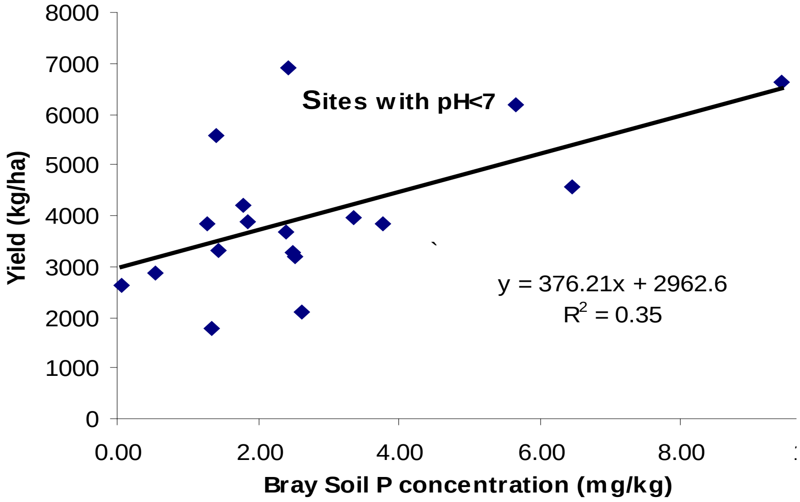


Figure 12. Example of rice yields in crop survey (by land class), Pogro 2006.

A qualitative synthesis of main observations in each site/year is given in Appendix 11.11 and summarised below with respect to the resource assessment aspect of this activity:

- Achievable *potential* yield with good rainfall, as judged from the best farmer's fields, was ~7-8 t/ha in all land classes, compared with the region average of <2 t/ha.
- Yields in medium upland (baid) can be as good as in lowland (bohal), the main difference being in ‘dry’ years, when crops in lowland and medium lowland are generally better as they benefit from run-on and seepage. The unsuitability of transplanted rice to medium upland is considered in Section 7.1.8.
- Some farmers said kanali was the most consistent area in which to grow rice. This land class is relatively ‘safe’ for water and it is easier to manage N than lowland because through-flow of water following N application in the monsoon is lower. Many bohal crops appear to be N-deficient (discussed later).
- Yield variation was far greater within than between land class, so management (e.g. fertilizers, timeliness, plant protection) is likely to be the biggest contributor to variation, except where drought affects the baid.
- For all single soil or management variables, the relationships with yield were generally weak and inconsistent across sites/years.
- Main soil variables statistically related to yield were soil P (Fig. 13) and N (Fig. 19 in Section 7.3.3). Fig. 13 is an example of responses to *soil fertility*. Response to *fertilisers* is discussed in Section 7.3.7.

Figure 13. Rice (paddy) yield response to soil P, Pogro soil and crop survey, 2006



Although the relationship between soil P and yield in all years was generally weak (Fig.13), any trends were positive. A weak response is to be expected despite soil P deficiency, because P is added to many fields in organic form or sometimes DAP. Other variables also impact on yield. Multiple regression with soil P and added P was also not significant. The response in Fig.13 is at least consistent with published 'critical' P concentrations of ~3-4 mg P/kg (Bray) for rice grown in flooded conditions.

Although no single soil variable consistently explained much of the yield variation, soil N and P together explained over 60% of the observed yield variation in 2007 (Fig. 14).

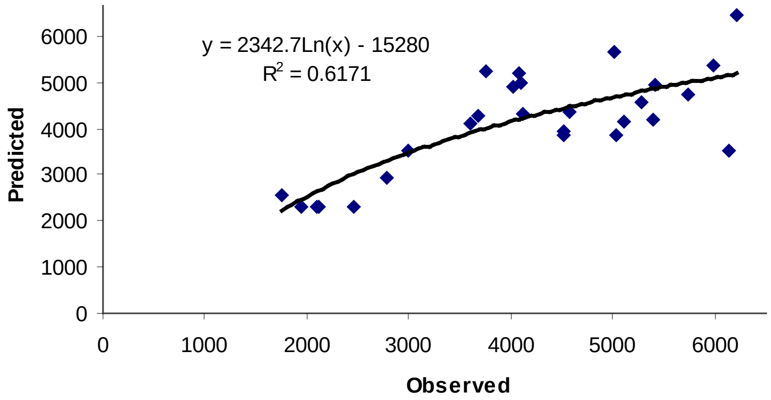


Figure 14. The relationship between observed rice yields and yield predicted by multiple regression using measured soil N and P.

7.1.5 Weather monitoring and recording

This analysis puts rainfall in the project years into the longer-term context. Fig. 15 shows the comparison between long-term rainfall exceedence curves for the area around Pogro, based on the 0.5 x 0.5 degree gridded rainfall data from the Indian Meteorology Department, and the data collected in the Pogro catchment throughout the project. There is similar rainfall variation, suggesting the annual rainfall in Pogro during the project is representative of the long-term frequency distribution averaged across a $0.5^0 \times 0.5^0$ area.

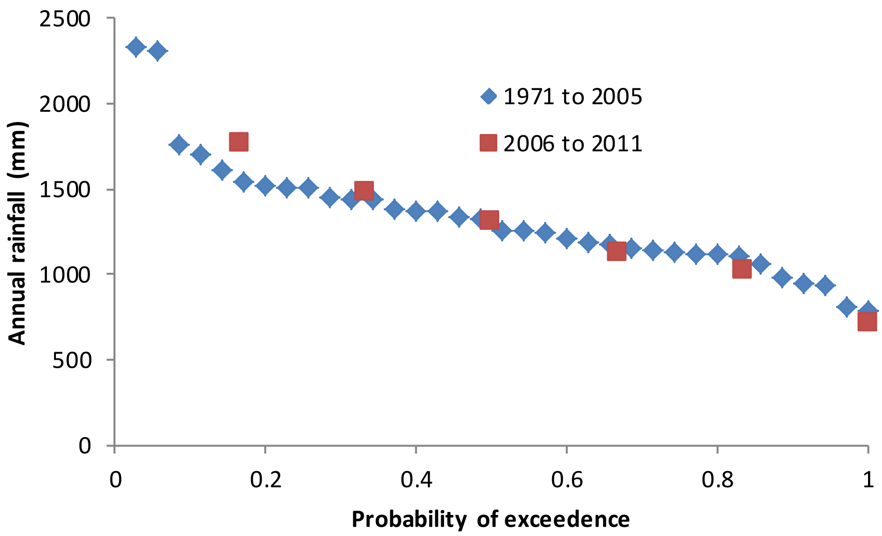


Figure 15. Annual rainfall exceedence curves for the Pogro study site. Long-term data is from the Indian Meteorology Department gridded dataset.

Mean monthly rainfall from the same datasets (Fig. 16) suggests slightly more pre-monsoon rain (May) in Pogro, less in July and August and an increase in September. With only 6 years of data, no comment can be made regarding long-term change in the monsoon pattern, but reduced rainfall in July and August can have a significant impact on transplanting rice. Greater pre-monsoon rain may create new cropping opportunities.

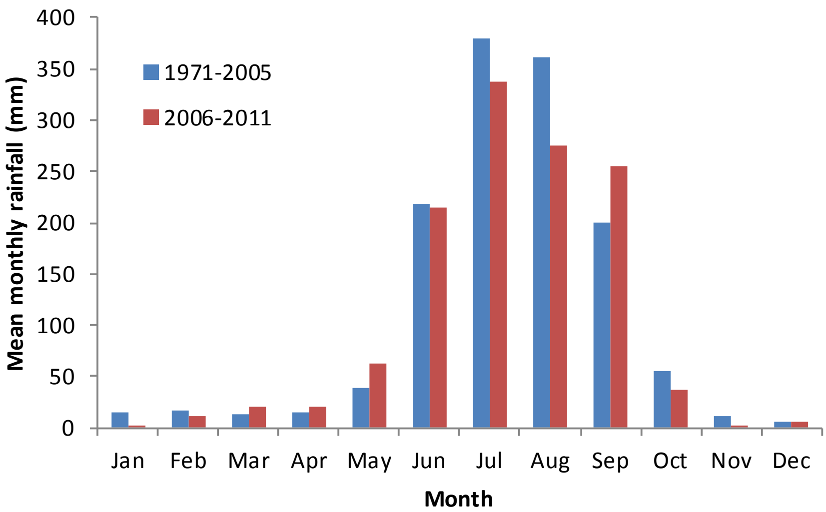


Figure 16. Mean monthly rainfalls for Pogro (2006-11) and the local area (gridded data)

7.1.6 Shallow groundwater assessment via wells and piezometers

The wells in the catchment are typically 8 m deep, with an annual variation in water level of between 4 and 7 m. Some of the wells (4, 8, and 14, see diagram in Section 5.1.5 for locations) rise to within 1 m of the surface, indicating a strong interaction between shallow groundwater and soil water in some locations. Wells 4 and 14 are near ponds, and are likely to be directly fed by recharge from the pond. It is interesting to note that villagers reported that in the north of the catchment there are some tube wells that had been dug to a depth of about 80 m without finding a significant source of water, while elsewhere the deeper groundwater gave a secure source of water. These data give information on the behaviour of the deeper groundwater systems, which is still important in terms of understanding the hydrology of the study site, even though the focus of the interventions is on the shallow (annually-recharged) groundwater systems.

Fig. 17 shows the difference in residence time for water in the shallow aquifer along a transect from the upland to lowland (piezometers 13, 14 and 4). In the upland (piezometer #13), while water was occasionally observed near the surface, this did not last long, draining down through the medium upland to the lowland. The residence time of water in the medium upland (piezometer #14) was considerably longer, with water within a metre of the surface through to mid-November, indicating the potential for seepage pits as a source of water in this area for a short period after the monsoon recedes. In all years except for 2010, water was observed at least briefly at the surface in the medium upland.

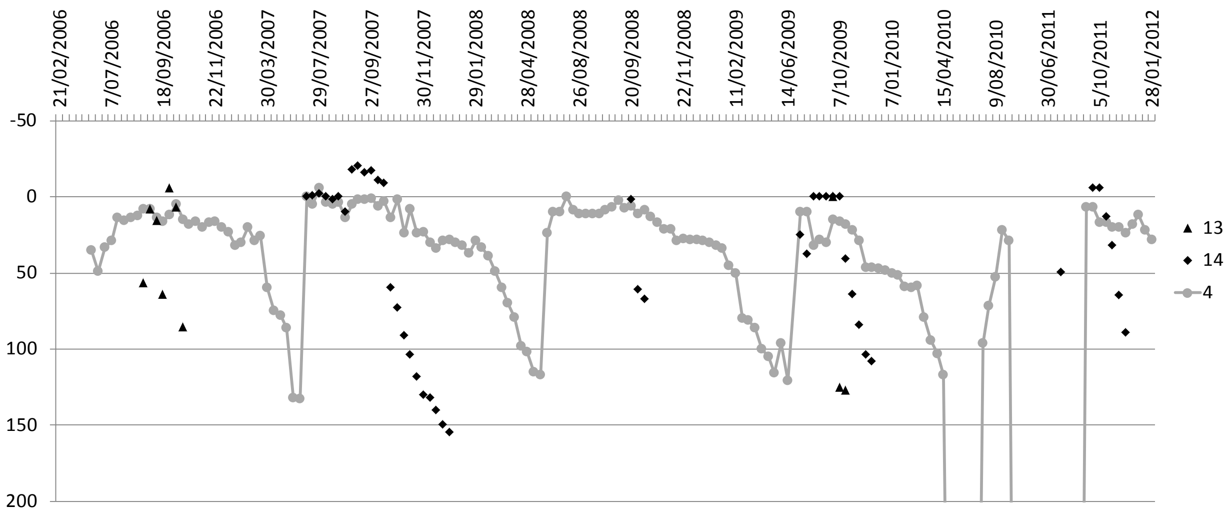


Figure 17. Depth to groundwater (cm) along transect from upland (Pz 13), through medium upland (Pz 14) to lowland (Pz 4).

2010 was the driest year during the project, and resulted in water levels considerably below the surface. Even in the lowlands (piezometer #4) the shallow groundwater did not rise to the surface. In comparison, the transect running down the lowland area draining from pond #1 (piezometers #3, 12 and 4) showed a strong influence of the pond, that had received some runoff from hard surfaces in the Pogro village earlier in the monsoon.

Observations in all years show that constructing ponds in upland drainage lines transforms the land immediately below the pond into lowlands. Ponds store runoff water during the monsoon, which continues to 'leak' into the drainage line after the monsoon recedes. Pond construction is a main mechanism for converting 'quick flow' to 'slow flow'.

The piezometer data also indicate a flow constriction downstream of piezometer #12, with water observed at the surface well into the dry season in all years (late March). A pump test conducted on the trial seepage pit (located between piezometers #12 and #4) in Feb 2009 showed a strong recovery, with a recession time constant of 5.5 days, indicating that the subsurface flow constriction was downhill of this location.

Modelling of the groundwater response observed in the piezometers and wells suggests that generally the groundwater system can be represented by a linear store with a time constant of 150 days. Physical interpretation of this is difficult as the time constant is influenced by the transmissivity, the storativity (or effective porosity) and the length of the aquifer. Furthermore, the amplitude of the variation in groundwater levels depends on both the recharge rate and the storativity, so without additional information, only a crude estimate of the groundwater resource is possible at this stage. However, Figure 18 shows modelled groundwater storage assuming a time constant of 150 days, and recharge equated to infiltration from the surface store of the study-site scale hydrological model. Water level data have been linearly scaled to the modelled groundwater storage. The modelled water level is too high in the dry season and responds too quickly at the start of the wet season. This is a consequence of not including the impact of the soil store on the recharge. The groundwater modelling will be reassessed when the revised hydrological model has been adequately tested.

Generally, lowland areas have access to groundwater resources for longer (maintained by subsurface flux from upper parts of the catchment), with limited access in the upper parts of the catchment outside the wet season. Exceptions to this are sites influenced by local effects, including the location of ponds that are a persisting source of recharge, and flow constrictions which limit the downhill flow of groundwater, increasing the residence time.

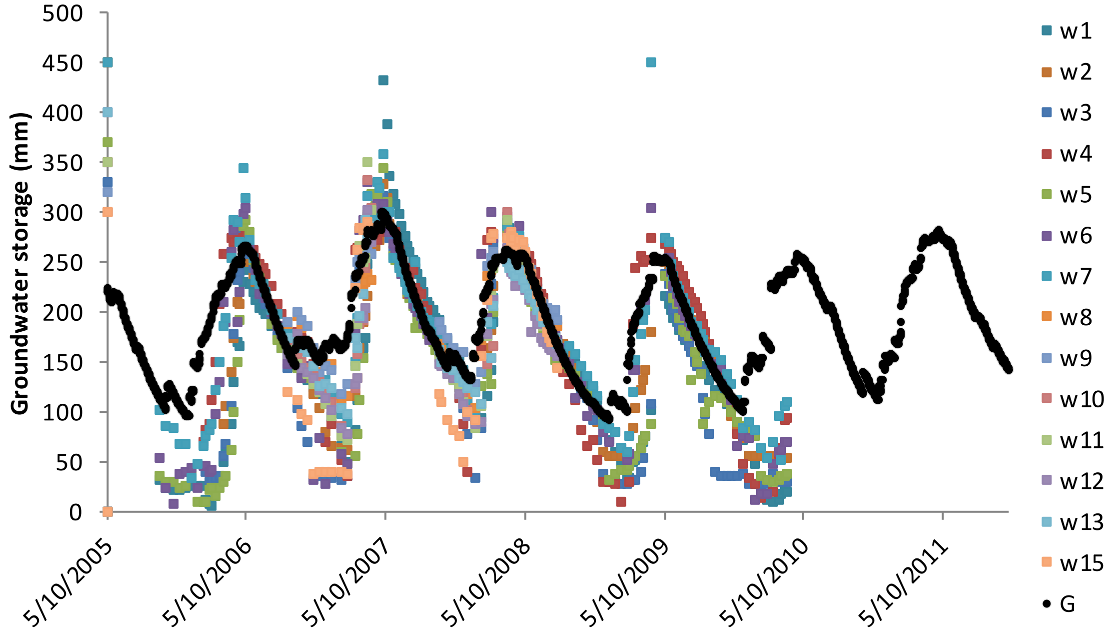


Figure 18. Modelled groundwater (black circles) and scaled water level for monitored wells.

Overall the data show:

1. Ponds are a significant source of groundwater recharge (recession rates of ponds in the dry season as high as 20 mm/day compared with a Penman evaporation rate of ~7 mm/day). This is also reflected in the height of the shallow groundwater table monitored below the pond, as well as in the distribution of the lowlands.

2. There is significant spatial variation in the transmissivity for the shallow groundwater, resulting in variations in the water holding capability across the catchment, which will affect the effectiveness of WSD structures.

3. The medium upland has limited capacity to hold free water (up to 2 months for Pz 14, see Fig. 15), while the upland is unable to hold water (at least to the depth monitored by the piezometers of about 1.5 m).

4. Variability in the response of the shallow aquifer suggests that an experimental approach should be adopted when planning WSD interventions, with test holes used to explore the potential water resource before carrying out WSD work. This recommendation is included in a set of 'Guidelines' developed for PRADAN's use (Section 7.5.2).

7.1.7 Gauging runoff via at Pogro watershed, including an adjacent 'control'

Rainfall through the 2011 wet season and the resulting discharge through each of the culverts are shown in Fig. 19. This shows the similarities (e.g. very similar event profiles) and differences (e.g. magnitude of response to event in late October) between the flows through each culvert, due to a combination of the land use and degree of WSD, as well as possible spatial variations in rainfall. Some remaining problems with the flow data are still to be resolved (e.g. the flow peak through culvert A in late September exceeds the value expected if 100% of the rainfall is converted to discharge).

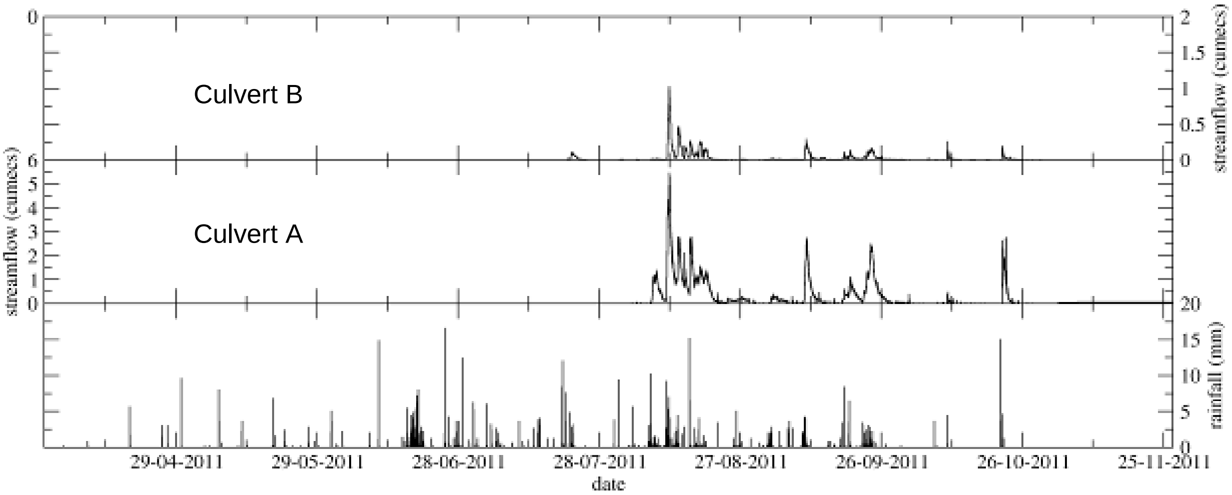


Figure 19. Rainfall plus observed flow at both culverts, 2011 wet season.

The daily observed and modelled results over the entire data period (Fig. 20) show the impact of low rainfall (2010) on storage in the ponds, as well as the lack of water security for transplanted rice in the medium uplands. The poor storage in 2010 highlights the limitation of WSD work for dry years, when there may be little or no runoff captured to provide 'rescue irrigation' for rice. This stresses the need for other options to ensure food security, which is discussed further in Section 7.1.8. (While 2010 was a dry year, there was over 700 mm of rainfall from May through December, with 556 mm in June to September.)

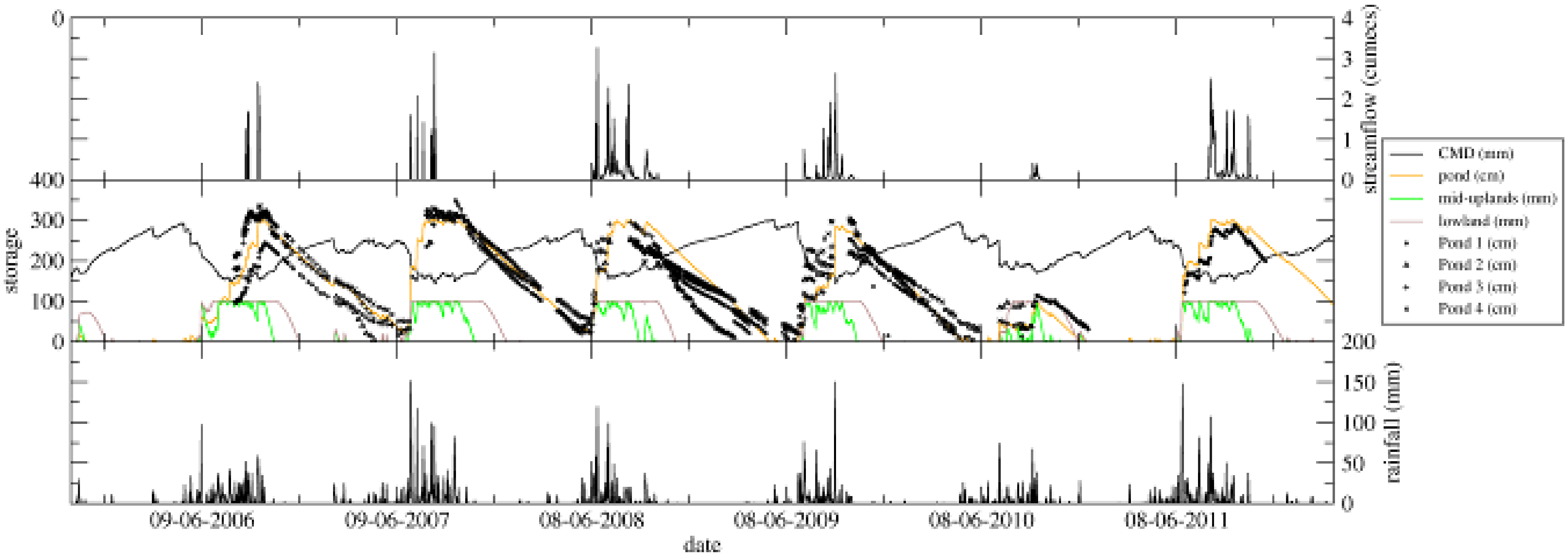


Figure 20. Modelled results for culvert A for the study period. *The top panel is observed discharge, middle panel shows modelled storages (lines) and observed pond levels (points) – note the different units in the legend. Bottom panel shows daily rainfall depth.*

Using the gridded data from 1971-2005, a long term prediction of the runoff coefficient (discharge depth divided by rainfall) through culvert A is shown in Fig. 21, along with a fit (formulated to asymptotically approach a runoff coefficient of 100%). Note that the scatter in the plot is due to the influence of the distribution of rainfall within the year, and reflects the natural variability. The formula for runoff coefficient can be used to predict the volume of discharge based on the annual rainfall, and hence the upper limit for water harvesting. For example, an average annual rainfall of 1200 mm has a runoff coefficient of 0.37, corresponding to a total discharge through the culvert of approximately 440 mm. Of this, approximately 30% is generated in the lowland areas (22% of the catchment area), and 55% in the Baid (53% of the catchment area), with 11% generated in the Tanr land (10% of the catchment area), and a small contribution (4%) from the ponds and their contributing area (15% of the catchment area). This highlights the importance of a distributed system of water storage, and the difficulty in optimising the storage for a variable climate. Future work will need to consider rainfall variability (both in time and amount), land area required for storages (resulting in a decrease of productive land), as well as defining the primary goal of WSD work (providing security in the wet season, access to water in the early to mid-dry season, or a combination).

$$r = 1 - e^{-(P-350)/1850}$$

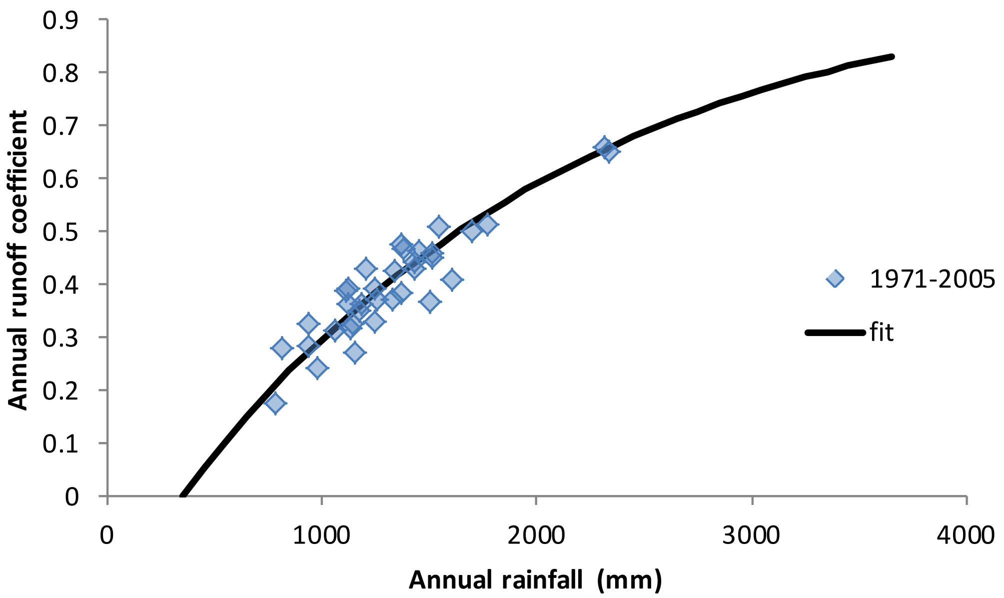


Figure 21. Runoff coefficient for 1971-2005 predicted by catchment-scale model for Pogro

7.1.8 Soil water balance modelling and assessment of risks and opportunities for crop production

Water balance modelling was used as part of the resource assessment to quantify soil water availability at Pogro for 2006-11 using climate data collected on-site. The model was also used with longer-term climate data for Hazaribag, further south on the EIP, to explore longer-term variation in water availability.

The model estimated available water (including ponded water) through time to give us an appreciation of the risks faced by lowland (ponded) rice in the important medium-uplands. It also helped us to evaluate opportunities for alternatives to flooded rice in the kharif and evaluate opportunities for multiple cropping. Also, whilst modelling essentially captured the risks and opportunities related to rainfall without any water harvesting, it also highlighted where water harvesting might increase cropping opportunities.

The water balance for Pogro is given in Fig.22 and for Hazaribag in Fig. 23. Information about the water balance derived from the Pogro modelling, and its agronomic interpretation, is summarised in the upper half of Table 3.

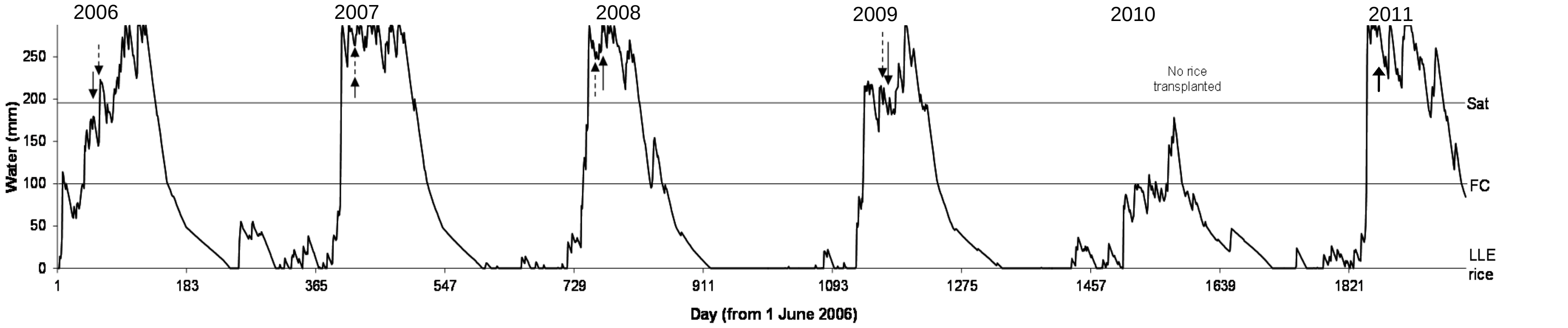


Figure 22. Available water (for rice) in medium-uplands, Pogro 2006-2012. Major x-axis divisions 1[st] June (normal onset of monsoon is early July. Vertical arrows depict predicted (dashed) and observed transplanting. Horizontal lines show measured soil saturation (Sat., water is ponded above this), estimated field capacity (FC), and the measured lower limit for water extraction by rice (LLE). A summary of findings is given in Table 3.

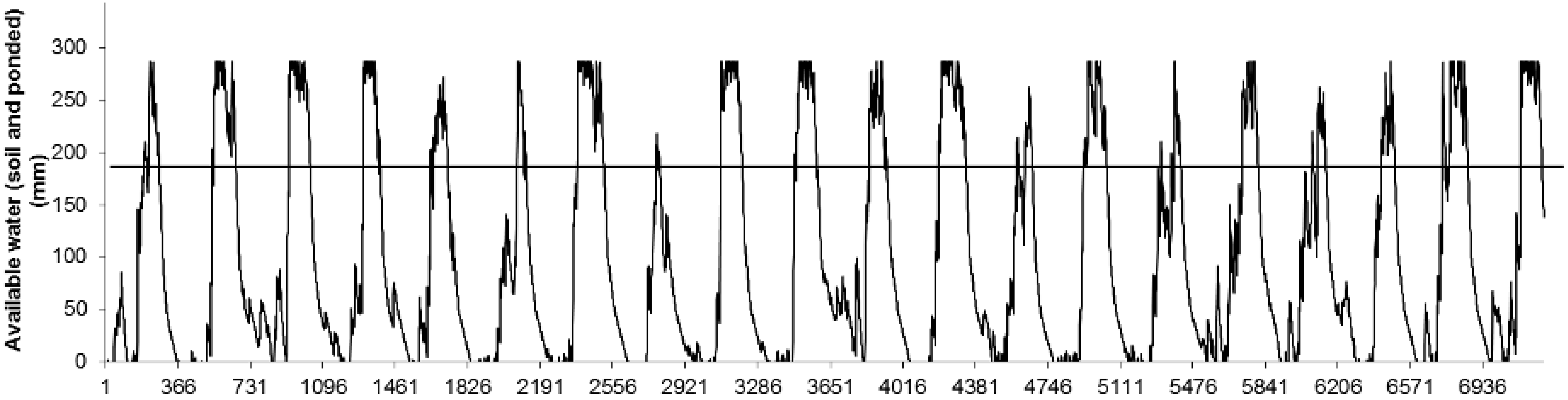


Figure 23. Available water for rice at Hazaribag from 1988-2007. Major x-axis divisions denote 1[st] June. The horizontal line denotes soil saturation.

The observed and predicted dates for transplanting rice (shown by the arrows in Fig. 22) are close in most years. Farmers and PRADAN professionals verified that the model gave a credible picture of variation in water between and within seasons, and could be used to predict the dates of important agronomic events such as the time of ploughing and transplanting as well as any periods of 'drought'.

The most striking feature of the modelled water in Fig. 22 is variation in the date when ponded conditions (water >190 mm) commenced after onset of the monsoon, along with variation in when ponds drained at the end of the monsoon. Together, these result in very large variation in the duration of the ponding that is essential for conventional transplanted rice. Ponding duration was estimated to have ranged between 0 and 106 days during the 6-year observation period (Table 3). Also notable is the periodic draining of fields during the monsoon.

Only 2 of 6 years appeared to be 'good' for rice in the medium uplands (2007, 2011), an assessment borne out by farmers (Table 3). Rice in medium uplands also failed widely in 2005 at Pogro (see photo below).

In addition to failure during the project (Fig. 22), rice was also severely drought affected in 2005 just prior to project inception (photo, left).

Note that when asked why she was harvesting the straw of the failed crop, this woman responded 'my husband told me to', reflecting their respective roles in agricultural decision-making (Section 7.2.3)

The analysis reported in Table 3 shows that although annual (and monsoon) rainfall were variable (range 723-1429 mm annual rainfall, CV = 0.29), the duration of ponded conditions for rice was even **more** variable (CV=0.57). Rice is much more risky to grow than suggested by rainfall variation alone. In some years there is no ponding, and on average the duration of ponding is less than required even for medium duration varieties.

High *average* **runoff** and **drainage**[13] shown for the rice-fallow system in Table 3 illustrate why it is often said that the EIP has abundant agricultural potential with its vast water resources that can be harnessed through WSD. Rice-fallow uses only about half the annual rainfall, with significant amounts of this being lost through weeds and bare soil. The balance runs off or drains beyond the reach of roots to shallow groundwater.

The longer-term modelling of the water balance at Hazaribag (Fig. 23), reveals similar inter-annual variation as at Pogro, with some complete failures and less than half the years being judged 'satisfactory' for rice. The coefficients of variation (CV) for rainfall and ponding duration were 0.23 and 0.36, respectively. On this basis, plus responses from farmers verifying model predictions, we are reasonably confident that our Pogro experience represents the longer-term and has wide applicability on the EIP.

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[13] *beyond the root-zone to shallow, annually-recharged aquifers*

Shorter-duration varieties are often promoted to avoid drought, but it is clear that the nature of climate risk is such that early-maturity alone is not sufficient to manage climate risk. It does not deal with a faltering start to the monsoon that delays transplanting, or deal with intermittent draining of fields.

Table 3. Hydrologic and agronomic assessments for rice-fallow and alternative non-flooded cropping systems in medium uplands at Pogro, based on soil water balance modelling

	2006	2007	2008	2009	2010	2011	Mean	CV
Rainfall total (mm)	1153	1774	1139	1029	723	1429 to Nov 4th	**1240**	0.29
Rainfall June-Sept (mm)	1126	1518	1004	944	603	1225	**1070**	0.29
Water balance, rice-fallow								
Annual ET (mm)	647	846	663	576	641	662	**673**	0.13
Predicted runoff (mm)	122	568	167	131	0	290	**213**	0.93
Predicted drainage (mm)	360	366	327	316	69	401	**307**	0.39
Ponding duration (d)[1]	79	106	54	65	0	99	**67**	0.57
Farmer's summary of each year for rice	Poor year some med. upland Transplanting delayed, period drained	Good year despite slightly late onset of monsoon	Bad year Early monsoon and transplanting but early end to monsoon	Very bad year Transplanting delayed and early end to monsoon	Disaster No rice transplanted	Good year		
Soil water availability for non-flooded crops (days) – two drainage assumptions								
Drainage 3 mm/d[2]. (period ASW>1/3 FC)	180 (147)	171 (136)	179 (146)	154 (116)	191 (106)	183 (163)	**176 (136)**	0.07 (0.16)
Runoff $_{D=3mm}$	222	668	267	231	0	390	**296**	0.75
Drainage $_{D=3\ mm}$	309	311	250	262	69	324	**254**	0.38
Drainage 10 mm/d[3]. (period ASW>1/3 FC)	172 (139)	162 (133)	177 (145)	148 (111)	187 (104)	178 (154)	**171 (131)**	0.08 (0.15)
Runoff $_{D=3mm}$	9	271	107	113	0	187	**115**	0.90
Drainage $_{D=3\ mm}$	560	738	436	394	107	552	**465**	0.46

[1] *Ignoring drained periods between first predicted transplanting opportunity and 1 September.*

[2] *Assumes no ponding, AW=150 mm, drainage rate 3 mm/d, excludes pre-monsoon showers. Assumes no further water is used when 10 mm remains at end of season. Weather data end 5 Nov 2011. (Figure in brackets is for the period up to when the soil dries to 1/3 UDL and water becomes limiting)*

[3] *Assumes no ponding, AW=150 mm, drainage rate 10 mm/d following soil remediation; excludes pre-monsoon showers. Assumes no further water is used when 10 mm remains at end of season. Weather data end 5 Nov 2011 so rates of water use after this are based on assumed E*0.5 (no more rainfall).*

The CV for **runoff** is high (0.93), even higher than for ponding duration for rice. It seems then that any agronomic strategy for food security should not be based on capturing runoff alone – in some years there is little runoff except for local areas with low infiltration (roads, degraded uplands). This conclusion based on water balance modelling of medium uplands is reassuringly similar to that derived from hydrologic modelling of the watershed (Fig.20), quite a different approach to predicting runoff.

Whilst water-harvesting structures such as the '5% model' of PRADAN may provide life-saving irrigation to rice, there will be years when it cannot. As runoff cannot be assured, and as short-season varieties do not promise food security, additional food-security strategies are needed.

Drainage to shallow groundwater occurs in every year (CV=0.39, Table 3). Restoring degraded uplands through agro-forestry and measures such as PRADAN's '30x40' model will further increase drainage and aquifer recharge and increase the amount of water available from shallow aquifers. This water becomes available late in the kharif and into the *Rabi*, so if this water is to be used for food security it is important that alternative crops be found that can use it. This water also creates the opportunity for multiple cropping.

Shallow **groundwater** is an assured although spatially and temporally variable resource, but not all farmers can access it as it requires fields that are in a drainage line (particularly below a large pond) or low in the landscape, and a shallow well or 'seepage pit'. Or a willing seller at the right price (there is scope for a local water market). Although shallow groundwater is assured it generally comes too late to save rice in medium-uplands in dry years (and can't easily be transferred anyway).

If rice is to remain the staple crop and the basis for food security, then the additional food security strategy must be to grow rice in a way that does not depend on ponding.

This raises important questions about the **reliability of rainfall for non-flooded crops** including aerobic rice. This is explored in Fig. 24, with results summarised in the lower half of Table 3. This simulation is relevant to rainfed crops without any ponding or irrigation. The important prediction is that in every year there is abundant water, continuously available, for at least 5 months - with no irrigation. The duration of available water for rainfed crops is by far the least variable of all the measures of water security (CV = 0.07) in Pogro (Table 3). For the period 2006-2011, the duration of available soil water varied in the narrow range from 154-191 days. 'Drought' in East India is a perception based on transplanted rice. Drought, if defined as crop failure due to low rainfall, need not occur (see photos below).

Project fields in 2010 show that non-flooded crops can succeed in the driest years. Successful DSR (left, foreground) is shown in medium uplands with paddy (background) transplanted far too late or not transplanted at all (nursery, middle-right). Vegetables also grew well in uplands.

The simulation in Fig. 24 assumes the drainage rate of soil remains the same without flooded rice. In time, however, drainage may improve and this will mean soil drains faster and be wet for a shorter period. Does this matter?

Further simulation was carried out with an assumed drainage rate of 10 mm/hr, which is about average for uplands not used for rice. These results are presented in Fig. 25 and summarised in Table 3. Even when soils drain at a much faster rate, the practical effect on soil water is minimal - a few days earlier drying after the monsoon (but note soil is less likely to be wetter than 'field capacity'). The results in Table 3 also show that an increase in drainage rate from 3 to 10 mm/hr sharply increases drainage to shallow groundwater at the expense of runoff. This has no direct effect on the volume of discharge from the watershed, as the shallow groundwater (unless used for irrigation) eventually reappears as discharge. The increased drainage rate simply shifts the balance from quick flow to slow flow from the watershed. Naturally, the increased accession to shallow groundwater is a resource available for irrigation.

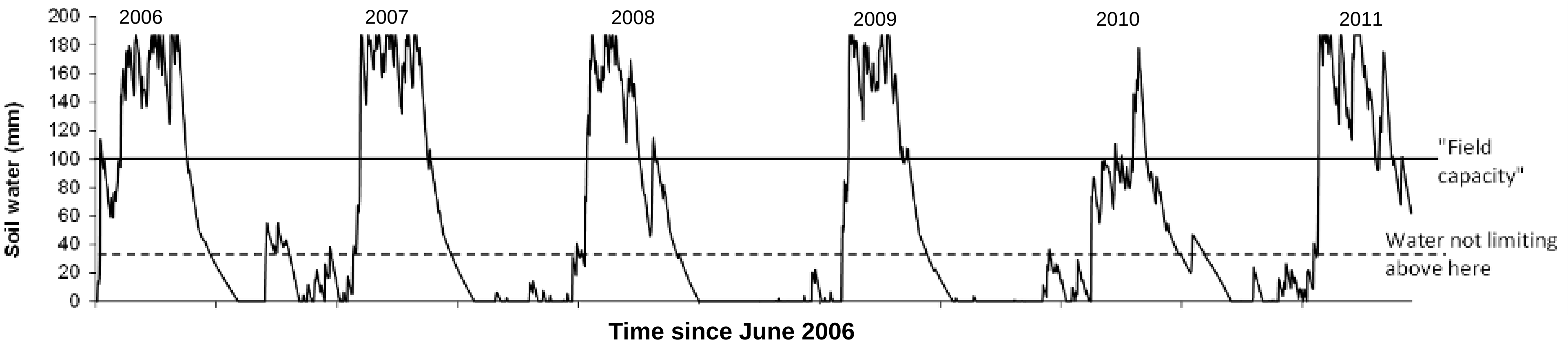


Figure 24. Soil water at Pogro with bunds open (no ponding) and no irrigation, 2006-2011. (x-axis divisions denote 1st June). This figure shows the water available for rainfed crops with no irrigation. Note that water can rise above field capacity during wet periods. It is assumed that water is less readily available below about 1/3 of FC, the dashed line. The simulation assumes that drainage rates are the same as for puddled rice (3 mm/d).

