Background Paper

5% Pit Technology Technical Report
Purulia, West Bengal, India

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PRADAN

Poverty-Focused Smallholder Water Management
Promoting Innovative Water Harvesting and Irrigation Systems
to Support Sustainable Livelihoods in South Asia

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**History of Evolution Of The Model**

PRADAN (Professional Assistance for Development Action) is a non-govt. rural development organization and is engaged in designing and field implementation of rural poverty alleviation programmes. PRADAN set up a ‘Resource Management Team’ in Purulia town of East Bengal in 1987 to assist voluntary agencies, informal community groups and other grass-roots development organizations of the rural people in programme implementation and organization-building utilizing land and water resources. One of the first collaborators of the PRADAN Team helped Sevabrata (a local voluntary organization) to draft a wastelands development project proposal, which was submitted to the National Wastelands Development Board for grant-in-aid. The Society for Promotion of Wastelands Development, New Delhi (SPWD) was then contacted by the Team on behalf of Sevabrata, for technical and financial assistance.

The SPWD agreed to take up a collaborative action programme with Sevabrata. It was agreed by the three organizations that this project could be an innovative one and of a pilot nature, with the purpose of a model of Lac-vegetable intercropping on uplands. Lac is an insect which is hosted by trees like Palas (Putea species) etc and from which shellac is obtained. Some districts of the Chotanagour used to grow lac but the trade was recently on a decline, because of large-scale of barren uplands (private or government) available in almost all places with Palas etc. Trees so that they will supplement the income of the poor though lac-rearing. The same lands will also be intercropped with rainy-season vegetables after taking up moisture conservation measures so that the productivity is further enhanced and an immediate income to the farmers becomes possible.

For a beginning, stretches of private wastelands in the villages of Jamgoria, Rakdih and Champati were selected to start the project and SPWD did the financing to Sevabrata. (SPWD – Sevabrata collaboration is still) An organizational model for project implementation and a profit sharing mechanism for the participant villager were also chalked out.

Dinabandhu Karmakar a local activist and Pradans proponent of the Jaladhar and 5% percent model took the immediate responsibility of guiding Sevabrata in project implementation, by being a resident in the project area itself. As the earthwork for moisture conservation began, we thought initially of going for the conventional models. SPWD also provided us with some moisture conservation, guidance from senior PRADAN colleagues, collection, analysis of rain-fall data and an intuitive understanding of the local topography, soil structure and socio-economic condition of the population led us to evolve the model that we will discuss now.

Land distribution and land use pattern for farming in Chotanagpur

<table>
<thead>
<tr>
<th>Elevation of land</th>
<th>Ownership</th>
<th>Land use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upland</td>
<td>Big farmer/Land patta</td>
<td>Degraded forest/barren/</td>
</tr>
<tr>
<td>Holder/Forest with minor millets or legumes during monsoon.</td>
<td>marginally cultivated</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>-----------------------</td>
<td></td>
</tr>
<tr>
<td>Medium upland monsoon</td>
<td>Big/medium farmers</td>
<td>Paddy mostly, during</td>
</tr>
<tr>
<td></td>
<td>Small farmers to a much lesser extent.</td>
<td>Occasionally suffer from Rain failure.</td>
</tr>
<tr>
<td>Low land</td>
<td>Big/medium farmers</td>
<td>Paddy of longer duration during monsoon. Usually does not suffer from rain failure. Cultivation during winter and summer may be possible using minor irrigation sources.</td>
</tr>
<tr>
<td>Homestead land</td>
<td>All farmers</td>
<td>Vegetables, maize etc in the Monsoon. Vegetables are in The winter if there is a Working well.</td>
</tr>
</tbody>
</table>

It may be worthwhile to mention here that though the marginal and the small farmers are always poor, the medium and the big farmers are not necessarily rich in this plateau. Even when they are well off they are poorer as compared to their counterparts outside the plateau with an equal land holding.

**Issues in conserving moisture on uplands**

It is evident that farmers struggle to prevent any breach in the bund of farmland, which they have traditionally inherited. But when soil conservation department on uplands does similar land development work, nobody takes care of those.