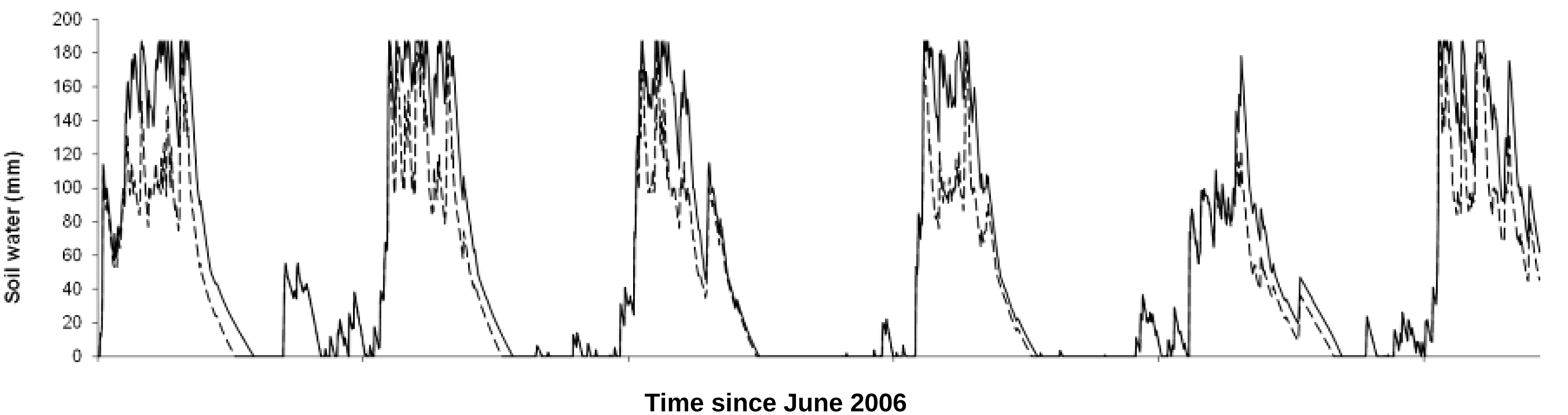


Figure 25. Simulated soil water at Pogro on fields with open bunds assuming drainage rates of 3 mm/hr (solid line) and 10 mm/hr (dashed line)

So far in this discussion, we have considered the high risks associated with flooded rice cultivation on medium uplands and argued the need to produce rice in a way that does not need ponding. We have also shown that the duration of good soil moisture extends beyond the season of most crops likely to be grown in the kharif. This means that soil water is likely to be available for a second crop, in some years without irrigation. From Figs. 22-24, the most predictable component of water is in the **soil** at the end of the monsoon. It is potentially available for *Rabi* crops if shorter-duration rice is grown and harvested early (early-mid October).

Further analysis shows that in some years there is enough soil water for a rainfed second crop, but for this to succeed early maturing rice (or other crop) is needed, and timely harvest, soil preparation and planting is needed.

Clearly, revolutionary new farming systems are needed if water resources are to be used effectively, in addition to new ways of growing rice in medium-uplands.

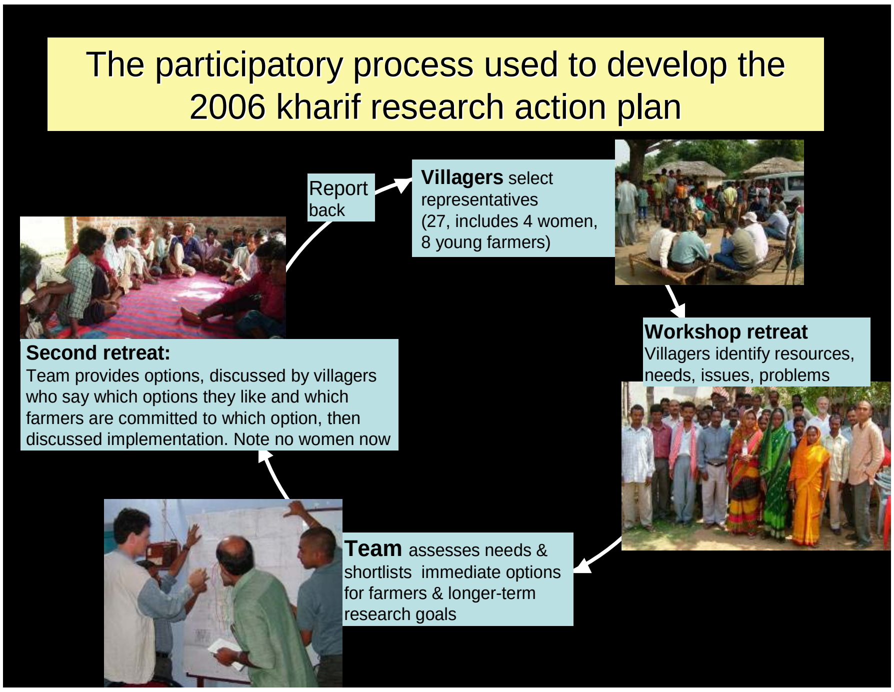
7.1.9 Water resource assessment using electro-magnetic induction

See Appendix 11.3.

7.2 Developing social capacity

7.2.1 Engaging villagers in all activities – women and men

The project started in 2006 in Pogro and Amagara with workshops on problem definition. As well as men, women and young men were engaged. Women did not initially nominate to participate, but the team invited them. In this workshop people identified their resources, needs, issues and problems. After the workshop, the team assessed the needs and shortlisted immediate options for families and longer-term research goals. The team met again with villagers to provide options that were discussed by them. After this they nominated options they liked and were committed to trying. Then we discussed the implementation. Trials were undertaken and the team reported back to the villagers with the results, observations were shared and discussed and then planning again.



Our subsequent observation -The rigor needed for experiments was missing. On-time execution of work was a challenge. However, we saw in Amagara that SHG women were already planning with families and efficiently implementing watershed activities.

Our reflection - Women's participation was absent in both Pogro and Amagara in the final meeting before implementing the research plan. Women had dropped out after the initial meetings. The focus with the men was on the immediate material benefits for the farmers (seeds, fertilizers, etc.) rather than the outcomes/ learning's of the experiments. We needed to re-engage the women in a meaningful way, having also observed what they were doing in Amagara in implementing watershed activities.

The plan - The team then planned to directly engage women's Self Help Group (SHG's) in planning and implementation of the experiments in Amagara.

What we did - Two representatives from each of 6 SHGs constitute an implementation group called the Village Core Committee (VCC) for watershed activities. This group was then involved in the implementation of the ACIAR work following an orientation meeting. The VCC met weekly to monitor progress and PRADAN joined them.

The observation - The scenario changed. Participation of women increased the rigor in experiments and results started to come. The farmers assumed responsibility, with PRADAN not needing to pursue farmers to get things done. We had many successful experiments. The uptake of the learning's increased significantly. The various platforms of SHG and its institutions[14] became active in dissemination of the learning's through exposures & workshops.

The action-learning processed through the annual cycle (Fig. 2). At May-June meetings, participant farmers were selected by SHGs and a schedule for implementation of experiment was developed in a co- learning process with farmers. There was much sharing of experiment results in meetings and 'field walks' and encouraging the family as a basic unit for intervention planning, with emphasis on participation of all family members.

Our learning – This was to include both the farmer and their spouse. Significantly, the SHG-based institution ensures women's participation along with the men of the household in all planning of trials and implementation, bringing rigour and ownership to the activity.

This model of engaging with women through this system with help from the VCC was taken to Pogro (see 'Forming and supporting women's SHG', below). This broadened the role of the VCC[3] and SHG, with them filling an institutional gap to ensure women's and household participation in activities to improve livelihoods. Our observation was that this greatly impacted on the women. However, the levels of impact were different between Amagara and Pogro. The women at Amagara had greater enhancement of self-esteem and confidence in decision-making around WSD and agronomy, which is discussed further in Sections 7.2.2, 'Forming and supporting SHGs' and 7.2.3, 'Gender'.

A reflection - What happened was that we engaged with women as farmers, not just as SHG members **- this was new**. This was transformational for the Purulia team of PRADAN, who have institutionalised it through the SHG-system. This is considered further in the section on up-scaling in the SGSY project.

7.2.2 Forming and supporting women's self-help groups

SHGs have been the base for implementing any activity in PRADAN, Purulia[15]. PRADAN had a history of involvement with Amagara and SHGs were strong, having already implemented WSD. There had been no prior engagement with the three villages comprising the Pogro watershed, although there were some weak SHGs. The decision was taken to not strengthen them until it was time to plan WSD interventions.

When the research was initiated in the project, women were deliberately engaged in discussions about objectives and activities, but contrary to PRADAN's practise they were engaged as individuals, not as members of an SHG. When it came to project

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[14] The 'institution' is the Federation of 34 villages with PRADAN-initiated SHG's (at Block level).
[15] All SHGs promoted by PRADAN are women SHGs

implementation the women dropped out in both research watersheds as already explained. At that stage the SHG was not focused on as the base for project implementation, and men had apparently self-selected themselves for participation in the project's agricultural activities. The team subsequently experienced issues with poor project implementation (in 2006) and were reminded of the good work women were doing in implementing WSD activities in Amagara (and elsewhere). With this, we engaged with SHG institutions in Amagara to build their capacity and knowledge of the agronomy research, to manage project implementation along with WSD implementation. Steps were taken to strengthen SHGs in Pogro village (but not the other two in the Pogro watershed) and involve them in project implementation, but for reasons detailed below (7.2.2), the SHGs were not given the support normally provided. In both Amagara and Pogro village, weekly meetings of the VCC undertook joint field transects, making observations and reflecting upon them, and planning ahead.

In Amagara this had great impact on the women, and the implementation of field trials and other similar activities went smoothly. There have been important changes in self-perception among the women in Amagara (discussed in gender) and agricultural productivity (discussed in M&E and out-scaling sections).

Implementation of project plans went less well in Pogro, and impacts on women and agriculture were less pronounced. When it was time to finally develop and implement a WSD plan in Pogro/Damraghutu/Belghutua, we took in the experience of Amagara and planned around further SHG strengthening. As a first step, before the 2008 kharif, the men and the women of Pogro were given designed exposure to Amagara on the successful experiments and the role the SHG institutions played in streamlining watershed activity as well as ACIAR activities. The exposure appeared to impact on them positively, after which they re-oriented their SHGs into the PRADAN's system. Special capacity building events were organized for the women, especially VCC members. These gave the illiterate women confidence and skills for proper planning and the motivation to implement the program effectively and efficiently. There was a mock session on how to do planning. Since these VCCs are village level institutions, in the Pogro watershed area there were three VCCs. Documentation for this capacity-building event is in Appendix 11.12.

The women of the VCCs in Pogro/Damraghutu/Belghutua engaged with all family members of each SHG, thus ensuring community participation. From January to June, 2009 the VCCs oversaw planning and implementation of the project WSD plan (over all villages), including construction of 48 water harvesting structures (**below**) and a large area of 30x40 model[16] that included 10 ha mango plantation (2,500 trees). A small area of degraded land was reclaimed through land levelling for very poor farmers with small land holdings. The work was undertaken in a very short time, within 20 weeks, and involved the VCC investing Rs.1,475,330 (of SGSY funding[17]). In this, the major achievement was that of the Belghutua VCC. The capacity building event and the handholding thereafter helped the women to achieve what they did.

[16] Hillslope bunding on a 30' x40' grid, to retain runoff and channel it into small pits to increase infiltration
[17] The project included funds for this, but with ACIARs agreement, these funds were used to provide salaries for PRADAN staff to support the wider SGSY project, enabling the up-scaling activities reported later in this report. SGSY funds were then used to construct the necessary interventions in the watershed.

Whilst the project team was satisfied with the participatory planning of the final WSD plan, its implementation over 20 weeks in 2008/09 fell short of expectations. Our initial impression was that staff turnover in PRADAN failed to provide continuous, trusted support for the VCC's, who came under pressure from vested interests to vary from the agreed plan. Implementation was made more difficult by the project requirement that it happen quickly to maximise the post implementation period for monitoring. Further, the project team had interacted since 2005 with Pogro villagers who, when it came to implement the WSD plan, exhibited reduced enthusiasm for the interaction. By contrast, the villagers of Damraghutu and Belghutua had very little interaction with the project prior to 2008, and came to implement WSD with greater expectations and enthusiasm. There are also important ethnic differences between the villages.

It is noteworthy that involving women did not exclude the men, whose engagement occurs in the normal course because of the socialization process in India which compels a woman to take the man along with her (the reverse is not the case). In the planning events, men and women together sat to decide what would be suitable for their family. In our work, the decisions are now mostly taken jointly.

In the three VCCs of the Pogro watershed there are 17 SHGs which cover 243 families. This outreach of SHG's is an important tool in ensuring community participation. During the first forming years, the exposures and training generated a lot of energy. During planning of the kharif season in 2009, much keenness was observed among both women and men. At the same time, hydrological interventions were also taking place and the team expected some good experiences in agronomy. But 2009/10 and 2010/11 had poor monsoon rains and cropping plans suffered.

Reflection on the Pogro watershed None of the VCCs functioned as intended during and especially subsequent to implementing the WSD plan. Belghutua was most effective and efficient, Damraghutu had little scope of work, and Pogro VCC, which had the lion share of activities, did not meet the challenge at all. We suggest multiple reasons for this.

1. *First*, there was very little time between strengthening of SHGs and forming the VCCs for WSD implementation, which did not give time to strengthen the bonding and mutual support among women. (Later focus group discussions in Pogro [Appendix 11.13] revealed the weakness of PRADAN's early engagement through the project in Pogro.)
2. *Second*, since the VCC was in the focus most of the time, the primary group, i.e. the SHG members, was not invested in sufficiently. This created an unbalanced power dynamic in the SHGs, making the institutions weak. This happened partly due to heterogeneous composition of members in the group and partly the frequent turnover of the staff engaged in that area and their varying lack of effectiveness in dealing with social capacity building.
3. *Third*, the available option of good wage labour in the nearby City of Bokaro gave more assured cash income than intensified agriculture, reducing the incentive for villagers to invest in their agriculture (they focused mainly on their food security crop, rice) – wage labour provided ready cash, whereas agriculture had risks which they were not ready to take, especially when they began in 2009-10, the first of two bad monsoon years.

The women in Pogro were unable to build bonds among themselves, and could not fight existing village politics. However, the women in Belghutua grew more confident in dealing with institutions and managing WSD activities and they understood fertilizer trials and their results[18]. Together with the success of Amagara, this suggests the process of engaging women in agriculture can be replicated elsewhere given the necessary attention to SHGs.

Overall the experience introduced a new perspective to engaging with women in SHGs around agriculture. The journey is from the instrumental use of the SHG platform for

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[18] Focus group discussions with the Belghutua VCC support this.

organising (men) farmers, to where women's capacity has been built to make them respected "farmers" (See Section 7.2.3).

7.2.3 Gender studies – engaging women more effectively

PRADAN's approach to community-mobilisation around SHGs provided the opportunity to learn about engaging women more effectively and gender mainstreaming. At the mid Project Review, it was agreed that the scope of the project would be broadened through a variation, to derive principles that can be applied by ACIAR in similar projects elsewhere.

Despite PRADAN's experience that women seem to be more effective agents of change than men, the agronomic work in the early stages mainly engaged men, despite deliberate attempts to engage women in mixed-gender activities, as described above. So the approach of the project was broadened to specifically include women in training and identification and evaluation of agronomic practices, as well as managing watershed development activities. The gender study was focussed on understanding the woman's present status, perceptions of self, and how the engagement process impacts on the woman. Does the process and approach of equal participation of women help transform identity from "farm labourer" to "farmer"?

Structured interviews – the role of women in agricultural tasks and decision-making

Structured interviews with 200 women in 2008 captured the role of women in agriculture in four villages with different development status. Amagara at this time had both a history of PRADAN intervention and a more recent history (through the project) of women being engaged equally with men in learning about agriculture. Gokulnagar had a longer history of PRADAN SHGs but no project exposure. Pogro had been exposed to the project but with little effort to strengthen SHGs. Kashidi had not been exposed to PRADAN.

A sample of the results highlights the gender inequality in roles, with women engaged in all the back breaking jobs (Table 4). The extent to which women performed the most back-breaking tasks came as a surprise. It was also surprising that the development history of the village made no real difference to this. That is, although membership of an effective SHG builds a sense of self-efficacy in a woman (Section 5.2.2) it does not change her role in agriculture.

Table 4. Performance of back-breaking jobs according to gender (2008)[1]

Job	I do it myself (%)				Done jointly with my family (%)				Hired Labours (%)				Only men (%)			
	K	P	A	G	K	P	A	G	K	P	A	G	K	P	A	G
uprooting seedlings	100	97	100	93	0	3	0	7	0	0	0	0	0	0	0	0
using FYM in fields	100	97	100	97	0	3	0	3	0	0	0	0	0	0	0	0
Transplanting paddy seedlings	100	99	100	97	0	1	0	3	0	0	0	0	0	0	0	0
weeding	100	99	100	97	0	0	0	3	0	1	0	0	0	0	0	0
Reaping	100	99	100	97	0	0	0	3	0	1	0	0	0	0	0	0

[1.] Female respondents. K- Control Village Kashidi, P-Pogro, A- Amagara, G-Gokulnagar, an advanced village

The role of SHG groups in fostering greater participation by women in *decisions* around agriculture is shown in Table 5. In villages with a short (Pogro) or no (Kashidi) experience of SHG's, agricultural decision-making is done mainly by other family members. In Amagara and Gokulnagar, more mutual decisions are taken.

The most striking feature of the data is in Amagara, where women had been involved in the ACIAR project from 2006. Here, decisions around seed selection and fertilisers are made mutually in most families (the two right-hand columns under mutual decision-making in Table 5), whereas even in the 'advanced' village of Gokulnagar, with a long history of PRADAN SHGs, these decisions were made by other family members. The difference between Amagara and Gokulnagar seems to be in the way Amagara women were given responsibility for implementing the project's agricultural plans and thus treated as farmers.

Table 5. Role of women and SHG's in decision-making around agriculture (2008)

	My opinion is important (%)				Other family members decide (%)				Mutual decision making (%)			
	K	P	A	G	K	P	A	G	K	P	A	G
Who decides on seed selection ?	0	1	0	3	100	91	5	87	0	8	95	10
Who decides on the kind of fertilizers to use?	0	0	0	3	100	97	50	87	0	3	50	10
Who decides on the crops & vegs. to cultivate?	0	1	0	3	86	91	15	0	14	8	85	97
Who decides about marketing the produce?	0	1	0	3	57	51	0	0	43	48	100	97

K- Control village Kashidi, P-Pogro, A- Amagara, G-Gokulnagar, advanced village with SHG's in usual way

The women in Amagara, who developed a good level of confidence with fertilizers, subsequently played an important role in facilitating fertilizer training of SHG Federation members (representing 34 villages). Participation of women in training of agronomic practices and understanding the basics of fertilizers and pesticides reflects a difference made by the project. These women became a source of inspiration for other women to take up mustard experiments in their field.

Focus Group Discussions (FGD)

Focus group discussions (FGDs) were held in Nov 2011 as part of the gender work and M&E, to understand how the engagement process impacted on the women and their self-perceptions. Separate FGDs were held with VCC members in Amagara and Belghutua, and with two SHGs, Sarnadharam of Amagara village and Divi Durga of Belghutua. The following summary of the FGDs draws out the effect of engaging with women differently (as farmers). Further details of these FGDs are given in Appendix 11.13.

The FGD with Amagara VCC confirmed that the changes suggested in Table 5 have been sustained and actually broadened. The women not only spoke about what they had learnt about fertilizer, but also cultivation of different crops in different categories of land and irrigation. They said they were able to plan beforehand and decide what to grow. These women spoke about the change in approach between implementing watershed development in 2002, when women were instructed by men to do the work, to the situation where they formed the VCC and were given charge of doing similar activities, to now when they manage research activities in agronomy. Now they say:

> "*Dadara bhabche sab didider hate daiytta chale gelo* (the men are wondering to themselves, all the responsibility has been transferred to the women!)
>
> "*didider rajjotyo*" (the women will rule now)
>
> *"Earlier there was nothing for women."*

In between they talked confidently in detail, step by step, about the changes happening in the village and themselves. They spoke about their trainings, the handholding of PRADAN staff in meetings, encouraging them, teaching them and helping them to learn. The participants believed there were benefits in handing responsibility for work to women:

> *"if you give responsibility to women it happens properly".*

The participants also commented on the change in their agricultural practices and how they now valued land that in the past had not been valued and how:

> *"this year (2011) has been good rainfall and people are cultivating everywhere".*

The group spoke at length about the various on-farm trials that had been carried out illustrating an understanding of the nature of the trials and the outcomes in relation to the application of fertiliser for various crops.

The Sarnadharam SHG in Amagara brought out a revolutionary insight during their discussions. They explicitly said:

"Not some change, there has been a complete transformation".

The members in this group introduced themselves as farmers, including statements such as "*I cultivate potato, tomato and paddy*" and "*we have a mango plantation ... today we are planting potatoes*" without any prompting from the facilitator, a significant finding demonstrating change in their perceptions of their role in the family and community.

The participants talked about their learning about vegetable production and the use of fertilisers from PRADAN professionals. During discussion it was also observed that the transformation included the approach people have to valuing water. They said:

"we don't waste our water any more - people are very possessive of their water – people are using this water for cultivation."

It was significant that the women talked at length about how '*proper planning is required for agriculture'*. They spontaneously told the present rate of fertilizers being used.

The following excerpt gives a glimpse of how their understanding on agriculture in the family has become comprehensive.

"*Even to apply fertilizer you need man power. If you plant too many fields, how will you manage between two people? Doing it in the right time is also important. If you give food in proper time, then only it will be beneficial. You also have to irrigate. Agriculture requires a lot of intensive engagement. At times we don't even have time to wash our hands".*

In the Belghutua VCC the women had knowledge about watershed development interventions, they know about the fertilizer experiments, and exhibited confidence to talk on this. The impacts of the works were not talked about. They could explain how water can be tapped for irrigation and in which type of land, and also about interventions like the 30x40 model. Similarly, on probing they talked about the fertilizer trials and their outcomes, but less was spoken of impacts, except a dug well to support their horticulture which has helped them immensely during the dry summer months. They took pride in themselves for being able to oversee the implementation and monitoring. They talked about the confidence they have now to go and demand support from institutions like the Panchayat or Block Development Office and bank.

In response to the direct question about their personal-level learning, they spoke about their enhanced courage and knowledge on agriculture, WSD, mobility enhancement, etc. The women from Belghutua VCC reported that initially people would laugh at them for being involved in the various activities but now they are no longer laughed at and have improved their status in the community.

They also openly shared about the problems their SHGs are going through. We identified that power dynamics were at play. They sought assistance and said they wanted to revive the VCC as they could learn so many new things when it operated regularly.

The Devi Durga SHG of Belghutua is heterogeneous, with women from both Schedule Castes and Schedule Tribes. During the FGD, nothing specific on the interventions of the project came out apart from a few lines on SRI paddy and the new technology of creeper cultivation on trellis. They talked about the SHG forum and its second tier Clusters and how they as women draw strength from each other. Being part of these institutions gave them confidence to deal with mainstream institutions like Panchayat.

Comparing the experience of Amagara and Belghutua, by Nov 2011 there was evidence in both locations of enhanced self-esteem, confidence to interact with institutions and knowledge about watershed activities. However, knowledge and understanding of agronomy, and engagement in intensive agriculture, was far less in Belghutua women than in Amagara, where the women clearly had a strong view of themselves as 'farmer'. Being a 'farmer' implies considerable status.

Overall, the transformation among women in Amagara is of a different order than that of Pogro/Belghutua. This difference is despite the fact that, since 2008, women at both locations have been actively engaged in learning about agriculture and planning agricultural interventions through the project. Member of the implementation team, Ms Kumbakar (PRADAN), points out that the process and approach with Amagara was supported by strong, established SHG-based institutions whereas the SHGs and VCC in Pogro/Belghutua were weak (Section 7.2.2). She suggests that given a designed approach and process, where women collectives are functioning well, the transformation experienced at Amagara is replicable, that is the transformation from 'farm labourer' to 'farmer', that underpinned the transformation in agriculture referred to in the Amagara FGDs and documented in Section 7.4.4.

Whilst even without proper attention to developing SHGs there was some enhancement of self-esteem and confidence among the women, the synthesis of FGDs highlights the importance of information and learning dissemination in *strong* SHGs to maximise the benefit of the new process of engaging women. In the absence of this learning dissemination, power dynamics dominated in the Belghutua VCC (Section 7.2.2). This was compounded by our designed engagement in agriculture with them.

Mixed-gender FGDs

We conducted two mixed-gender FGDs in late 2009 to better understand the changing gender roles (total of 55 people, 42 women and13 men). The evidence from these focus groups supported the observation that engaging women as farmers had widened their role in decision-making with positive impacts on livelihoods. There was also a lot of discussion about the effect of this on women's esteem, with 4 of the men specifically saying:

> *"We no longer dismiss women's suggestions"*

This evoked expressions of agreement from others, and no disagreement.

Overall our findings suggest that greater role sharing arising from dealing with women as farmers extends beyond the decision-making. For example, when men and women are introduced together to a new activity, and trained as equals, they tend to go on and share the tasks. Some women have reported that men are 'creating space' for them to participate, and are more willing to provide assistance with domestic work. This suggests a substantial positive shift in role divisions from the survey in 2008 (Table 4) when women alone bore the burden of back-breaking tasks. Women seemed to accept the increased workload resulting from their new role, as they recognise it is contributing strongly to improved livelihoods. Many women reported greater financial independence.

It is evident that engaging with women as farmers has challenged deeply embedded cultural norms and leads to positive change in roles in the tribal family and community. Whilst men seem to be treating women differently, it remains to be seen whether this is because they now recognise they can generate significant income, or whether they see them more equally as human beings.

Emerging principles for engaging women effectively

Our engagement with villagers is challenging deeply embedded socialisation and changing the place of women in tribal society in a positive way. This is important, and ensuring consistency and systematically designed processes is even more so. This engagement is transforming women[19], taking them through a journey where we build confidence in them to break the stereotyped identity of women.

We developed some basic processes or approaches that should provide a better chance of bringing transformation among women regarding creating an internalised identity of “farmer” and enhanced self-esteem, and social status with it.

i. Give women 'design space' (a designed, designated role) which is reinforced by an appropriate institution, the VCC in our context, which is legitimised by the SHG Institution (which needs to be strong and functioning well).

ii. Ensure participation (reinforce the new 'institution') by -

- Creating norms for villagers that to participate in a development activity, it can only be on the basis that women equally participate.
- Sensitivity to needs of women that need to meet if they are to attend (e.g. time of day, duration of meeting, transport, child minding etc. (establish these needs through initial group meetings with women). Need to consider in the project budget, including special training materials for illiterate women.
- The handholding support and guidance designed-in with set milestones over a timeline until a stage when they can take full charge. Consistent engagement in the initial period to boost confidence and encourage.

  Repeatedly during FGDs women mentioned PRADAN support and help to learn.

iii. Regard women as farmers, not as SHG members alone. Break away from our own prejudices that illiterate rural women cannot learn the fine technologies of agronomy.

Learning - Our changed perception of women leads change in their self-perception.

7.3 Improving agronomic knowledge and skill (human capacity)

Most activities met several objectives. Thus villagers were engaged in most activities with the aim of improving their knowledge and management skill, regardless of the underlying objective of the activity. The activities described below warrant special mention.

7.3.1 Workshops

There were many workshops and meetings with farmers for various purposes. The core belief was that farmers are a resource of important local knowledge and experience, and to build their capacity they need to be the co-traveller in this journey of exploration, not mere recipients of the outcomes. In this process, farmers and researchers learn together. The fertilizer workshop is outlined below as an example.

Fertilizer workshop

This arose from a meeting with villagers in 2006. Rather than go to farmers and ask them to a fertilizer training activity or a research activity with fertilizers, we engaged with them with an open mind to learn about their situation and look for solutions together. Through this process they requested the fertilizer workshop, after which they came forward to participate in fertilizer research, taking a step towards experiential learning, taking the risk of research. Details of how the workshop content and process were developed and then evaluated were given in Appendix 11.4. It was designed on action learning principles. The format comprised two workshops with in-field experience between.

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[19] Women themselves spoke about a ‘transformation’, but our reflection is that the primary transformation needs to be in our (professionals) attitudes. Transformation in men in the communities appears to follow

1. *Workshop 1.* A day of mostly theory using a range of media including: a role play communicating the need for both water and nutrition; samples of fertilizer to view, smell (and taste!); nodulated legumes to inspect/discuss and a quiz to conclude with (to reinforce learning and foster reflection) before asking participants about their next step and offering the opportunity to test some fertilizers in their fields.
2. *In-field experience*. A fertiliser experiment on their own field (a simple strip or split-field from the farmer's perspective, but with each field a replicate it became a statistically powerful measure of response to the fertiliser tested.
3. *Workshop 2*. Reflection on observations, planning future actions by the farmers.

Workshop 1 included live samples of plants, fertilizer samples and empty fertilizer bags to show labels, PowerPoint presentations, sub group tasks, role-plays, interactive talks and feedback. Participants first learnt that fertilizers or water alone cannot ensure high productivity. Then they learnt the importance of fertilisers, major plant nutrients supplied by various fertilizers, requirements of different types of plants (legumes *v* cereals). An important feature was giving farmers fertiliser samples to see, feel and taste and then examine the bag and its label. Illiterate farmers learnt to recognise fertilisers by sight and name and to identify it on a label. One farmer spoke for many by saying:

"Now I know, I can talk to the dealer and he can't cheat me".

After this knowledge-building they were asked if anyone wanted to test what was learned. This was an opportunity to continue learning in their home situation. Most participants were eager to test their new knowledge. An experiment plan on the crop of their choice (from a range we nominated) was planned[20]. These simple nutrition trials recorded fertilizer responses in farmer's fields, but given the number of fields (replicates) it was meaningful for scientists wanting to know about gross nutrient deficiencies in the region.

The first day ended with a quiz, and an evaluation by the farmers (and later the team, leading to a refined program). It has been further refined and the content simplified to facilitate conduct by PRADAN Assistants (graduates) and supported by community resource persons (CRP's) who should ultimately be able to conduct the workshops (CRP's are trained by PRADAN, but they are not graduates - most have elementary education).

The results from the fertilizer experiments were shared at a second workshop which followed harvest of the trial crops. Note that when observations were shared they were not confined to P response – farmers made many other useful observations, leading to realization of the importance of crop management apart from nutrients applied.

This second workshop was designed to end with farmers making a commitment to take their next step - to learn by their experience and to change what they do. The farmers questioned the results, e.g. different fields show different responses to the applied fertilizers (i.e. fields are different, so a single recommendation is not good). The response was overwhelming. This led to more complex fertilizer trials with multiple doses of P.

This process of engaging with the community helped the farmers to learn about their land, plant nutrition and fertilizers, building their capacity to understand their resources better.

General comment about engaging people in learning

These participatory workshops, planning and review meetings with farmers, sharing experiment data, and field walks to see the results, provided opportunities to poor farmers to learn how to act, rather than depend on outsiders for solutions. Similarly, the importance of approaching the community with an open mind, rather than with preconceived ideas and prescriptions was well demonstrated. After seeing the potential of participatory processes to engage with the community for learning, other such workshops were organised in the villages where special SGSY projects are being

[20] *These also became the nutritional trials in Maize, Black gram, Finger millet, and Paddy*

implemented. Many participants in the earlier fertilizer workshops worked as resource person for the workshops organized in other villages. It was important for PRADAN to see that with experiential learning farmers can become better problem solvers and less dependent on PRADAN for repeated provision of the same basic information. Not only does this develop the farmer, but it has the potential to free the professional from a *'transactional'* role to play a more *'transformational'* role.

7.3.2 Activities to understand adoption and design learning approaches

The "Vegetable Learning Experience"

This learning activity was designed to change farmer's perceptions about themselves and their land and evaluate an approach for PRADAN to use that can facilitate these changes.

In Amagara where the focus was on agronomy work, the PRADAN team was struggling to help the farmers to intensify agriculture after the WSD work which comprised a large number of water harvesting pits being put in place about 5 years before the ACIAR project. The farmers were reluctant to switch from the traditional rice-fallow mono-cropped system to a more entrepreneurial cropping system. Another concern was the propensity of farmers to cultivate kharif paddy even in the medium uplands which was not so suitable for this crop, thereby putting themselves under higher risks of crop failure leading to a vicious cycle of inappropriate crop choices and poverty.

To bring about the desired change, a learning approach was adopted to maximise the chance of changing farmer's perceptions (from poor farmer/beneficiary depending on government or other assistance, to owner of resources that can be managed for improved livelihoods) and about their resources (e.g. 'poor' uplands can be used for high value, out-of-season vegetables returning more to a farmer than rice, with which it competes for labour and other resources). This was also an opportunity for PRADAN to learn how to more effectively facilitate change. For this action learning work which involved growing early season kharif vegetables in medium-uplands and uplands, a group of 8 volunteer farmers were selected. After negotiation, the farmers agreed to set aside around 30-35 decimal (0.12-0.14 ha) of uplands and contribute all labour for early season vegetables while the cost of seeds and fertilizer would be borne by the project (no inputs were provided subsequently).

Before the activity a semi-structured interview[21] was conducted with the farmers to map their perceptions about his/her self and perceptions about his/her resources, including their perception of risks associated with this activity. After this the farmers were helped in crop and land selection - the crops selected were early season tomatoes, cabbage and cauliflower. This was followed by classroom training on packages of practices (developed with the farmers) along with field support in growing the crops.

The total outlay from the project was only around Rs 7,000, but the farmer's total income was around Rs 35,000 in 3-4 months. Not all participants earned the same income, which ranged from Rs 3,000 to Rs 8,000. While the crop was in the field other villagers were motivated to visit them and after the harvest results were shared in a community meeting.

Post-harvest, a semi-structured interview was conducted with participants to record changed perceptions. What came out clearly was enhanced confidence as farmers (increased self-worth) and also increased confidence to adapt to new technology.

There was a strong response from the community with many new farmers wanting to grow vegetables the next year. We gave no further project support other than taking farmers to HARP for a guided exposure and training support. Even so, many farmers adopted vegetable cultivation in uplands and also pre-kharif and *Rabi* vegetables, adapting with their resources (location, irrigation potential). By 2012 these changes had been adopted

[21] *The data have been lost through 'misadventure'. These notes are based on recollection.*

by 142 farmers in Amagara (with approximately 160 households). Further details are given in Section 7.4.4 dealing with the evaluation of new farming systems.


Tangible outcomes of the "vegetable Learning Experience"

7.3.3 Using soil and crop surveys to build human capacity

These were used as learning activities for farmers to:

- appreciate the real rather than perceived value of different land classes;
- understand the concept of achievable potential yield;
- appreciate the importance of management in achieving higher crop yields; and
- identify key management factors.

Farmers reacted enthusiastically to this activity, especially when results were presented in a way they could compare their yields with other farmers with the same class of land (see Fig. 12). The huge variation within land class surprised farmers as much as the small difference between land classes. Some of the highest yields were in medium upland, evoking vigorous discussion amongst participants, challenging their perceptions about the value of different land classes and highlighting the importance of management as a factor under the farmers control to influence yields.

Many questions were raised generating discussion around why apparently similar fields (same land class) gave such different yields. Farmers were forthright in sharing their views, sometimes telling another farmer they were 'poor farmers', often for a good reason which the farmer agreed with! Inevitably the focus was on timeliness of transplanting, weeds, pests and diseases and use of compost or fertiliser - all sensible. This reinforced the learning that management leads to much of the yield difference. Although ‘drought’ can reduce yields, almost all farmers failed even to capture the potential that rainfall offers because of management constraints they can deal with.

The value of this exercise lay in farmers seeing starkly how good or bad their fields were, and sharing in the group about actions to improve yields in terms of management, which is within the grasp of the farmer - not merely fate or having only 'poor' land.

Soil fertility data were not needed. Yields alone initiated valuable discussion. Soils had been sampled but we never had results in time for meetings. Farmers were critical of this, reinforcing the importance of sitting with farmers soon after harvest to share results - they are keen to find out, but quickly lost interest and patience.

Nevertheless, soil fertility data helped explain important aspects of management. Fig. 26 showed that soil N (by inference compost) is important, but fields that are high in N (or compost) can still yield poorly.

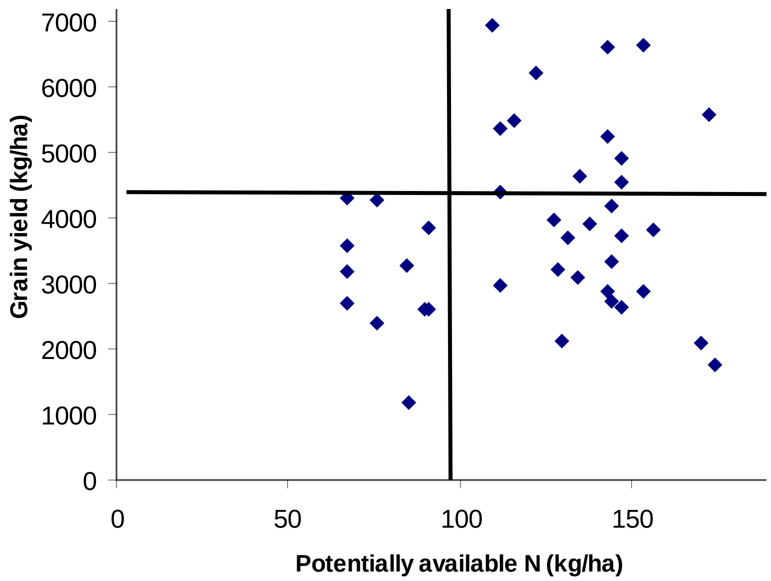


Figure 26. Available N at sowing in relation to rice yield, Pogro 2006

Farmers seeing this graph located their own fields and discussed why they had more or less N at sowing than in other fields (compost, manure etc), and why high N may not have resulted in good yields (usually weeds or diseases). The use of strip plots or split fields (see Section 7.4) allowed farmers to explore reasons for differences in their own fields.

The main management-related variable other than fertilizer that affected yield was pest and disease incidence (Fig. 27) and weeds, although farmers also discussed the age of seedlings at transplanting (that reflected both seasonal conditions and management skill).

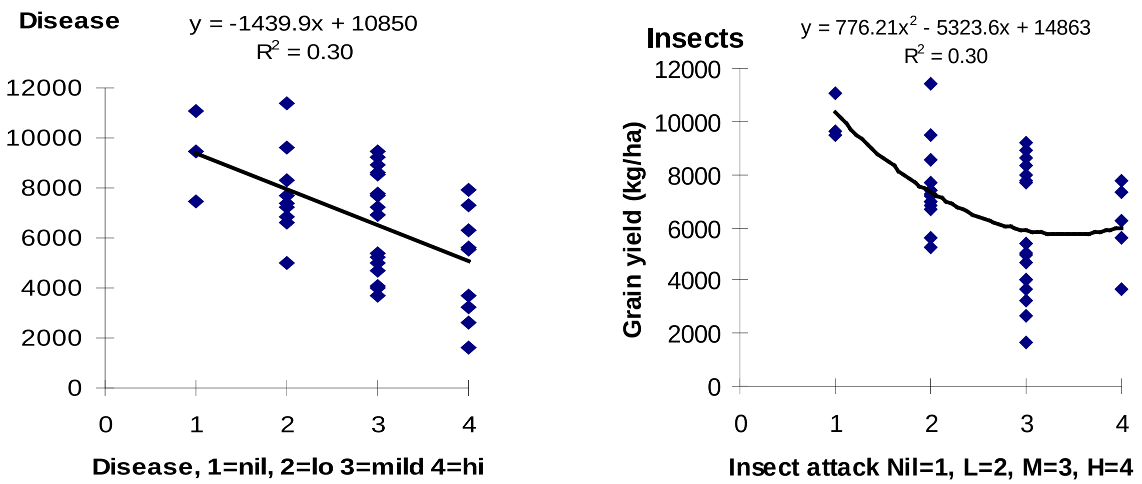


Figure 27. Yield response to the pests and diseases, Amagara soil and crop survey, 2007

Guidelines to using crop surveys as an extension tool have been prepared.

7.3.4 Learning cluster

Experience at Amagara prior to the project showed that development will not occur just because water harvesting structures are provided, but we learned that with a good process and appropriate activities it is possible to bring about rapid change. We were keen to apply the learning principles in Pogro to see if there was a model here that PRADAN could apply elsewhere. We asked "what if the physical watershed development occurred in two stages - in the first stage a small number of co-located families, a cluster, would receive water harvesting structures and work with the project team to first envisage how the water might be used and then to make plans and implement them, becoming a focus for designed learning for the whole village, not just the cluster." WSD would then occur in the second stage across the whole village/watershed, with the expectation that villagers would, by then, be equipped to use the 'new' water effectively. We assumed that undergoing a structured learning process would change attitudes, confidence and practices. This process would provide enough space and time for farmers to follow the action learning cycle (Plan - Do - Observe - Reflect - Replan). Hopefully, they would become better problem solvers and less dependent on PRADAN for 'solutions', and the cluster of families would become a learning resource for the whole village.

Six farmers were provided with new water harvesting structures (see photo, below), built by villagers under oversight of the VCC. These were outside the physical watershed boundary (but in the Pogro village). The farmers were helped through the action learning cycle to take a second crop using water from the new WHS. They went through a process of technical skill upgrading, a structured learning activity both for these farmers as well as for the other villagers. In this process, the wider community was helped to explore the rationale for the steps followed, assuming the exploration will help them to take similar decisions in the near future (the rest of Pogro received water harvesting measures in the first half of 2009).

After rice, farmers went for wheat and mustard, in both cases with good yields of around 1.5 t/ha for mustard, and 4 t/ha for wheat. This is the first time ever they have gone for a second crop, yet received such good yield. One farmer referred to their achievements as a ‘miracle’. Another reported:

"farmers passed by on the way to market earlier in the Rabi and laughed to see us cultivating and sowing crops with so little water apparently available (in the seepage pit which, for a period after the monsoon, re-fills after emptying). *Now the farmers are shaking their heads and saying this is impossible."*

Wheat ready to harvest (Pogro Feb, 2009)

Of the six families, three went for a third crop, of brinjal and bottle gourd. Based on the experience, the farmers grew mustard in the next *Rabi* rather than wheat as water requirement in wheat (they thought) is higher and it was affected by severe termite attack.

Through this experiment the farmers went through a process where they realized the importance of crop planning according to the available resources especially water. After harvest, all participants plus the SHG groups met to share experiences and sensitise everyone to the importance of having a plan to use the water, in preparation for the following *Rabi* when the whole village will have WHS. Events were held for villagers to come and learn at the site of the work, so many more from within Pogro watershed were exposed to the work in designed activities. Also, 102 villagers from 5 villages outside the watershed were exposed to these initiatives, especially families outside Pogro who have new WHS or other irrigation infrastructure. Based on the *Rabi* experience the same process was initiated in the Kharif with the aim of helping the farmers to have a 200% cropping intensity in land under the command of the WHS, using the available water resources - 19 families went through this learning activity. Families who took up *Rabi* cropping under the ‘learning cluster’ activity have continued to grow *Rabi* crops, but spread to other villagers has been slow. The reasons for the slow uptake, compared with rapid uptake in Amagara, were discussed under Formation of SHG’s (Section 7.2.2), Gender (Section 7.2.3) and in the monitoring and evaluation. PRADAN has adopted the ‘learning cluster’ as a key strategy in out-scaling in the successor ACIAR/ AusAID project.

7.4 Developing crop options and farming systems

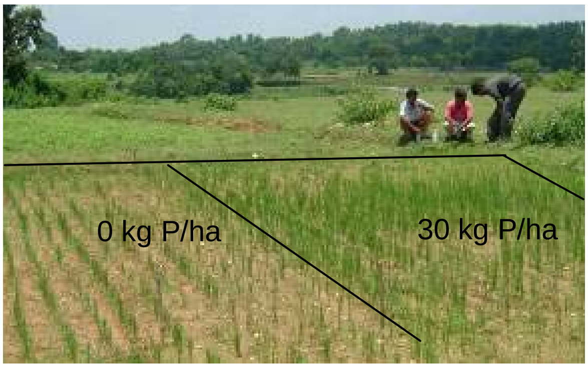
7.4.1 Evaluation of crop options for *kharif* (non-flooded) and *Rabi* (includes P x irrigation experiments for *Rabi* crops)

A short-list of crop options was developed with farmers, to provide alternatives to flooded rice in the kharif, and for the *Rabi*. Vegetables were included to provide options from the pre-monsoon period right though until the *Rabi*. Reasons for each crop varied, and in some cases farmers changed their assessment of the importance of a crop as work progressed, maize being one crop that was dropped from the work. In choosing crops, we were mindful of developing systems based on these crop options, so the work included varieties of different duration, and also work on short-duration rice was undertaken as it would enable earlier planting of a *Rabi* crop (not reported). The experiments, reasons for crop selection, and main outcomes are given in Appendix 11.14. All experiments were replicated, usually in a randomised complete block design with farmer's fields as blocks. For *Rabi* crops, the development of crop options necessarily involved studies on irrigation and crop nutrition (in particular P) in factorial experiments. These fertilizer results are summarized here, but most fertilizer response work was on rice and is reported in Section 7.4.2. These crop development activities also provided necessary data for modelling, the soil 'upper limit' and 'lower limit' of water extraction for a range of crops and land classes.

Results from the experiments were used to develop agronomic 'packages', in some cases supplemented from literature or PRADAN's experience. We don't advocate a 'package of practices', but rather encourage adaptation to each field or farmer's circumstances. The 'packages' below are a summary of the results and a starting point from which farmers develop an approach that suits them. Project learning on crop options, soils, and water was integrated into a 'cropping systems learning tool' shown in Section 5.6.1.

Upland direct-seeded rice

- Line plant, 20 cm spacing (behind plough if no seeder is available but spacing will be irregular)
- Short duration variety (80 -100d) (Bankura 1, Khandagiri)
- N - 70 kg/ha (20 kg at or before planting, 30 kg first weeding, 20 kg flowering), K - 30 kg/ha (broadcast with N at/before planting); P - 15 kg/ha banded with seed at planting [22]
- Manual weeding about 15, 30 das

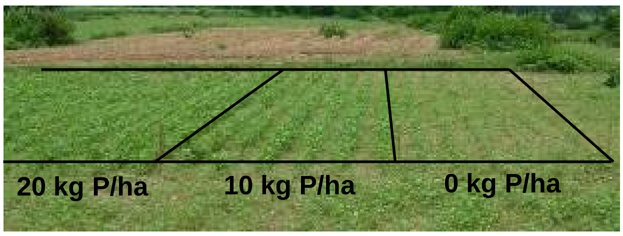


This should give 4 t/ha paddy, about 4x regular upland paddy in EIP (0.9 t/ha). DSR is also suited to medium uplands with a 100d variety, and more N may be justified.

Black Gram

Important pulse, usually broadcast in uplands with no inputs other than ash collected from the kitchen. In experiments, black gram always nodulated well without inoculation, an important trait given there is no guaranteed commercial inoculant. 'Improved varieties' seem little better than 'local variety' – needs a concerted effort with wider range of germplasm. Yields >1 t/ha, more than 4x existing yield, but can be improved. Crop needs to be seen and treated as a valuable, high income pulse, not a poor subsistence crop.

- Local variety
- 15 kg/ha P, 30 kg/ha K – banded
- Line sown (behind plough)
- at least one inter-culture for weeds
- Treat as vegetable crop in small, well managed plots.



Mustard

Farmers received good yields (>1.5 t/ha) and profit in participatory experiments. A typical plot of 0.5 bigha (1/6 ac.) gives net return of 2,300 Rup (over a year's oil).

- Varieties (B9, yellow; Varuna, brown)
- 4 kg/ha (8kg/ha if thinned), line sown (20 cm spacing, 2-3 cm deep), behind the plough if no seeder.
- 70 kg N (split 20 kg planting, 30 first weeding, 20 flowering [post-sowing N follows an irrigation]), 50 kg P/ha and 30 kg K /ha. N&K broadcast at or before planting, P is banded with seed.
- Up to 3-4 irrigations (total ~160 mm), depending on residual water and any sub-surface lateral inflow to the field

- Weeds, pests disease controlled – aphids main pest, controlled by *Thiomethoxam*[R]

P x irrigation experiment, Amagara 2006.

The bare plot received no phosphorus

A pot experiment was carried out to see if the mustard was responding to S as well as P. The results (not shown) suggest the response is entirely to P.

Improving weed management will be important for obtaining these yields. Less irrigation may be feasible, to force crops to use more of the residual water after rice.

Mustard response to irrigation and P fertilizer at Amagara in 2006

Irrigation and P together explain 44% of the variation in yield (Fig. 28). Best yields approached 2 t/ha. About 30 kg P/ha was needed and, in this experiment, 80 mm irrigation (2 applications). Farmers were amazed by the response to P, two commenting 'no P - no crop' and 'P saves me two irrigations'.

$$Y = -990 + 60P\ (kg/ha) + 34Irrig - 0.79\ P^2 - 0.2\ Irrig^2 \quad (r^2 = 0.44,\ 5\ reps)$$

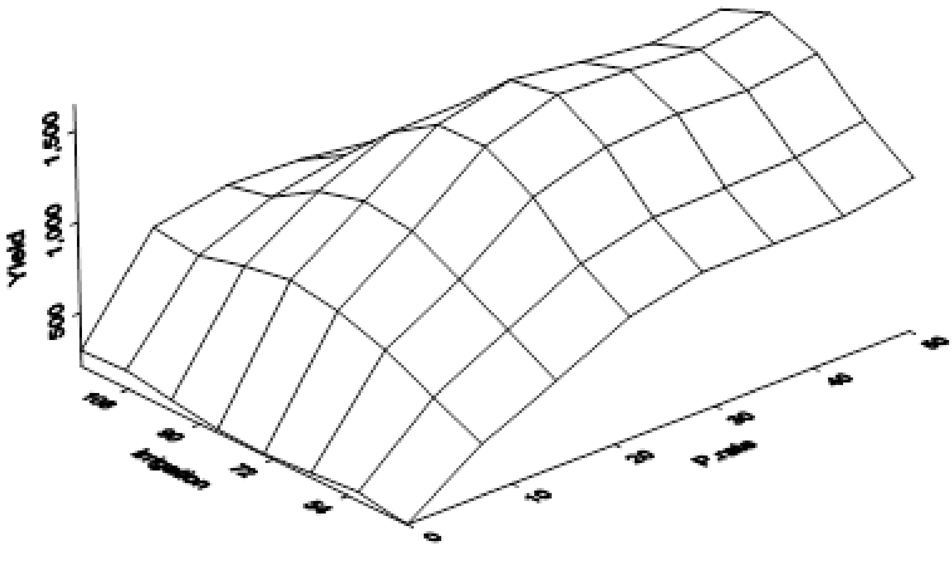


Figure 28. Mustard yield response to P (kg P/ha) and irrigation (mm). *Amagara 2006*

The high P rate required reflects the low P status of the soils, and that rice culture leads to relatively insoluble P in Al- and Fe-precipitates. Dry surface soils in the *Rabi* further reduce P uptake. The 30 kg P/ha is much greater than P removal, but any excess P will be mobilised later in the flooded rice, where soil P was noted earlier to be low and sometimes deficient. Taking a longer-term view, P application to *Rabi* crops reduces the costs of maintaining soil fertility and sustaining long-term rice productivity

Wheat

More than 4 t/ha should be readily achievable, as in Amagara in 2006 (the only year of trials there) and again in Pogro in whole fields in 2009 (the first time these farmers had ever grown any *Rabi* crop, and they did it with only initial training from PRADAN).

- Line plant - 250 mm spacing is OK and will allow planting behind the bullock-drawn country plough if no seeder is available. Aim for 150+ plants/m^2 or a sowing rate of ~50-60 kg seed/ha.
- Use a suitable variety (we used superseded Sonalika, the only seed locally available)
- Fertiliser: 90 kg N (split 30/40/20), 30 kg P/ha, 30 kg K/ha. Broadcast N, K at planting or before but place P with the seed at planting, More N may be top-dressed later if crop is growing well and water is available (either in subsoil or irrigation).
- Up to 4 irrigations (~160 mm[22]).

It is difficult to get farmers to apply less than 4 irrigations and force crops to use residual water. They see wheat as a fully irrigated crop. Its reproductive plasticity as a rainfed crop for variable rainfall is under-appreciated.

Wheat response to irrigation – Amagara, 2006

The response in Fig. 29 is 17 kg/ha/mm of irrigation, which is about as expected with no rainfall and infrequent irrigation (hence low soil evaporation). The intercept of 1,930 kg/ha implies that around 115 mm of transpiration was obtained from residual water after the rice (assuming a transpiration efficiency of 17 kg/ha/mm). Something of this order is the value that farmers should be putting on the residual water.

This is an important rule-of thumb – 17 kg/ha/mm residual soil water

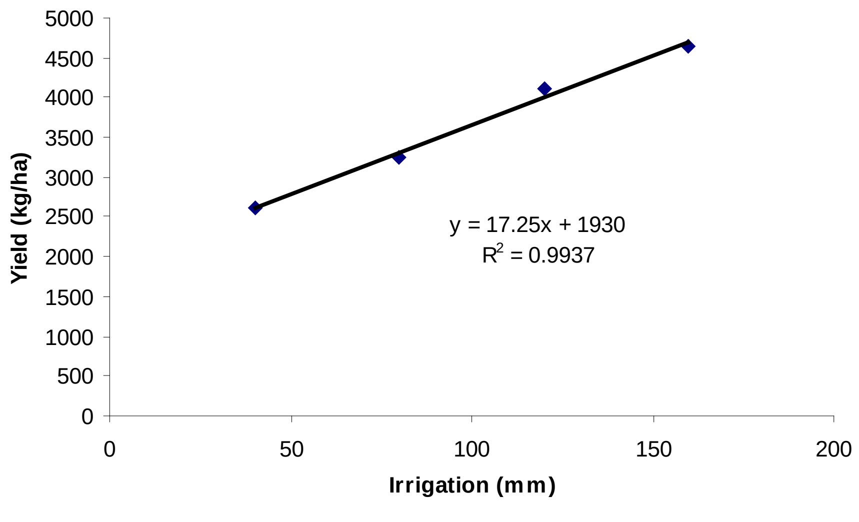


Figure 29. Wheat response to irrigation with P (50 kg P/ha) and N (90 kg/ha) non-limiting
(Mean of only 2 replicates, so not too much should be placed on the exceptional statistics)

Although the estimates made above suggest residual water use may have been around 115 mm, the potentially available water in medium lowland appears closer to 160 mm.

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[22] Measuring irrigation in on-farm trials. Farmers were consistent with the rate of the 'swing bucket'. We measured the bucket volume and recorded duration of irrigation (Application= number of swings x volume)

Full versus supplementary irrigation

These results from Amagara allow us to make preliminary comparisons between two contrasting irrigation strategies; full or at least 'high' irrigation, *or* minimal irrigation to ensure crop establishment, formation of secondary roots and adequate uptake of the banded fertiliser P. A well-irrigated wheat crop (4 irrigations, ~160 mm) yielded around 4.4 t/ha. With one irrigation of ~40 mm (potentially over 4x the area) the yield was 2.5 t/ha. From this, about twice the total yield can be obtained by spreading scarce water over a bigger area and forcing crops to use the residual water. An important caveat is that we do not know if lateral inflows of water provided more water than these calculations imply.

Wheat response to P-fertilizer

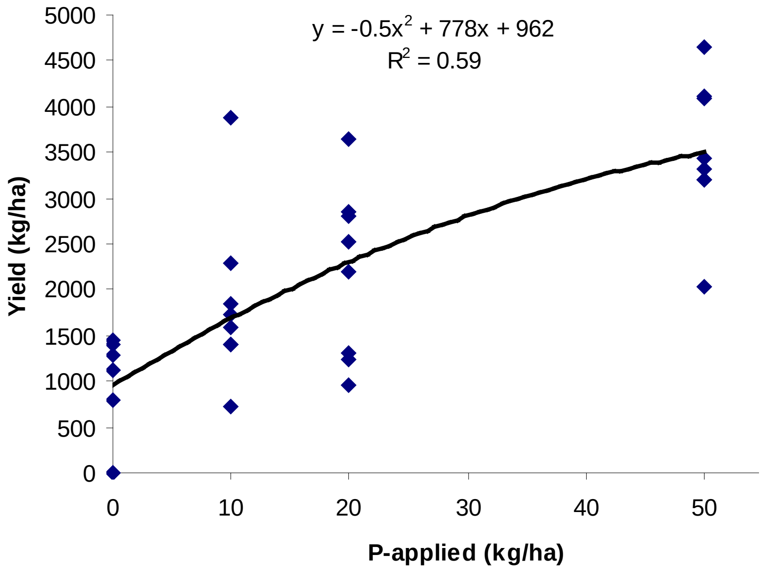

***Figure 30. Wheat response to P-fertiliser** Amagara, 2006*

The result in Fig. 30 suggests that ~30-40 kg P/ha is needed. Much of the variation between replicates of P rate is due to irrigation response.

The integration of crop options into systems is considered in Section 7.4.4, following further consideration of soil fertility and rice crop fertiliser requirements, below.

7.4.2 Nutrient responses in transplanted rice

Crop surveys showing responses to N and P applied by farmers

The low P status of soils on the EIP was noted in Section 7.1.2, but is P so low that even rice will respond to P-fertilizer? N is also low in virtually all soils on the EIP, although widespread use of compost/FYM and urea (at varying but often low rates), together with free-living N-fixation in ponded paddy fields, should go some way to addressing N deficiency. There were weak relationships between yield and soil P (e.g. Fig. 13) or soil P and N (Fig. 14) in the survey of farmer's fields, and weak evidence that rice responded to farmer-applied P (Fig. 31). Farmers referred to the 'red appearance' in some fields, which is a typical symptom of acute P deficiency. Note that acute P-deficiency can also look like N deficiency, so care is needed in making visual assessments of plant nutrient status.

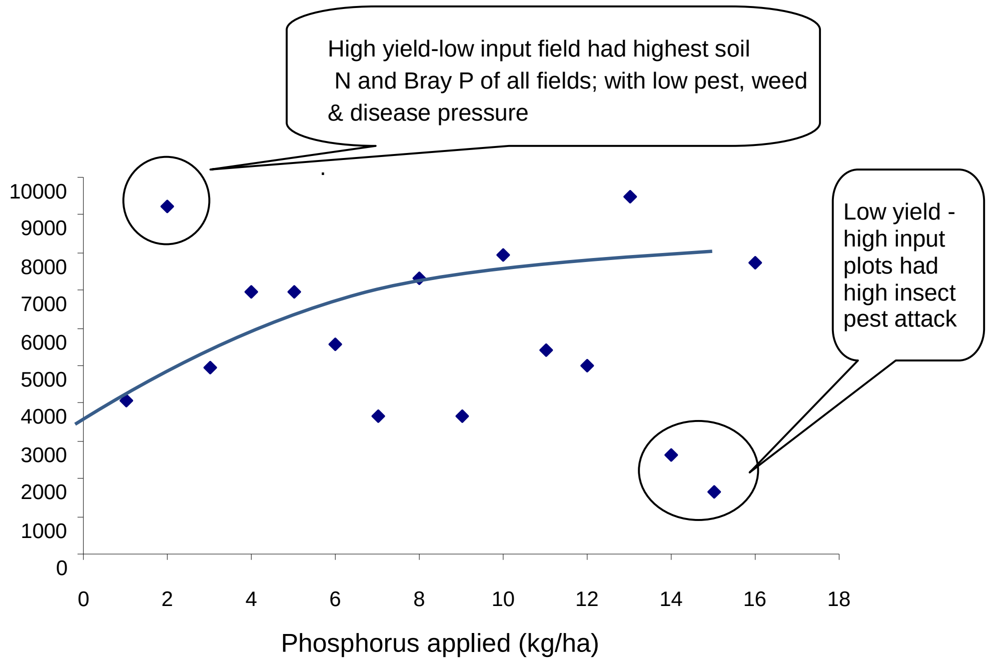

Figure 31. Yield (paddy) response to applied-P in Amagara crop survey, 2007 *(hand fitted curve with apparent 'outliers' removed)*

In the Amagara crop survey, the median application of P was around 11 kg/ha, mostly associated with the use of DAP (much more common than in Pogro). This amount would replace the P removed in around 6 t/ha grain. Although it is good to see P being applied to rice, it appeared during our fertilizer workshops that farmers were not knowingly applying P when using DAP. DAP acidifies soil and the worst form in which to apply N. Where both N and P are needed, it would be preferable to use urea and single superphosphate. This finding has important implications for policy on fertilizer subsidies. Ideally, it should not apply to DAP.

For N, there was substantial yield variation amongst the monitored fields due to N applied by farmers (e.g. Fig. 32) or N and P (Fig. 14), pointing to N deficiency in some crops.

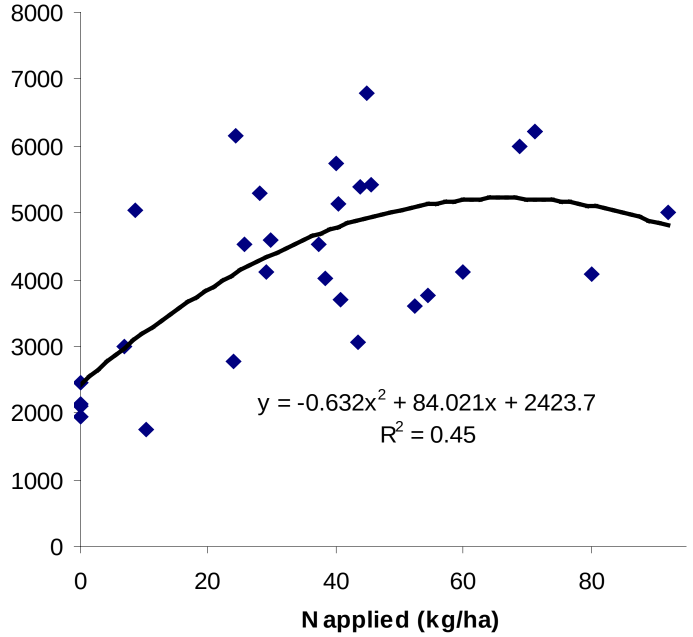

Figure 32. Yield responses to fertiliser N - fertility survey (no added treatments), Pogro 2007

Matched-field experiments using N and P – Pogro 2006

Sets of 3 adjacent paddy fields were matched and treated with one (i) the farmer's normal treatment, (ii) 50 kg/ha N added or (iii) 50 kg N + 20 kg P/ha. Responses show that farmers would benefit from increasing the rates of N and P applied to rice (Fig. 33).

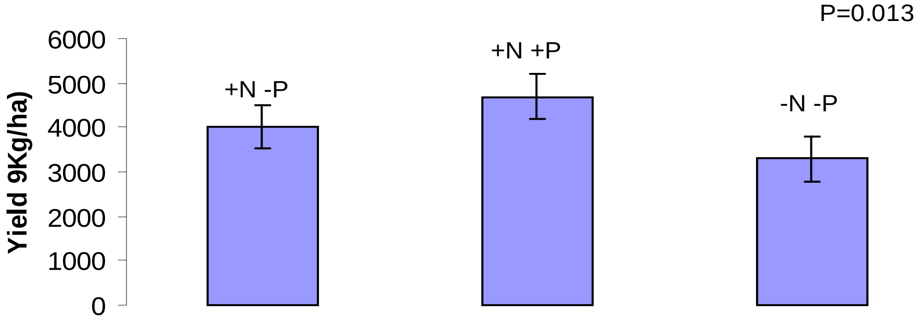

***Figure 33. Yield response to N and P, Pogro 2006**. (6 reps, '-N and -P' are the farmer's rate)*

P was applied by most farmers as organic fertiliser, although there was some use of compound fertiliser (DAP). Superphosphate was unknown. The question here was simply 'would farmers benefit from increasing N application, or by increasing both N and P. From the results, crops would benefit from both. There was no attempt to assess optimal rates, although as it happens the rates used in this experiment were close to the 'optimal' that could be crudely deduced from the crop survey in 2007 (Figs. 14, 31).

No further work was undertaken on N because it is already well-researched for flooded rice, and we think management issues can be addressed by using the IRRI leaf colour chart (which needs training) and if necessary splitting N into smaller doses.

Research *is* needed on N management of aerobic rice, which does not benefit from free-living N-fixation in the paddy.

Split-fields to study P and K responses in Pogro and Amagara - 2007

The matched-field approach was replaced by a split-field approach when farmers agreed that two halves of a field could be separated by a low bund. Fields were split for either K or P, with one half receiving the farmer's rate and the other an additional 30 kg/ha of P or K. Interactions were not tested. N was added at 100 kg/ha to remove this as a constraint. K was included in 2007 because of soil results indicating marginal concentrations of K and because we had observed responses to K in black gram in 2006. The results in Table 6 for Pogro show that both P and K, added independently, each increased yield by around 25%, confirming the P response observed in rice in 2006.

Table 6 . Rice (paddy) yield (kg/ha) responses to P and K in split-fields, Pogro 2007

Farmer P	Plus 30 P	Farmer K	Plus 30 K
4358	5368	3619	4458
P<0.01		P<0.05	

At Amagara there were no statistically significant responses to P or K (data not shown), but very large differences between fields (P<0.05). P responses were large in three fields that were greatly below the average yield, but these responses were 'lost' amongst the other replicates. We observed rice responding to residual P following application to the previous *Rabi* crop (a failed maize experiment – poor seed). This experiment also included strips of Zn in all plots, but there was no evidence for a response (P>0.05).

That fields in Amagara should, overall, be less responsive to P than in Pogro is not surprising, as the soil P data presented earlier showed that Amagara overall had higher soil P concentrations than Pogro and there is greater use of MAP. Nevertheless, soil P data at Amagara show there are fields with soil P low enough to anticipate a response in rice, if we accept international data on critical P concentrations for rice.

Rice response to P is relatively uncommon because reduced soil conditions make otherwise insoluble forms of P available to rice. Also, away from alluvial floodplains, in regions such as the East India Plateau (and elsewhere in Asia), although the acid leached soils are inherently low in P, we hypothesise that erosion of uplands has deposited sediment from surface soil that is *relatively* rich in P on terraced land lower in the landscape, obviating the need for P-fertiliser. However, with improved management of uplands this source of P will diminish and we can expect to see increasing incidence of P-deficiency in rice unless adequate P is supplied in either organic or inorganic forms. As population pressure forces the conversion of uplands to paddy land, the newly created terraces ('medium uplands' or 'baid') will benefit most from sediment deposition, depriving lowland rice soils of its external source of P. Indeed, the soil survey results in both Amagara and Pogro show that the lowland or lowland is the lowest in P, which is likely to have resulted from P removal over many years with little or no fertiliser use, combined with a more recent conversion of uplands to paddy having reduced sediment-P inputs.

Omission trials

In 2008 there were no statistically significant responses to P or K at either Amagara or Pogro. This greatly surprised the scientists, but the farmers in our end-of-season review and reflection workshop made several important observations. The first was that 2008 started as a very wet year but the monsoon ended early, leaving many baid areas short of water resulting in many poor crops which could not respond to P. Along with this, the farmers discussed individual fields in terms of their location, history and current management and were able to explain to their satisfaction why there had not been any responses. It appeared that farmers were now giving us their best fields to work on, so perhaps nutrient responses were less likely. Finally, based on their experience, the farmers expressed their confidence that indeed crops were responding to P and they would continue to use single superphosphate.

Conclusions about P, K and N in rice from soil tests and experiments

Phosphorus

Soil surveys in Amagara and Pogro show many soils are low in P, and from responses obtained in fertiliser experiments at Pogro (and in some fields in Amagara), we can be confident that P-deficiency is reducing transplanted rice yields for many farmers[23]. It is a major finding of the project, and from wider soil sampling is relevant to Jharkhand also.

This situation is likely to worsen as the effect of terracing the medium uplands becomes more apparent along with reduced erosion in the uplands. Where farmers are using DAP as a starter fertiliser in rice, as a source of N (not consciously P, we think), this may be supplying sufficient P. As DAP has an acidifying effect on the already acid soils it would be preferable for farmers not to use DAP as a source of N. In this case, single superphosphate would be needed to supply P, but this is very rarely used.

Further research is needed to better understand the chemistry of the acid soils of the EIP in relation to P-nutrition of rice and the detection and correction of P-deficiency.

The chemical changes associated with cycling between aerobic and anaerobic conditions increases the likelihood of responses to P-fertiliser in non-flooded crops including direct-seeded (aerobic) rice. In the *Rabi*, soil-surface drying will further reduce the availability of P and increase fertilizer requirements.

The following decision support tool was developed to assist with assessing P-fertiliser requirements for traditional rice (bottom x-axis) and other crops (pulses any season, top x-

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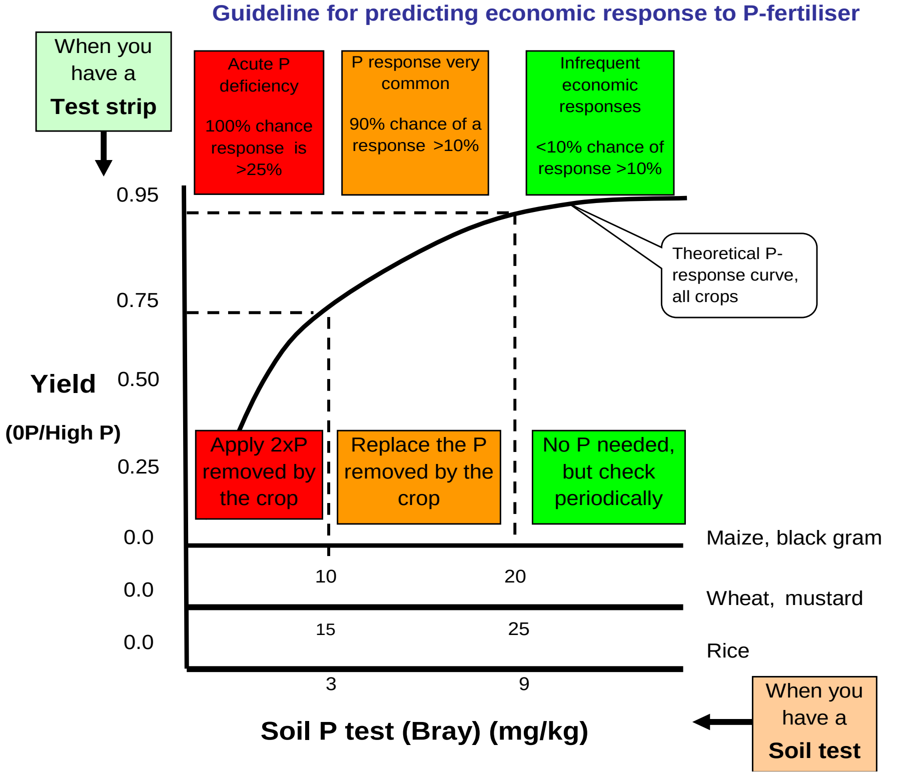
[23] A pot experiment with aerobic rice was used to test if the large responses to superphosphate are partially due to reduced Al toxicity, but when P (as SSP) was applied in factorial combination with dolomite (to raise pH and reduce Al in solution) there was a 5-fold response to P but no response to dolomite nor any interaction.

axis; all *Rabi* crops, middle x-axis). It may be used if a reliable soil test is available (unlikely) or if a test-strip has been used in the field (which we encourage). The rationale behind this approach to soil fertility assessment, based on a theoretical P-response curve, is described in Appendix 11.15.



Potassium

Nothing conclusive can be said about K in rice, although low-marginal soil K and some crop responses (black gram and rice in one year) suggest deficiencies are likely. There is some evidence from the crop surveys that K may be influencing the incidence of pests and diseases, which agrees with farmer-thinking (e.g. ash is used for this sometimes).

Nitrogen

We have obtained quite strong evidence that rice yields are limited by N deficiency. This may not be just because insufficient N is supplied. N can be difficult to manage, especially in wet years. There would be much to be gained from use of the IRRI leaf colour chart and using this to guide split applications of N. Training is required, and this merits a workshop with farmers to develop training material for other farmers.

7.4.3 Evaluation of methods used to determine fertiliser requirements

See Appendix 11.15.

7.4.4 Development and adoption of farming systems based on earlier-maturing rice

The objective was to provide the foundations for a farming system by providing farmers with crop options, confidence (in themselves and their resources) and tools to integrate options into a system that would optimise use of water resources and improve livelihoods. An ambitious attempt to compare alternative farming systems in a participatory experiment and test the key assumptions was abandoned after two attempts in favour of monitoring the way in which farmers themselves were integrating the components we were working on, and to evaluate the outcomes.

Lessons about the farming systems experimental approach

Evaluation of a farming system strategy experimentally proved to be impossibly difficult because the measure we had for the effect of early maturity on yield was always confounded with land class and planting time, with all three factors varying at once. So we did not really know the effect of short season variety (early maturity) on yield or residual water, and this will depend on the particular season and class of land. The only way to test this experimentally was to have a range of maturities sown at the same time in identical fields, and to replicate this several times. Ideally, the work would have had different land classes, and the work would be repeated in good and poor seasons. Another reason a farming systems experiment was difficult is that farmers in a participatory experiment cannot be forced to follow through with a designed sequence of crops or events. There were always good reasons why a farmer who intended to follow a design chose to do something different. We had to turn this from being a problem for us to an asset, and this is when we turned to monitoring and evaluation, leaving farmers to do the integration. Further details of our experience in developing a farming systems methodology are given in Appendix 11.16.

The best way to evaluate a farming system strategy is to record the adoption by farmers, to observe how they went about integrating all the information on rice maturity, new crops, fertilisers and irrigation to develop their own systems. Two approaches were adopted, linear tracking of land use (reported here) and family case studies that capture the socio-economic impact of the change (Section 7.7).

Linear tracking of land use in Amagara

To track changes in cropping systems and practices in Amagara, a longitudinal study was conducted over 6 years from project inception, involving the 8 farmers directly associated with experiments **and** others who have not been directly associated with trials. The usage of fields for vegetables and non-rice crops was continuously monitored (supplemented with satellite imagery – not presented). The results for both the kharif and *Rabi* periods are shown in Fig. 34. They reveal an astonishing uptake of vegetables (and field crops in the *Rabi*), noting that prior to 2006 the only vegetables was in small areas near homesteads and the area of field crops other than rice was negligible. No material support was provided after the 2006 kharif. **Adoption occurred without subsidies**.

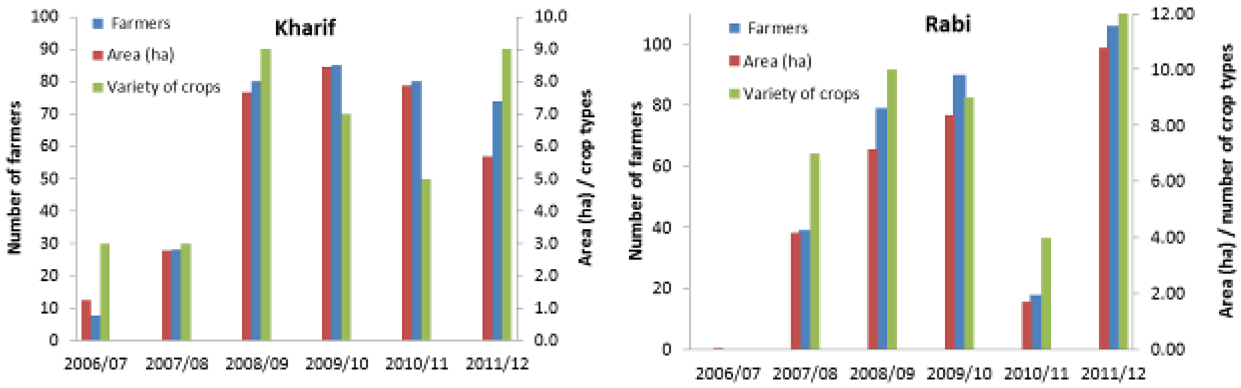


Figure 34. The uptake of new cropping systems in Amagara, 2006 to 2012 (excludes rice)

The n*umber of farmers (families)* growing vegetables for market (the largest crop category adopted) in the kharif grew from 8 in 2006 (farmers engaged with directly) to >80 in 2008, most with no direct dealing with the project. This was half the families in Amagara. Numbers stabilised at around this figure for kharif cropping but rose further for *Rabi* cropping. By 2012, three-quarters of families in Amagara had moved away from traditional mono-crop rice. Numbers dropped because of drought in 2010, which was especially bad in the Amagara area, but rebounded in 2011 suggesting a high degree of resilience.

The *area of alternative crops* in the kharif, or of any crops in the *Rabi*, rose together with the number of farmers adopting more intensive systems. The area appeared to plateau in 2008, although the area of *Rabi* crop did rise again in 2012 when >5% of the area of Amagara watershed was growing vegetables in the kharif, and >10 of the area in the *Rabi* was cropped, mostly to vegetables. Areas sown to mustard and wheat earlier have largely given way to the more profitable vegetables.

Increased cropping was not confined to farmers with large landholding. The case studies and focus group discussion reported in the M&E (Section 7.7) show that leasing land and share-cropping gave landless and marginal farmers an unprecedented opportunity to improve livelihoods through agriculture. The farmers at Amagara clearly stated that now nearly everyone in the community is involved with agriculture (food production other than rice) and that many landless members of the community were leasing land to cultivate.

Regarding the apparent plateau in the area intensively cropped, we cannot determine if this is because water and/or labour resources are now fully utilised, but this is important further enquiry. It remains to be seen if the cropped area continues to increase by making better use of residual soil water (left after the monsoon) and greater use of supplemental rather than full irrigation. The water balance modelling work suggests that a much greater area of *Rabi* crop is possible, but if increased *Rabi* cropping does occur, it may mostly be early-sown field crops with little or no irrigation, and with modest yield expectations.

Also, it remains to be seen what uptake of year-round cropping is possible in other villages with little or no WSD. Much of the expansion in *Rabi* crop in Amagara was associated with water bodies created by earlier WSD, but not utilised.

It was most striking that the *number of new crops* experimented with by farmers far exceeded the numbers introduced by the project. Around 9-10 non-rice crops are being grown at any time in Amagara. By 2007, vegetables were being grown in the *Rabi*, which we had not suggested. The first exposure to out-of-season vegetables in the kharif was on upland soils, but vegetables are now grown widely in all land classes depending on the time of year. Initially only 3 types of vegetables were grown, but by the 2008 kharif this had expanded to 9 vegetable types, which farmers had sought out themselves and integrated into their farming system. Vegetables have to an extent replaced rice, but initial enthusiasm for wheat and to some extent mustard has waned. Clearly farmers are rapidly changing farming systems, growing new crops, dropping some rice and becoming much more intensive. The impact of this on families is evaluated in Section 7.7, M and E.

7.5 Effective and sustainable watershed development - hydrologic considerations

7.5.1 Models that capture the function of water harvesting structures

Using data collected in the Amagara and Pogro study areas, simple spread-sheet models representing the behaviour of selected water harvesting structures have been created. These models are a key input into the development of the guidelines for design of WSD. These models include:

1. The influence of runoff controls (bunds, pits, 30x40 plots, ponds) in increasing local soil moisture as well as recharge to shallow and deep groundwater systems, and subsurface flow to downhill areas.
2. The local and downhill impact of paddy scale interventions in recharge areas (e.g. 5% pits)
3. The performance of seepage pits in discharge areas

7.5.2 Develop guidelines for designing WSD intervention plans using models, monitoring (and a dose of common sense)

In low- to mid-lands, the goal of WSD interventions is to hold water in the landscape in a form that can be accessed in the early to mid dry-season, as well as increasing security for wet season crops. In the case of upland areas where agro-forestry and perennial horticulture options are employed, the aim is to increase the water retention time to enable plants to access more water, thus increasing the crop yields.

Guidelines for the design of WSD have been built based on models that represent the behaviour of the different structures, including the interactions between structures, coupled with basic understanding of hydrologic response. The guidelines are designed to assist the planner in deciding the type and arrangement of structures to be installed on a site ranging from a hillslope to a small catchment. This is achieved by understanding how the structures operate, what factors might limit their effectiveness as well as the likely limits to the volume of harvestable water.

With all water harvesting structures, the trapping efficiency (fraction of retained water that can be successfully extracted) needs to be considered. Some water will flow through, around or under the structures depending on the local terrain, geology, etc… This flow past the structure becomes available for downhill / downstream users. The guidelines adopt a 20% trapping efficiency as a rough guide. Thus, if 150 mm of water has been retained by the WSD structures, the available water for irrigation is estimated at 30 mm. This limits the amount of land that can be irrigated, and reduces the risk of running out of water, hence increasing security for the farmers.

General guidelines, most of which PRADAN already follow (directly or indirectly), are:

1. Consider the contributing area (for runoff/groundwater recharge) as well as the residual water (rainfall - evaporation - runoff) from the wet season. This includes the structures to be installed in the contributing area (i.e. ensures consideration of the hydrological connectivity of the landscape).

2. Determine key hydrological characteristics: rainfall / evaporation rates, slope, infiltration rate, indications of depth to groundwater (auger holes, but also local knowledge).

3. In recharge areas (mostly medium upland) consult with farmers regarding sites with surface water, and observe catchment in November (early dry season) to look for evidence of sub-surface water (presence of green vegetation, or use an auger). Revisit in February to determine depth to groundwater (again, using an auger) to assess the potential duration for which shallow groundwater will be available.

4. In discharge areas, as a general rule, seepage pit volume should be approximately 50% of the required volume of water per irrigation, although this will vary depending on local conditions, and can be larger if fish-rearing is planned. Pit design for irrigation should be based on fill rate as well as depth to water table (i.e. use an adaptive approach to pit design - stop at the point when it is not possible to remove seepage water from the pit if this is reached before design depth is achieved).

5. Structures in the upper parts of a catchment that increase water retention also increase recharge, leading to an increase in shallow groundwater storage. This can advantage downhill / downstream users by increasing the water available for irrigation, but also can be detrimental if there is a significant increase in the inundation period (observed in Amagara). If it is necessary to ensure availability of water in the upper parts of the catchment, 'leaking' structures may be sealed to limit infiltration loss, which can be evaluated following observations of the performance of the structure over 1- 2 years.

6. Assume a trapping efficiency of 20% (i.e. 80% of the available water is made available for downhill / downstream users[24]) for nearly all water harvesting structures (ponds may be higher, though even these would rarely have >50% efficiency given infiltration and evaporation losses, though this figure would depend on when the water was used). This is a reasonable estimate of the limit of efficiency of WSD structures, with significant improvement only possible at considerable cost.

7. Water can be stored in different parts of the landscape: surface water, soil water, shallow and deep groundwater. These storages are linked in that there is a significant flux of water between them and this must be considered as such when designing WSD (extracting water from the shallow aquifer will potentially reduce recharge to a deeper aquifer, and reduce surface water).

7.5.3 Developing and applying models to evaluate the potential out-of-catchment impacts as WSD is scaled up over larger areas of the EIP.

One of the objectives of the project is to simulate the impact of watershed management interventions through hydrological modelling for planning and management of watershed development activities. The model developed for the catchment-scale modelling of the Pogro study site is being used to explore the impact of WSD across the EIP, using long-term gridded climate data from the Indian Meteorology Department. These modelled flows are being compared with gauged flows at a collection of sites:

- Dams in the vicinity of Pogro and Amagara (Parga, Shaharajore and Kumari, with catchment areas of 18, 43 and 95 km^2 respectively)
- Stream gauges near Hazaribagh, though data is of poor quality (Hurdag, Nagwan, Olidih and Banikdih and Usri, with areas of 23, 92, 34, 64 and 731 km^2 respectively)
- Stream gauges in the Brahmani basin with good quality data: Tilga (2,987 km^2), Jaraikela (11,641 km^2), Gomlai (21,644 km^2) and Jenapur (36,667 km^2)

Initial application of the Pogro model to these catchments indicated a reasonable reproduction of the overall volume of discharge, though there were deficiencies in the temporal distribution of the stream flow. With the current testing of a revised version of the Pogro model, the model will be applied to the EIP in August.

7.6 Up-scaling and out-scaling project learning

There were two components to project up-scaling and out-scaling. The first applied project learning to villages included in a PRADAN (Purulia team) SGSY-funded project in which ACIAR funded some professional salaries. This up-scaling started with pre-kharif planning in 2010, thus providing two years of data for evaluation and improvement in the process.

The second followed a decision by AusAID to fund a four-year program to upscale project learning through PRADAN and out-scale to poor communities across the EIP. This funding will come in two tranches, the first for one year as an extension to the present project, which is considered here. The second will be incorporated into a new project.

7.6.1 Applying project learning in PRADAN’s Purulia team

This section traces the implementation of project learning into the planning and operations of the PRADN Purulia team. Annual plans, observations, reflections and revised plans for the 3 years of the project are given in detail in Appendix 11.17 - two years for the complete action learning cycle, and the third for the plan only (2012). Results for each of the two completed years are given below for the number of families engaged, land area

[24] *The fraction left for environmental flows and downstream users requires research and political debate.*

planned for year-round cropping, and the area over which the plan was implemented. The impact of these activities on family income and quality of life are considered in M&E (Section 7.7).

Results and Discussion for 2010-11

The training program for PRADAN staff, CSP's, SHG's/Clusters and AMC's was completed mostly as planned (see Methods). Crop planning was undertaken with more than 2,000 families but it was not possible to complete the planned sensitization of staff to gender roles in agriculture (change in self-perception of women in agriculture) or to sensitize women in the villages on this aspect.

2010 was a drought year with monsoon coming some 2 months late and with too little rain for transplanted rice (see Fig. 21). Even DSR failed in many fields, but failure of DSR was not universal and there were also some successful kharif maize and vegetable crops (see Section 7.1.8) showing that kharif cropping is possible with rainfed crops in a drought when transplanted rice cannot be grown. The poor season impacted severely on the implementation of plans but also afforded an opportunity to learn more about adaptive management that lies at the heart climate-responsive cropping. Few families were able to implement their pre-kharif and early kharif plans, and if they did the crops mostly failed, leading to discouragement and in many cases abandonment of the plan altogether and migration before a 'rescue' *Rabi* plan could be implemented. Nevertheless ~700 families were helped to implement a plan in the late kharif/*Rabi* for pulses and oilseeds in 70 ha using soil moisture (much of this land was fallow where rice had been planned but not planted). The area planned under various crops in the ACIAR up-scaling is given in Table 7, although the kharif plan (food crops, mostly rice) could generally not be implemented.

Table 7. Participation in up-scaling and crop area (all families)

Crop	Families Involved	Area under crop (ha)	SHG's involved
Short duration paddy	533	85	
Paddy through SRI	837	97	
Maize	144	28	
Net Coverage under Food crops	1,077 (some > one option)	210	188
Pulses	504	53	
Oilseeds/short duration mustard	225	17	
Kharif vegetables	1,133	73	
Net coverage under Cash crops	1,163 (some >one option)	120	205

Despite the general failure of kharif plans and frustrations for the team and farmers alike, the success of the 'rescue' plan helped the community as well as PRADAN to appreciate the limitations of a 'static' cropping plan. It helped everyone to regain some confidence and work towards developing tools which will make the plans developed by families more dynamic in the coming season. But another concern was the intense need for Professional time at all stages - from ensuring adoption of sound agriculture practices to system setting, capacity building of the farmers, institutions and the women, and subsequent programme management.

Results and Discussion for 2011-12

This year had a stronger focus on women's participation in agriculture, which was well reflected in execution of the plan. Women actively participated in mobilizing SHG members and extensive planning, with the help of their AMC and SP, under minimal supervision of the professional. Participating families developed a plan for up to 5 fields per family. Farmers were helped to select varieties and techniques to enable increased cropping intensity on the same piece of land. Techniques such as Macha for creepers, vegetables and DSR (dry and wet method) and SRI for paddy were promoted. The SHG Clusters arranged 'exposures' to demonstrations in farmer's fields.

Heavy pre-monsoon showers saturated fields, setting back plans for pre-kharif and kharif vegetables, but raising hopes for paddy after the dismal 2010-11. Although kharif vegetables were delayed, it was a good year for Macha production, which elevates creepers above the ground. Fields with creepers growing on soil or bushes damped off due to water logging but the Macha with clear ground was easy to drain. Crops in the Macha gave around twice the production from growing on soil. On seeing the benefit of the Macha, many farmers constructed their own. Macha also influenced cropping intensity, with 75-80% taking second or third crops, enhancing income by up to 3-4 times.

The Purulia team collected data on the plans and achievements for each family, and these were summed to provide an overview of the total plan and a measure of achievement for the up-scaling work (Table 8). The opportunity to engage in the program was taken to almost 5,000 families, of whom more than 3,000 responded positively by paying their money (Rs 30/family) to participate and developing a cropping plan. Of these 2,374 actually implemented their plans, achieving more than one crop on a piece of land. Overall the plan was achieved on 0.14 ha/family (Table 8), which is about one-sixth of the total average landholding per family. Note that the program was limited to 4 fields per family, and not all fields will suit multiple cropping, so overall the proportion of land area taken into multiple cropping was quite significant.

Table 8. Overall achievement of the Purulia team in 2011-12

	Planned	**Achieved**
Farmers (families) engaged	3118	2374
Total area in program (ha)	697	317
Average land/farmer (decimals[25])	55 (0.24 ha/family)	33 (0.14 ha/family)

In a detailed further study of 4 villages, 66% of fields taken into planning for year-round cropping had at least some access to irrigation (Appendix 11.18), raising the question of how applicable the concept of year-round cropping is to families with little or no access to irrigation. However, 65 % of medium uplands were used to grow two or more crops (Appendix 11.18, Table 2), and it is difficult to imagine that much of this land (15 ha of 22.6 ha total) had access to streams or ponds large enough to fully irrigate the area. It seems more likely that most of this area of medium uplands supported crops largely on residual water, as noted above for some families in 2010/11(following the late rains in 2010).

Summary of experience with up-scaling in 2011-12

This year was a good time for agriculture but we stand at a turning point where we still need to address issues such as:

- Ensuring and increasing women's stake in the program.
- Mobilizing funds from the community to make it a self-sustained process.
- Capacity building of AMC's for better management linking and liaison with other stakeholders such as market and bank and Government.

It was an exciting experience where the women led the program in a more systematized way. Further monitoring is needed to track adoption and any dis-adoption, and in particular to see if there is any change in the role of MGNREGA in generating livelihoods and to track any emergence of land and water markets. It is also important to see if

[25] The decimal is locally used to measure land area. 1 decimal = 436 square feet = 40.46 m^2

women continue to take an equal or leading role in development and to determine the social and cultural impacts of these changes.

Insight from Pogro

Overall, the response from families within the villages of the Pogro watershed has been disappointing compared with other villages participating in the out-scaling work. The possible reasons for this are discussed further under M&E (Section 7.7). However, there has been some response. Following limited but successful uptake of Macha creepers in the kharif, some women planned to grow vegetables under Macha in the *Rabi*, but only on land near homesteads because of fear of uncontrolled grazing. With wheat and mustard, farmers are maintaining line sowing and application of fertilizer. The area is slowly increasing, notwithstanding grazing which remains unregulated in Pogro after rice has been harvested (see Section 7.7 for further comment).

7.6.2 Up-scaling in PRADAN and out-scaling to East India Plateau

Capacity building for senior PRADAN staff was carried out in combination with an innovations workshop held in PRADAN Delhi office during 3 to 5 November, 2011. The workshop attended by 12 senior PRADAN staff (5 Programme Directors, 2 Team Leaders and 5 Integrators (4 Integrator Theme/1 Integrator State Unit) identified innovations across PRADAN, a significant one being the ACIAR research project. The workshop was organised to determine the innovations from the ACIAR project as well as across other PRADAN Projects and develop processes for dissemination of the learning and further action plans wherever required. It identified learning from the ACIAR project of relevance to the Development Apprenticeship program within PRADAN. Within the workshop it was agreed that the learning should be included in the Development Apprenticeship training program, and this has commenced. More than 40 Apprentices will graduate in 2012 from the revised program.

Members related to the ACIAR Project and Purulia team have extended support to the adjacent PRADAN, Bankura team. They have imparted training to the professionals in that Team and also the Community Service Providers. The Bankura team subsequently used the learning/decision-making tool have helped around 2800 families to adopt the concepts of “cropping systems” while developing their farm plans. Workshops have been held for PRADAN professionals including team leaders and field guides on the conceptual basis of INRM perspective in PRADAN and learning in agronomy from the ACIAR project. The workshops involved 18 participants and were held from 7 to 14 April and 26 to 29 April 2012. PRADAN professionals from four teams in Jharkhand and West Bengal conducted agronomy workshops with ~150 community resource persons (CRPs) who represent communities PRADAN is working with and provides services to those communities.

7.6.3 Learning about the engagement process

The project developed processes that enabled engagement across various groups of people who had widely varying backgrounds, knowledge and understanding. Each of the participants received a benefit from their participation in the project.

The process of engagement with the various communities used in the project built on PRADAN’s usual mode of operation but incorporated a considerable shift towards farmers (both men and women) participating in the development of new knowledge through experiential learning based within their farming systems. This approach provided a considerable shift because, while a participatory approach to development was always at the core of PRADAN’s approach, the meaning of ‘participatory’ had been limited to farmers making decisions to choose between alternative options presented to them. Those options might either be traditionally available within the community or have been put forward by external change agents. Modern scientific knowledge related to farming was usually prescribed by PRADAN extension workers following the recommendations made by the line departments, research institutions, Agricultural Universities or in some cases guided by the trials conducted by PRADAN in farmers' fields.

PRADAN as an organisation had not developed participatory processes to involve farmers in conducting systematic research in their fields to generate new knowledge. However, knowledge generated in that way enabled farmers to verify the knowledge developed with respect to their own farming situation. The ACIAR project has demonstrated the potential of using an expanded participatory research methodology where farmers play an active role in conducting research. This experience has influenced PRADAN's approach.

While the changes in the engagement processes are being implemented within PRADAN, what is still being explored by project staff is the relationship between the projects research outcomes, the participatory engagement processes that were used, and the theory that surrounds participatory processes. That exploration and publication of the results will provide a key outcome from the project.

An important research outcome related to the way in which various approaches used within the project sit within a continuum of participatory learning processes that have been applied in development contexts. In doing so, the project took a pragmatic approach with the approach taken operating at several places along that continuum at different stages of the project and applied various techniques to meet the outcomes as appropriate to the context. The context included the skills and knowledge of the various participants and their level of experience in engaging with outsiders. Of particular interest is the engagement across the various groups involved. The project worked with at least four groups each with different world views and cultural basis for their understanding and interpretation of the world in which they work. These groups may therefore also have different ways of knowing and understanding the world in which they operate.

The four groups are

1. Farmers, male and female, literate and not literate
2. PRADAN professionals who are tertiary trained to at least bachelor degree level in various discipline areas, have multiple learning styles and life experiences, but share a passion for the work they do and have completed the PRADAN development apprenticeship, so have many shared understandings and a shared passion. However, they are not homogenous in their knowledge and approach to development.
3. Scientists from India university-trained with largely scientific backgrounds
4. Scientists from Australia from various backgrounds but largely scientists with a farming systems background and approach.

The groups are also differentiated from each other by the language that they use in social and business communication. For example scientists from Australia participating in the project only speak English; Indian scientists speak multiple languages but have often been educated in English, so English is their professional language. The farmers generally speak multiple languages, for example in Amagara their tribal language and Bengali. PRADAN staff members generally speak multiple languages with English the organisational language and Hindi also used widely in the organisation. However, for PRADAN staff communication with communities in West Bengal will use Bengali and not the tribal languages. In all cases therefore language can be a limiting factor in communicating between the various groups and could distance them from one another.

7.7 Monitoring and evaluation

M&E was given the status of a project objective to ensure we addressed the criticism that WSD projects are often not evaluated properly.

7.7.1 Increased cropping intensity and diversity

In the LogFrame, two **Key Indicators** of project **impact** were "increased cropping intensity" and "increased crop diversity". Together, these two were considered to provide the "**platform for food security and livelihood improvement**".

Amagara

For the Amagara watershed, where the development and adoption of new cropping systems by farmers was carefully documented (Section 7.4.4), we found that more intensive and much more diverse cropping systems were quickly implemented **without subsidies** and **without direct project engagement**, when farmers were given crop options and had the confidence, knowledge and skills to use them.

The series of focus group discussions (FGD) in Amagara (synthesised in Appendix 11.13) highlighted that community members are learning from each other, suggesting the 'learning approach' taken by the project may have led to self-sustaining development:

"This way the entire village learns from each other, then the entire village will come onto the path of progress".

Amagara men illustrated their change to a more sophisticated approach to agricultural production, involving problem-solving that is substantially independent of PRADAN:

"Earlier we would just sow the seeds not thinking much about the production, whatever will happen, will happen. Now we think – How can I get the maximum production from this crop? There is a continuous effort; earlier this effort was not there."

The statements by the men at Amagara highlight a significant change not only in their capacity as farmers but their desire to continue to improve. The farmers were able to outline an understanding of alternative ways in which they had learnt things.

Change in land use is underpinned by changed perceptions

The increased cropping intensity and diversity in Amagara was strongly associated with changed perceptions of the value of water and land. The FGDs conveyed a strong sense of the value now being placed on water and the resultant improvement in water-efficiency:

"*We don't waste water any more, people are very possessive about their water – people are using this water for cultivation*." VCC Amagara

The FGDs also powerfully convey the changed perceptions of the value of land for crops other than rice:

"*Earlier only 1 or 2 people would cultivate, nowadays even those who do not have any land lease other people's land and cultivate*."

"*The land full of stones which had no value earlier is like gold now*"

"*All the tanr and gora were barren; when people saw that they earned money, then others thought let us try then we can also earn*."

PRADAN professionals expressed that the changes in Amagara came about by:

- *"Enabling farmers to develop their own knowledge,* and
- *Acknowledging that women were farmers."*

Purulia out-scaling – increased cropping intensity and diversity

Significantly, even in the short period of out-scaling through the Purulia team, families have intensified and diversified their cropping (Section 7.6.1). Further research is needed to see if perceptions of land, water and self also change in these villages despite streamlining the process of engagement.

Not all villages respond equally

Although project activities had significant impact on cropping intensity and diversity in Amagara, and also when averaged across 2,700 families involved in the Purulia out-scaling (Tables 7 and 8), not all villages were equally impacted. Most notably, project activities had less impact on the villages within Pogro watershed, which is discussed below. In the Purulia out-scaling, not all of the four villages studied in detail in 2011/12 responded equally by intensifying and diversifying cropping (Appendix 11.18), indicating the need for research into reasons for varying impact and how these can be addressed. Differences between villages were explored through the FGDs in Amagara and Pogro (Appendix 11.13). Briefly, FGD participants from Amagara confirmed that land-use had undergone great change, but much less change was reported from Belghutua (a village in Pogro watershed). Participants in all three Amagara FGDs spoke of significant changes in land use, both the crops produced, and also the seasons in which they could be produced. Participants in the VCC FGD at Amagara typically said:

"Earlier we migrated very far for work" and *"the land would remain barren"*,

"*now there is cultivation in all lands...such that there is no grazing land left"*

All FGDs in Amagara highlighted the important role of the ACIAR project and PRADAN in changing land use.

Participants in the Belghutua FGDs focused primarily on engineering activities stating:

"*we did various works, like we made hapa and land levelling*".

One Belghutua farmer commented that in the last five years there have been some changes – "*mango plantations, hapas – but no one is doing agriculture"* (referring to agricultural production other than rice).

Uncontrolled grazing after rice

An issue having major impact was the different way in which the two communities dealt with livestock. At Amagara, as agricultural activities expanded, the way in which grazing animals were managed also changed, and animals are no longer allowed to graze freely after rice harvest. At Belghutua, livestock continue to graze in the traditional manner, being released to graze freely after rice harvest, causing difficulties with other crops.

"*Cows and goats graze freely. The moment paddy is harvested; people allow cattle to graze freely. If you don't construct a fence it's impossible to do agriculture in that season.*"

Farmers at Belghutua

But we observed that some farmers *do* succeed, despite the difficulties. This farmer (left) in Pogro watershed (Belghutua village) was determined to grow both wheat (nearing harvest) and vegetables with her daughter, doing so after the WSD plan had been implemented but without project engagement other than earlier exposure to learning activities.

Strength of the SHG institution

The important question is how the communities in Amagara came to value land and water resources so highly and come to regulate grazing after rice, when those in Pogro did not, despite significant project presence. The focus group discussions in the SHGs at Belghutua and Amagara highlighted the importance of information and learning dissemination at SHG level to maximise the benefit of the new process of engaging women. In the absence of it, power dynamics dominated in the Belghutua VCC. This was discussed in detail in the Sections on' Forming SHGs' (7.2.2) and 'Gender' (7.2.3).

Access to irrigation

Participants in Amagara thought that access to irrigation was fundamental to increased cropping intensity:

"*It is only because of the hapa that we are able to engage in agriculture – we are able to cultivate tomato with ease"* VCC Amagara.

"*Everyone has their own pumps now."* Amagara SHG.

Given the statement above that "*we don't waste water any more*", access to irrigation (for some farmers) may have really meant better utilisation of existing water resources. For example, men at in the Amagara FGD said that many in the community had thought the ideas being presented to them (in 2006/07) in relation to agricultural production were "fanciful and risky", and that there was particular concern at that time in relation to the provision of water to irrigate the crops. This concern was despite Amagara having good, but under-utilized, water resources.

Differences in access to irrigation also apparently helped explain differences in the impact of out-scaling work in 2011/12 on cropping intensity and diversity (Appendix 11.18).

Nevertheless, the Pogro experience shows that improving access to water through WSD alone does not bring about development. As already suggested, strong institutions based on SHGs are also required to deal with local politics and personalities and help balance the issues arising from competing interests of community members (like unregulated grazing). SHG institutions also go on to deal more effectively with established institutions such as the Panchayat and banks, as suggested by the FGDs (Appendix 11.13).

Local institutions may also deal with the emerging conflicts over access to water for irrigation that were hinted at in the FGDs (*"people are very possessive about their water"*), and issues around leasing land (referred to in the case studies, below).

In Amagara prior to the project, PRADAN had developed the SHG institutions and implemented a WSD plan to provide new water resources for irrigation, but this too was insufficient to trigger the development now seen in the village. Engaging with women differently and providing effective learning opportunities seem to have been the final critical ingredients for success – but this requires further research. None of the evaluation techniques was definitive on this point.

Additional factors

Of other factors appearing to impact on the Belghutua community's land use, the most important emerging in the FGDs was the greater engagement of community members with locally available and also distant labouring work. Men at Belghutua participating in the FGDs emphasised the importance and immediate reward from being involved with wage labour rather than agriculture. In particular they emphasised the delay of at least three months from the planting of a crop and receiving any income from the crop

There were also tensions arising from ethnic differences amongst the Pogro villages, whereas Amagara is only tribal.

7.7.2 Impacts on farm/family income

Other Key Indicators of impact that directly address livelihoods are discussed below for Amagara and the upscaling villages, **increased farm income, reduced migration** and **increased participation in education.**

Amagara

In Amagara in 2008, the 80 farmers who had developed new cropping systems agreed amongst themselves at a village meeting that they received, on average, an additional income of about Rs. 15,000. This figure was probed more deeply through a set of 18 randomly chosen farmers whose land-use and income was monitored closely from the

2006 kharif until the end of the 2011/12 *Rabi*. Only four of these farmers/families had been engaged directly in project activities (starting with the 'vegetable experience' in 2006). The additional income (above rice and home consumption) derived from cropping intensification and diversification is given in Table 9.

Table 9. Additional (non-rice) income for 18 monitored families at Amagara

	2008-09	2009-10	2010-11[1.]	2011-12 (incomplete)	2011-12 adjusted
Income from owned land	8,257	7,270	3,344	3,921	
Income from other land (leased, sharecropped)	3,364	3927	2,304	3,053	
Total additional income	10,873	10,706	5,302	6,794[2]	10,976[3]

[1.] *Drought year;*
[2.] *Total excludes unharvested Rabi crops and income from two farmers who had discontinued farming.*
[3.] *Estimate of income from all crops including unharvested Rabi crops and for two farmers who had stopped farming (based on their 2008 to 2010 data).*

From Table 9 it appears farmers at the village meeting may have over-estimated their additional income, possibly giving gross rather than net income.

The drought in 2010 reduced the added income from agriculture, but it is noteworthy that despite the drought the 18 families earned an additional Rs 5,000. Also noteworthy is that income recovered in 2011-12 as families resumed intensive agriculture, suggesting a degree of resilience.

Further research is needed to find out why income (and crop area, Fig. 34) plateaued in 2009-09 after a rapid rise from 2006. It is also important to know if this level of income is sufficient to reduce demand for cash from other sources including MGNREGA and day-wage labour. The labour market generally needs further research as communities generate more income from agriculture, which has the potential to create a range of job opportunities but at the same time constrain labour supply to further intensify agriculture.

Purulia out-scaling

In 2010/11, income data for participating families was collected from 537 families, a 25% subsample of participants from ~25 villages (Table 10). The data include the full range of families including those who abandoned plans and migrated, partially implemented plans, and those who implemented the 'rescue' plan in the *Rabi*. Data refer to total income.

Table 10. Proportion of families with income derived from up-scaling interventions.

Income range (Rs.)	Number	%
<2,500	108	20
2,501-7,500	184	34
7,501-10,000	57	11
10,001-15,000	78	15
>15,000	110	20
Total	**537**	**100**

Almost half the families generated more than Rs. 7,500 in a year when most families in Purulia had failed crops and little or no agricultural income at all Families with greatest economic benefit from interventions were generally those who switched from paddy to vegetables and also those families who went for late kharif/*Rabi* cropping using soil water. Overall, there was evidence that rainfed crops can thrive in conditions where transplanted rice fails, provided flexible plans have been made that accommodate these crops.

In 2011/12, detailed data were collected from 20% of families participating (592 families). Data for annual family income before intervention, and the additional income produced through the interventions, is given in Table 11. Pre-intervention income is comprised almost entirely of rice used for home consumption, but this has been converted to its cash value. Post-intervention income refers only to product sold at market, so it is the *additional* cash income. All of the sample families had an average annual income of at least Rs. 10,000 (A$200) p.a. before intervention, but 70% earned only Rs 10-20,000 pa (mostly for home consumption). For data presentation, the surveyed sample of families was categorised according to annual income prior to intervention (Rs 10,000-20,000, 20,000-30,000 and >30,000) and then each category was sub-divided according to the *additional* cash income derived from the intervention (up to April) (Table 11).

Table 11. Additional cash income[1] derived from interventions in 2011-12. Values are for the percentage of families grouped according to additional income within categories of average pre-intervention income (sample of 592 families).

Annual income before intervention	Additional Income (Rs.)				
	<2,500	2,501-7,500	7,501-10,000	10,001-15,000	>15,000
Rs. 10,000 – 20,000 (409 families)	25%	42%	25%	4%	4%
Rs. 20,000-30,000 (160 families)	4%	8%	14%	39%	35%
Above Rs 30,000 (23 families)	0	0	0	0	100%

[1] *Based on data from up to 5 fields for the crop year (pre-kharif to Rabi), largely based on cash income from vegetables. Cereals, oilseeds and any vegetables for home consumption not included.*

Overall, the greater the pre-intervention income the greater the benefit derived from our intervention. Of the 409 poorer families, 135 (33%) had additional incomes over Rs 7,500, but only a few (8%) earned more than an additional Rs 10,000. This compares with the group of 160 slightly better-off families, of whom 141 (88%) had additional incomes over Rs 7,500, and 74% were over Rs 10,000. Interventions had significant impact on these families. They appear to have had some proclivity towards agriculture, and our interventions facilitated a quicker take-off. The better-off (relative) category of 29 families were already into some intensive agriculture, and introduction of new technology like the trellis coupled with the shift in crop patterns in medium uplands brought huge gains.

The reasons for differences between families need to be fully explored. Are they related to land and water resources, labour supply/age, levels of debt/cash reserves, risk aversion?

Although poorer families benefitted least, 80% of families overall benefitted by at least an additional Rs 2,500. The average benefit across all families was about Rs 8,500, which was close to the target improvement of Rs. 10,000 per family. This benefit was from a maximum of five fields per family, which is considerably less than the total landholding of most families, so substantially greater benefit should be derived as skills improve and more fields are brought into improved production methods and more intensive cropping.

The average cash benefit derived from this intervention is comparable to the benefit derived from participation in the MGNREGA scheme, and similar to families who successfully implemented the ‘rescue’ *Rabi* plan in 2010-11. It remains to be seen whether families will find the opportunity to improve livelihoods through agriculture more attractive than participation in MGNREGA, although this seems least likely for poorer families unless the reasons for their below average benefit can be addressed. It will be important to monitor uptake in future, and when doing so to learn if families who do not take up more intensive agriculture lease land to other farmers and sell any unwanted water resources.

7.7.3 Other impacts on families (focus group discussions)

FGDs all commented on how lives had improved during the time the ACIAR project had been operating. However, the two communities had very different responses to enquiries about changes that had taken place in their lives during the time of the projects.

Members of the Amagara SHG commented that there had been "*Not some change, there has been a complete transformation".* In contrast, the SHG Belghutua stated that "*When there is work we have food and when there is no work there is no food*", suggesting that in Belghutua the impact was not only from changes in agricultural production.

For both communities a key measure of the improvement in their quality of life was the increase in the emphasis on the education of children and the number of children attending school. This focus appeared greater in Amagara in comparison to Belghutua.

In Amagara, for women the building of their self-esteem was probably the most important area highlighted, followed by the advantages that the increased income had provided especially in the areas of education, no longer having to work outside the community, and the ability to have choice in the selection of essential items. At Amagara women also talked about increased access to consumer goods.

At Belghutua, whilst enhanced self-esteem was noted, the participants were less able to articulate the changes in livelihoods that had taken place, with a few exceptions where people were producing tomatoes.

The source of the improved quality of life varied between sites. In Amagara agricultural production in both rice and other crops in particular tomatoes had become sufficiently important and productive that farmers were able to stay at home and farm rather than seek outside work as a labourer. At Belghutua external but locally available labouring work had become more important, leaving people limited time and desire to participate in agricultural production other than the core family activity of rice production. Men at Belghutua emphasised the importance and immediate reward from being involved with wage labour rather than agriculture.

The farmers at Amagara clearly said that agricultural production had increased considerably in recent years, and with that increase had been an improvement in the livelihoods of the community members.

The women from Amagara commented on some negative social impacts from the increase in income, in particular the increase in alcohol consumption and associated antisocial behaviour of some males, although the women had taken action and the sale of alcohol is banned in their village. With their increased self-confidence, the women responded to those negative impacts in effective ways.

The women at Amagara acknowledged that the change involved … …

Hard work:

"Agriculture requires a lot of intensive engagement. At times we do not even have time to wash our hands"

A high level of skill:

"*everyone does not cultivate on the baid – only those who are capable can cultivate on the baid"*

And access to finance:

"*You need to invest money*".

Overall the participants in the FGDs at both communities stated their quality of life had improved during the ACIAR project. The Amagara community was able to clearly link the improvement with changes in their agricultural activities in relation to land use, selection of crops and productions methods that had been developed with the project and PRADAN staff. In the case of Belghutua while agriculture had played a role the emphasis appeared to be on external wage labour.

7.7.4 Family case studies – Amagara (2008/09)

Nine family case studies were carried in Amagara in 2008/09 to provide supplementary information on project impacts in terms of cropping practices (cropping intensity, new crops, use of fertilizer), food security, dependency on migration/daily wage labour, family income and how it is used, children's education and utilization of medical services. In addition, from the narrative we hoped to gain further insight into how much of these were project impacts and what could be attributed to other activities, and what the impact on women may have been. Not all of the families had participated directly in the project activities. The age of the 'household head' varied from young (with a one-year-old child) to 'old'. A synthesis of the data is reported in Appendix 11.19 against three evaluation themes: learning through the participatory research, changed perceptions of land and self, and changed income and any impacts on quality of life. The case studies showed:

- All farmers reported 'experimenting' with vegetables in the kharif, with some also starting to grow them in all seasons (subject to rainfall and/or irrigation)
- Most farmers also grew mustard, but only for home consumption (although this eliminated a cash outlay, as all families need mustard oil). Some grew wheat, but this was replaced in time with more profitable crops.
- All farmers referred to learning about and using fertilisers, specifying phosphate and potash. Some specifically referred to replacing DAP with SSP and urea. (DAP is widely promoted in the area but is expensive and further acidifies soil)
- Many farmers referred to what may be called a new 'culture of agriculture', making reference to new perceptions about themselves, the potential of uplands and medium uplands and the potential to derive a decent livelihood from agriculture.
- Before intervention, food security (rice sufficiency) averaged 6-7 months although one landless family depended almost totally on migration and wage labour, and one family was 12 months food secure
    - All but one family needed to migrate or take daily wage-labour out of the village prior to the project.
- By 2008/09 all families had 12 months food security (one said they had 11 months because of their small holding of poor medium uplands, but this family also had a good cash income from vegetables on leased land)
    - Dependency on migration/wage labour was apparently greatly reduced, but this could not be carefully quantified.
- Although PRADAN had introduced new rice varieties that had increased yields, it appeared that learning about fertilisers (and pesticides) further increased yields (this is consistent with our observations of N, P and K deficiency in many fields.
    - In at least 4 families (who volunteered the point), the increased rice yields had led to surplus for sale (earning up to Rs 8,000/family/year), or allowed the farmer to take some land out of rice for vegetables
- Additional annual income derived from vegetables ranged from <2,000 to >50,000 rupees for the 9 families.
- Several families reported increased diet diversity with home consumption of vegetables
- The younger farmers talked about having money for children's education (specifying 'private' education) and in some cases also talked about having enough money for improved medical care.

- Most families spoke about using their new income for equipment (e.g. pumps) home improvements, insurance, bank savings (for seed, fertiliser etc) as well as family matters (e.g. weddings)
- In at least 3 cases the new intensive agriculture depended on leasing land,
  - in all three, lease arrangements changed during the project (after 2008/09)
- Most but not all of the intensification depended on at least some irrigation
- Although most families had undertaken cropping after harvesting rice, none referred to any issue around free-grazing at this time. This is notable, as unregulated grazing is often cited by farmers and researchers/bureaucrats as a barrier to adoption of cropping outside the kharif (rice) season. In the case of Amagara at least, it seems local arrangements have been made to manage this.

Interviews concluded with general comments in which farmers made statements and the interviewer sometimes inserted their own observations:

“This gave me the opportunity of managing my home more easily and spending more time at home (wife)

“ Things have changed for better (husband, with ‘a satisfying smile on his face’).

“… I recently separated from my family and started living on my own with my wife and two children, which had a negative impact on my land holding as a result of land division. My paddy yield is inadequate for our sustenance therefore we depend on vegetable cultivation as our main source of livelihood ... but … we still send our two sons to private school to provide them better education” (young farmer)

“…happy … crop yield has improved due to the use of phosphate, potash and urea, learned through ACIAR experimentation. Earlier used high yielding varieties but I could not get satisfying results due to insufficient knowledge about fertilizers and pesticides”

“… successive [past] failures in vegetable cultivation made me cynical about the future of vegetable cultivation in Amagara but the successful trial of tomato, cabbage and cauliflower dispelled the myth surrounding vegetable cultivation”. (Elderly farmer)

“Earlier my ignorance about other cropping options forced me and my wife to work as daily wage labourers outside our village once the kharif season was over, for most of the year, but the introduction of vegetable cultivation has changed all that (husband, middle aged).

“Whatever vegetable cultivation you are getting to see today in Amagara it is the result of ACIAR experimentation” (wife).

“Nowadays my sons are mostly performing the agricultural activities and taking keen interest in vegetable cultivation”, “my elder son has returned from Jamshedpur to cultivate in his own fields” (elderly farmer).

“We used the money from selling paddy on repairing the house, and fixed some amount in bank that we received from selling the vegetables … also purchased a thresher machine and insured some amount with Life Insurance Corporation”.

“Earlier it was difficult to meet ends depending on paddy cultivation only but with the introduction of vegetable cultivation we could arrange for our food throughout the year” (wife, elderly)

“My son has just started going to school and my daughter is merely one year old. I can take them to doctors or nearby hospital and purchase medicines whenever they fall ill which was earlier impossible. My vegetable produce has spared me from going out of the village to work as wage labourer … now I can spend some time at home” (Young wife).

"… cultivated cucumber, cowpea and ladyfinger so efficiently that I not only got good returns for my produce but it motivated other cultivators of this village to take up cucumber and lady finger cultivation … our living standard has improved with a marked change in the family's food habit. Now the inclusion of various vegetables in their diet has reduced dependence on bottle gourd and pumpkin as the main source of vegetable consumption. (Interviewer comment on an 'enterprising farmer' who had invested heavily on vegetable cultivation after watching the success of vegetable cultivation through ACIAR experimentation).

Three of the case studies were updated in April 2012

All three of the case studies followed up depended on leased land and in all three cases the lease arrangement had changed.

- One could not afford, or would not pay, the increased rent demanded for the land, which by then had proven its real value,
- One said he was the victim of 'jealousy',
- One lost the lease for unspecified reasons.

All of these three families made new arrangements:

- One took up a new share-farming arrangement and is thriving,
- One took a job as an agricultural input salesman (despite illiteracy) and is happy (but less well off) and
- One landless person reverted to local wage labour and selling 'rice beer' although they were growing vegetables on their homestead land.

These lease issues point to the increasing value placed on both land and water, the vulnerability of the landless, and the new opportunities being created when agriculture generates more local wealth.

In situations where family income had collapsed after the initial success it was not primarily due to climate (despite the 2010 drought from which farmers recovered), or markets, but to the availability of land for lease and possibly access to water for irrigation.

It seems important to understand how land and water markets emerge and what local institutions develop or are needed to equitably manage access to land and water as well as manage free-grazing in the *Rabi*. Just as important is understanding of the emerging labour requirements and employment and business opportunities as agriculture generates more wealth in developing communities.

The updated case studies remind us that climate risks include both excessive monsoon rain (2011) as well as drought (2010), but an adaptable cropping system can still capture opportunities.

7.8 Other discussion points

Availability of climate data

The project was dogged by the availability of, or ready access to government-held weather and gauging data. This seems to have been addressed under new government policy that has come too late for our project.

Soil testing

The project experienced difficulty obtaining timely, credible soil testing. There is need for capacity building in this area. The residue of funds remaining in the ICAR project account is being used for ICAR (Patna) laboratories to participate in the Australian laboratory quality assurance program (ASPAC). ICAR (Patna) will use this as a foundation for improving laboratory services through regional soil testing laboratories for which they have responsibility.

Soil acidity

There is some interest in establishing a national research centre for acid soils, in East India, but the emphasis should be on quantifying the rates of acidification and the acidifying processes, in order to minimise further acidification. There is no need for research on acid soils per se.

Extension processes – engaging with KVKs

The project clearly established the benefits of taking a modern 'adult-learning' approach to 'extension. This does not sit comfortably in India, where the emphasis in education is on the knowledge held by the expert. Much could be gained by working with KVKs in East India to develop professional short courses in modern extension approaches, first to build capacity at senior levels and then to build capacity in front-line staff. The course could be experiential and built around tools and techniques such as the crop yield/management surveys, fertiliser workshops with (including test strips) and water workshops.

Project linkages

The hydrologic models developed in the present project are being revised and in future will be re-applied to address important issues around the cumulative impacts of WSD as it is scaled-out over large areas. It is important that the new project retain links with ongoing ACIAR-funded hydrologic research in other parts of India.

8 Impacts

8.1 Scientific impacts – now and in 5 years

Now

Nil. Papers have been written and conference presentations have been made but impact not gauged.

In 5 years

We will have prompted hydrologic research by others on the down-stream impacts of up-scaling WSD - our work will be seen as seminal (at least for East India) as the first to have addressed the issue experimentally, and for providing modelling approaches (as used in current ACIAR project LWR/2006/072).

Appreciation of the proposition that WSD may not be the best initiator of development, and that WSD should be preceded by improved land and water management that makes better use of existing water resources – the knowledge, skills and attitudes required for this will lead to more effective implementation of WSD and use of the water provided.

We expect that more of the agronomic research in East India will be based on our ideas (and publications) of 'response cropping' based on soil water and expected rainfall. The paradigm will be changing from fixed 'model' farming systems to flexible systems, with wide acceptance of the concept of climate-responsive cropping (that can improve livelihoods even without full WSD).

Wide acceptance of the relative advantages and disadvantages of aerobic rice (direct-seeded, dry-sown), SRI rice, and traditional transplanted rice and the preferred agro-ecological niche for each.

We will see more on-farm research, with Indian scientists more willing to venture into the field and undertake truly participatory research which is both useful and scientifically sound.

We will have stimulated in-field fertility assessment by Indian scientists in East India, resulting in more reliable understanding of soil chemical and physical constraints, and location-specific fertiliser recommendations rather than broad prescriptions. In particular, we will have stimulated research on P and its management, and subsoil pH will be recognised as a significant constraint on some areas.

Agricultural extension in East India will have started to adopt a more contemporary adult-learning approach.

Recognition in India at least that the role of women's groups (SHGs) in development need not be confined to the traditional roles of microfinance and health, but can be broadened to provide leadership of agricultural development programs in which women are regarded as farmers and not merely farm labourers.

8.2 Capacity impacts – now and in 5 years

Now

Farmers

Changes in perception of self (e.g. "I too can be a good farmer") and resources ("my baid land is more valuable even than my bohal", "Earlier only 1 or 2 people would cultivate, nowadays even those who do not have any land lease other people's land and cultivate"

“The land full of stones which had no value earlier is like gold now”, “All the tanr and gora were barren; when people saw that they earned money, then others thought let us try then we can also earn.” This has been well documented in Amagara, beyond the families directly engaged in project, and apparently increasingly so where up-scaling has been implemented.

Farming is seen as a viable source of livelihood - widely perceived in Amagara, and increasingly elsewhere in Purulia out-scaling. Changed perception is a capacity impact.

Farmers have new agronomic knowledge (fertilisers, crop options, irrigation, soil water) and skills (line planting, banding of P fertiliser etc.) – most of Amagara (documented in FGDs, case studies) and increasingly evident in Purulia through the out-scaling.

Ability to apply new knowledge and skills to develop individual cropping systems

- Evident in Amagara beyond the co-operating farmers, and self-sustaining with minimal PRADAN support.
- Year-round crop planning has been implemented by 2,700 families in Purulia with PRADAN oversight (but managed by women’s institutions)

Women are participating as farmers, contributing to decision-making, planning and implementation of plans.

New crop growing technologies developed like direct seeded rice and cultivation of creepers in kharif on “trellis” - already being replicated outside Purulia in Jharkhand and Orissa by other agencies, with support from farmers (as Resource Persons who are both men and women) from Purulia.

Farmers are ‘experimenting’ as a way of learning, learning from each other, and developing ways as a community to solve problems like unregulated grazing (i.e. they are becoming ‘self-mobilising’ [Pretty, 1995])

PRADAN

This was first assessed formally in 2008 (Appendix 11.20) and less formally on several occasions since based mainly on changes in PRADAN practices and programs.

- Accept value of involving farmers in ‘research’ to generate local knowledge
- More scientifically-based approach to WSD used by Purulia team of 8 professionals
- Greater rigour in assessing agronomic opportunities and constraints
- Training or professionals in the PRADAN Purulia team (beyond the project) to work with communities for planning year-round cropping.
- Enhanced capacity (processes) to engage with families in generating agriculture-based livelihoods (taken up by Purulia team).
- In Jharkhand, PRADAN has adopted the idea of the “Learning Cluster” in 10 villages (part of the new ACIAR project), to serve as learning ground for farmers in surrounding villages as well as the participating families/villages
- Capacity-building learning activities which develop agronomic skills and transform self-perceptions and perceptions about natural resources are being implemented more widely by PRADAN in a separate project in 100 watersheds.
- Enhanced capacity to build institutional relationships at the highest level
- Senior PRADAN staff have undergone capacity building in relation to major project learning (workshops and other training).
- Project learning has been partially implemented into the curriculum of PRADAN’s Apprenticeship program

Australians

- Ability to work effectively with poor rural communities on a large scale
- Understanding of hydrological characteristics of WSD in high rainfall monsoon dominated regions.

In 5 years

Relevant project learning identified in capacity-building activities in 2011 will have been fully incorporated into the curriculum of PRADAN's Apprenticeship program, enhancing the capacity of PRADAN to train its staff and enhancing the capacity of its graduates – all of the process learning and some of the technical learning has wide applicability beyond the EIP.

Project learning is likely to have been implemented by most PRADAN teams in East India (present up-scaling is aimed at 22 teams).

PRADAN teams influenced by the project will have intervened with over 200,000 families, resulting in enhanced capacity as described above for Purulia.

8.3 Community impacts – now and in 5 years

8.3.1 Economic impacts

Now

Agriculture in Amagara has become a viable source of livelihoods.

- 80 of 142 Amagara families in 2008 reported income improved by at least Rs 15,000 (stated at group meetings not detailed survey)
- Over the period 2008-2012, 18 monitored families (random sample) in Amagara have generated an average of Rs 11,000 p.a. additional income (over rice) from vegetables (grown from pre-kharif to *Rabi*) and field crops such as mustard – this was in all years, except the drought year of 2010/11 when it was Rs 5,000
- Increased income has substantially reduced dependency on day-wage labour and migration.
- There is some evidence of young people returning home to farm
- Cash incomes are being used to purchase agricultural assets, like water pump sets for irrigation, that should boost future productivity
- There is some evidence for new jobs being created to service the growth in agriculture - e.g. community resource providers, input sales-persons
- Investment in life insurance and bank deposits noted in case study families, that should build economic resilience to help cope with production and market variability.
- Rapid change seen in demand for land to lease (especially land previously seen as low value – uplands and some medium uplands), especially for landless and marginal families – leasing has benefitted farmers able to secure land on fair terms, but a regulated 'market' needs to emerge that ensures stability and equitability (could be a local market regulated by the VCC or similar)
- Water now seen to have real 'value', and there is anecdotal evidence of some water trading.

Other villages in Purulia, through up-scaling of project learning with 2,700 families, reported increased average income from agriculture in 2011/12 by Rs 8,500 from a maximum of five fields per family.

5 years

Intensification of agriculture, with a shift from paddy on unsafe lands towards cash crops like vegetables, will be adopted by more families, leading to better living standard – for 200,000 families participating in project out-scaling.

8.3.2 Social impacts

Now

- Seasonal migration has reduced in Amagara with attendant improvement in social condition
- Case studies, FGDs reveal additional cash spent on education, better medical care
- Women report working harder in the fields but say they are rewarded in terms of both family cash income and greater self-esteem.
- In Amagara, women now seen as ‘farmers’ and accorded greater respect (although unknown if this is because they can earn income or whether there is greater inherent respect as people)
- Men and women report that less dependency on day-wage labour and migration gives more time at home.
- Families are investing on improved housing
- Some evidence for increased alcohol consumption with increased prosperity (but the issue is being managed by the women).

5 years

These need further research

8.3.3 Environmental impacts

Now

Farmers in Amagara and Pogro have attended pesticide training workshop and most have improved application practices

5 years

Continued monitoring and research on the hydrologic impacts of upscaling WSD is needed to address this.

8.4 Communication and dissemination activities

Farmer training

- Because of the highly participatory nature of the project, every field activity was exercised as a farmer 'training' or 'learning' activity, including soil profile descriptions (always engaging farmers) and various activities for water resource assessment (farmers took most measurements). A meeting for reflection and planning always followed the soil/crop surveys, participatory experiments on fertilizers and crop options, the 'vegetable experience' in Amagara and the 'learning cluster' in Pogro. There were also 'field' walks' and planned 'field exposures' in which participating farmers generally spoke about their work to other farmers.
- Specific training modules were developed for PRADAN to use with farmers:
    - Fertilizers and fertilizer management
    - Fertilisers
    - Water management
    - Safe and effective use of pesticides.
- PRADAN (Purulia) developed and implemented a program to reach 5,000 families within the duration of the project using principles arising from the project. This has required the Team Leader (Mr Choudhury) to run workshops with his professionals and to recruit and train villagers as community resource persons, and implement an ongoing program of training for villagers (all within the resources normally available to PRADAN). Elements of the farmer training modules have been included in this this activity. Overall, the up-scaling has required around 150 workshops to train professionals and key support staff including the Federation (32 women), Cluster Leaders (around 994 women) and Agriculture Management Committee (AMC) members (40 women) (women leaders of the federation with specialised roles to monitor the up-scaling) and more than 500 planning workshops in the villages over two years.

With the project team

Monitoring and Evaluation Workshop

Weed Management Workshop

Several meetings focused on training of PRADAN staff in Purulia in the development of guidelines for WSD plans, as well as lessons learnt from the monitoring of the Pogro catchment

Numerous forums on various themes related to the project, mostly during annual project reviews

With other PRADAN teams

- Workshop on watershed development design guidelines with 12 PRADAN professionals (Feb. 2010)
- Write-shop to draft communication products from the project (Delhi, Feb 2010)
- INRM workshop with 8 Team Leaders from Jharkhand (in Ranchi) 2010 (Appendix 11.21)
- A 2-day workshop (April 2012) on "Climate-Responsive Cropping Systems" to communicate project findings to government officials and frontline NGO staff in East India. More than 80 people attended on day 1 and more than 50 professionals from various NGO's continued through day 2.

- Within the up-scaling component funded by AusAID there has been a workshop of PRADAN leadership to identify project learning to take up (an outcome was a process for PRADAN to nurture innovation within the organisation), capacity building workshops for other senior staff (e.g. team leaders), and workshops on the Apprenticeship curriculum (which is being revised to reflect the immediately applicable project learning)

Seminars

Seminars on the project have been presented to:

- Georg August University (Gottingen) and University of Hohenheim by Cornish in 2008,
- ICAR staff at Patna on separate occasions by both Cornish and Croke in 2010,
- Ambedkar University (Delhi) by Cornish.
- Senior Government officials in Delhi in May 2012 by Choudhury and Cornish.
- ACIAR project leaders in Canberra on ‘participatory processes’.

This is in addition to staff seminars in Australia.

Other

Three articles were published in the PRADAN newsletter (NewsReach) describing the project, and articles have been written for the ACIAR South-Asian Newsletter and Partners magazine

9 Conclusions and Recommendations

9.1 Conclusions

9.1.1 Overview

Although the focus of the project was on water harvesting as a basis for livelihood improvement, the most important technical conclusions relate to the risks of growing transplanted rice in medium uplands (the main land class for growing rice, especially for poorer families) where, even after full WSD, crop failure is inevitable in dry years when there is little water to harvest for irrigation. Improving family *food security* must therefore depend primarily on improved use of rainfall and soil water. The technology for achieving this is readily available and accessible to all families. There is no need to wait for full WSD which can do surprisingly little to reduce the impacts of drought on transplanted rice. Exploitation of deeper groundwater resources to provide drought relief is not seen as an option because it is not uniformly available and use for irrigation will compete with domestic use.

An unexpected but important conclusion is that even *without* water harvesting, land and water resources can be used much more productively in well-managed climate-responsive cropping systems. These flexible systems have the potential to respond to opportunities. As well as being more productive they must be inherently variable, because they respond to rainfall variability (but they may be much less risky than mono-cropped rice). Water harvesting can reduce the variability of climate-responsive cropping and further substantially increase production; however, farmers with the capacity to respond to rainfall variability will benefit the most from WSD.

To increase production with reduced climate risk, farmers must depend less upon transplanted rice and adopt a systems approach in which they identify and respond to cropping opportunities provided by the available water, which varies between years and between land classes. Climate-responsive systems contrast with the rigid systems now practiced and often promoted to farmers. Crop options for use in climate-responsive systems were identified with farmers, but both in Amagara and in the scaling out to more than 2,000 families, farmers themselves developed new systems, each to suit their own unique circumstances. Well-managed climate-responsive systems may have the potential to make rural development largely independent of government input subsidies; however, the need for greater expertise will need to be met though improved training.

In terms of the processes used in development, adult-learning provides the foundation for breaking dependency on extension professionals, whether from the government or NGO's. Development involves complex changes and demands a new approach to extension based on adult-learning principles with a central focus on the meaningful engagement of women as farmers.

Project learning about climate-responsive cropping and engagement processes has been mainstreamed into the programs of the PRADAN (Purulia) team, the core project partner, demonstrating their utility. As an organisation, PRADAN has incorporated project learning into its in-house staff training program, the Development Apprenticeship, and the first 40 apprentices trained in the revised program will join teams in the field in East India during 2012. PRADAN has held capacity-building activities with senior staff to ensure the new graduates are fully supported.

9.1.2 The biophysical reasons for low productivity and high climate risk

Soil water measurement and two different approaches to modelling show that transplanted rice is inevitably a risky crop in 'medium uplands', as the necessary ponding cannot be assured. Shorter-duration varieties alone cannot deal with variable rainfall (and climate change). Alternatives to transplanted rice are needed for the medium uplands.

There is large yield variation between fields of rice within land classes in the same year, which is mostly related to N and P nutrition and plant protection, pointing to relatively easy potential gains in rice productivity. Some farmers already achieve 7 t/ha in lowlands and medium lowlands, and even in medium uplands when water is not limiting.

Soil surveys and participatory fertilizer experiments reveal unusually variable soil, which is probably related more to land levelling for rice and variation in the level of inputs used by farmers, than to soil type and topography. Field-specific fertilizer management is needed to support efficient use of water resources. Acute P-deficiency and insufficient P-fertilizer may explain why past *Rabi* cropping has mostly failed, not primarily the lack of irrigation although irrigation increases production from crops with adequate nutrition.

Soils degraded by rice culture, especially by the puddling that is needed to reduce infiltration to retain ponded water, will need remediation for greatest productivity from other crops.

9.1.3 Validation and promotion of water harvesting principles (watershed development) (Objectives 1 and 2)

As with other WSD, PRADAN's 'ridge to valley' approach based on the '30x40' and '5% model' (and other structures) retains some water in the landscape that would otherwise run off. In our research watershed, this water was used in the pre-*kharif* period (given good pre-monsoon showers) and *kharif* to increase crop area and diversity and reduce climate risk. Some of the water is retained in annually-recharged shallow aquifers and withdrawn later using 'seepage pits' or dug wells, and used to fully or partially irrigate crops in the late kharif and *Rabi*. PRADAN's approach was shown generally to be hydrologically sound and effective. Suggested improvements include (a) planning interventions according to an assessment of the water that can be harvested and extracted, taking into account rainfall variation and risk, (b) guidelines for less rigid and more effective placement and design of structures, and (c) guidelines for utilisation of available irrigation water, crop type, crop area, timing and amount of irrigation etc.

WSD, when combined with farmer-learning about crop options and improved crop management (Section 9.1.4), has led to substantially improved livelihoods. In a well-developed watershed, families with water resources and access to land in all land classes should be able to crop for much of the year (on various parts of land), from the pre-*kharif* period through to late in the *Rabi* (as evolved in Amagara during the project).

Preliminary hydrologic assessments suggest that the most practical levels of WSD in the high rainfall Plateau region will have little adverse cumulative impact on downstream water users, although work in progress (Croke) will evaluate this further.

WSD alone cannot ensure food security as there is little water to 'harvest' in some years.

9.1.4 Develop crops and cropping system options and improved agronomy to effectively use harvested water (Objective 3)

[Raising productivity and reducing climate risk with little or no WSD]

This agronomic objective originally related only to the use of 'harvested' water for irrigation. With the important insights listed at point 9.1.2 it was broadened to include the effective use of all water resources, with a special focus on reducing the climate-risk that is high with transplanted rice in medium uplands. The approach and technology developed can be used by poor farmers whether WSD has been implemented or not.

The key to achieving food security is to appreciate that enough rain falls **every** year for alternative *kharif* crops to succeed in medium uplands. **False** perceptions of 'drought' reflect experience with puddled rice. The foundation for future food security must be better management of rainfed crops. Where rice is the subsistence crop, *food security* depends on (i) improving and stabilising rice yields in the best areas for transplanted rice (lowlands) and (ii) converting other land to aerobic direct-seeded rice (DSR without puddling).

With further research across agro-climatic zones, and rigorous evaluation in farmer's fields, aerobic rice (DSR without puddling) should become the mainstay of *food security* for families without access to sufficient area of lowland for transplanted rice (most poor families). The research is needed to address management difficulties with aerobic rice/DSR including weeds, crop nutrition (P and N) and the logistics of harvesting early (in the monsoon). Other adapted rainfed crops may supplement rice as staples for food security, e.g. maize and millets.

For *cash income,* alternative *kharif* crops including vegetables and pulses and *Rabi* crops including wheat, mustard, pulses and a range of (irrigated) vegetables, proved successful.

Vegetables are relatively safe and remunerative *kharif* cash crops for select uplands and medium uplands, changing farmer's perceptions about the value of these land classes. In almost all years there should be sufficient water held in soil after short-season rice to grow a *Rabi* crop with little or no irrigation (but requiring timely planting and good crop management), but early rice maturity requires an area for grain drying. More research is needed to identify any circumstances when *Rabi* crops may not be able to access the subsoil water left by rice because soil degradation restricts roots to shallow soil.

Although we conclude that WSD is not essential to initiate rural development, irrigation reduces risks and increases yields. We suggest that once farmers have gained agronomic skills and knowledge with rainfed cropping systems and effective use of limited water resources for irrigation they will be better placed to effectively use new water resources made available by WSD.

9.1.5 Evaluation of the impacts on communities (Objective 4) and PRADAN's capacity (Objective 5)

Monitoring in the Amagara research watershed reveals increased cropping intensity and diversity over time, to the point where crops are now grown almost year-round, with most families in Amagara having both intensified and diversified their cropping. Although 2009 and 2010 were drought years, and 2010 in particular was difficult for intensified cropping, the farmers in Amagara were fully engaged in their intensive systems in 2011 showing a high level of resilience (in both the cropping systems and the people). This is the best evidence for the conclusion that WSD retains water in the landscape, so providing a foundation for improved livelihoods. Family case studies reveal the impact of this on food security, reduced forced seasonal migration and other indicators of socioeconomic impact.

Monitoring of cropping intensity and family income in the up-scaling to 2,700 families by the Purulia team shows that, even without WSD, very significant improvement in livelihoods is possible. Training modules were developed and used with development professionals, women's SHGs and community resource providers, to build the capacity required to make the Purulia up-scaling succeed.

PRADAN has taken this learning into its in-house staff training program and in the new ACIAR/AusAID project is set to scale out the work to 200,000 families in the EIP drawing on the training modules developed by the Purulia team.

9.1.6 Gender and the engagement process for development (Objective 6)

Objective 6 was to develop guidelines for processes and methodology to effectively incorporate gender sensitivity in projects. This arose mid-project and built upon other work on the processes used for engaging communities in development.

Agricultural intensification across whole villages has been achieved without providing material or financial support to farmers. Rapid adoption of technology was underpinned by participatory action learning that emphasised capacity building of farmers in terms of their self-perceptions (as farmers) and perceptions of their resources, their skills and knowledge, and their overall problem solving capacity. There was a transformation from a dependent recipient of aid to an independent entrepreneur. This rapid adoption and changed perceptions requires more intensive engagement by the development professional in the beginning of intervention in order to achieve greater and more lasting benefit later on.

Women do most of the back-breaking work in agriculture, but do not see themselves as farmers. Purposefully engaging women as farmers and giving them decision-making responsibility, equally with men, changed the nature of the engagement from transactional to transformational. Improved understanding of the role of women in tribal communities was used to modify approaches to intervention.

SHG members are generally engaged in savings and credit activity. Historically, when engaged in agricultural activity it is an instrumental use of the SHG forum to reach male farmers. With the engagement evolved in this project, the focus is now on building the identity of a woman as a “farmer”, equipping her with the knowledge and skills equally with men, helping her to occupy more space in decision-making in the family and to earn respect. The process transforms self-perceptions and elevates status. The role of SHGs need not be confined to micro finance and women's issues, and much is to be gained from broadening the role of women in livelihood generation, from farm labourer to farmer.

For these transformations to occur, however, it is essential that the SHGs are strong and function to facilitate learning and mutual support.

9.2 Recommendations

9.2.1 Draft recommendations for immediate adoption

1. Research and extension and relevant policies should aim to substantially shift small-holder dependency for food security away from transplanted rice to other rainfed kharif crops (including DSR)[26], for which sufficient water is assured in all years for a single crop and in many years for a second crop.

   WSD creates new water bodies for irrigation and boosts production and improves livelihoods, but it cannot be relied upon for food security.

2. Extension agencies should promote climate-responsive systems not fixed ‘models’. These can be implemented with or without WSD. In the current project, these have been promoted under the banner of ‘year-round flexible crop planning’

3. Farmers will develop their own unique climate-responsive systems, but they need to be equipped to understand their water resources (that vary in space and time), and match them to a range of crop options (access to quality seeds of proven varieties of pulses, mustard, wheat and vegetables) – this does not require any new technology but it does require an appropriate, modern approach to extension that is respectful of the capacity and aspirations of farmers

4. Extension agencies should take a participatory approach, allowing the farmer to learn rather than be told. This builds self-confidence in farmers and a capacity for independent learning and innovation. This approach has implications for education of development professionals and for the level of funding for development support.

[26] Transplanted rice will remain in lowlands and better medium uplands. Forestry and perennial horticulture and small animals also play a role but were outside the scope of the project. Any policy shift towards DSR/aerobic rice must be backed by further research.

5. Any successor ACIAR project should develop strong links with relevant KVK's and aim to develop professional short-courses for retraining of State extension workers.
6. In all extension activities, a condition of participation is that the wife is given equal opportunity to the husband to join and learn, and that both be encouraged to jointly plan their development (women are explicitly recognised as farmers rather than as farm labourers).
7. Women's institutions (SHGs) be recognised as leaders of agricultural innovation, with their role not restricted to micro-finance and women's issues, nor instruments for reaching male farmers.
8. Crop monitoring and associated group learning can be confidently recommended to extension workers and development professionals as a way of helping farmers to learn more about their resources and especially how to improve crop yields. It could be seen as a second step once farmers have learned how to develop year-round cropping. For PRADAN, this experience could be incorporated into the Apprenticeship program.
9. Fertilizer recommendations should be based on field history (past manure/fertiliser use and cropping) and preferably *also* an omission trial to identify specific needs and required rates (see research opportunities). Simple fertiliser tests can be carried out with crop monitoring (above).
10. ACIAR, through any future project, should support enhanced capacity for soil testing in East India, by introducing key ICAR laboratories to the ASPAC quality assurance program, so these laboratories can then support the re-invigoration of regional soil testing laboratories as per GoI plans
11. The guidelines for WSD planning developed in this project should be adopted, and if needed, adapted to different regions.

9.2.2 Possible future research opportunities

1. Refine technology for dry-bed direct-seeded (aerobic) rice. Dry-bed culture is essential for two reasons (i) to reduce climate risk associated with dependency on ponding and (ii) to ameliorate degraded rice soils and improve productivity of alternatives to rice and any following *Rabi* crops. This research includes:
    a. appropriate mechanisation for resource-poor farmers,
    b. appropriate weed management,
    c. nutritional management (P because soil is aerobic and crops need more P-fertiliser and N because of reduced free-living N-fixation).
    d. suitable varieties with a range of durations
    e. grain drying - short-season/early-maturing rice will usually be harvested at a time when rainfall is likely, so some enquiry is needed into the best way to provide poor families with drying facilities for grain (which may be as simple as a sheltered concrete platform for community use).
2. Soil management. Rice culture destroys soil structure and often makes the soil inhospitable for other crops, especially when rainfed and subsoil root development is required. Degraded soils are also often hard to irrigate. Two aspects require attention; one is surface structure in relation to ease of tillage, crop establishment and irrigation, the other in relation to soil drainage, root growth and use of subsoil water.
3. Understanding the implications of changed soil water balance for local catchment water resources, when soils are remediated and drainage rates potentially increase. This is an extension of current work on the effects of WSD (including water use for irrigation) on the catchment water balance, and should lead to guidelines for calculating sustainable use of newly available water resources - type of crop, area of crop, irrigation strategy etc.

4. Alternative crops or new rice production technology are urgently required for the medium uplands. There is a case for a systems comparison with rice grown in contrasting ways: transplanted, DSR (wet and dry-bed) and SRI. Hypothesis could be:

    - Well-managed aerobic DSR reduces climate risk (by timely planting and early maturity) and opens up more opportunities for multiple cropping. Any loss in yield with early maturation (in 'good' years) and increased input and management costs are offset by higher long-term yields and reduced yield variability
    - SRI is less drought-sensitive than transplanted rice, but nevertheless depends on puddling and therefore will suffer delays in some years.

    Only systems comparisons that allow crops to be planted at their optimal time will reveal the costs and benefits of the various methods of rice culture. Moreover, if soil is not puddled and actions are taken to remediate structure, there may be benefits for other crops that only a systems study can reveal. Any experimentation will need to support systems modelling using longer-term climate data.

5. Although impressive improvements in crop diversity and intensity have been achieved in Amagara, and initiated more widely, it remains unclear how far development can proceed beyond basic food security without full WSD. It remains to be seen by how much farmers without access to significant water resources (ponds, wells etc.) for irrigation can use climate-responsive cropping to enhance cash income.
6. In Amagara, development occurred quickly and then appeared to stabilise. Further monitoring/research in Amagara, and a sample of other villages in which the Purulia team has intervened with climate-responsive cropping, is needed to establish the constraints on further development and at what point these constraints operate (e.g. labour, water, markets, risk, low return relative to MGNREGA). A better understanding is needed of both dis-adoption and adoption of climate-responsive cropping.
7. Research is needed to learn if the income generated by improved agriculture is sufficient for it to compete with other sources of livelihood such as MGNREGA, day wage labour and migration over the longer-term – presumably this will vary between families depending on socioeconomic considerations.
8. Research is needed to understand how the income derived from improved agriculture is disposed of, not only within families (education, housing, marriages, consumer goods, investment in agriculture etc.) but across the community.

    Important questions arise about whether agricultural intensification is constrained by labour or if it actually generates employment (e.g. farm labourers for larger farmers) and draws labour in (e.g. reduce migration). We also need to understand the emergence of new types of employment (e.g. in agribusiness and advisory services, transport, value-adding.)

9. Research so far has focused on annual cropping. Future research should move to farming systems including animals. Research opportunities include low-cost improvement of uplands for grazing with small inputs of P (on pulses such as black gram?) to promote growth of indigenous annual legumes that are widespread. A related issue will be socio economic factors around livestock access to, and management of, communal grazing lands, and also unplanned grazing of *rabi* crops.
10. Future farming systems research should consider risk[27] management strategies including the role of agro-forestry/perennial horticulture, livestock, development of market linkages, on-farm grain storage and off-farm savings/investments.

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[27] Includes production risks (drought, flood and weeds pests and diseases) and market risk, and there are probably institutional risks associated with withdrawal of government programs, access to finance, and land, water and labour markets.

11. It is important to recognise that as climate-responsive farming systems respond to climate-related risks and opportunities, their production will inevitably vary, just as the climate is variable, and that farming families will need to learn strategies for using the high production in good years to sustain them in poor years. These risk management strategies could range from grain storage at home to bank deposits. Research is needed with farmers to develop viable strategies. Risk management also needs to consider market and biotic risks (pests and diseases) - it is notable in this regard that farmers inevitably give priority to vegetables when innovation occurs, with little attention to alternative crops for either food security or cash income, and this seems to be a risky strategy even if it offers good short-term income.
12. Further research into the development process is needed to learn if the ‘condensed’ process developed by the Purulia team is effective and efficient – is cropping intensified and diversified after PRADAN support is reduced, do farmers show evidence of independent problem-solving, do women engage equally with men and does this lead to good decision-making/implementation and greater self-esteem for women, what are the social and cultural consequences of engaging women equally with men (and traditional roles are challenged), if rainfed agriculture is improved, do farmers then seek support for WSD to provide more water resources and can they use these resources well with minimal further intervention by extension workers?

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11 Appendixes

11.1 PRADAN's 9-step approach to resource mapping, developing watershed intervention plans

1. Pre requisites for planning

Social mobilization of the community is preferably in the form of women-managed SHGs in the villages for blending them in the planning process.

Visioning of better life and awareness generation on importance of Integrated Natural Resource Management (INRM) for livelihood enhancement is done for the community through training and INRM video show and exposure to a successful watershed area.

2. Delineate the ridgeline and drainage lines:

For preparing developmental plan of a village the ridgeline and drainage point for the small watersheds within the village are demarcated with the help of the villagers.

Take the revenue map of a village. Help the villagers to mark the ridgeline and drainage pattern of each of its sub catchments on the revenue map.

[Note: In addition to PRADAN doing this in the usual way, the project team used D-GPS. It is unlikely that GIS and GPS can be used to significantly improve the cost-efficiency of the mapping procedures, but if so we have demonstrated how this could be done quite cheaply and provided introductory training]

3. Map the physical, human and socio-economic resources on a family-wise basis:

Resource mapping is done with the involvement of villagers as only they can give a clear depiction of resources of their villages. PRADAN collect demographic data, food security, assets, migration, livelihood portfolio, labour, access to water resources. Facilitate the villagers to plot different types of land with different colours on the same map. Show patches with their local names and depict water bodies, plantation, settlement etc.

4. Map the land ownership in each patch:

To know who owns land and where, and also identify the lands owned by govt., forest dept. and community

5. Wealth ranking:

Wealth ranking for all the families in the village is done to have a clear picture about the number of families falling into the domain of poorest, poor and not so poor categories and their present livelihood patterns. This will help to prioritize the intervention plans.

6. Map depicting present land use:

Map the present land use of each plot along with its characteristics (type of soil, depth of soil, water holding capacity, slope etc.)

Note the problems faced by community in each type of land along with their understanding of quality and yield of present use.

7. Problems faced and their proposed remedial measures:

During visit to each patch (group of fields in a similar area), interact with the land owners and generate options to deal with the problems and ensure better return to them.

Through the project this has shifted to more intensive involvement of the whole family. Each family is helped to come up with their own plan for enhancement of their livelihoods which then get integrated at community level plan.

For each alternative, social, technical, economic and environmental viability is explored and the best option is chosen.

Thus proposed land use and treatment plan for all the lands are finalised. Treatment options include '30x40' model and plantation crops for uplands, and 5% model and seepage pits for rice land, plus other measures such as ponds, wells if necessary and 'land shaping'. Parts of the watershed suited to these interventions are marked on the map.

8. Plan for all families:

Check for families whose livelihoods are not sufficiently addressed so far; Identify specific needs of the people especially women for addressing their hardship; Identify crucial gaps of villagers in basic needs; recognise key stakeholders for fulfilling the needs of the community; and prepare plans for addressing all the above to transit all from their present state to the visualised state.

9. Prioritization and action plan preparation (the Intervention Map):

Prioritise the planned interventions based on ridge to valley and 'poor first' principles and implement the plan as far as budget allows.

11.2 The soil water balance model

The intention with modelling was to characterise the risks and opportunities for the Plateau region rather than predict crop growth and yield. This approach avoided the need to develop and validate a rice model. The study region is remote, has little research infrastructure, and experiences significant social unrest and related security issues. The research necessarily reflected this reality, in some cases requiring simplifying assumptions because reliable data were absent and could not readily be collected.

A single-layer 'tipping bucket' water balance model was used, based on Cornish and Murray (1989) but modified to include (i) drainage beyond the crop root zone and (ii) the potential for water to pond above the soil surface during rice culture. Evapotranspiration (ET) was modelled simply as a function of reference evapotranspiration (Eo) estimated by the Penman-Monteith equation (Allen et al., 1998).

A running water balance was computed for the rainfed rice-fallow system in which lowland rice varieties are grown during the monsoon cropping season (*kharif*) and grazed weeds grow during the subsequent fallow period. Only medium-uplands were modelled, as these are the most widespread rice lands (~75% of the Pogro rice area). Also, the water balance of the lowlands is too uncertain because of inflows from runoff and subsurface seepage that will sometimes exceed outflows. It was not feasible to take the necessary measurements to confidently model water in this position in the toposequence. Hydrologic modelling was used to better understand water across the landscape, including lowlands, and provide a 'second opinion' on the water balance of the medium uplands.

The daily soil water balance is described by the equation:

$$AWC_{time\ 2} = AWC_{time\ 1} + (rainfall + irrigation + run\text{-}on) - (ET + runoff + drainage),$$

where AWC is the plant-available water held within a range between an upper limit (UL) determined by soil properties and a crop-specific lower limit of extraction (CLL); ET is evapotranspiration; drainage is downward flux beyond the root-zone. Maximum AWC is termed the potential available water capacity (PAWC).

During rice growth, water ponds above the soil surface, effectively adding to the potentially available water. Therefore the model described below estimated the 'Available Water' (AW) that included both the AWC and any ponded water.

Values for upper and lower limits of soil water content are commonly based on laboratory pressure-plate determinations of wilting point (WP, typically under 1.5 MPa pressure) and field capacity (FC, at 0.01 or 0.03 MPa), although we could find no published values for rice-growing soils of East India. Pressure-plate values do not reflect differences between plant species that may be important in drier soils, and may over-estimate FC in compacted soils because grinding creates pores that do not drain under low pressure. The pressure plate FC may under-estimate field upper limit in slowly-draining soils.

The approach taken here was to make field measurements of the upper and lower limits for the crop and soil concerned. For comparative purposes, pressure-plate values were also determined for soils from six of the pits used for soil profile description, which represented the toposequence. Field estimates of UL and CLL were made as part of the on-farm research. Water data were collected mainly to provide starting soil moisture for any crop that might be sown following rice, but also provided estimates of UL and CLL and limited soil water data for model verification.

Key assumptions in the model and derivation of parameter values.

- On medium upland, any run-on or lateral inflow from fields higher in the landscape is balanced by losses to fields lower in the landscape, and in this toposequence position there is no groundwater discharge or upward flux from groundwater (Fig. 1).

- The potential effective root-zone (soil profile) depth was assumed to be 90 cm. This was based on root observations in soil pits and soil water measurements under rice in wet and dry years.
- The upper limit (UL) for soil water holding capacity of medium upland soil was set at 290 mm for the 90 cm root-zone, as described in Section 5.1.

  This was water held at saturation, not 'field capacity' or 'upper drained limit', as the soil is usually near-saturation under lowland rice. The field values obtained for UL at saturation were less than the values derived using the pressure-plate at 0.03 MPa on soils from the soil pits. The higher values from the laboratory were inconsistent with the total void space (above), and were presumably an artefact of grinding.
- The CLL for rice on medium upland was 110 mm for the 90 cm root-zone (the range for 11 fields was 60-140 mm) (Fig. 11). This was determined in 2008 when good early and mid-monsoon rainfall preceded early cessation of the monsoon forcing well-grown crops to mature on stored soil water, as described in Section 5.1.
- The difference between UL (300 mm) and CLL (110 mm) is the potentially available soil water (PAWC), an average of 190 mm (range 150-230 mm). The model was tested for sensitivity to this value.
- During the rice season, water ponds above the soil surface, effectively adding a layer of stored water. Ponding depth was set to 100 mm, although the model was tested for sensitivity to variation in this value. Model runs with no ponding simulated the situation where a rainfed crop such as direct-seeded (non-flooded) rice was grown.
- Runoff was assumed to be 'saturation excess' only, that is all rainfall infiltrated until the soil profile was saturated (=PAWC).

  This major assumption can theoretically lead to significant errors in predicting soil water, given the low infiltration rates measured, but for practical purposes the errors arising will be small for the following reasons. After rice harvest all soils in the region dry and crack except for the sandiest (that are regarded as 'too leaky' for good rice production). Our observation is that subsequent rainfall infiltrates very quickly via these cracks, which then empty quite quickly by both lateral and downward movement into the dry soil. Infiltration studies showed that at least 50 mm of rain infiltrates very quickly before steady-state infiltration (K_{sat}) is reached, at measured rates of 1-5 mm/hr. Even then, the low infiltration will not often lead to infiltration excess runoff, as follows. First, cracks remain open after wetting, until the land is ploughed, so a capacity to retain local runoff remains. Second, ploughing creates surface storage on the flat (terraced) fields that is sufficient to hold relatively large falls of rain allowing it to infiltrate over several days if needed. For example, if 30 mm rainfall is held in surface depressions it will infiltrate in less than a day. Third, with the onset of the monsoon and the probability of much greater daily falls of rain, the land will be puddled for rice and the bunds closed, thus preventing all runoff until the bunds are over-topped. Infiltration rates of 2-3 mm/day through the puddled layer (So and Kirchhof, 2000) will be sufficient to saturate the soil profile (depending on the drainage rate of the soil below the puddled zone).

  The best evidence that the errors from this assumption in practice are small is that the predicted dates for first cultivation of fields (and planting of the rice nursery) and transplanting (that requires ponded water) correspond closely with observed practice in all years (Fig. 22).
- Drainage rate beyond the root-zone was set at 3 mm/d when the profile was wetter than 'field capacity' (FC). Sensitivity to variation in this value was tested.

  The drainage rate was estimated as part of the work to determine UDL after the wet year 2007. It was based on measured changes in the 0-90 cm profile water content between 23rd January 2008 (near saturation) and 5th March 2008, minus estimated evapotranspiration. The figure (3 mm/d) is comparable to 2 mm/d which So and Kirchhof (2000) consider necessary for rainfed lowland rice.

- A value for FC was needed to define when drainage would cease. The value needed to be estimated rather than measured, as the field soils drained slowly and did not meet the requirements for field determination of FC. The laboratory determinations were invalid because they were affected by grinding. Field capacity was thus derived from field-determined soil texture (McDonald et al., 1990; Kew et al., 2004) and, for surface soils, checked against opportunistic field measurements associated with infiltration studies in the watersheds and laboratory determinations associated with pot experiments. Total water content at FC was set at 210 mm for the 0-90 cm soil profile, or an average 23% by volume or 14% gravimetrically with ρ_B of 1.65 g/cm^3.
- The value for profile water at FC was also used in the model to set a threshold for available water below which plant water stress reduced ET to less than E_o. Allen et al. (1998) state that $ET<ET_o$ when AWC is <0.5(FC-CLL) for most crops and forages, or for rice <0.2 of saturation, giving thresholds of 50 mm and 38 mm, respectively for the present soils. The threshold value used was 50 mm, below which ET = 0.5 E_o.
- We assumed that ET = E_o when AWC > 0.5*(FC-CLL) because the soil surface under rice is either (a) wet, as it usually is during the monsoon with its high rainfall and low evaporation, leading to Stage 1 evaporation, or (b) covered with ponded water, or (c) covered with a full crop canopy. This simplification will occasionally result in over-estimation of ET, viz. when the soil surface is not wet (Stage 2 evaporation) and ground cover is incomplete, conditions that are most likely following rain falling outside the monsoon period and of no consequence for rainfed rice.
- Because of insufficient actual water data over time to ‘validate’ the model in the conventional sense, model output was tested for ‘sense’ with local farmers and development professionals to see that it adequately captured the seasonal dynamics of water and its agronomic implications (e.g. for seedbed preparation, transplanting, and the date fields drain of free water). These observations are discussed under model performance.
- ASW was set to zero (i.e. at the CLL) to initialise the model.

References relevant to water balance model

Allen, R.G., Periera L.S., Raes, D. and Smith M. 1998. Crop evapotranspiration – Guidleines for computing crop water requirements. FAO Irrigation and Drainage paper 56

Arshad M.A., Lowery B., and Grossman B. 1996. Physical Tests for Monitoring Soil Quality . In: Doran J.W., Jones A.J., editors. Methods for assessing soil quality. Madison, WI. p 123-41.

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Kew, G., Wetherby, K., Zimmerman, T. and Meissner, T. 2004. SuperSoil 2004: 3rd Aust. New Zealand Soils Conf. 5-9 Dec. 2004, University of Sydney Australia.

McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J. and Hopkins, M. S. 1990. ‘Australian Soil and Land Survey Field Handbook’. 2nd Edition. Inkata Press. Melbourne.

So, HB and Kirchhof, G (2000). Management of clay soils for rainfed lowland rice-based cropping systems. Soil and Tillage Research 56, 1-2.

11.3 Evaluation of electro-magnetic induction as a tool for water resource assessment

Electro-magnetic induction (EMI) measures the bulk conductivity of materials. It has been widely used to map soil salinity and, at the time of project inception, was just being calibrated in research for possible use in soil water assessment. Bulk soil profile conductivity is an index of water within the depth of measurement, and with calibration should be able to provide actual estimates of soil water.

The instrument most commonly used is the EM38 that measures to about 1 m depth, but there is a second instrument, the EM31, that measures to about 6 m depth. Therefore together, these instruments cover the range of soil water for crops and shallow groundwater. Whilst both instruments can be used for point measurements, they are most commonly used with GPS to map salinity, and possibly water.

The possible use of EMI was explored as a tool for assessing the spatio-temporal variations in water resources across the Pogro study site. The figure below shows maps of conductivity using the two sensors trialled under dry and wet conditions. A general increase in conductivity is noticeable under wet conditions (right most panels in Fig. 11.3.1), particularly in the Baid and Tanr lands. However, due to the low concentration of salt in most (but not all) of the soils in the catchment, the difference is small in some cases, with some areas appearing to have a higher conductivity in the dry season (presumably due to instrument drift or the interpolation of the point data). This shows that electro-magnetic induction can be used to give a relative indication of the variations in the available water both in time and space. The usefulness of the technique is limited by variability in the salt concentration in the soils (making calibration difficult), as well as the collection of the data being fairly labour intensive given the terrain. Consequently, EM surveys will likely only be useful in small, targeted sites, and not applied generally across broad regions.

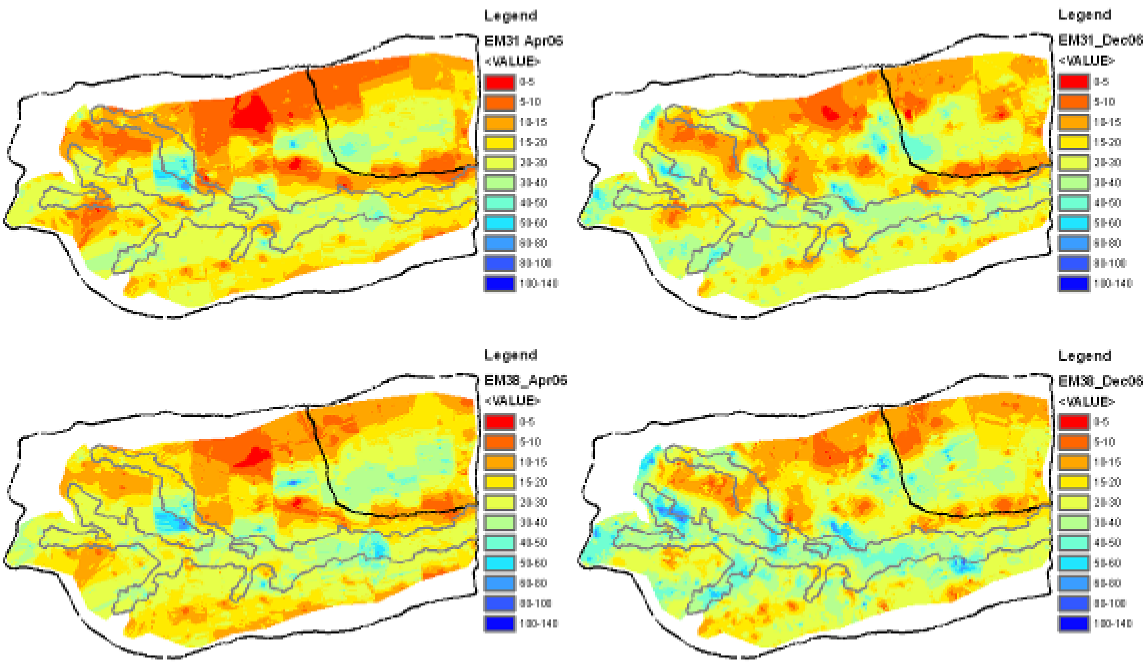


Fig. 11.3.1. EM31 and EM38 conductivity maps for dry (April 2006) and wet (December 2006) conditions (grey line marks boundary of most of the Bohal area in the Pogro catchment).

EMI was also used to assess if farmer's assessments of land, as reflected in local patch names, are an indicator of shallow groundwater or soil water resources. Indications are that farmers have a remarkably good assessment of their land, which should obviously be considered when assessing water resources and planning interventions.

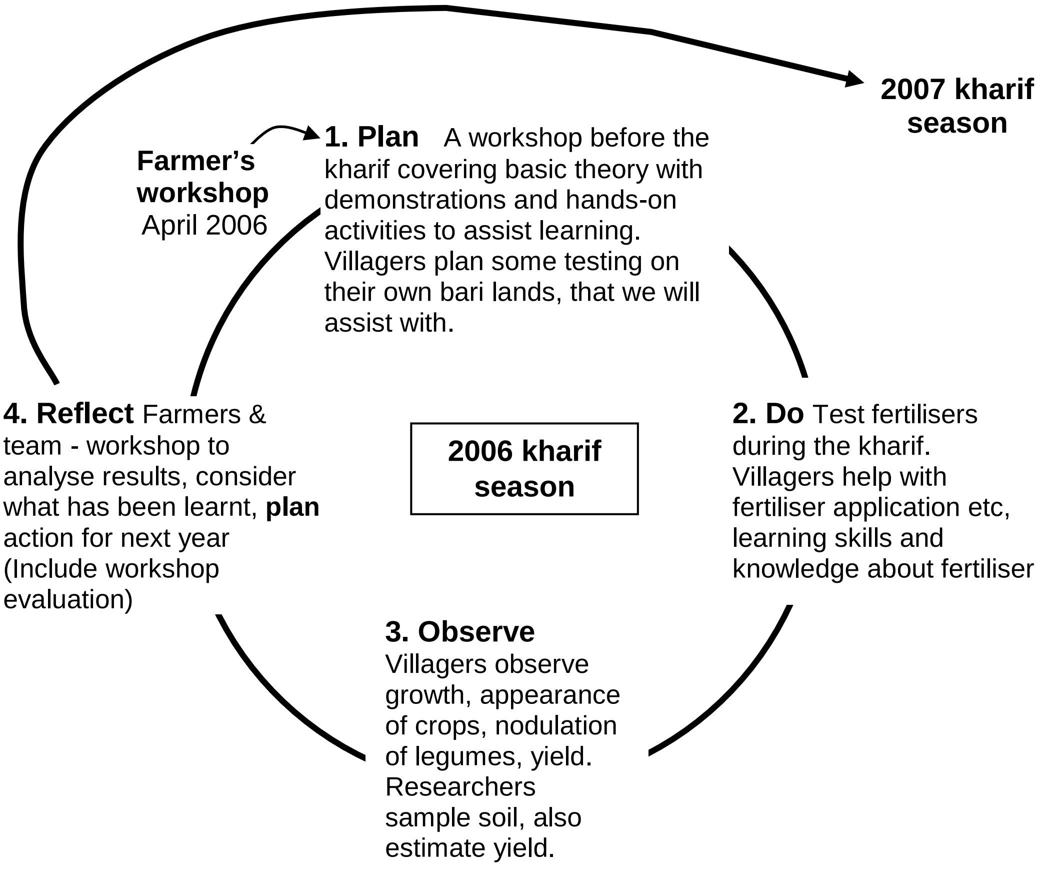
11.4 Fertiliser action-learning activities in 2006

The following documents illustrate how action learning activities were developed. The initial draft document was the basis for discussion, and not all ideas were adopted. We have included these notes and the subsequent plans and evaluation so readers can see the way we have gone about developing learning activities.

The fertiliser learning activity – draft proposal

An outcome of the farmer's workshops in April 2006 was a clear need for fertiliser training. We could address this with a 4-step action learning activity, such as that pictured below. The idea would be to help farmers relate theory to practice and lead them to make informed decisions on their own land.

Proposed activities also need to be designed to influence knowledge, attitudes and skills of farmers, and meet research goals of the project. These attributes need to be assessed before and after the activity as part of project evaluation and to improve our practice.



Action learning about fertilisers and crop nutrition

Proposed aims of the action learning activity

1. To equip villagers to make informed choices about which fertiliser to use in different types of crops, taking into account soil fertility.

Farmers will be able to match fertiliser types to different crops and soils and estimate rates to apply.

2. Other aims:

- To improve the capacity of farmers to prepare seedbeds, plant in lines (where appropriate) and apply fertiliser appropriately.

- To quantify responses to N, P (and K?) in the two classes of bari (homestead) land (that which receives manure, and that which does not)
- To develop an action learning program that can be adapted widely for use by PRADAN and others.

Background

Farmers appear to understand the need for fertilisers, but are highly risk-averse and very reluctant to make investment in fertilisers. New knowledge and positive experiences are needed to address the issue of risk aversion. Perceptions of risk are worsened by ignorance of the different types of fertiliser and crop requirements. Farmers have difficulty stating the difference between superphosphate and DAP, and between DAP and urea. They have, however, observed that ash gives good responses in legumes (indicating K deficiency), that fertiliser is more critical for maize than for legumes (indicating shortage of N), and some farmers observed 'swellings' (nodules) on legume roots (maybe suggesting 'effective' nodulation without inoculation. Some *farmers* observed that big yield increases may be achieved with fertilisers (some nominating 4-5 times increase). In general growth is poor over most of the bari land, possibly suggesting general P deficiency in addition to any N or K deficiency. Although 'homestead' or 'bari' land is commonly thought to be high fertility because it receives domestic and animal wastes (sometimes composted) it emerged that only land closest to the house is treated this way. The area treated depends on family wealth, as reflected in the number of animals owned. Many farmers have only a tiny area of 'fertile' bari, with much of it apparently degraded and of low fertility. Regardless of fertility status, bari land is used in the monsoon for maize (first crop sown) and then pulses, oilseeds and/or vegetables (tomatoes, brinjal etc). Crop sequence is not managed to take advantage of N fixation in legumes.

Expected outcomes from the overall activity
(On reflection – this was too ambitious)

1. Farmers will understand basic concepts of soil fertility (eg plants need food just like people do, we feed the soil [with manure, fertiliser, compost] which then feeds the plant, what is removed must eventually be replaced)
2. Farmers will recognise the main fertilisers available and what they contain (including the approximate cost per kg of N and P in each).
3. Farmers will know the difference between legumes and other crops (oilseeds and grasses) with respect to nodulation and N requirements
4. Farmers should be able to dig up a plant, locate Rhizobium nodules and make some assessment of their effectiveness.
5. Farmers will know broad rates of fertiliser to apply with regard to crop, soil fertility, risk of crop failure (eg a 'dry' location), desired yield (and how to determine that), and farmers risk aversion.
6. Farmers will broadly appreciate the concept of 'fertiliser efficiency', ie that usually we need to apply more of a nutrient than a crop removes because of unavoidable losses to the soil (or atmosphere in the case of N)
7. Learn the benefits of band placement of P fertiliser versus broadcasting
8. Know how to evaluate need for, and response to, fertiliser (visual symptoms, test strips)
9. Develop skills in measuring and applying correct rates.
10. Farmers attitudes to fertiliser will change having learnt that using fertiliser at appropriate rates can capture an opportunity with acceptable risk (allowing a move from absolute risk aversion)
11. Project team will have improved scientific understanding of the relative importance of N, P and K deficiency in bari land for a cereal (maize) and legume (black gram?), fertility variation, and nodulation effectiveness.

12. Project team will better understand reasons for decisions around fertiliser use
13. PRADAN will have improved capacity to train farmers in fertiliser use.

Methods for the pre-monsoon ‘planning’ workshop

Workshop design needs to focus on both content and process, with plenty of time for reflection.

Examples of learning aids (content) could include:

- Pots of maize, black gram (or other pulse) and say a vegetable that has received no fertiliser, +N, +P, +N and P, +N, P and K (on the pulse). These would be used to demonstrate visual signs of deficiency (eg anthocyanin for P deficiency), growth responses, and any interaction. If used, this demonstration would need to be established early, and may need young and older plants hence two planting dates.
- Posters showing deficiency symptoms
- Posters in local language with diagrams highlighting main messages of workshop
- A learning activity that highlights the fact you can’t deplete soil nutrients forever without production falling
- Some legume plants to dig up and look for nodules
- Bags of the common fertilisers, with some way of visualising how much of each nutrient is in each.
- Samples of fertilisers containing the same amount of N or P removed from say 100m^2 plot by an ‘average’ maize crop (caution here, because of the idea of feeding the soil as well as the crop, to account for fertiliser inefficiency)

The practical activity during the monsoon

This needs to be an activity which meets farmer needs and is statistically sound to ensure scientific credibility. Each farmer, or groups of farmers, agrees to conduct a test on a nominated crop, ensuring that across the village each crop is represented sufficiently to provide replication. Each farmer or group works on one crop, for simplicity, but data will later be pooled for all farmers. Involve as many farmers as possible to increase exposure to new ideas and to provide the maximum data for sharing and analysis.

Each plot would have been sown by the farmer as a matter of course. We are not asking farmers to sow plots especially for us, although we may ask for special care in sowing and applying fertiliser. Each farmer or group would establish one plot of their nominated crop on bari land close the house (‘high’ fertility’) and one elsewhere in the bari on what they consider poorer land. PRADAN would assist with training in land preparation, line planting and fertiliser application <u>if required</u> (maybe at the pre-monsoon workshop), but that all farmers would need to apply fertiliser in the same way for the given crop.

In each plot of crop, strips of fertiliser will be applied. No fertiliser is applied to the rest of the plot, as per farmer practice. If fertiliser is applied in the farmer’s normal practice, we need to know how much and decide if the rate of our fertilisers should be varied.

Two alternative approaches could be taken to rates of fertiliser. One is to use a fixed rate for each fertiliser and crop type. The rate would be negotiated with farmers as one that would give a good return at acceptable risk (keeping in mind that rainfall-limited yields are probably at least 5 times higher than actual yields). All farmers would use the same rate. This would be analysed as a split plot (main plot is the crop type, split for fertiliser) with the number of replicates determined by the number of participating farmers or groups.

An alternative approach would be for individual farmers or groups to decide rates having regard to the expected risks and returns involved. This way, a kind of competition may develop, where groups of farmers suggest rates that will give best profit, and they grow their crops accordingly, comparing results at the end. Rates may be simply low, medium or high for each of the fertilisers, reflecting a range of attitudes to risk, from risk-averse (low rates) to opportunity-seeking (high rates). If the process was well managed by us to accommodate statistical considerations, we could have main plots for crops, split for rate.

Facilitator worksheet for fertiliser workshops (June 22, 23, 24 2006)

Introduction (30 minutes)

Q. Why are we having the workshop?

A. They asked for training, we think it's important also, so we have organised it

Aim:

1. To equip farmers to make more informed choices about which fertiliser to use on which crops
2. Initiate the process of learning – lay down foundations for interaction between farmers and scientists

Farmers asked to say what are their thoughts, expectations at the moment – we say what we can deal with at workshop

Role play with 4 farmers who are asked to volunteer, one to play the role of a farmer who is asked to choose a day-wage worker from candidates given a glass of water, or puffed rice, or both for breakfast. (Message: both nutrients and water are necessary. Water is important, but it is already given to you. Nutrients are not all given, you have to manage them. Do play and ask what they observed.

The workshop process:

This is the beginning of a process that will continue for 3 more years. This event helps us understand their experience so we can relate to the issues raised. So the more they share their experience the more we will understand their needs. The tasks will help them to share their experience and us to share our knowledge. We will try to help them to interpret their experience to produce new knowledge for them.

	What they know	Section Content	Processes used	Desired outcome/learning
Section 1				
10.30 11.00 – 11.45	What do they apply, how much, when, the basis of decision (type of crop, site history, symptoms, local knowledge?	Maize (context) - N - P - K Cowpea or black gram: N,P, K -Without fertiliser yields trend down – with the right fertiliser yields and returns get better -HYVs need more etc Legumes versus grasses Etc	Small groups (3) discussion facilitated to draw out what is known, not known or incorrect (but not openly divulged - used only to focus rest of workshop) *Farmers* nominate legume Plenary -Group reports (15 mins) -Farmer case studies of using fertilisers why and the responses possibility ? how to use? (10 mins) -Group comments (10 mins) -"teaching" (5 min) A scientific response (ie interpretation) from us (max 5 mins)) to the farmers, that provides information on the key workshop themes of this session and leads into rest of workshop. We provide scientific comments and uses this as a basis to teach (including reasons why someone might use a fertiliser with no response) *Pots* to show legumes and grasses different *Slides* of roots/nodules to illustrate	Appreciation that nutrients are important for plant health and …… ….. differentiate between high and low yielding crop needs and …. … between legumes and non legumes (the big exception)
11.45	Tea			

	Section 2			
12.00 - 12.20 12.20 -1.00	How well do they differentiate between crops and between fertilisers?	Using fertiliser based on: - Symptoms (eg leaf colour, stunted growth, lodging) - ? - ? - ? Choosing fertilisers based on what they contain and the crop to be fertilised Using fertilizers for balanced nutrition	Small group: (20 minutes) Focusing questions and activities to identify knowledge gaps and needs: 1. Q. In what situations do you use (urea, super or MAP/DAP, or ash) 2. Give fertiliser samples (and manure?) and discuss what they would do with them: first urea, then SSP, then Sufala (elicit what they know and is right, or what could be improved). Note risk of making participants hesitant to contribute Plenary Feedback/summary (15 mins) 3. interpreting labels (15 mins) Teaching (Ashok) reinforcing what is right and noting where more knowledge is needed … leads to rest of workshop 4. *slides* of deficiencies – discuss best kind of fertiliser (relate back to section 1 – the more you harvest the more you need – if you see symptoms it is to late, you don't always see symptoms, symptoms can be misinterpreted) (10 min)	i. Ability to differentiate between fertiliser types ii. Understand there is no need for a compound fertiliser where either N alone or P alone is required iii. Understand there is no need for N on a legume if it well nodulated iv. Appreciate that knowing the types of fertiliser and composition allows us to choose the cheapest form of what is needed v. Importance of balanced nutrition (but fertilisers don't have to provide all nutrients)
1.00-1.15	How are fertilisers applied	Basic messages of: - split application (broadcast or banded) for N - banding for P better than broadcast	Plenary (10-15 mins) Posters (to be reinforced in practical work in field, later)	Application to maximise efficiency – foundation only
1.15-40		Reinforce learning Gaining commitment	Quiz – fun with reward (10 mins) Commitment to action (15 mins) Dina and Peter ask 'now that you have this knowledge, how will you use it in the kharif': - Would you like to try some fertiliser test strips in rice? - Would you like to try test strips in bari land crop? For rice land: offer fertiliser strips or paired plots to farmers at workshop who Avijet sampled soil in paddy (N, P K Zn?) -we apply fertiliser and take risks but engage farmers in observing and learning For bari – black gram For gora land - finger millet done	Reinforced learning, provides workshop evaluation Commitment of farmers to being involved in followup action (fertiliser trials) Farmers committed already
1.40-1.45			Interview with scientist (5 mins)	Reinforced learning
1.45-2.00			Evaluate how well we have met their expectations () (15 mins)	
Discuss kharif plans with farmers eg one farmer one crop (farmer to nominate), fertiliser treatments with finger millet (15 mins)				

Evaluation questions for farmers: (Score by show of hands: 1, very low to 5, very high)

1. Do you think the workshop will help you to use fertiliser correctly?
2. Did the workshop encourage you to participate more in this ACIAR/PRADAN program? (surrogate for asking if the workshop met expectations)

Also: this was an introductory workshop. Practical work will follow. What topics would you like covered in more detail? (Put up a list of topics)

Questions for Quiz (and answers) – to assess and reinforce farmer's learning

1. What do plants need nitrogen for (better growth, vigour)
2. What do plants need phosphorus for (to balance N, better roots etc)
3. Name another nutrient (potassium) (resists diseases a bonus point)
4. Which fertilisers contain only N (Urea)
5. Which fertiliser contains only phosphorus (SSP)
6. Name a fertiliser that supply both N and P (DAP)
7. Name a fertiliser that contains N, P and K (Sufala)
8. Where else can we get all the nutrients n, P and K (manure)
9. At what stage would you apply this type of mixed fertiliser (ie a mixed fertiliser or manure) (before or at planting)
10. what nutrient does ash supply (K)
11. where can legumes get their nitrogen from (air or nodules or bacteria)
12. What are the signs that the legume is producing its own nitrogen (nodules and good green colour)
13. when should we use higher rates of fertiliser (when we want higher yield and we have a certain supply of water)
14. Once we have added higher rates of fertiliser to land with assured water, what else do we need to do to get the high yields? (weed and pest control)

Fertiliser workshop evaluation by project team

Pogro village workshop, Purlia, 22nd June 2006

Take-home messages for us in italics

Session 1

<u>Introduction</u> – went well except DK forgot a bit he had to pick up later

Sense that farmers expected a lot of us, because they knew so little, and so for some there was some disappointment that we did not provide 'answers'. They wanted us to give answers/formulas, but we wanted to lay foundations. Knew only about urea – the extent of their knowledge

Liked <u>role play</u> – farmers made link between food and water and water and fertiliser

We decided to have one farmer, but DK had to ask 3 because the first farmer chose water, with a good reason that one can wait for food but not water. Message: *we had to be adaptable for farmers to take the message we hoped for.* But when we got more farmers we got the intended response. Asked the plenary 'who made the better decision'.

Laid out 3-year plan for soil, nutrient and water inter-related program, seemed to appreciate it. *Repeat appearance of farmers at activities supports farmer interest* (Ashok checked at lunch and farmers confirmed interest)

First task, the message got through, farmers engaged well. Farmers had no problem responding despite DKs trouble with some translation. Emerged farmers only knew about urea, not as we expected, so this limited response. But although we made false assumptions about what they knew, it brought out a major limitation in their knowledge. Even on corn they only use urea. One farmer had a rule of thumb to use 1.5 kg urea per 1.0 kg seed. Source of knowledge about DAP was a local non tribal farmer. Difficult for farmers to grasp that urea was not the only fertiliser. *Had to repeat message in many ways to reinforce* – shows our process good.

Human nutrition was not a good parallel to explain that a balanced diet is needed. It did not improve understanding (many villagers survive only on rice).

Slides

- The slides of nodules were good, but *better to have live plants.*
- Slides of deficiency symptoms useless at worst, possibly misleading ('if I don't have symptoms like that I don't have a problem') *Don't use such slides in future*

Case study was good – eg showed that once farmers moved to new HYV they must stay with these varieties – can't go back to tall varieties (with compost) because soil so depleted.

Session 2

Q1 differences between fertilisers Farmers blank: "this is why we came – we want the answers" They rejected this question. *In future, don't ask this question if earlier responses show farmers only use urea.* But this question could be changed to put later as a hypothetical in the quiz

Q2. Looking at fertilisers. Generated a *lot of interest and learning* – liked the smell test as it helped them to check if they are sold the right thing in market. *Tangible* – being able to see and smell the fertiliser.

Note - Samples need to be distributed at the same time to the 3 groups (by the facilitators) (*prepared before hand*).

Evaluation of progress towards aims in Session 2:

Farmers understood content of our aim (i) in this section, but aim (ii) needs practical experience. Understood now why legumes yield well without any fertiliser- some had seen the nodules and could group them as pulses, but did not know about N. Aim (iv) was not done (that is with calculations as Shane suggested), but farmers were asking for this information. *They could use our table of fertiliser costs and composition, that needs to be prepared in user-friendly form for use in future workshops.* And further training is needed, perhaps give table to a few more literate farmers to work on and share with others. For (iv), they understood but not using the human nutrition – they need to experience responses to multiple nutrients (strip tests). This supported by later question about what happens if I put fertiliser on and it is dry – said N will harm crop in dry spells – we said this is true for N, but P and K may help carry plants over in dry spells.

No statement was made by farmers that 'now we have learned we will go and do it' – suggests they have heard, but *need experience to believe and act*. This supports our idea of making this a 2-stage, action learning activity.

Justice was not done to 'how are fertilisers used?', except split N went well, also P and K should be applied (farmers answered this question in quiz). *Should do banding of fertiliser in practical work in field.*

Reinforcing and evaluation

Quiz was fun, well engaged farmers, and questions answered well (12/14). Showed clearly that farmers had learnt a lot, and that the quiz had helped reinforce learning.

Farmers did not answer which fertiliser contains only P – (we did not give them the name!). The other one they couldn't fully answer was the need to control weeds and diseases to get good responses to higher fertiliser.

High level of apprehension about using any fertiliser (as in our strip test) but after some reassurance they came forward. *The presence of a 'trusted' independent scientist was important to allow farmers to air their concerns about a range of issues (health, soil health, effects on water etc and have them honestly addressed).*

Process

Dina not 'fully satisfied" but can't say how to improve but ……..

- Too much of the team jumping in – farmers need time to think before we jump in. The 'anchor must invite others in the team to jump in.
- Giving time to farmers is important, more time than getting the information right, is to get the farmers thinking.
- Could do with some better visuals
- The nutrient deficiency slides did not help. Omit.

Content

DK had trouble translating English to Bengali (a content problem that says presenter needs to be prepared with thoughts and resources in Bengali)

Table with projector created a problem – isolated some farmers. Need to correct tomorrow –put on floor.

Time and time again they wanted rates and recipes (saying we knew something and were holding back) but understood in the end that we are undergoing a *process* that will let then determine this. We told them they don't have to have confidence in us, they can do tests hand have confidence in what they see. In the end, 16 of the 26 farmers said they wanted to participate with us in the test strips (now whole fields)

Dina – could improve efficiency of workshop by working with literates in one group and non literate in another (need to manage perception that we discriminate against the less literate - our process was more literate friendly. For less literate need more visual resources? Have a more user friendly process for all.

This is more than a four hour workshop to do it well.

Facilitator worksheet for fertiliser workshop 2 (October, 2006)

Workshop for reflection and future planning

Introduction (15 minutes)

Q. Why are we having the workshop?

A. To find out what we learnt from the field work

ACIAR Team Aim:

3. To reinforce 'intended' learning from the fertiliser workshop
4. To find out any other 'emergent ' learning
5. Stimulate and motivate
6. Action plan

Context to explain to farmers:

- Within overall objective of increasing cropping intensity and diversity and crop yields THIS IS THE BOUNDARY OF THE PROJECT – must focus on few major crop options
- Part of a 3-year project – activities will build on one another
- We won't provide prescriptions – but will sit together and learn
- Farmers suggested the crops and land, we suggested fertilisers and management – now let's learn

		Section Content	Processes used	Desired outcome/learning
Section 1				
10.20 - 11.00	1. What were the expectations of farmers and team for this activity	Experiences of the work on black gram and other crops/nutrition work	Focus groups (3) one for black gram, one for short-duration paddy and finger millet, and one for those who did not participate. Plenary (Arnab) Presentations /questions (15 mins/group) Ashok to document on butcher's paper Flip chart Researcher's expectations on a flip chart to be turned over after the plenary	To know why farmers participated in the first place (baseline data). To know how well farmer and researcher expectations matched To know if any mis-match affected project conduct and outcome - gaps
11.00 - 12.05	2. Knowledge of what we (farmers and team) learnt in relation to intended outcomes (fertilisers and soil fertility)	• Farmers own observations on nutrient responses • Crop yield data (black gram) • soil P data • nodulation data photos of nodules	Focus groups: 3 simultaneously, each with representatives from each crop group and non-triallists. In relation to fertility/fertiliser, the *focussing questions* are on a) soils, b) crops and c) responses to fertiliser (15 mins) Plenary presentation of findings (record on butcher's paper (20 mins) Plenary: Sharing of researcher's data (10 mins) Group discussion (15 mins) Summary: (5 mins)	Knowledge about fertiliser reinforced: • Soils deficient in P and crops respond to P applied • There is an optimal P • Legumes don't need N (if nodulated well) • Non legume crops respond to N
12.05 - 12.20	Tea Break *Section 2*			

12.20 -1.00	3. Identify and analyse gaps between what outcomes were expected and what were achieved	What transpired earlier (ie the earlier outcomes are this section's content) • Farmers observations • Team observations	**Reflection** in 'fishbowl' groups: one for black gram and rest look on etc: Ask farmers and ourselves to be frank about what we could have done better (and not just blame the fertiliser, the crop etc). Discuss • What did farmer's find difficult, why • what did not work well and why, • what went well • how would you do it next time **Presentations** (5 mins each group) Our reflection (5 mins) • …farmer commitment strong – but sometimes difficult for them • good opportunity to increase crop diversity, intensity, and yield (by fixing nutrient deficiency) • P is generally very deficient – soil test plus crop responses • K appears to be deficient for legumes (explains response to ash) • N very deficient (for non legumes) • For black gram, both P and K needed, but the K may come from ash, if farmers have it. • Banding of P • Weed control critical – yields could be doubled maybe if better • Lots of learning for researchers as well as farmers:- o An unknown problem with baid (N, soil structure? Need to solve o Soils less fertile than we thought o Plenty of residual water to be used o Potential value of mulch to aid germination and improve soil fertility **Summary** (15 mins) Open to farmers about what they want us to study in their catchment	Participants appreciate what they could have done better and commit to do it better Any new significant new research questions exposed Process Knowledge that will help us improve our process (workshop and practice) to enhance farmer learning; including the research team relating better to the farmers And ……
1.00-1.30	4. Action Planning		**Group session**: (30 mins) 1. Research- Who wants to work with us next year on • fertilisers • New crop options 2. What role they play, kind of support do you want from us 3. What can we do differently This means commitment to further workshop to develop specific plans, as well as commitment to kharif4. Farmers - What intentions do you have to do things differently in your own fields (15 mins) Q. What are the things that you have learnt, other than about fertilisers	…….. Farmer's stimulated to take action (participate in fertiliser and crop option work next kharif) • Identify farmers to collaborate next year – and participate in the design (BEFORE Shane's visit - Farmers identify fields for work - Shane to do EM • Identify factors to consider in planning next year • Any planned changes for other fields identified so o we can support (what type) them o find out if intentions are to change, an indicator of adequacy of project, and o get farmers to reflect on the recent experience and use it to support change
Lunch				
	5. Evaluation	How was workshop knowledge applied: did it change farmers behaviour? Learn how to strengthen process		

11.5 Learning cluster

This activity was designed to prepare Pogro villagers to use new water resources made available by WSD. Previous Amagara experience had shown that merely providing water is not enough to initiate agricultural development and improve livelihoods, but success builds confidence that, with and new knowledge and skills, can lead to change. A small sub-watershed within Pogro village but outside the hydrologic boundary of Pogro was developed with ‘seepage pits’ for 5 families. These families were guided to grow *Rabi* crops (that had never been grown before), but otherwise they provided all labour and inputs. Meetings were held with farmers to draw out observations and reflect on them. The first aim was to facilitate change in these families through a successful experience of growing crops in the *Rabi*. The second aim was to use these farmers as a focal point for learning for the whole village in the year prior to full WSD. Finally, the cluster of families/fields was used for ‘exposure’ visits from other villages.

Learning cluster - Steps followed in structured learning activity				
Sl. No.	**Intervention**	**Process**	**Output expected**	**Role of PRADAN**
1	Planning workshop	Each family (Both Husband & wife) will make plans around their hapas, VCC members will also be present and help the families to plan around the hapas	Each family will have a *Rabi* plan around their hapa, VCC also owning the plan	To facilitate the workshop
2	Field visit	PRADAN professional along with the family. members visit the hapa, find out the feasibility of the plan, and finalise the action plan		Helping the farmers to judge the feasibility of their plan
3	Explaining the family on the steps of implementation	Meeting with the target families	Family came to know the rationale of each steps	Explaining the rationality
4	On -field demonstration	Follow the process of I do, you observe ,Do jointly, then you do I observe	The member become confident to carry out the process on their own	Ensure the learning process
5	Joint exploration	Regular field visit of PRADAN staff, family members, VCC members & possibly the other villagers	Everyone should know what is happening in the field & why, fix action plan accordingly	Ensure the learning process
6	Arranging exposure visit of other villagers	Interaction between the target families and the villagers on the steps followed, problems faced, experience so far and expectations from the intervention	The villagers will leave the place motivated to take up on their own field.	Facilitate the discussion
7	Making it an agenda in the weekly VCC meeting	Discussion on the progress of *Rabi* plan, problems encountered and	VCC will make action plan on monitoring , Ownership building around the *Rabi* plan of the VCC members	Facilitate the discussion
8	Collection of Bio-physical data at different stages	Target family with the help of VRP	Required data will be collected on time	Ensure the process
9	Analysis of data			Done By PRADAN staff
10	Sharing of result	Workshop with the villagers	Helping the villagers to analyse the potential of water, suitable cropping system and it's financial implications	Facilitate the discussion

11.6 Hydrological model for the Pogro study site

The primary model used in this study is IHACRES (Jakeman *et al.* 1990) rainfall-streamflow model, using the catchment moisture deficit (CMD) version of the non-linear loss module (Croke and Jakeman, 2004). The model has been modified for use in this study in two ways:

1. Inclusion of a surface store to account for the impact of ponds, bunds, pits etc on the infiltration and runoff. Five land surface types are considered in the model: upland areas draining to ponds, ponds, Tarh land, Baidh land, and lowland (Bohal and Kanali) areas.
2. The CMD module has been modified to partition water between the shallow and deep aquifers, and only models subsurface fluxes (surface fluxes are handled by the surface store module).

The conceptual diagram of the model is given in Fig. 1. Overland flow from upland areas is assumed to drain to either ponds or upland areas that have water control structures (bunds, pits etc). Overflow from the ponds and upland structures then contribute to the lowland storage, and any overflow from the lowland storage appears as stream flow at the culvert. This structure ignores some of the fine detail of the Pogro catchment (e.g. the forestry area in the south-east of the catchment, part of which drains directly to the culvert, and the fact that while most of the ponds are located in the upper parts of the catchment, some are located lower in the catchment), but does capture most of the characteristics of the study site.

Input data needed by the model are:

- Area of catchment, and proportion of each land class
- Infiltration rate (K_{sat}) for each land class
- Storage capacity of each land class
- Evaporation/infiltration threshold (currently used for the baidh and lowland land class only)
- CMD module parameters (d, h, n, and f)
- Rainfall and potential evaporation time series

The surface module produces estimates of overland flow, evaporative loss, storage and infiltration. The overland flow is convolved with a transfer function to generate the contribution to streamflow at the catchment outlet, using 2 identical stores in series (Nash cascade) to reproduce the delay in peak as well as the overall shape of the peak. The infiltration is passed to the CMD module to provide estimates of the inputs to the shallow and deep aquifers. The shallow aquifer is assumed to contribute to streamflow within the study catchment through a single exponentially decaying store, while the deep aquifer produces a subsurface flow that contributes somewhere downstream of the gauge.

The model can operate at any temporal scale, though this will impact on the parameter values, particularly the infiltration rates. Initially, the model was applied at a 10 minute resolution, so that impacts of loss of information regarding rainfall intensity could be avoided. For application to the East India Plateau, the model will be applied at a daily time scale due to the resolution of the available rainfall data. This means that the infiltration rates used in the model will need to be reduced significantly in order to adequately capture the runoff.

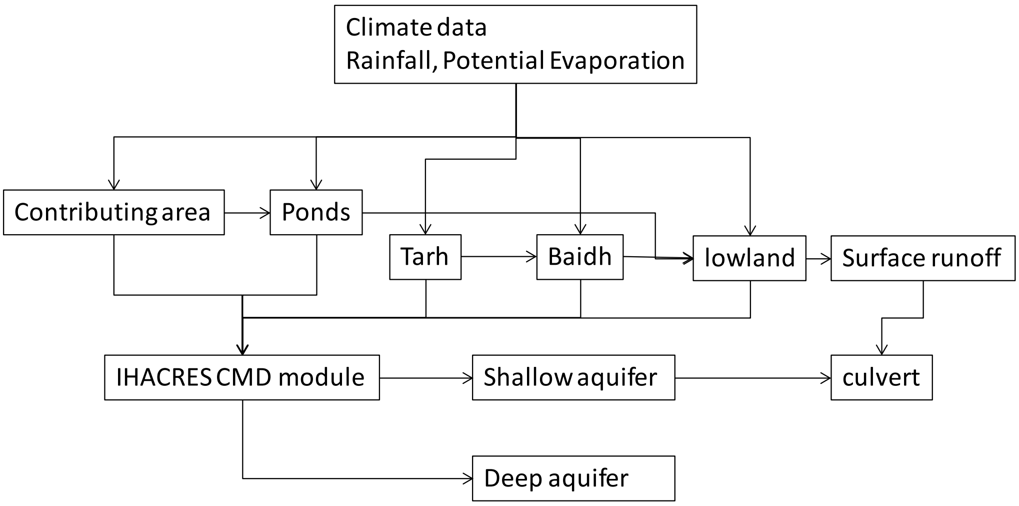


Fig. 1. Conceptual diagram of modified IHACRES model applied to Pogro study site.

Surface store

The surface store module is a simple mass balance calculation that takes into account direct rainfall on the surface, runoff from the uphill contributing area, evaporation loss and infiltration into the subsurface system. For the lowland land class, the evaporation and infiltration are decreased when the CMD decreases (i.e. catchment becomes wetter) below a set threshold (150 mm). This is because under wet conditions, the surface storage in the lowland areas is maintained by water from the shallow aquifer system (as seen in the piezometer data where the groundwater level was above the surface for many of the piezometers in the Bohal area).

CMD module

The modifications to the CMD module involved rewriting the module to produce two outputs: *U* (contribution to the shallow aquifer) and *R* (contribution to the deep aquifer) rather than just the effective rainfall, though without addition of extra parameters (over the 2 segment form in Croke and Jakeman, 2004). The evaporative loss from the moisture store uses the original functional form adopted by Croke and Jakeman (2004).

The revised drainage equation was derived using the same approach as taken for the original module, where the assumption was made that at a particular soil moisture, there is a set fraction of rainfall that goes to *U* and a different set fraction that goes to *R*. This can be represented by:

$$\frac{\Delta U}{\Delta P} = n\left(1 - \mathbf{f}_U(M)\right), \quad \frac{\Delta R}{\Delta P} = (1-n)\left(1 - \mathbf{f}_R(M)\right)$$

$$\Delta M = -\Delta P + \Delta U + \Delta R$$

$$\frac{\Delta M}{\Delta P} = n\,\mathbf{f}_U(M) + (1-n)\,\mathbf{f}_R(M)$$

where *n* is the fraction of drainage that goes to the shallow store under saturated conditions, $\mathbf{f}_U(M)$ and $\mathbf{f}_R(M)$ are functions that determine how the flux to both aquifers varies with catchment moisture deficit (*M*), and *P* is the input to the moisture store (in this application, this is infiltration from the 4 land classes). Taking the limit as D tends to zero gives the differential equation:

$$\frac{dP}{dM} = \frac{1}{n\,\mathbf{f}_U(M) + (1-n)\,\mathbf{f}_R(M)}$$

which can be expressed as:

$$P_k = \int_{M_i}^{M_f} \frac{dM}{n\,\mathbf{f}_U(M) + (1-n)\,\mathbf{f}_R(M)}$$

11.1 .

Conditions on $\mathbf{f}_U(M)$ and $\mathbf{f}_R(M)$ are:

1. Lie between 0 and 1
2. $\mathbf{f}_U(0)=0$ and $\mathbf{f}_R(0)=0$
3. Non-decreasing functions (derivative never negative)
4. $\mathbf{f}_U(x) \rightarrow 1$ and $\mathbf{f}_R(x) \rightarrow 1$ as $x \rightarrow \infty$
5. $\int_0^{x_1} \frac{dx}{\mathbf{f}_U(x)} = \infty, \quad \int_0^{x_1} \frac{dx}{\mathbf{f}_R(x)} = \infty, \quad x_1 > 0$

The last condition states that an infinite amount of rainfall is needed to reach a completely saturated condition.

An additional condition is that the above integral can be solved analytically for M_f, as well as ultimately U and R.

The simplest functional form that meets all six conditions above is shown below. The solution of this set of equations is then:

$M > h$

$$M_f = M_i - P, \qquad U = R = 0$$

$d < M \leq h$

$$M_f = M_i e^{-P(1-n)/h} - \frac{nh}{1-n}\left(e^{P(1-n)/h} - 1\right), U = 0, R = P - M_i + M_f$$

$M \leq d$

$$\Gamma = \frac{dh}{nh + (1-n)d}$$

$$M_f = M_i e^{-P/\Gamma}$$

$$U = n\left(P + \frac{M_f - M_i}{\Gamma d}\right), \qquad R = P - M_i + M_f - U$$

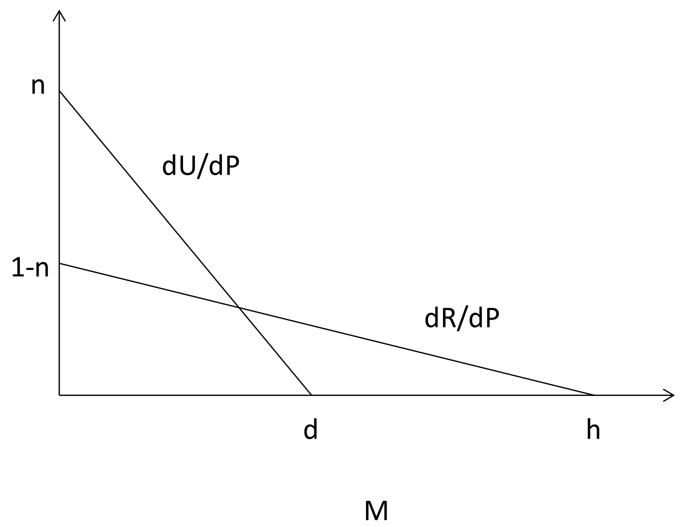


Fig. 1. Fraction of rainfall that becomes U & R as a function of catchment moisture deficit M

11.6.1 Application

The model has been applied to both gauged culverts, and the observations of pond water level. Calibration is a two stage process:

1. Areas were determined from the GPS survey of the catchment, coupled with analysis of the Hydro1K 7.5 arcsecond DEM.
2. Ksat values were initially set using the infiltration measurements carried out through the project. The values were: contributing area for ponds (1 mm/hr – mostly compacted areas around villages), pond (0.4 mm/hr), tarh land (30 mm/hr), baidh land (5 mm/hr) and lowland (0.1 mm/hr).
3. The upland and pond storage modules are calibrated using the observed pond water levels. The observed levels are assumed to be representative of all the ponds in the study site (the model does not model individual ponds, just a single representative pond, so if the pond in the model overflows, it is assumed that all ponds overflow at the same time).
4. Time constant for the shallow aquifer is set to 5.5 d based on the 2009 pump test.
5. The remainder of the model is calibrated to the observed streamflow through the culverts. At the moment, calibration has been done by hand.

11.6.2 Pogro

The model was applied to the Pogro catchment at 3 temporal resolutions: 10 minute, hourly, and daily. For all model runs a value of the coefficient of determination R^2 (also known as the Nash Sutcliffe efficiency) was calculated using all points with available streamflow data (manual and automatically recorded). The available data suggest that the catchment area for culvert A needs to be increased from 1.98 km^2 by at least a factor of 2 in order to generate the estimated streamflow. There are three possible causes for this:

- Under-estimation of the rainfall (a common problem, but usually of the order of 5%, not 50%, Duchon and Essenberg, 2001);
- Over-estimation of the streamflow;
- Catchment area under-estimated.

To the west of the catchment, there is a dam which can overflow into the study site. Assuming all the overflow from the dam comes into the study site, this would given an increase in the catchment area to 3.79 km^2. The match between this and the required increase suggests this may be a valid solution. The implication of this is that in the late wet season, the runoff from the catchment is about 100% of the rainfall, but this is not unexpected due to the very high rainfall during the wet season.

10 minute resolution

A rough (by eye) calibration of the model was made to both culverts. The adopted parameter values are given in Table 1. The coefficient of determination (Nash Sutcliffe model efficiency) for culvert A was 0.65, and culvert B 0.19. As the model has not been properly calibrated yet, the results shown here should be considered preliminary. Note that the parameter values were fixed over the entire period, meaning that the impact of the WSD work that was done during the project (mostly in the 2009/2010 dry season) is not taken into account. The result is a tendency for the modelled flows to start before the recorded flows in 2010 and 2011. While this could be taken as indicating the impact of the WSD work on the flows through culvert A, there is a similar effect on the flows through culvert B, indicating that further work is needed on the model to adequately capture the climate driven impacts on the generation of stream flow through the two culverts.

The AWS was installed in the 2006 wet season, so initial values for storages (particularly pond storage) are incorrect leading to under-estimation of pond storage throughout that year (for better indication of modelled storage for 2006, see the daily model results). Aside from 2006, the model captures the variation in the recorded pond storage reasonably well, indicating that the combination of the contributing area draining to the ponds coupled with the storage and K_{sat} for the ponds and their contributing area is adequately capturing the fluxes into and out of the ponds. The impact of weather patterns for each year on the duration of inundation in the Baidh and Bohal areas can also be seen in the third panel.

To reproduce observed flows in the late wet season, a threshold for infiltration was included in the model leading to no infiltration from the Bohal or the Baidh when the catchment moisture deficit (determined in the CMD module) is below their respective thresholds. Evaporation was also switched off, with this transferred to the CMD module (simulating the replenishing of the surface water in areas where the shallow groundwater level was above the surface). Initially, it was perceived that the CMD module would generate the flow through the shallow aquifer. However, the model (given the current calibration) does not produce a suitable input to the intermediate flow storage to represent this (the slow component is not visible in the plots shown, and the recession of the flow peaks are not reproduced). Modifications to the model are being investigated to enable this flow component to be better represented in the model.

Table 1. Parameter values for Pogro model

Parameter	Culvert A	Culvert B
Pond contributing area		
Maximum storage (mm)	3	3
K_{sat} (mm/hr)	1	1
Ponds		
Maximum storage (mm)	3000	3000
K_{sat} (mm/hr)	0.4	0.4
Tarn		
Maximum storage (mm)	3	3
K_{sat} (mm/hr)	30	30
Baid		
Maximum storage (mm)	50	50
K_{sat} (mm/hr)	0.5	0.5
Infiltration threshold (mm)	130	130
Bohal		
Maximum storage (mm)	100	100
K_{sat} (mm/hr)	0.05	0.05
Infiltration threshold (mm)	180	180
CMD module		
Infiltration threshold (mm)	150	150
Flow threshold (mm)	200	200
Recharge threshold (mm)	150	150
Stress threshold (mm)	150	150
Fraction of recharge when saturated	0.1%	0.1%
UH module		
Quick flow time constant	0.2	0.08
Number of stores	2	2
Shallow aquifer time constant	5.5	5.5
Number of stores	1	1
Deep aquifer time constant	30	30
Number of stores	1	1
Land use		
Pond fraction	2.5%	3.5%
Baidh fraction	52.8%	34%
Bohal fraction	22%	40.2%
Pond contributing area	12.5%	17.5%

Daily resolution

The model has also been applied to both culverts at a daily resolution. If rainfall is assumed to be constant across a time step (i.e. 1 day), then this results in a significant decrease in the intensity and an increase in the duration of rainfall, leading to either modifying the model to use information on rainfall intensity; making some assumption about what the intensity was; or modifying the K_{sat} values for the areas with little surface storage (i.e. not the ponds or bunded paddy fields). Given that the model will be applied on a much larger scale using gridded daily rainfall and temperature data, the last option (modifying K_{sat} was adopted). For both culverts A and B, the K_{sat} value for the contributing area for ponds was decreased from 1 to 0.7 mm/hour, based on the modelled storage in the pond surface store. All other parameters were fixed at the values in Table 1.

11.7 Upscaling details in Purulia 2010

Process	Content	Outcome	Frequency	Status
Planning workshop with SHG member's families (2 SHGs together), women facilitated to participate actively. CSP would ensure the plan completion.	• Concept sharing of the cropping system through IEC material and experience sharing. • Family wise planning	-Plan of interested families generated, indenting for inputs for ensuing season completed -SHG members jointly develop the plan to make it group's plan -The AMC member in charge and the CSP in charge is also being groomed	Once	Conducted with approximately 4000 families with a total of around 240 professional days engagement. Around 2000 families registered with the Federations to participate in the agriculture process by paying Rs25/ only to the Federation.
Indent collation and procurement of inputs	The CSP enters the indent format with accountant of federation and procures inputs from federation, distributes it to farmers	The inputs reach the farmers on time.	Every fortnight and as & when required	Performed as per need of the programme. Systems developed to perform the task.
-On field demonstration by staff, CSP on crops. -Demonstration in farmer's field observed and reflected by other farmers of the village -Women specially encouraged to be the participant in the demonstration	-Field demonstration on practices and system (PRAXIS learning) Hands on training to the farmers	Women growing confidence with technicalities in agriculture Farmers trained	Ongoing with each new crop	Continuously done by the Professional and CSP in the field.
Field visit by PRADAN staff in each village regularly (once in 10 days) The men farmers join in SHG women are taken along while doing field transact explaining the observation to gather, reflect and interpret	Field transact along with SHG women	Update and verify progress Train the women to look into crops critically and analysing the observation and interpret Capacity building of farmers Immediate action points followed	ongoing	Continuously done by the Professional and CSP in the field
Weekly meetings with CSP and AMC of a contiguous area in every CSP's work domain in rotation.	Meetings followed by field visits. The progress of each farmer's crop is reviewed and discussed in line with the prescribed format. Review on the prescribed format Sample field visit of good, average and bad crops and any critical field Farmers (men & women) accompanying during field visit	Update on the progress and conditions of crops in the field Any emergency attended Grooming AMC member to play her role as management committee & developing knowledge in agriculture Grooming of CSPs in understanding the issues Generation of action points Capacity building of farmers (men & women)	Weekly or fortnightly	Were conducted when crop was in field. Every Professional had to look after 8-10 villages and conduct these meetings, which occupied most of the time.
PRADAN staff conducting FAST- field agriculture seminar & training with CSP, women and men farmers,	Designed exposure to farmers fields Observing , reflecting & drawing out learning's	Grooming AMC members (all women) Grooming CSPs Building new knowledge Generating action points Capacity building of farmers (women & men) and staff	As and when required	Enthusiasm declined as farmers were losing interest.
Discussion in SHG meetings on progress of each members crop	-The SHG members discuss on the progress of each members towards her plan in agriculture and crop status. -The SHG women members review, reflect CSP's performance & support reviewed and plan actions.	Improve plans if needed Women learn more about culture of agriculture Role & the self perception of the women on their role in agriculture changing	Weekly	Could not be done because of unavailability of Professionals to facilitate this process in 400 SHG's.

	-Women look into agriculture practices			
CSP reporting to clusters in the cluster meeting	CSP presents an analysed data on the progress of SHG members, SHG wise	The SHG institutions take charge of the developments Creating space for the women to understand critical areas of agriculture Building confidence to talk about agriculture practices Building confidence in making critical decisions	Monthly	System could not be set.
Monthly meeting with CSP and AMC by PRADAN professional	Review and monitor the progress in the field Cross learning among the AMC and CSPs	Knowledge building from experiences, observations, reflection Capacity building of AMC members in management	Monthly	Conducted monthly. Helped to develop alternate crop plans/options because of the drought and also take these to the farmers.
AMC reporting to federation Board	AMC representative making formal presentation on the progress of agriculture program	AMC learning to present data Federation board members learning to manage program and review performance of program	Bi monthly	4 such events conducted which helped in developing alternate crop options to cope with the drought.
Review reflection meeting with the farmer families in each village by staff	Designed sharing of outcomes, observations and experiences and reflecting on them	Generate new knowledge Women actively generating knowledge Action plan ; next round plan is ready	Quarterly	On-going and would also form part of the process of planning for the coming year. With all the approximately 2000 families Agriculture pass-books were introduced to capture the crops cultivated and the ensuing income, which would form the basis of discussion in these meetings.

11.8 LogFrame developed at a workshop in Toowoomba in August, 2006

VISION "Substantially improved and continually improving quality of life for the rural poor in the East India Plateau with effective collaboration between different stakeholders enabling the community to sustainably manage their resources" (the long-term scenario that team members desire for the East India Plateau)

(IMPACTS) The VALUE of project's contributions	1. Quality of life; Participants making positive changes will improve the quality of life of farmers and help progress towards the teams vision		2. Sustainable management of natural resources	
(OUTCOME) Changes in PRACTICES - change that result from the project. These are 'higher-order' outcomes	Changes in farmer & agency practices that will be required – having biophysical understanding and having processes and agency capacity to support change will lead to change 1. Farming practice – Constraints other than knowledge are not expected to preclude knowledge being used to achieve change (Current practices must be improved to become sustainable and able to support the 'dignified' quality of life desired for the East India Plateau)		2. Collaboration – Collaboration of the community and different agencies will provide the necessary knowledge and skills to achieve real change on the ground (Government, NGOs & communities will have to work together to share their knowledge and overcome the local constraints to the improved farming practices needed for sustainable management and a better quality of life)	
(OUTCOME) Changes in participants' KNOWLEDGE, SKILLS, ATTITUDES & ASPIRATIONS These are lower-order outcomes that need to be achieved in order for achieve higher-level outcomes	Enabling of agencies and community to make changes 1. Biophysical knowledge – better biophysical understanding will help identify better farming systems & local farming practices	2. Skills to apply knowledge – agencies & community also need the skills to apply improved knowledge & decision support tools to their own farming systems	3. Capacity building – agencies and community must have the capacity in terms of resources, structure and desire to enable change	
(OUTPUTS) The direct measurable results of project activities	1. Trial results – compilation, analysis & interpretation of research trials is needed to better understand the watershed & local farming systems	2. Tools for the application of knowledge – Decision support tools will help people apply new/existing knowledge to their own farming systems	3. Workshops and training materials – workshop process & materials must be developed & used to understand and apply the project experiences locally	4. RDE process – a clear RDE process is developed to engage all participants and improve watershed development
(ACTIVITIES & RESOURCES) Things the project must do	1. Agency commitments – agencies meet time & resource commitments to achieve project outputs & outcomes	2. Research trials – trials are planned & developed to better understand the watershed & local farming systems	3. Workshops/community activities – workshops/activities are planned, developed & run with participants	

Description of success and suggested indicators – working paper (Aug 2006- May 2007)

Impacts - the VALUE of the project's contributions

1. Improved quality of life: Describe successful outcome: ... what will improved quality of life look like in the EIP?

Indicators:	Ways to collect/verify (who, how, when)
Platform for food security/nutritional sufficiency throughout the year (a). Crop diversity, crop yields, cropping intensity and surplus food kept by participants in case study watersheds	PRADAN resource assessment surveys already collect this information. This information has been done at the beginning of the project and can be repeated at the end of the project
Increased income/opportunities (b). Sources of income (crop diversity) (c). Levels of migration (less is good) (d). Increased income	 Actual measure (crop diversity in resource assessment surveys) Additional surveys Modelling using crop diversity/yield/intensity data?

2. More sustainable management of natural resources: Describe successful outcome: what will more sustainable management of natural resources look like in EIP?

Indicators:	Ways to collect/verify (who, how, when)
Baseline condition and use of natural resources (a). Catchment runoff (b). Level of cover (c). Maintenance/replacement of Phosphorus Other indicators could be developed if we need more detail. E.g. level of erosion, amount of water harvested, fertility levels (eg Organic carbon %).	Measurement at base of catchment - modelling Number of days of crop/hectare/year (survey) Number of people adding phosphorus (survey) Situation statement and EIP Baseline data summarising practices and conditions in both the case study watershed from PRADAN resource assessment survey (if further details required)

Outcomes (higher-order) – Changes in farmer & agency PRACTICES

1. Improved farming practice: Describe successful outcome: … what are the key farming practices in the EIP that will change as a result of the project? ….

Indicators:	Ways to collect/verify (who, how, when)
Practices used in villages - Practices are to be assessed simply by recording the number of farmers using each of the following practices: (a). Growing a second crop (b). Number of crop species grown (c). Undertaking weed control (d). Use of fertiliser (e). Use of line sowing Others are area of second crop and farmers investment in agricultural land (Rs)	The extent of these practices is to be measured by simply surveying farmers (yes/no). These are not currently in the Baseline survey and so would need to be added (or asked retrospectively in the near future)

2. Effective collaboration: Describe successful outcome: ... what will collaboration between agencies and between agencies and the community look like in the EIP? ….	
Indicators:	**Ways to collect/verify (who, how, when)**
Quantity and quality of collaboration (a). Extent of FARMER participation in activities - Directly involved in participatory trials - In other learning activities to share results (eg nutrition wkshops) - Other project activities (field walks etc) (b). Quality of agency participation in activities - Activities with joint planning/interpretation by agencies	Observe/document number of farmers in each project activity We can assess 'quality of participation' by documenting how many of these activities have explicit farmer participation in planning + interpretation of results Observe/document number of farmers in each project activity Again, we can supplement this with survey of quality of participation (e.g. wrt Pretty's typology) at end of project
Ongoing collaboration (c). Number of joint future projects (lasting partnerships)	Review of future project proposals and activities

Outcomes (lower-order) – Improved agency & community KNOWLEDGE, ATTITUDES, SKILLS & ASPIRATIONS)

1. Biophysical knowledge: Describe successful outcome: … what are the key research questions that the project will answer? ….	
Indicators:	**Ways to collect/verify (who, how, when)**
Knowledge of key project topics: (a). Watershed hydrology/water harvesting (b). Integrated soil & water management (c). Crop options/choices/agronomy (d). Potential downstream impacts (ie. Water yield & quality)	Can assess via traditional documents/publications (e.g. annual reports, scientific articles, situation/baseline statements, tools developed to apply knowledge). An example is PRADAN's new Booklet for WSD (benchmark of current knowledge) However, changes in both FARMER and SCIENTISTS knowledge can be assessed by annual technical reviews of results with the self-help groups in the villages and also groups of scientists in the project

2. Skills to apply knowledge: Describe successful outcome: ... what decisions will people on the EIP be able to make as a result of the project? ….	
Indicators:	**Ways to collect/verify (who, how, when)**
Skills developed in these same key project areas: (a). Watershed hydrology/water harvesting (b). Integrated soil & water management (c). Crop options/choices/agronomy (d). Potential downstream impacts (ie. Water yield & quality)	As described above

3. Other capacity building: Describe successful outcome: ... how effectively can participants utilise the available expertise in the EIP? ….

Indicators:	Ways to collect/verify (who, how, when)
Farmer capacity (a). Number of effective self-help groups **Agency capacity** (b). Desire to and ability to work in small groups (c). Attitudes towards the project, project activities and specific technologies	Observe/document as part of project activities. This will complement assessment of knowledge and skills which also build capacity Surveys at end of the project, with feedback from the project retreat and project review. Again, this will complement assessment of knowledge and skills which also build capacity

Outputs - Enabling change (improved agency & community knowledge, attitudes, skills & aspirations)

1. Trial results: Describe successful outcome: ... what are the key research questions that the project will answer? ….

Indicators:	Ways to collect/verify (who, how, when)
Research questions are answered and other insights developed: (a). Watershed hydrology/water harvesting (b). Integrated soil & water management (c). Crop options/choices/agronomy (d). Potential downstream impacts (ie. Water yield & quality)	As above (in 'Knowledge of key project areas')

2. Tools for the application of knowledge: Describe successful outcome: ... what decisions will people on the EIP be able to make as a result of the project? ….

Indicators:	Ways to collect/verify (who, how, when)
Ability to make informed choices on resource utilisation and new expertise (a). Number of scientists using decision support tools (b). Number of villagers/participants using decision aids at workshops	Observation/survey Observation and documentation at activities

3. Workshops and training materials: Describe successful outcome: ... what workshop materials and use of workshops are expected in the EIP? ….

Indicators:	Ways to collect/verify (who, how, when)
Training materials developed and used successfully (a). Number of workshops (b). Number of people who attended workshops to help people understand and apply their project experiences locally	Archive of project resources Attendance records & survey of usefulness of materials

4. RDE process: Describe successful outcome: ... what are the features of the RDE process to be developed in the project? ….	
Indicators:	**Ways to collect/verify (who, how, when)**
RDE process is documented for WSD across the EIP and other regions	RDE guidelines included in publications such as PRADAN's booklet of watershed development (Symposium suggested at end of project to involve policy people as well and share insights)

Activities & resources used in the project

1. Agency commitments: Describe successful outcome: ... agencies are become fully committed to the project in the EIP ….	
Indicators:	**Ways to collect/verify (who, how, when)**
• Agencies have met staff time commitments	Declarations in annual progress reports

2. Research trials: Describe successful outcome: ... research trials have been planned and conducted as required by the project and participants ….	
Indicators:	**Ways to collect/verify (who, how, when)**
• Number of research trials planned and developed	Declarations in annual progress reports

3. Workshops/community based activities: Describe successful outcome: … workshops & community based activities are planned & conducted as required by the project & participants? ….	
Indicators:	**Ways to collect/verify (who, how, when)**
• Number of workshops/community based activities planned and developed	Declarations in annual progress reports

11.9 Soil fertility in the research watersheds

Detailed data for soil analysis from 2006-2008, Pogro

	Min N (kg/ha)	OC (%)	Extr P (Bray) (mg/kg)	Exch. K (mg/kg)	Soil pH (water)	Soil EC (mS/cm)
			Baid 2006			
Average	**137**	**0.61**	**6.3**	**93**	**5.5**	**0.06**
Max	198	1.38	24.2	253	6.7	0.12
Min	85	0.30	0.0[28]	30	4.7	0.03
			Kanali 2006			
Average	**139**	**0.64**	**4.2**	**107**	**6.0**	**0.05**
Max	207	1.03	16.1	175	7.0	0.11
Min	91	0.42	1.5	53.6	5.1	0.02
			Bohal 2006			
Average	**106**	**0.73**	**3.5**	**79**	**7.2**	**0.11**
Max	150	1.20	5.9	124	8.3	0.19
Min	67	0.44	1.1	44	5.9	0.05
			Baid 2007			
Average	**96**	**0.69**	**4.0**[29]	**71**	**5.2**	**0.07**
Max	129	0.91	16.0	123	7.1	0.12
Min	71	0.47	0.0	37	4.4	0.05
			Kanali 2007			
Average	**85**	**0.62**	**3.0**	**51**	**5.2**	**0.07**
Max	103	0.79	7.0	86	6.0	0.13
Min	56	0.35	2.0	29	4.5	0.04
			Bohal 2007			
Average	**95**	**0.74**	**2.3**	**48**	**5.9**	**0.12**
Max	153	1.32	10.7	81	8.5	0.28
Min	62.4	0.41	0.0	28	4.5	0.03
			Baid 2008			
Average	**107**	**0.68**	**4.3**	**80**	**5.7**	**0.04**
Max	145	1.30	14.4	261	7.9	0.11
Min	62	0.45	0.0	34	4.4	0.05
			Kanali 2008			
Average	**96**	**0.74**	**2.5**	**83**	**6.0**	**0.05**
Max	140	0.93	9.6	124	8.2	0.10
Min	60	0.46	Missing val.	50	4.8	0.01
			Bohal 2008			
Average	**97**	**0.69**	**2.6**	**72**	**5.9**	**0.05**
Max	118	1.21	6.9	134	8.7	0.22
Min	54	0.36	0.7	31	4.9	0.01

[28] *Zero means below limit of detection.*

Soil analysis from Amagara, 2007

add rest of Amagara data if we have it

	Available N (kg/ha)	OC (%)	Bray P (mg/kg)	Exchangeable K (mg/kg)	Soil pH	EC (dS/m)
Tanr (non arable uplands)						
Average	**76**	**0.50**	**5.7**	**66**	**4.68**	**0.03**
Max	129	0.91	13.1	99	5.43	0.08
Min	50	0.05	1.6	38	4.25	0.02
Near homestead (often intensively cropped with household 'waste')						
Average	**66**	**0.74**	**22.9**	**154**	**6.18**	**0.07**
Max	78	1.28	30.7	255	7.62	0.13
Min	56	0.44	9.9	50	5.64	0.03
Far homestead (may also receive high inputs of organic materials and intensive cropping)						
Average	**72**	**0.74**	**23.0**	**143**	**5.75**	**0.06**
Max	90	1.17	42.4	255	7.14	0.21
Min	62	0.06	9.1	74	5.29	0.02
Baid						
Average	**75**	**0.49**	**9.6**	**51**	**4.99**	**0.04**
Max	101	0.75	30.2	95	6.06	0.14
Min	56	0.08	1.5	29	4.33	0.01
Kanali						
Average	**98**	**0.56**	**8.2**	**82**	**4.87**	**0.05**
Max	112	1.00	42.4	126	5.85	0.08
Min	90	0.35	1.3	45	4.39	0.02
Bohal						
Average	**88**	**0.89**	**2.4**	**67**	**5.82**	**0.059**
Max	112	1.42	17.0	98	6.75	0.090
Min	67	0.45	0.5	49	4.85	0.020

11.10 Soil fertility - Jharkhand soil survey, 2010

All values are the mean of 6 fields

		Olsen P (mg/kg)	Bray (mg/kg)	Exch K (mg/kg)	OC%	pH
Gumla	tanr 1/gora	5.5	12.3	240	0.70	5.64
	tanr 2	2.6	2.3	179	0.72	5.49
	tanr 3	6.2	3.6	197	0.47	5.22
	Baid	2.4	3.3	143	0.72	4.95
	Kanali	4.4	5.0	131	0.72	5.32
	Bohal	1.3	1.3	92	0.77	5.18
Lohardaga	tanr 1/gora	1.6	5.1	53	0.40	5.55
	tanr 2	0.4	1.2	66	0.45	5.38
	tanr 3	0.6	2.5	49	0.46	5.65
	Baid	2.5	2.2	79	0.39	5.53
	Kanali	3.6	2.5	86	0.61	6.73
	Bohal	1.7	1.6	58	0.58	6.13
West Singhbum	tanr 1'gora	2.7	8.0	83	1.16	5.40
	tanr 2	0.6	5.1	60	1.04	5.05
	tanr 3	22.3	19.2	161	0.46	5.66
	Baid	3.9	14.4	60	0.48	5.16
	Kanali	5.9	4.3	66	1.04	5.21
	Bohal	0.5	0.4	80	0.97	5.20
Khunti	tanr 1/gora	2.0	1.0	45	0.41	4.64
	tanr 2	1.1	1.9	43	0.63	4.68
	tanr 3	5.9	8.9	65	0.54	4.87
	Baid	0.5	0.5	53	0.75	5.03
	Kanali	1.7	1.0	45	1.31	4.78
	Bohal	1.7	2.1	51	1.45	5.10
Dumka	tanr 1/gora	2.9	2.1	63	0.98	5.19
	tanr 2	1.5	1.1	80	0.57	5.02
	tanr 3	12.3	22.2	194	0.96	5.59
	Baid	4.8	2.3	76	1.00	5.44
	Kanali	3.1	0.3	41	0.75	5.88
	Bohal	2.1	0.6	41.0	0.79	6.02
Godda	tanr 1/gora	2.1	4.2	56	1.13	5.85
	tanr 2	5.8	7.8	88	1.18	6.20
	tanr 3	3.3	1.7	71	0.92	6.52
	Baid	2.5	1.6	37	1.17	7.21
	Kanali	8.7	5.3	74	1.45	6.65
	Bohal	3.3	1.7	71	0.92	6.52
Bankura	tanr 1/gora	1.2	1.3	50	0.97	5.52
	tanr 2	3.7	1.7	106	1.27	5.44
	tanr 3	9.4	2.0	69	1.07	5.47
	Baid	10.6	8.4	74	0.89	5.17
	Kanali	2.2	2.1	60	1.20	5.39
	Bohal	2.4	1.4	56	1.41	7.15

11.11 Summary of resource assessment - soil & rice crop surveys

For building farmer knowledge/changing attitudes to resources and management)

Pogro - Paddy rice	
Kharif 2006	Highest yield by land class in kanali land (av. 4 t/ha), but differences between land classes were small. Top yields overall ~7 t/ha - but yields very variable. High yields had 'higher' soil mineralisable N (but many high-N fields still had low yield) (Fig 5). Weak positive response to soil P (Fig 4). Yield in paddy appears to increase with Bray P to c. 4-5 mg/kg Soils low in OC, P and K, but very highly variable, especially for P. pH low in uplands, also variable. There are differences between land classes, but much less than within land class. Clear evidence of K transfer from cropped areas to homestead area. *Observations on methods*: Farmers very interested to see/discuss comparative yield data in a group – good learning process Yield varies in response to many factors, so hard to get simple correlations between crop or soil factors and yield – need large differences and/or sample size, and more powerful multivariate statistics.
Kharif 2007	Highest yields again in kanali (av. 4.3 t/ha) with baid lowest (3.9 t/ha) then bohal (4.2 t/ha). Highest yield 6.8 t/ha, similar to 2006 All higher-yielding fields have higher amounts on mineralisable N and OC in soil (as in 2006), with good control of weeds, diseases. Clear signs of P deficiency in some crops. Apparent response up to ~10 kg P /ha in survey (see below) Soils low in C, P and K, but very highly variable (as above), especially for P. Sustained interest in this group learning exercise. *Methods*: Yield varies in response to many factors ... see above (and also applies to Amagara)
Kharif 2008	Average yield over all land classes was 3.6 t/ha, a decrease from 2006 and 2007, associated with high initial rain (and possible N problems), then low rain after September and some crop failures in baid. Top yields 6.9 t/ha (similar to previous years). Yields in baid, kanali and bohal were 2.9, 4.4, 3.5 t/ha, for surveyed fields not in the omission trial (so low sample numbers). Hard to explain yield variation, except for water
Amagara - rice	
Kharif 2007	Av. Yield over all land classes was 5.9 t/ha, with baid, kanali and bohal 4.7, 5.2 and 7.8 t/ha. Yields highly variable, with best yields (>7 t/ha) in the absence of pests, diseases (both highly significant) Added N appeared to increase yield by 2 t/ha overall (confirmed by split-field results, below). Apparent responses to P (but mostly small) in absence of pests/disease. Compost appeared beneficial, possibly because it provided K which may have reduced pests/ diseases? Exch. K was weakly associated with pest and disease incidence. Soils also low in OC and K, but P more variable. Not as low in P as in Pogro As with Pogro, farmers liked this group sharing and learning.
Kharif 2008	Mean yields overall were 4.4 t/ha, i.e. less than in 2007, possibly related to high early-season rainfall and lower late-season rainfall. Mean yields for baid, kanali and bohal were 3.2, 4.8, and 5.1 t/ha, respectively. Top yields ~7.0 t/ha. Lower yields appear to be explained by either drought (in baid) or weeds and/or pests/disease.

11.12 Capacity building with Pogro-Damraghutu VCC members

A training of three Village Core Committees of Pogro –Damrughutu watershed zone was organized to facilitate the process of knowledge sharing on Natural Resource Management, generating discussion about the role of Village Core Committee in family based planning to address livelihood issues of every SHG member and village at large, and enhancing their food security. The training started with 12 members of Pogro V.C.C, 4 members of Belghutua V.C.C. and 12 members of Damrughutu V.C.C. and the Village Resource Persons of the respective villages. At the start of the training, an enlarged map of Pogro- Damrughutu Watershed was pasted on the board in such a manner that every participant could see it clearly. After seeing it all the participants started whispering among themselves. To get a clear idea about their understanding of the map they were told to have a close look at the map and express their feelings. When asked about what they understood about the map most of them responded ‘We are illiterates so how can we say what is written on it?’ with some amount of confusion on their face. At this Mr. Kuntal Mukherjee who was facilitating the process requested Menakadidi to come near the board and express her idea about the map after observing it closely. She pointed out some of the colors used in the map like red, green, yellow, blue, saffron, brown with other participants adding on to the list of colours. Some of the didis tried to draw attention to the fact that many colours were used more than once. Then Mr. Sudipta Das explained about the purpose of using different colours to depict different resources, assets and infrastructure like ponds, railway tracks, roads, houses etc. He added that all the participants knew the places well because it was the map of Pogro- Damrughutu area and some of them had even saw it. Hearing this some of the didis discussed among themselves about different coloured areas depicted in the map in a bid to identify those area. As they were asked to identify village resources like ponds, various types of land, roads and households most of the participants successfully identified the resources by relating to the appropriate colours and got appreciation for identifying the places properly from all the present members. Then Mr. Kuntal Mukherjee asked the didis ‘Now tell me do your lands, ponds, roads and other resources are appearing more familiar to you or not?’ At this didis confidently replied in positive. After this, Mr. Sudipta Das explained vividly to the participants about the natural flow of water, run off water, water retention at various land types by drawing pictures. Didis also expressed their views about retention capacity of various land types based on their experience.

In the following session, discussion was centered on how to make a happy family. All the participants were told to visualize a happy family and the prerequisites for making a happy family. All the participants seemed to be very enthusiastic and brimming with ideas. Susar bibi from Belghutu V.C.C told that ‘drinking water’ was very important for making a happy family. Another member from the group added that not only drinking water but also water was required for agricultural purposes too. Therefore, all the members had put ‘**water**’ at the top of their priority list. Then Nisu sing Ghatwal from Palasdih mentioned about ‘**fuel wood’** for cooking. Another didi opined that ‘**land**’ was necessary for providing everyone food. ‘**Money’** came fourth on their priority list with most of the participants speaking about the need of irrigation, water harvesting structures, plough etc. Participants also referred about the need of ‘**acquiring knowledge**’ on agricultural processes to get better yield and ensuring optimal use of land through adopting line sowing, crop rotation and vegetable cultivation. Last of all they mentioned about the need of ‘**manpower**’ to carry out various activites. At this juncture Mr. Sudipta Das invited six illiterate participants to come forward for playing a game and handed each of them papers with alphabets of ‘Sukher Sansar’ meaning ‘Happy Family’ written on them. As the participants stood there in a haphazard manner he asked another member to come and organize them in such an order that ‘Sukher Sansar’could be read properly. Padmadidi came up and started organizing the group but ended up organizing them in the sequence of ‘Sansar Sukher’. Then Mr.

Sudipta Das rectified her and discussed each of the criteria for ‘Sukher Sansar’ in detail by asking questions like ‘Tell me where we can get water? How can we obtain fuel? Try to remember the map, the pink coloured areas- what did it indicate?’ The participants replied quickly by saying that it was forest. Then he added that though we could get fuel from forests but we were also destroying them. While discussing about different sources of getting money didis mentioned of government funds. Mr. Sudipta Das helped the group by mentioning specifically the name of government schemes availed by them and the government agencies like B.C.W., Central Government, West Bengal government responsible for implementing the schemes. In the case of ‘knowledge’ all the participants referred to PRADAN. Mr. Sudipta Das also explained to the participants how ACIAR project was helping them in acquiring knowledge on agricultural processes through experimentation.

11.13 Synthesis of focus group discussions

Focus group discussions (FGD) were held in Nov 2011 with the VCC and SHGs in Pogro/Damraghutu and Amagara to support M&E, and the study of gender and engagement processes. A synthesis of the data, structured for reference to key indicators in the M&E, is given below between and within the two communities.

Preface

It is important to note that the ACIAR project was just one of a large number of things that were happening for the various communities. The activities and influences were not only from PRADAN but from various other organisations and the internal relationships within the community and the community's relationships with other communities adjacent to them. Therefore, to assign a definitive relationship between a particular activity and an outcome is difficult.

Quality of life

Both communities and all groups within the communities commented on how their lives had improved during the time the ACIAR project had been operating. However, the two communities had very different responses to enquiries about changes that had taken place in their lives during the time of the projects. Members of the SHG at Amagara commented that there had been "Not some change, there has been a complete transformation". In contrast the SHG Belghutua stated that "When there is work we have food and when there is no work there is no food." Suggesting that in Belghutua the impact was not only from changes in agricultural production.

For both communities a key measure of the improvement in their quality of life was the increase in the emphasis on the education of children and the number of children attending school. This focus appeared greater in Amagara in comparison to Belghutua. In Amagara for women the building of their self-esteem was probably the most important area highlighted followed by the advantages that the increased income had provided especially in the areas of: children's education, no longer having to work outside the community, and the ability to have choice in the selection of essential items (for example being able to choose the type of soap they used). At Amagara women also talked about increased access to consumer goods such as mobile telephones and the ability for children to choose the clothes they wanted to wear. At Belghutua the participants were less able to articulate the changes that had taken place with a few exceptions where people were producing tomatoes.

The source of the improved quality of life varied between sites. In Amagara agricultural production in both rice and other crops in particular tomatoes had become sufficiently important and productive that farmers were able to stay at home and farm rather than seek outside work as a labourer. In contrast, at Belghutua external but locally available labouring work had become more important leaving people limited time and desire to participate in agricultural production other than the core family activity of rice production. Men at Belghutua emphasised the importance and immediate reward from being involved with wage labour rather than agriculture. In particular they emphasised the delay of at least three months from the planting of a crop and receiving any income from the crop.

The farmers at Amagara were clear in stating that agricultural production had increased considerably in recent years and with that increase had been an improvement in the livelihoods of the community members. They stated that now nearly everyone in the community was involved with agriculture (in this case the term agriculture is interpreted as being food production other than paddy rice) and that many landless members of the community were leasing land to cultivate. One farmer provided an outline of the seasonal production of various crops. The statement was made that “We were trained by PRADAN in agriculture, we have learnt a lot from them”.

The women from Amagara commented on some negative social impacts from the increase in income in particular, the increase in alcohol consumption and associated antisocial behaviour. It was reported that in some cases men are selling trees for timber production and using the money for the purchase of alcohol. The women have taken action and the sale of alcohol is banned in their village however, it is still available from adjoining villages – the women plan to continue their campaign to reduce the availability of alcohol in the community.

Not all changes were positive and there was acknowledgement from women at Amagara that the change involved hard work “Agriculture requires a lot of intensive engagement. At times we do not even have time to wash our hands.”. The women also commented that a high level of skill and access to finance is needed “Everyone does not cultivate on the baid – only those who are capable can cultivate on the baid. You need to invest money.”.

Overall the participants in the FGDs at both communities stated their quality of life had improved during the ACIAR project. The Amagara community was able to clearly link the improvement with changes in their agricultural activities in relation to land use, selection of crops and productions methods that had been developed with the project and PRADAN staff. In the case of Belghutua while agriculture had played a role the emphasis appeared to be on external wage labour.

While the increased income at Amagara had many benefits it also has some negative impacts including increased alcohol consumption by some men and an increase in peoples’ workloads. The women had however, with their increased self-confidence, responded to those negative impacts in effective ways.

Capacity building

The capacity of the communities at both sites increased during the project, for both communities there was enhanced knowledge in relation to management of their personal affairs as well as how to work more effectively with outsiders. In addition both communities demonstrated improved capacity in the ability to plan their agricultural activities and in the technical aspects of crop production though the application of that learning was greater at Amagara than Belghutua.

Men at Amagara clearly illustrated their change to a more sophisticated approach to agricultural production: “Earlier we would just sow the seeds not thinking much about the production, whatever will happen, will happen. Now we think – How can I get the maximum production from this crop? There is a continuous effort; earlier this effort was not there.”

The statement by the men at Amagara highlights a significant change not only in their capacity as farmers but their desire to continue to improve. In addition, the farmers were able to outline an understanding of what they had learnt and alternative ways in which they had learnt things.

The FGDs carried out at both sites highlighted the capacity building that had taken place. However, there was considerable difference between the two communities with the Amagara community illustrating considerably more learning or use of their learning than demonstrated at Belghutua. All groups at Amagara were able to provide multiple examples of what they had learnt and how they had applied that knowledge, for example, “We have learnt how to cultivate vegetables and the use of fertilisers and “we (the VCC) would also visit and overlook. We would discuss them at the meeting and talk about the amount of fertiliser that needs to be given to a crop

The women at Belghutua talked about how they had learnt new techniques in rice growing as well as vegetable cultivation. However, they experience issues in crop production including pest attack and shortage of water preventing them from growing crops in the dry seasons. They compared their bare fields with those of others whose were “full of crops” without demonstrating that this difference was a result of greater knowledge or resources. However, descriptions of the activities carried out in the project could be provided such as “For the experiments we divided the land into several plots and gave different fertilisers in different plots. We did this to understand the fertiliser required. We saw in some plots crops grew well, in some they did not.” VCC Belghutua.

A key focus for all groups from both communities was the illustration of the impacts of various applications of fertiliser through the field activities and conversations that some members had held with Peter. For example “Discussion around fertilisers – phosphate, urea, mustard cultivation, paddy; Peter told us about it” (VCC Amagara). One farmer from Amagara also commented specifically on his interaction with Peter and how the farmer had been able to demonstrate his knowledge and build his self-esteem from the interaction. The members of the VCC at Belghutua talked about the trials as well as their learning about fertiliser, water use, crop selection and cultivation.

With respect to the ACIAR research project farmers at Amagara were able to outline at length and in some detail the processes involved in the various on-farm trials including determination of land type and the appropriate use of different land types, evaluation of soil pH and the fertiliser trials stating that before the project they did not know about how to determine the quantity of fertiliser required or how to measure its impact.

Several of the male farmers commented on how community members are learning from each other “this way the entire village learns from each other then, the entire village will come onto the path of progress”.

Within PRADAN it was felt that several factors contributed to enhancing the success of the project including:

- Enabling farmers to develop their own knowledge
- Acknowledging that women were farmers

In addition PRADAN staff involved with the project gained considerable technical knowledge in relation to the value and use of various land classes and in the production of crops appropriate to those land classes.

Does land-use, cropping intensity & diversity change

There were major differences in the way FGD at Amagara and Belghutua talked about changes in land use, with participants from Amagara stating that land-use had undergone great change but much less change was reported from Belghutua. The way in which land is being used at Amagara has undergone major change and the participants in all three Amagara FGDs spoke of significant changes in land use both in the crops produced but also the seasons in which they could be produced “Earlier we would migrate very far for work” and “the land would remain barren”. “now, there is cultivation in all lands.....such that there is no grazing land left” VCC Amagara. In all cases the important role of the ACIAR project and PRADAN in changing land use were highlighted.

The participants in the Belghutua FGDs focused primarily on the engineering activities including “we did various works, like we made hapa and land levelling”. Another Belghutua farmer commented that in the last five years there have been some changes – “mango plantations, hapas – but no one is doing agriculture” (referring to agricultural production other than rice). One issue that had a major impact was the different ways in which the two communities dealt with livestock. At Amagara as the agricultural activities expanded the way in which grazing animals are managed has also changed and the animals are no longer allowed to graze freely after the rice harvest. In contrast at Belghutua the livestock continued to graze in the traditional manner being released to graze freely after the rice harvest causing difficulties with crops other than rice. “The other reason is that the cows and goats graze freely. The moment the paddy is harvested, people allow their cattle to graze freely. If you do not construct a fence it is impossible to do agriculture in that season.” (Male farmers Belghutua)

“It is only because of the hapa that we are able to engage in agriculture – we are able to cultivate tomato with ease” VCC Amagara

“We don’t waste water anymore, people are very possessive about their water – people are using this water for cultivation.” “Everyone has their own pumps now.” (Amagara SHG)

“Earlier only 1 or 2 people would cultivate, nowadays even those who do not have any land lease other people’s land and cultivate.” “The land full of stones which had no value earlier is like gold now” “All the tanr and gora were barren; when people saw that they earned money, then others thought let us try then we can also earn.” “We also cultivated fish in the hapa.” (Farmers Amagara)

Several factors appear to impact on the Belghutua community’s land use, the most important of which was the greater engagement of community members with locally available and also distant labouring work.

Gender

While there was a contrast between the responses of women form the two sites all of the women’s groups demonstrated large increase in their capability and self-esteem. The women from Amagara stated that initially they would follow the instructions of the men. Then PRADAN staff members told them to form a VCC to oversight the various activities and they started to oversee the hapa excavation work including ensuring they were the correct size and making payment to those who had excavated the pits. This involved managing the bank account in association with the lekhok who would for example write the cheques. The women stated that “at first we would feel very scared because we are not literate. We would feel scared, what would I say at the bank?”. “Then slowly the dadas from PRADAN taught us”. The group spoke at length about the various on farm trials that had been carried out demonstrating how they had participated and illustrating an understanding of the nature of the trials and the outcomes in relation to the application of fertiliser for various crops. Similarly the women from Belghutua reported that initially people would laugh at them for being involved in the various activities but now they are no longer laughter at and have improved their status in the community.

For women in Amagara it was the change that had taken place in their role, and with that status in agriculture, that had had a major impact. This change was clearly illustrated in the SHG group where the women the women introduced themselves as farmers including statements such as “I cultivate potato, tomato and paddy” and “we have a mango plantation ....today we are planting potatoes” without any prompting from the facilitator, a significant finding demonstrating change in their perceptions of their role in the family and community. The situation has not developed to the same extent at Belghutua and one (male) farmer commented “In a tanr land 30x40 was done, after that you can plant some good trees … we understand all that if only the Didis (women) would implement it” (Farmers Belghutua). This suggested that farming had not developed into a partnership between family members to the same extent as it had at Amagara.

The women in Belghutua commented that their biggest learning had been – “Courage and knowledge” (VCC Belghutua): “The courage to move around, to interact. Also the agricultural knowledge I have gained I can apply it in my own field”

(VCC Belghutua). This indicated that they had developed considerably during the project.

Female participants from Amagara believed there were benefits in handing responsibility for work to women stating “if you give responsibility to women it happens properly”

Engagement

The various communities appeared to have had very different experiences and levels of engagement with PRADAN. In Amagara members of the community did not distinguish the project activities from the normal relationship with PRADAN except where foreigners were involved. In Belghutua the differentiation of activities was even less clear for the community and only with prompting did they outline the various activities with which the community had been involved and tended to focus on the research and construction activities rather than those carried out as part of PRADAN’s normal activities. Farmers commented “At first no one understood the concept of “watershed”. When at first the dadas came to survey we did not understand what was happening. Many surveys happened in the beginning”.

The men at Amagara were able to outline the nature and processes in the community’s engagement with PRADAN including the development of the SHGs as the initial step in the process. However, they also outlined the issues that had been faced at the start with many in the community thinking that the ideas being presented to them in relation to agricultural production were fanciful and risky and that there was particular concern at that time in relation to the provision of water to irrigate the crops.

While there was a clear difference in the ways in which the two communities had responded to the research project, the FGDs were not able to provide a direct causal link between the processes used in the project and the outcomes in this area. Other factors such as the concentration on cash income from labouring jobs in Belghutua compared with the aim of community members in Amagara to no longer need to work as labourers have also had considerable impact on the way in which the communities’ engaged with the process and the way in which they had responded to the activities. It is also difficult for the members of the community to distinguish between the activities of PRADAN and those of the project. In Amagara the focus of the women was on the outcomes from the various activities rather than the activities themselves. Only when they were specifically prompted did they comment on the project activities they had been involved with. In Belghutua the focus of the communities was mostly on the activities they had participated in rather than the outcomes from those activities.

Community members also struggled at times to distinguish the PRADAN-based activities from those associated with other organisations. For example, women from the SHG at Belghutua “expressed their discontent as they were landless and not received any benefits”, with the benefits in this case being an expectation they had of receiving livestock while livestock had not been offered in the ACIAR project, suggesting there may have been some confusion over the area being covered within the focus group discussion.

11.14 Experiments to develop kharif and *Rabi* crop options

Crops (experiments)	Location	Comments
Black Gram. P, K responses (3 yr), plus variety evaluation (1 year) and weed management (1 year), both of which failed (late planting because of heavy rain, poor management)	Pogro	Important pulse - poor farmers treat it as subsistence crop and get low yields. Big response to P, farmers convinced of P application in Pulses. Work in 2009 aimed to improve general crop agronomy, and address any farmer perception that black gram is a subsistence crop that does not merit better management.
Maize N & P trials - 2 years	Amagara Pogro	Once important early kharif crop supplementing during rice deficit - now less popular (once rice is productive) Troubled experiment, first year bad seeds. Second year, bad weather, bird damage, impatient farmers (sold cobs before data collected). Responses to N and P but too many problems to be conclusive scientifically.
Finger millet Nutrition one year, and demonstration of good package of practices one year	Pogro	Once an important nutritious, drought tolerant, crop -renewed interest with new varieties Particularly for poor farmers with little good paddy land. First year only 3 reps survived and N treatments confused so could not analyse. Clear responses to N, P unsure. Second year failed - planted late, cattle freed before crop matured and grazed the crop, the farmers harvested the immature crop.
Direct Seeded Rice (DSR) Nutrient responses (N & P) Also experiments with weed management at Pogro which failed - plants started well but later stalled and succumbed to weeds.	Amagara Pogro	Seen as a way of getting early maturity, making second crop more likely - matures before transplanted paddy, so important for food deficit families. An important strategy of ours for developing cropping systems. Also, when it is an upland variety, it may be a better crop than less water-assured (risky), medium uplands where transplanted paddy is more vulnerable - we see it as essential to displace flooded rice from the risky baid. Trials went well in Amagara, in Pogro the crop started well but growth was stunted before flowering, we suspect Fe, Al toxicity?
Wheat Irrigation and nutrient responses	Amagara Later in Pogro farm 'cluster'	Seen as viable *Rabi* crop, farmers wanted it as rice supplement. Good crops (> 4 t/ha) with adequate P and < 200 mm irrigation, the balance of water met by residual water). Farmers later lost interest with termites and higher returns from vegetables. Of less interest as paddy improves - may be popular if rice fails in a bad monsoon. The trials went well, although with various mishaps only two useable replicates. It was surprising for the farmers to experience such good yields.
Mustard Nutrition & irrigation	Amagara	Mustard Important oil seed. Grown for own consumption to reduce this cash cost of cooking oil. There was a lot of enthusiasm and involvement by the farmers. The effect of P was stark, farmers mentioned "no P no Mustard"
Early season Vegetables	Amagara	Seen by us as an opportunity to change farmer's perceptions about the value of 'poor' uplands. They traditionally grow small areas around homestead, but only in main season (Nov-Feb) not early as in our work (Aug-Nov/Dec). This was an experiment to change the farmers' perception towards their self and their uplands; it had a big impact in the village, more crop diversity in the uplands/medium uplands in kharif and *Rabi*. Very successful.

11.15 Soil fertility assessment

11.15.1 Evaluating the methods available for assessing soil fertility

The soil fertility assessments and fertiliser experiments were designed as learning experiences for both the professional and farmers, and to equip farmers to learn for themselves in future. All P experiments in the kharif were part of the action learning workshop discussed previously (Section 7.3.2).

Development professionals require some assessment of soil constraints if they are to facilitate improvements in cropping in ‘new’ villages without falling back on generic recommendations that are unhelpful given that soils are so variable (Tables 2 and 3). The immediate requirement for the *professional* in a new watershed or village is a broad assessment of fertility rather than field-specific information. Beyond that, we have an interest in enabling farmers to learn rather than merely provide prescriptions.

Farmers, on the other hand, might benefit from assessments of fertility in their fields, especially after PRADAN or other professional has moved on. They need to be able to make decisions for specific fields. Ideally, the professional would like to equip the farmer to learn about fertiliser requirements for themselves, in their own fields. From the methods below, it should be possible to design activities which are not simple ‘demonstrations’, and which are more useful than a professional soil survey which is of little relevance to farmers.

- *soil testing* - 3 years as part of fertility survey, *ad hoc* thereafter
- *soil/crop survey (Section 7.1.2 and 3 and Section 7.3.4)* - 3 years
- *paired-fields* - 2006,
- *split-fields* - 2007,
- *omission trials* - 2008 and
- conventional *P-response experiments* - all years.

In the following discussion, we present our brief assessment of the different methods for both professionals and farmers. In Section 7.4.3 we present selected data to demonstrate the nutrient responses found in rice (*Rabi* crops were shown in Section 7.4.1).

Soil testing

This provides a rapid catchment assessment for soil chemical fertility, and an easy but not necessarily reliable guide to the fertility status of specific fields. It is most likely to be used by a professional for a watershed assessment, but many fields need to be sampled because of high levels of variability between fields. A soil test alone cannot predict nutrient requirements - for rigorous interpretation of soil tests, 'critical' values and dose-response curves are needed. These tend to be soil/crop/climate specific. Dose-response curves for fertilisers are usually determined in controlled experiments. They can be determined in the field if a wide enough range of nutrient application rates is found and we measure soil fertility and control relevant management (impractical). An advantage of developing response curves for P from farmer’s fields is that we know the response to P under realistic farmer’s conditions. Dose response curves could not be developed within our project, and ‘critical’ values from literature are often not appropriate. Soil tests may miss a critical deficiency or multiple deficiencies, and should be supported by evidence of field response. Soil testing has a role, but it does not live up to initial expectations.

Farmers expressed interest in doing soil tests, but international experience is that interest often doesn’t follow through to practice because of costs, lack of timeliness in getting results and issues of test credibility. Soil testing is not cheap, nor readily available in India.

Soil testing together with a survey of crop management and yield

This combination can potentially indicate the severity of a nutrient constraint. It may also provide a dose-response curve if a range of fertiliser inputs is used, but the example from Pogro (Fig. 24) shows a lot of uncontrolled variability which cannot be explained easily.

There is only an indication of crop responses to added P, and careful examination of the data was needed to explain three 'outlier' points (Fig. 24). This doesn't inspire confidence.

However, the curve is at least from farmer's fields, unlike a classical fertiliser experiment which is on one field only, with all other constraints removed. It can demonstrate to farmers the importance of crop management (like pest and disease management) (even if soil fertility is not measured). It could be a good entry point for PRADAN to a new work area (with or without soil testing).

Test strips (or split fields)

A strip of fertilizer is applied to a field or the field is split for zero (or farmer's usual rate) and added nutrient (2 treatments). Each field is a replicate and all treated fields in a watershed/village are combines for analysis by paired t-test.

These were easy to manage and statistically powerful. They are very effective with farmers for observing and learning. Farmers can easily do these tests themselves.

The test strip, where a single nutrient is added, is compared with the rest of the field (control). But, deficiency of the nutrient tested may be masked by multiple deficiencies, so caution is needed! Results are field-specific but, with enough replication, can give a picture of a watershed overall and the variation within it which is useful for the development professional. No firm conclusion can be drawn for any field not included in the study, although farmers will make comparisons based on land class, field history and crop management.

Addresses uncertainty about a single nutrient e.g. PRADAN may ask "is K deficient in this area?" or farmers "do I need P in this field?", "is my current rate of P enough?"

In ponded rice use test-strips and split fields *only* for 'immobile' nutrients such as P and K.

Replicated omission trials

These are an elaboration on the strip-test, including more nutrients and having a control in which all nutrients are applied. Single nutrients are omitted from strips in the field. Multiple deficiencies can be detected, and they are statistically powerful. They can also provide a reliable guide to target yield (because all nutrients that may be deficient are added), although for this there needs to be good plant protection and timely planting with appropriate varieties. When farmers have a potential yield in mind it helps to raise expectations and management skills.

Nutrient response experiments (dose-response experiments)

This is the classical experiment, usually at a research station. Relevance to farmer's fields where management is less controlled is always questioned. Can be done by PRADAN in farmer's fields - each field has all the treatments and is a single replication (a 'block').

Our experiments were statistically analysed as randomised complete block experiments (RCB's). These experiments demanded a lot of resources. They are best done with only one or two nutrients, the ones identified by prior soil testing or some other evidence as the most limiting for crops. Any other nutrients that are known to be deficient are supplied.
This gives a fairly simple experiment to interpret, and should not be 'confounded' (confused) by unexpected deficiencies. But applying the results to other fields assumes that there are no other deficiencies. It can take many experiments in different sites/years, for each crop, to be confident. If we lower the level of precision (or confidence), then we might decide to use literature values supported by a smaller number of confirmatory experiments. We adopted this approach in developing decision support material for P.

General comments - Farmer's learning about fertility

- Soil testing initially engages farmer interest, but they need to get answers back quickly or they lose interest.
- Soil fertility/crop surveys use a lot of resources but provide (a) good farmer learning and (b) a general idea of responses to soil fertility. They don't give a good dose-response curve.
- Replicated strip plots and split fields give excellent idea of overall responsiveness to P (or K etc), but no definitive information on rates or information for individual fields not tested. Test strips can sustain farmer interest after soil testing.
- Fertiliser workshops were a positive experience.
- Dose-response experiments are good for farmer-learning if they are in farmer's fields. One or two nutrients are best.

Guidelines for the use of these 'tools' have been drafted. These 'tools' may be rewritten appropriately for different audiences. Note in particular that a pragmatic guideline to assessing P-fertiliser needs is given.

11.15.2 Field guide to assessing likely soil fertility and fertiliser response

Rationale

PRADAN requires some assessment of soil constraints if it is to facilitate improvements in cropping in 'new' villages, without falling back on generic recommendations. The requirement is for a broad assessment of a new catchment, rather than field-specific information. Farmers, on the other hand, might benefit from assessments of fertility in their fields, especially after PRADAN has moved on.

It is difficult to obtain reliable, timely soil testing in India, and even if it was available, cost would preclude it for most smallholder farmers. So alternative assessment approaches are needed.

The alternative approaches

Soil testing – provides rapid catchment assessment for soil fertility and soil constraints (with enough tests[30]); and provides a quick, easy guide to fertility status of specific fields. But:
- not cheap or readily available (or credible);

[30] Barry and I started on this using data from the stratified sampling, but this work has been temporarily set aside

- a soil test alone cannot predict P requirement (we also need 'critical' values and a dose-response curve, which tend to be soil/crop/climate specific);
- 'critical' values from literature often not appropriate;
- may miss the critical deficiency or multiple deficiencies,
- best supported by evidence of field response.

Soil testing together with a survey of crop yield and management – Can indicate the severity of a nutrient constraint, as well as provide a dose-response curve if a range of fertiliser inputs is used, but there is a great deal of uncontrolled variability which cannot be explained and which reduces precision in picking a recommended rate. But:

- the dose-response curve is at least on farmer's fields, unlike a classical fertiliser experiment which is on one field only, with all other constraints removed
- it can demonstrate to farmers how important crop management (like pest and disease management) can be (even if soil fertility is not measured)
- could be a good entry point for PRADAN to a new work area (with or without soil testing)

Test strips (split fields), each field is a replicate for analysis by paired t-test - easy and statistically powerful, and very effective with farmers. But:

- require a fair amount of work and
- may be masked by multiple deficiencies, site specific.
- Split fields OK only for less 'mobile' nutrients such as P, K but not N.

Replicated omission trials with a nutrient rate – provides a reliable guide to target yield, rates (if >1 rate is used for a nutrient known to be deficient), multiple deficiencies can be detected, statistically powerful.

Farmer's learning about fertility

- Soil testing initially engages farmer interest, but they need to get answers back quickly;
- Soil fertility/crop survey demands a lot of resources but provides (a) good farmer learning and (b) a general idea of responses to soil fertility. It doesn't give a 'good' dose-response curve (and farmers do ask about rates, especially when they see inter-field variability.
- Split fields(replicated) give excellent idea of overall responsiveness to P (or K etc), but no information on rates or information for individual farmers not in the experiment. Test strips (with crops) can sustain farmer interest after soil testing.
- Fertiliser workshops a positive experience.
- Replicated dose-response experiments good, but large with more than one nutrient.

11.15.3 What these tools can tell us ....

Nutrient / property assessed	Assess as first step in WSD?	Is this property a problem?	Can it be readily addressed (technically)?	Can it be economically addressed?	Research/development needed
OM	No Assume low	Yes – eg associated with low infiltration in uplands	No – lack of raw material, high decay rate	Technically yes, economically not known	• Residue retention to improve physical properties & infiltration & retain surface water to aid rainfed crop establishment post-monsoon • mulches
N	No Simply assume it is low	Yes for all non-legume crops. Nodulation OK (in black gram)	• Urea • Pulse crops • Legume mulches	• Will get costlier/much is lost • Difficult in rice rotation (for us) • Probably	• split applications of N use of N colour chart • Pulse varieties/agronomy; relay crops • Glyricidia- organic, slow-release N
P	Yes Extent and severity of deficiency is unknown, but variable	Acute – in much of the uplands, and possibly all crops after rice. Rice sometimes	Yes Superphosphate Manure/compost	Yes	• Regional soil assessment • Soil P 'thresholds' for rice, mustard, wheat and a kharif pulse ....?[31] • Farming systems approach to application
K	Yes. Extent and severity unknown	Yes, but extent unknown	Yes	To be determined	Soil values low to marginal by standard criteria, but crop responses variable. Most likely an emerging problem – needs work
Zn	No	Not field crops	Yes	Yes	No
S	?	Unknown?	Yes	Yes	Not directly assessed, but SSP responses are not to the S
Low pH	Yes	Some uplands	No	Only by crop choice (eg avoid rice if pH< 5, Al>40? Maybe OM	Assess subsoil pH/Al constraint in Pogro, set guidelines Regional assessment?
High EC	Generally no		No	No	• No – except determine salt at Pogro • Keep a watch as WU and irrigation increases

[31] *We are close to this, although it will be far from perfect.*

11.15.4 A guide to the methods to use for each approach to fertility assessment

Attribute	Approach	Method detail	Comments
Chemical fertility	Soil testing	Stratify the landscape to be assessed into 3-4 major land classes, usually based on topography and land-use: tanr, bari, medium uplands (baid), bohal, kanali Sample a minimum of 5 fields per land class, avoiding any obviously unusual situations (such as compost heaps, locations where straw has been burnt) Collect 10 samples per field to the usual depth of ploughing (0-10 cm in East India Plateau) in a zig-zag pattern across the fields to obtain a representative soil sample for that field. Mix thoroughly to give a composite sample for each field. Sub-sample each composite sample to obtain representative soil to send to the laboratory for testing, say about 250 g soil	Use this method for a broad assessment of a village or watershed, to assess average levels of fertility and its likely variation. Individual farmers may want to test their own soil, but international experience says most won't. Consider first what tests are likely to be useful (see Table 2) Make sure you know what particular method has been used for each test, as the method can affect interpretation of the result. In particular, find out if pH used water and available P used Bray (as we have). Apparent deficiency does not mean crops respond economically to fertiliser, as responses may be small, fertiliser may be too expensive, or other deficiencies will limit any response
	Soil testing *plus* survey of crop yield & management	About 40-60 fields of a single crop type need to be soil-sampled and key management data recorded (variety, sowing/transplanting time, plant population, nutrient inputs (fertiliser, compost), a rating of weeds, pests and diseases (1, nil to 4, high) and yield. Statistics aren't essential, but data should be plotted on a graph with yield on the y-axis. The x-axis can be any one of the observations, starting with soil tests. Then carefully examine the data to see if there is (i) any trend in the graph and (ii) any pattern to variation in yield around the trend (e.g. at high fertility levels do high yields coincide with low incidence of pests?)	Takes a lot of resources. More informative than soil testing alone The crop survey alone (no soil testing) can be very informative for farmers and generate a lot of interest. It gets farmers observing, and this is the start of thinking, and thinking about "what can I manage/change?"
	Fertiliser test strips	Farmers apply fertiliser to part of a field, which may vary from half a field to a strip down the middle of a field, or possibly even comparing two adjacent fields which he thinks are identical. The rest of the field, the 'control', receives normal treatment whilst the treated section receives additional nutrient (only one variable, eg P or K). The whole field gets the same basic treatment for cultivation, weed control etc – only the single nutrient is added to the treated area. An alternative is to apply adequate rates of all nutrients to a whole field, and delete one nutrient from part of the field (see omission trial, below) Replication is necessary. At least 15 fields with the same crop need to be compared, preferably across land classes. Statistical analysis is not essential, as farmers will make their own judgement, but it helps. A simple statistical test, the paired t-test (in Excel) can be used for analysis.	A statistically powerful way of testing for a single nutrient deficiency, giving a very good idea if the nutrient tested is, in general, (i) deficient in an area, and (ii) how big the average crop response to fertiliser might be. It also tells you how much fields vary, but it can't tell you anything about fields that have not been tested, and it can't tell you how much fertiliser is needed. Test strips are excellent for farmers who want to know if they should be using a particular fertiliser There is a risk of getting no response to a nutrient, even when it is deficient, when something else is also deficient. For nutrients which move with water (N) , needn to prevent cross-contamination between strips, or half-fields. The approach is difficult with N, but easier with P and K but precautions still need to be taken to prevent cross-contamination. When interpreting results with farmers, one excellent way is to graph the results by land class (on the x-axis) with yield on the y-axis. First plot the yields for the *control* part of the field. Let farmers observe differences between land classes and between fields. Then show the yields with nutrient added. Pairs of data points can be linked with an arrow, an up arrow if the nutrient increased yields and a

<table>
<tr><td></td><td></td><td></td><td>down arrow if yield was reduced. Farmers will see that fields all behave differently, and see the need for information relevant to their field.</td></tr>
<tr><td></td><td>Fertiliser omission trials</td><td>First, determine which nutrients are to be tested.
The omission trial is carried out just like the test strip, except that part of the field receives all nutrients that might be deficient (the control) whilst strips laid out across the field have one of these nutrients at a time omitted.
As with strip trials, replication is needed.
A fertiliser requirement can be calculated thus:
1. Measure the yield response (y) to added nutrient
2. Determine the concentration (c) of that nutrient in the harvest crop (values which are good enough can be obtained from text books or local research data for well-managed crops)
3. Estimate a fertiliser efficiency (e) (this can be complicated)
4. Estimate fertiliser need (f) as:
$f = y \cdot c \cdot e$</td><td>As with test-strips, omission trials are a statistically powerful way of testing for nutrient deficiencies, giving a very good idea which of the nutrients tested is generally deficient in an area, and how big the average crop response to fertiliser might be. It can't tell you directly how much fertiliser is needed. But it can providee a reliable guide to target yield, and allows for nutrient requirement to be estimated (see adjacent column)
Multiple deficiencies can be detected.
Typically used as a glasshouse experiment with many nutrients, but can be done in the field, where it is best limited to a small number (?) of most likely deficiencies . Could you provide an example please?
Typical concentrations of N, P K and S in grain, to estimate nutrient removal:
<table><tr><th></th><th>N</th><th>P</th><th>K</th><th>S</th></tr><tr><td>Rice</td><td>1.5</td><td>0.2</td><td></td><td></td></tr><tr><td>Wheat</td><td></td><td>0.25</td><td></td><td></td></tr><tr><td>Mustard</td><td></td><td>0.4</td><td></td><td></td></tr><tr><td>Pulses</td><td></td><td>0.4</td><td></td><td></td></tr></table></td></tr>
<tr><td></td><td>Plant symptoms</td><td>Signs or symptoms are compared with photographs or descriptions.
One of the best decision tools available is the IRRI test for nitrogen (N) requirement in rice. Users need to be trained.</td><td>Photos and descriptions appear in many textbooks and on some internet sites. Typically, the symptoms shown or described are for plants grown under extreme deficiency, and may not occur under less extreme but nevertheless important deficiencies. So look for symptoms, but do not assume nutrients are not deficient just because there are no symptoms. Similarly, symptoms can be confusing and not fit the usual pattern, so look for other evidence to substantiate a suspected deficiency (e.g. do a test strip, check field history, check pH). To preserve / build a field history needs a frame work / chart – putting a tick mark once in every crop growing season can preserve observations for successive years and help farmers to preserve the field history and tell how to interpret history</td></tr>
<tr><td>Physical fertility</td><td>Infiltration</td><td>Double ring infiltrometer</td><td>Farmers often have a good idea of where high runoff occurs, but it can be more difficult to determine infiltration. The benefits of the 30x40 model should be greatest on uplands where infiltration is low (I could not relate to it. Are saying rate of infiltration or total amount of water infiltrate in such lands?) and the soil is least suited to cropping (what kinds of cropping?). An infiltration test may help determine if upland is best left for annual cropping, or if it should be converted to perennial crops using the 30x40 model (please elaborate how it helps?)</td></tr>
<tr><td></td><td>Root depth</td><td>Auger holes/pits</td><td></td></tr>
<tr><td></td><td>Drainage</td><td>Auger hole</td><td>Most plants need well drained soil but free water near the surface (visible in auger hole) may mean inflow of seepage water that crops can use – a good thing.</td></tr>
</table>

11.16 Evaluation of approaches to developing farming systems

2006-07 Rabi at Amagara

We had rice of different maturities in different land classes, followed by mustard or wheat. This cycle was to be repeated over at least two years, enabling us to look at yields/returns and costs of a 'system', that is to evaluate all but the last of our 7 assumptions. Experiments on irrigation and P response of mustard and wheat were carried out, with each farmer's field comprising a replicate. In addition to the problems with the approach noted above, having multiple irrigation treatments in a field proved to be very difficult with water transfers between treatments plus tedious, complicated management of irrigation demanding our time rather than the farmer's. We also needed an easier and more reliable way to estimate the amount of irrigation applied.

2007-08 Rabi at Amagara

We observed that the main system-effect of a short-season rice is to (i) possibly leave more water in the soil and (ii) enable earlier planting of the second crop, so it benefits from end-of-monsoon rainfall and/or residual water for longer. We came to appreciate that the land class and maturity-class of the variety is less relevant than the time of harvest/sowing a second crop (and thus the amount of water remaining and the prospect of future rain).

Therefore farmer's fields were chosen more or less at random across land classes. The only constraint in choosing farmers was they were willing to take a second crop. At the time of rice harvest, fields were stratified into 'blocks' based on time of harvest. Each block had 5 fields, each field receiving one of the irrigation treatments in subsequent *Rabi* crops. Each field was split for 5 P treatments. The first 5 fields to be harvested were assigned to the first 'stratum' or 'block', and so on until 25 fields had been harvested and sown to the *Rabi* crop (all mustard), thus providing 5 blocks or replicates (strata).

Activities

The experimental activities undertaken and their objectives were, briefly:

- Developing alternative crop options to kharif rice for unproductive baid land that should be retired from rice. The plan was to develop options that the farmers will take up on poorer baid, once rice yields are secured in better areas. Early season vegetable cultivation was taken up with 8 farmers in 2006 to change their self-perception and their poor risk taking ability and help them switch from unsafe paddy to more remunerative crops like vegetables.
- Developing kharif crop options for the arable uplands (gora). The main activity was vegetables (as in 2) and developing a package for upland direct-seeded rice, especially for poor farmers with little access to good rice land. This was quickly followed by a short duration, rainfed mustard utilizing the residual moisture in accordance with the work of developing cropping systems.
- Developing options for the *Rabi*, both rainfed crops grown largely on residual water and irrigated crops using harvested water (alternative crops, irrigation strategies). Lentil in lowlands using residual moisture after kharif. Wheat & mustard as irrigated crop options.

  Data for crops in the experimental work have been given in previous sections. What follows is the results of monitoring and evaluating how crop options were integrated into the farming systems of individual farmers.
- Monitoring and evaluation of farming systems and their adoption

11.17 Comparison across 3 years of Up-scaling at Purulia

Agriculture 2010-2011	Agriculture 2011-2012	Agriculture 2012-2013
The concept of moving away from 'Crop-based/ technology-based Planning" to "Year Round" planning had to be disseminated to staff, most of whom were not involved in the Amagara catchment or in the Research project directly. Developing a shared understanding and competency in staff to engage in that manner took time. All staffs who are from non-agriculture background by training, were also learning. The Team was also struggling to decipher the "Adult Learning Methodology / Participatory Learning" into some tools and principles which could be widely replicated with lesser professional time than what was invested in 1 catchment over a period of 3 years.	Started the cycle with review of last years' experience. Some major reflections & observations on 2010-11 were: • Because of erratic rainfall farmers and staff lost confidence. As plans were static in nature, we and the farmers could not respond to the climate variability. • Competencies of staff and Community Service Providers to support agronomy of wide variety of crops – 42 varieties as per count. • Not possible for 8 professionals to support and monitor the program across 120+ villages • SHG based institutions gradually got dis-involved in whatever we were doing. • Focus on women "as farmers" totally diluted. (Please. refer to main report for further details)	Started cycle with review of last years' experience. Major observations and reflections on 2010-11 were: • Remarkable change in nature of crops grown on medium upland • Substantial increase in cropping intensity. • " Macchan" as a technology fits very well with intensified cropping intensity in medium uplands. • Difficult to monitor engagement of SP's vis-s-vis hand-holding of farmers related to specific intervention points in crop agronomy. • Unable to create an environment of "collective learning" for the community. Rather, the "demonstration plots" in the farmer's field and exposures to those plots built more energy. • Staff unable to attend to community, SP and AMC meetings due to multiple engagements/programs. • Could not engage continuously with the SHG leaders who attended the training. • Need to create a 'Peer group" of women for continuous support & encouragement to each other.
Though we introduced the "Year Round" planning concept, somehow the focus became limited up to the planning part and there was a discontinuity with respect to plan and achievement. As the rainfall was poor, delayed and more erratic – farmers could not grow anything in the kharif, most fields were left barren and the paddy nurseries could not be transplanted.	Having gone through 1 cycle, staff were more confident with better understanding. Focus was quite directed towards "Year Round" plan which was traced through to the Achievement, completing the cycle. Purulia Team was involved in the UN funded Gender Equality project, so the perspective around Gender for senior staff was enhanced (with orientation and training) - reflected in training modules & development of other materials like semi-pictorial "Learning & decision making tool" to make the entire agriculture program more "inclusive" for even illiterate women. The conviction came from the experiences in the ACIAR project, while the UN project gave us a handle on how to address the challenges.	Focus is quite directed towards "Year-Round" plan and the plan will be traced till the Achievement thus completing the cycle. Along with that we are introducing the concept of *"Farmer's School"* as adult learning methodology – drawing upon the experiences of Amagara.
As the plan had a discontinuity with respect to the achievement thus we were unable to even map the intensity and coverage area -wise and season -wise.	As rainfall was good, most farmers could implement their crop plans. As we had showers quite late in the season, there was good moisture in soil, and harvested water in structures, helping farmers to intensify agriculture, especially after a very bad year. In 2011-12 we tracked the coverage & intensity both area & season-wise. Planning & reporting sheets were developed, which made the	We will be tracking coverage, intensity and, along with that, *"Adoption" of crop growing practices and technology.*

	process more user-friendly and could be used by the SP's.	
Planning was mostly done by "Service Providers" (SP's) after some demonstration by staff with SHG's. The SP's were all male and somehow the concept of cropping system got diluted for the reasons: A) it was a first-hand experience to adopt such planning exercise. B) Community based institution and women were somehow left behind once the Planning exercises with the families in the SHG were over.	We tried to emphasize community institutions (SHG, Cluster), and along with that renewed focus was given to actively engage with women. We imparted 1.5 days training to 2 SHG leaders from each SHG, training nearly 900 women on these concepts. Thus we were able to impart the concept to a larger mass, thereby the number of women who now had some orientation around the concept of round the year farming and cropping systems increased. As the training also had a strong "Gender" focus, women's participation was high. Thus overall we were able to reach larger numbers along with re-enforcing *"women's identity as a farmer".*	Disseminating concepts to larger mass, training more women leaders from each SHG--*"Chasi Sathi"/ "Agriculture Support Group".* "Gender" component of training has been strengthened. Training attempts to build an "identity" for SHG leaders who are coming to training. Renewed focus to be given to engage with the trainees at quarterly intervals to strengthen their learnings and identity, for it is being visualized that it is these "women" who would champion the changes in agriculture in their SHG's and community.
Primary learning materials like the flex called "Chas Bas Baro Mas" i.e. "Year Round Agriculture" somehow emphasized that round the year cultivation is possible with a few examples depicted on the flex	This year we introduced one more flex which mapped ideal time of sowing of different crops growing in the area along with mapping water intensity and soil water availability thus making it more rich in content -"Learning and decision making tool".	I*ntroducing display board* where the women's identity as a farmer is again re-emphasized and what, where the demonstration or research is to be conducted will be also captured. Along with that we are also introducing the concept of mixed farming and crop rotation to them.
Very skewed focus on residual moisture and utility of the same	One component of the training was completely dedicated for concept of residual moisture and possibility of different crops using the available moisture. The use of simple training tools like the "wet sponge" to depict the behaviour of residual moisture in soil, conveyed the message quite easily- but visually it was conveyed very strongly which women could articulate when they went back to their SHG's and got involved in the planning meetings.	Focus on utility of residual moisture maintained along with discussions on *crop combination and relation with root growth and water.*
Skewed focus on linking of one crop with another i.e cropping cycle	Here we also focused on cropping cycles and different possibilities such as altering varieties and even processes or technology of cultivation viz short duration rice followed by mustard or Gram, DSR dry/wet followed by vegetable /mustard	Drawing upon team learning from ACIAR, this year we are trying to emphasize more on utility of mid-upland with established technologies such as *line sowing, DSR (wet/dry) followed by less irrigation intensive crop.* The utilization of these *mid-uplands for vegetable cultivation replacing long duration paddy and Macha/Trellis are being discussed.*
Machha (Trellis constructed using bamboo, nylon threads and wire) as a technology has just set its foot but could not flourish	Machha as a technology flourished well and in many cases it was a factor for raising the cropping intensity from 200% to even sometimes 400%. The Team also made Video-documentaries on the new technologies introduced like DSR and Machhan for use as Dissemination and training materials.	Apart from use of Machha/Trellis we are also focusing on *soil health* and thereby introducing components such as fertilizer calculation, green cropping, altering soil by using lime/gypsum, sand/clay. pH and its roles in crop production are also being discussed *(but the concept was introduced only to the Service Providers).*

11.18 Details of Purulia upscaling in 2011/12 – case studies

In addition to the details of participation and income generation from the subsample of 592 families provided in the body of the report, detailed evaluation was carried out in villages with contrasting history of PRADAN's intervention. The analysis was across four villages selected randomly but representing the period of engagement and community profile of the entire 160 villages in which PRADAN works in Purulia. They were across four blocks.

Putidih is a Mahato (OBC) community village that PRADAN has been working in for the last 10 years, and has had significant investment in water harvesting structures.

Luskudi, where PRADAN have worked for 5-6 years.

Ona is a Tribal (Singh Mura) village, but not Santhals. They are one of the original inhabitants of Chota Nagpur Plateau – PRADAN has been working here for 2-3 years.

Rigid is a Santhal Tribal village where PRADAN has been working since 2008.

Of 250 farmers in the 4 villages, 163 registered for the program, paying the subscription of Rp.30. This participation rate of families (65%) was almost double the participation in the same villages in 2010/11 and compares well with the Purulia Team average for other intervention programs of 45%. Fifteen of the total 20 SHGs participated (75%).

Table 1. Plan generated after the training by SHG leaders

Particulars	Village Names				TOTAL
	Putidih	Luskudi	Ona	Rigid	
Potential farmers (in SHGs)	100	50	50	50	250
Total farmers registered with Federation	62	37	22	42	163
Total SHGs	8	3	5	4	20
SHGs In Plan	6	3	2	4	15
Land area in plan under cultivation (ha)	20	11	5	11	48
Average land per farmer (ha)	0.32	0.31	0.24	0.27	0.29
Total land fragments	299	183	74	111	667

Table 2 gives the area of land under planning in each land class and, taking into account multiple cropping, the total planned for crops and the net sown area actually achieved. The data show, for example, that in Putidih there was 15.1 ha of baid land in the plan, on which farmers planned to grow 18.9 ha of crop (ie some double cropping). They actually achieved 37.2 ha of crop, meaning that most of the land was double cropped and some was triple cropped. Farmers in Putidih and Ona over-achieved their plan but the other two villages under-achieved relative to their more optimistic plans.

Table 2. Achievement vis-à-vis land class for four villages (areas in ha), all crop types including rice

	Putidih			Luskudi			Ona			Rigid		
	Actual area	Plan	Net sown	Actual area	Plan	Net sown	Actual area	Plan	Net sown	Actual area	Plan	Net sown
Tanr/bari	3.2	3.1	6.6	7.5	14.9	8.2	2.9	4.4	6.3	5.8	8.3	3.1
Baid	15.1	18.9	37.2	0.4	1.2	0.4	2.3	3.1	4.9	5.2	8.8	2.9
Kanali	0.04	0.	0.1	3.1	7.5	1.1	0.0	0.0	0.0	0.3	0.5	0.1
Bohal	1.7	1.90	3.9	0.4	0.8	0.3	0.0	0.0	0.0	0.1	0.3	0.0
TOTAL	**20.0**	**24.0**	**47.8**	**11.5**	**24.4**	**10.0**	**5.2**	**7.5**	**11.2**	**11.4**	**18.9**	**6.1**

The farmers in Putidih were apparently more receptive to replacing rice with vegetables on their baid land and were thus able to grow up to three crops on a parcel of land (or they may simply have had better access to irrigation). In Ona village, most pieces of upland and baid were used to grow at least 2 crops - the effective area under crops throughout the year was 11.2 ha, 2.1x the land area.

Cropping intensity across all 4 villages is shown in Table 3. About 65% of baid lands planned for were used to grow at least 2 crops, 15 ha of 22.6 ha under plan. Of this, approximately 8 ha had 3 or more crops. The data also show that the kanali and the bohal areas under planning were small as they were primarily under paddy - but 18% of the bohal area that was put into intensive agriculture grew 4 crops, reflecting its good water status (but in the case of the land chosen by farmers, not prone to inundation).

Table 3. Cropping Intensity achievement vis-à-vis land class across villages

	Land area (ha)	100% cropping intensity		200% cropping intensity		300% cropping intensity		400% cropping intensity	
		Area (ha)	% of land	Area (ha)	% of land	Area (ha)	% of land	Area (ha)	% of land
Tanr/bari	19.1	4.80	25	4.36	22	1.31	7	0.57	3
Baid	22.6	3.42	15	6.43	28	5.87	26	2.65	12
Kanali	3.4	0.87	25	0.19	5	0.04	1	0.00	0
Bohal	2.3	0.31	13	0.34	15	0.00	0	0.41	18

Village-wise cropping intensity is given in Table 3, which shows achievement of intensified cropping was greatest in Putidih and least in Rigid.

Table 4. Cropping Intensity (in %) achievement village-wise

Cropping Intensity (%)	Putidih		Luskudi		Ona		Rigid	
	Planned (ha)	Achieved (ha)	Planned (ha)	Achieved (ha)	Planned (ha)	Achieved (ha)	Planned (ha)	Achieved (ha)
100	13.9	1.1	3.4	3.8	3.2	0.0	5.2	4.5
200	3.3	6.8	3.6	2.6	1.7	1.8	5.8	0.7
300	0.8	6.5	3.9	0.3	0.3	1.5	0.5	0.1
400	0.3	3.4	0.5	0.0	0.0	0.8	0.0	0.0

Table 5 records the nature of this shift. Two scenarios are compared, conversion to or adoption of a vegetable/pulse (or mustard) sequence or a rice/vegetable (or pulse or mustard) sequence.

Table 5. Adoption of alternative systems in uplands/medium uplands (total numbers of farmers and numbers for two patterns of adoption)

Putidih			Luskudi			Ona			Rigid		
Plan	Veg+ pulse/ mustard	Paddy+ veg or pulse/ mustard	Plan	Veg+ pulse/ mustard	Paddy+ veg or pulse/ mustard	Plan	Veg+ pulse/ mustard	Paddy+ veg or pulse/ mustard	Plan	Veg+ pulse/ mustard	Paddy+ veg or pulse/ mustard
37	8	29	35	35	0	18	2	16	40	1	1

In Putidih, most farmers adopted a sequence of paddy - vegetables (or pulse, mustard), but in Luskudi all farmers opted for vegetables (multiple crops) possibly followed by pulses or mustard. The stronger conversion of rice to vegetables at Luskudi was associated with adoption of the machan netting system (on uplands). In Ona there was strong adoption of second crops following rice (in medium uplands). In Rigid, farmers with medium upland only converted traditional paddy to SRI rice, apparently lacking the confidence to adopt any alternative to rice in the kharif or to attempt a crop after rice. However, there was still some uptake of vegetable cropping in the kharif on upland fields (3.1 ha) (Table 2).

The uptake of intensive agriculture in Amagara had been rapid, but Amagara had undergone WSD, unlike the most villages in Purulia. This raised the question of whether irrigation resources, whether provided by comprehensive WSD or not, are essential for farmers to take up more intensive cropping. Or is sufficient just to use available water resources more effectively? To begin to answer this question we examined the access to irrigation for the fields farmers planned for, in the case-study villages (Table 6). Overall 34% of the land had no access to irrigation, so it is significant that some farmers had the confidence to plan for more intensive agriculture on land without access to irrigation. This was most pronounced in Luskudi, where 43% of land had no irrigation and yet all farmers opted for an intensive vegetable-based system on their uplands resulting in net sown area just exceeding land area (Table 2). Similarly in Rigid, where despite lack of irrigation, there was at least a single crop of vegetables grown on upland (a new practice). Nevertheless, greater access to irrigation seemed to a significant factor in the relative success at Putidih and Ona in achieving greater cropping intensity.

Table 6. Access to irrigation of land under planning

Particulars	Putidih	Luskudi	Ona	Rigid	TOTAL
Total land fragments	299	183	74	111	667
Fragments with irrigation cover	246	104	54	38	442
Fragments without irrigation cover	53	79	20	73	225
% without irrigation	18	43	27	66	34

Research in the project suggests that for food security rice should be improved on the lowland (bohal) and medium lowland (kanali) where it is most suited, and that the less suitable land in medium uplands (and uplands) should be shifted to other safer and/or more remunerative crops (vegetables, dry-bed DSR and alternative crops). These case study villages show that crops other than rice can be grown on uplands and medium uplands and, if irrigation is available, crops can also be grown in the *Rabi*. There were also notable examples in all villages except Putidih where farmers attempted a second crop in the *Rabi* without access to irrigation.

11.19 Family Case Studies - Synthesis

Name	Introduction	Learning from experiments	Change perceptions of land and self	Income/quality of life	Comments
Bijoy Hembrom	35 year old farmer. Recently separated from his larger joint family- therefore landholding is limited. Currently lives with wife and two sons Approximately 1.3 acre of land spread equally across all land-classes (tanr-baid-kanali-bohal)	Knowledge about right dosage of ferilizer- phosphate and potash as more viable options in comparison to DAP Noted increased understanding of pesticide use	Land, which remained fallow post kharif now used for vegetable cultivation- onion, bottle gourd, tomato, Cowpea, radish, mustard in his fields Able to integrate various crop options post kharif into his own cropping system. Number of crops grown after kharif increased from 1 to 8 crops (vegetables and oil-seeds) Better and more diversified and efficient use of harvested water More confident as a farmer	Shift in crisis mitigation strategy - earlier distress sale of paddy, now income from vegetable sale invested in savings, seeds, fertilizers, pesticides. Recorded cash income of Rs 26,000 from post-kharif 2007 to kharif 2008 (after deducting household consumption worth Rs 7,000). Had food sufficiency of 6-7 months. Now gets higher paddy yields because of adoption of better practices - better seeds and crop protection chemicals, producing surplus paddy which can be sold. Increased expenditure in household consumption - able to meet medical expenses, which previously had to be neglected. Investment in education of children in private school (Rs. 250 a month) Round the year employment generated from own fields. No longer work as daily wage labourers in nearby market towns - changed identity from a labourer to a farmer.	
Sukumar Hembrom	Middle aged marginal farmer, lives with his wife and two sons Small land-holding with no bohal and little irrigation.	Knowledge about dosage of ferilizer- P and K as more viable option in comparison to DAP. Learnt to use SSP from crop responses in trials. Increased understanding of pesticide use Vegetables replaced paddy as his dominant crop Use of FYM for both paddy and vegetable cultivation instead of earlier practice of exhausting it for paddy	Taking medium uplands on lease as a viable option for income generation through vegetable (tomato) cultivation Able to integrate crop options post kharif into his own cropping system. Number of crops grown after kharif increased from 1 to 10 crops (vegetables oil-seeds) As his land-holding is very small, he understands that paddy alone would not suffice to feed his family, so the renewed focus on cash crops like vegetables - as most of his lands are uplands and medium-uplands. Reflects enhanced importance to vegetable crops and uplands (which in the previous scenario had less value)	Extra income through vegetable cultivation used for purchase of inputs- seeds, pesticides and fertilizer as also for sister's wedding Recorded additional cash income of Rs 23,000/ from vegetables and another Rs4200 equivalent of produce as household consumption - more diversity in diet for family. Investment in education of children in private school (Rs. 4000 annually); Profits invested in better housing costing Rs 20,000/.. Invested in 2 Life Insurance policies with an Annual premium of Rs 5000/. Investment for assets for improving agriculture like bullock & pump-sets for irrigation.	Durgamoni (wife) now a very confident farmer. Actively engaged in trials and also as an SHG & VCC member. This family's improvement depended on leased land. In 2010 their lease arrangements fell through and they had to develop a new share-farmer arrangement for 2011 that seems to be working OK

Haradhan Hembrom	Supports a family of 5 on 5 ac but no bohal, 1.3 ac kanali	Use Hapa water for second crop (mustard) Use of phosphate and potash		Gone from 6 month food security to now having surplus rice to sell	Sends both sons to school
Gangadhar Hembram	Aged marginal farmer with 1.6 acres of land-holding, **not** in possession of any lowlands. Supports a family of 8 members	Improved production due to increased knowledge of fertilizer and pesticide use- participated in Mustard fertility and irrigation trials. Improved paddy production with better understanding of transplanting seedlings and maintaining right spacing between plants (SRI). Enhanced knowledge raising proper vegetable seedlings Increased risk taking ability vis-à-vis vegetable farming	Previous held assumption/ myth was that Amagara land was not suitable for vegetable cultivation. The vegetable trials helped to break that myth.	Reduced (or no) dependence on wage labuor for sustenance Gone from 6 months food security (rice) to having surplus rice to sell	
Bharat Hembrom		"The experimentation has helped us in a big way through introducing us with the proper methodology of vegetable cultivation." Learnt about P, K. Enhanced knowledge and confidence to adopt vegetable cultivation Enhanced understanding of cropping systems with a 2nd crop (wheat)	Family moved away from traditional rice-fallow cropping system to intensive agriculture, now agriculture more diversified- growing 8 new crops across the year. Noted that mustard is for home consumption (as for most farmers) but this saves cash outlay as all families need mustard oil	Steady inflow of cash income through vegetable cultivation. Gone from 7-8 months food security to surplus rice to sell Engagement in their own fields and availability of work through hapa construction and land levelling in their village had made their life easier as they did not have to go away to work as daily wage labourers most of the year. Increased availability of finance through selling of vegetables for purchase of inputs for agriculture.	Kalomoni (wife) actively participated in trials, enjoys enhanced status in family. Active VCC member who monitored the SGSY earthworks and on-farm trials.
Subodh Hembram	Elderly farmer > 20 years' experience in cultivation. Large family (8 members) Has sizeable land-holding of 4.3 acres of which 3 acres is lowland and medium lowlands.	Better understanding of use of fertilizer- improved production in mustard due to use of phosphate Enhanced capability and increased risk taking -***first farmer in Amagara to grow cauliflower (as part of the vegetable trials) and then later on green pea***- in vegetable farming	Grows up to 11 types of crops + paddy - includes leafy vegetables (for quick income & low water requirement), vegetables, wheat, mustard. Growing up to 4 crops in a year from a single piece of land- 400% cropping intensity.	Apart from saving for seeds, pesticides, fertilizers and other agricultural requirements he invested the money from vegetables on purchasing pump and building a new house	

Sagar Chandra Hembrom	A relatively better off farmer in terms of land-holding - with 5 acres with half of it being lowlands and medium low-lands An elderly farmer, nowadays most of his farming is done by his children	Not direct participant, but the children of Sagar (aged around 15 to 20 years) receptive to the changes in the villages.	More interest in growing high value crops like vegetables than traditional paddy Significant production scale - primarily focused on the market. The younger generation are visualizing the potential to make a decent living from agriculture - ***reverse migration***	Elder son, who would migrate earlier chose to stay back and cultivate vegetables on his own fields; engaged in share-cropping with other farmers like Sukumar who have small land-holdings on a profit sharing basis. Earned Rs 20,000/ cash income in one year by growing different vegetables They used their money from selling paddy on repairing their house and fixed some amount in bank that they received from selling the vegetables. They have also purchased a thresher machine and insured some amount with Life Insurance Corporation.	
Iswar Hembrom	Iswar Hembrom an elderly farmer from Amagara used to work in Beldi mines. After retirement he engaged himself in fulltime cultivation along with his son	Increased understanding of fertilizer (P, K), pesticide and thus got higher yields from high yielding varieties Better understanding of use of water from hapas for vegetable cultivation and fish		Increased food sufficiency through extra income generated from vegetable cultivation. Although he said he is only 11 months food (rice) secure he has good cash income now from vegetables. Took out life insurance. Son also actively engaged in agriculture now and gaining good profit (tomato cultivation)	
SukhSing Mandi	Marginal farmer- 2 acres of medium uplands	Experiments helped him learn good agronomy skills. Replicate it in growing different vegetables	Lease of land (medium upland) for vegetable as a financially viable option . Growing up to 6 different types of vegetables in a year along with paddy and mustard.	Need for distress migration mitigated - can now eke out a living from own land, better family life and environment for children. Able to earn around Rs 24,000/ in a year from vegetables. Extra income generated through vegetable cultivation used for purchase of inputs- seeds, pesticides and fertilizer. Change in diet- Inclusion of various vegetables in their diet. Can afford health care for children. Investment in education of children (private), house repair Savings in the form of Life Insurance policies (Rs 5250/ annually) and Fixed deposits (Rs 6000/) in banks	Construction of WHS on his land helped diversify his agriculture as it reduced risk and gave him multiple options for utilizing harvested water. Success depended on leasing land but lease arrangements failed in 2011. Now works as agric. Input salesman in shop, despite illiteracy – using his knowledge

11.20 Change in PRADAN team members' practices and beliefs

(From a PRADAN workshop in Oct 2009)

Beliefs and practices	Before ACIAR was initiated	Now
1. With respect to approach to Natural resources management		.
a. On livelihoods promotion vis-a vis NRM	PRADAN is involved in land and water based / agriculture based (both irrigated and rain-fed) livelihoods intervention since 1987. The accumulated experience guided us to develop some technologies. Those technologies got further sharpened over the years. Later on by 1998 onwards PARADN have been trying to scale up those experiences (technologies) in different locations (across the country where PRADAN established teams) following participatory processes. Ministry of Rural Development invited PRADAN to prepare manual on INRM approach/ methodologies/ technologies. That guideline can be used a base document to PRADAN approach to INRM based livelihood promotion before ACIAR project started in 2005-06. Key approach was to increase the carrying capacity of local natural resources (the watershed) through land treatment & moisture conservation. This would produce more bio-mass in the form of food grains, pulses, vegetables, fodder etc.. Also focusing on sustainability of the interventions.	Involvement of farmers in conducting research to generate knowledge for natural resource management got added to PRADAN's perspective
b. On role and involvement of people	We believed natural resources could be managed only if the local people can be made equal stakeholders in the change. However we used to work with farmers who are ready to follow a redesigned package of practices. Involving farmers in rigorous scientific research was not in PRADAN's thought. They were perceived as active recipient of knowledge/ skills and technologies to enhance their livelihoods. We generally plan with the villagers on agriculture based on rain fed and available irrigation sources.	We value involvement of the villagers in developing the package of practices with relevance to local area perspective. Now we are better equipped to involve the farmers in utilisation of the assets and thus ensuring quick transfer of technology & skills to the community
c. With respect to role of women	PRADAN have been working with women - organising them into Self-Help-Groups, training them to transfer new knowledge and skills to enhance their livelihoods since its 1990 in large scale. But never tried to involve them in research. They play a major role in the farming practices in terms of contributing to the family workforce.	Women take charge the nature of our engagement with them changes- more transformational engagement rather than transactional
2. With respects to potential to rain water use – principle of harvesting and management (irrigation – live saving/supplemental)	Before ACIAR project was initiated, PRADAN primarily focused on management of rainwater, surface water and development of irrigation resources but did not give systematic attention to use of residual moisture after harvest of paddy. Sporadic efforts were made. We recognised that most of the rainwater is lost as surface run-off and sub-surface flows. The rainwater has to be harvested in the uplands and medium uplands, which can then be used for supplemental irrigation in Kharif, & with availability a second crop can also be grown.	ACIAR project could drew our attention to residual moisture Better scientific understanding of recharge-zones & discharge zones. Also appreciating the value of infiltration and the agricultural practices, which change the soil texture, compaction, etc.
3. With respect to ground water use	Wherever possible, PRADAN promoted open dug well to exploit ground water. It remained a marginal activity in comparison to stream based community	Apart from increasing our sensitivity about use of residual moisture, ACIAR project made us sensitive about hydrology and

	managed minor lift irrigations or watershed development Apart from that there was effort to exploit shallow ground through in the seepage pits in the lowlands along the drainage line after the withdrawal of the monsoon. This water can be used to grow a fully irrigated second crop.	water balance in a watershed Learnt the use of simple technology like piezo to study the ground water flow in the dry season.
4. With respect to residual moisture use	We were less sensitive. Had no idea of the significance of residual moisture, though some farmers in their local practices took this into consideration. So we never work on it.	Became more sensitive about residual moisture. Now believe that crops with respectable yields can be grown on residual moisture and some natural winter showers- provided weeds are controlled, sowing time & technology prevents loss of residual moisture. Also now aware about soil moisture profile, extraction of soil moisture by the roots and its implications.
5. With respect to crop loss due to crop –weed competition	We were conscious about the issue but never engaged deeply to work out effective solution. We introduced herbicides in some pockets of our operational areas without much thoughtful analysis of the situations and future consequences. Was not fully appreciating the crop loss due to crop-weed competition.	We are more conscious about the various issues related to weed management. We understand that evapo-transpiration by the weeds causes loss of soil moisture, thus if weeds can be controlled in fallows, then we can go for an early crop or use less irrigation to grow a crop
6. With respects to potential of people's engagement (the way we conduct training/ share information)	We were less conscious about what happens to the people because of our nature of engagement. PRADAN conducted designed training programme through HRD/ human behavioural experts. But did not ever applied similar approach in field practices. Trainings were more prescriptive in nature, where the learning agenda was mostly set by us based on our assessment of the need of the community.	Increased our conscious about our nature of engagement with people in training events. Fertiliser & pesticide trainings before we start our agricultural interventions contribute a lot to generate interest & involvement. Workshops can also be designed which evokes farmer curiosity and the learning cycle process contributes to knowledge building and change in practices.
7. With respect to people generating new knowledge	We use to think that PRADAN will generate ideas, generate new knowledge and try those with people but there was some element of "top down" orientation. Processes of involving community to generate knowledge from practical experiences were very rudimentary. Such knowledge was used only to generate package & practices for crops, which was again fed to the community as recommended practices.	ACIAR project strengthen the approach orienting us to be more "Bottom-up"- involve people in generating ideas, knowledge; take risks and conduct experiments to generate knowledge that people themselves will analyse and use (increases retention).
8. With respect to other research/ resource institutions in adding value to knowledge building of PRADAN and community	Did not have much exposure to institutions involved in research and doubtful about their purpose / relevance in the context of livelihoods of poor farming communities (apart from developing crop varieties). Did not believe that Scientists can come down to farmer's field. Thus no pro-active engagement with such institutions. Mostly with research stations to procure good seeds.	ACIAR project changed these views More confident of collaborating with such institutions and influencing them to set research agenda based on farmers need.
9. With respect to role of soil (physical & Chemical) in sustaining return/income from lands & water	Had tendency to follow package of practices as recommended by experts / experienced farmers. Never thought of conducting systematic trials. Understood that soil has to be replenished with chemical inputs and manure to sustain yields.	Convinced that conducting fertiliser trails are more appropriate/ scientific to work out fertiliser doses to sustain soil productivity. More informed and aware, especially about phosphatic fertilisers.
10. With respect to decision support tools	Had some understanding. Not referring to such tools other than occasionally Ashok's POP.	We are hopeful that reliable DSS tools will emerge out of ACIAR project
11. With respect to role of SHGs in anchoring change processes vis-à-vis NRM	PRADAN started working with SHGs in helping them to anchor NRM based livelihoods activities. Had the belief that women need to be involved in change processes, but not clear about their roles and how to involve them other than in the village/community meetings where decisions are taken or communicated. SHGs were also represented in the WS development Committee but their roles were merely ornamental.	This research project with recent discussion on gender / women's role in NRM project, made us more conscious Have been able to implement and demonstrate that SHG's can be facilitated to anchor change processes vis-à-vis NRM. The learning from this can be used for quick replication in other projects of PRADAN.

11.21 Jharkhand Team Leader's Workshop on INRM

Expected Outcomes - participants learn that:

1. Given landscape heterogeneity, locally generated knowledge will be better than imported knowledge, and more likely to be adopted and sustained
2. Farmers can contribute to knowledge generation, to meet emerging needs, with less dependence on PRADAN
3. By engaging farmers as 'learners' professionals can be liberated from role of service provider, to engage with communities as development professionals

Day 1							
10.00-10.15	10.15 to 11.00 am	11.00-11.30 am	11.30-11.45	11.45 to 1.00PM	1.00 to 2.00	2.00 to 3.00 PM	3.00-4.00 PM
Introduction *A vision for NRM - "good processes and good practices"*	Map existing perceptions about the role of farmers and PRADAN professionals in managing Natural resources: *What <u>role</u> do farmers and PRADAN professionals play in learning how to manage natural resources better?*	See the limitations/risks of existing perceptions, both for the farmers and for PRADAN	Tea break	Identify opportunities/ scope for reducing the limitation/risks in current engagement in INRM. What changes are desired?	Lunch	Visualize a process to facilitate the desired change	Experience in ACIAR project - A process for creating local knowledge and 'empowering' local communities as learners
	Process: Small group Assumption to check: Farmers are perceived as recipients of knowledge; PRADAN seen as providers of knowledge	Process: Individual exercise and sharing in the plenary (collect the notes to be included in the report)		Process: Sub groups and sharing in plenary (30 mins discussion +15 min presentations in the plenary).		Plenary	Plenary: Presentations and discussion
Day 2							
8.45-9.00	9.00-10.00 am	10.00-11.00 am	11.00-11.15	11.15-12.00 noon		12.00-1.00 pm	
Reflections on Day 1	Water and productivity	Identify components of WB to focus on		Interventions		Identify & remove agronomic constraints	Design a project to explore a new approach to co-learning in an NRM context
	Presentation showing that higher productivity means increasing water use (by useful plants), drawing out components of the water balance **(A separate module for this & next 2 sessions Introduction to NRM)**	Small group exercise for participants to assess which components of WB can be practically managed, and how		Plenary: Interventions that increase water use or use water more efficiently		Presentation on results of ACIAR project	Individual. Ashok/Peter support implementation. Participants re-convene afterwards to share observations, reflect, plan.