Among many reasons, following could be worthy of mention here.

a. Moisture conservation part has been given less importance where soil conservation has been taken care of

b. Commonly practiced methods like contour bunding and trenching for the sake of soil conservation have some inherent problems.

Let us elaborate the second one, so that we can compare the proposed alternative method side by side with this commonly practiced method.

Firstly the size of land-holdings (either big or small) is comparatively small in this area. Moreover it is fragmented and dispersed. Pieces of land have rectangular shape. Consequently, its boundary does not follow the loans of the contour line for conservation practices. Secondly, it requires skilled labor and close supervision to prepare bunds and
trenches along the contour. These are absent when such work was carried out.

Thirdly, in most cases, contour trenches and bunds are not prepared with proper calculation of amount of runoff water that is supposed to be retained by it, the result being frequent breach of the structures. Fourthly, in case of stony or gravelly soil that are coarse and loose structured, leakage is common phenomenon. Hence for one reason or the other (similar to faulty contour bunding, breaches, etc) in many cases those structures behave like drainage channels and enhance soil erosion.

In many villages in Purulia district, the soil conservation department of Government of West Bengal undertook soil and water conservation measures by raising field bunds on private lands. But the farmers themselves cut the bunds to drain out excess rainwater during cultivation of legumes, as they were vulnerable to stagnation of water.

Background On Agro-climatic Characteristics:

This section describes the existing state of kharif paddy cultivation and utilization of rainwater as done by the common farmer in Purulia district and in similar other agro-climatic areas of Chotanagpur plateau.

Assessment of the Rainfall Pattern and its implications of cropping

Rain from January to April:

In the month of January, the range of precipitation varies from zero (once in ten years) to as high as 48 mm (rarely occurs), average being 11.74 mm. Whatever rain may be received during this month, farmers generally ignore the incidence of rainfall except in a few cases they plough their nursery-bed for the next kharif paddy.

In February, quantity of rainfall that the area receives varies from zero (once in ten years to 41.4 mm, average being 15.88 mm. Agricultural practices for paddy-land are generally similar to what is do in January: but now more farmers start ploughing their nursery-beds for the ensuring kharif paddy. A few of them also plough their main fields to prepare them for plantation.

In March, range of precipitation varies from zero (twice in ten years) to as high as 81.6 mm average being 27.5 mm. Preparation during this month for kharif paddy are like that of the previous month.

In April, range of precipitation varies from zero (once in ten years) to 107.3 mm, average being 42.25 mm. Agricultural operations are similar as the previous month.
Rain in May and nursery raising for paddy

Precipitation during this month varies from 14.1 mm to 112 mm. The average is 64.22 mm. Number of rainy days varies from 2 to 12. Quantity of rain per day varies from less than one mm to as high as 71 mm. Number of effective rain days (i.e. more than five mm) varies from one to seven.

Farmers start sowing seeds in nursery beds during the third week of May (during Rohini Nakshatra which is considered as appropriate time for sowing paddy seeds; according to the Bengali calendar, the time is Aukshay Tritiya). Hence, effective rain in the third week of May is very important. A heavy rain in the second week of May is also helpful to go for sowing in the third week of May. A rainfall of 30 to 40 mm in this week facilitates easy nursery sowing. If it does not rain during this time, the farmers have to wait till there is an effective rain.

Quantity of rain-fall that can be considered as an effective rain:

Pradan considers five millimeters of rainfall as an effective rain in this region, but this figure may vary. Any rain event below this would not effectively contribute to the root zone or plant growth. Effectiveness of rain varies depending on several factors.

These factors are:

1. Type of soil: Quantity of rain which is sufficient to properly moist a nursery-bed in loamy soil may not be sufficient in case of sandy soil.

2. Farmer’s knowledge, awareness, capacity, and attitude towards utilizing rainfall opportunities: There are farmers who are cautious enough to trap every drop of water in his field. Whenever there is rain ploughing is followed by harrowing. This practice is considered to trap rain moisture in the topsoil and prevent it from being lost to atmosphere. Under such field conditions a few successive less than effective rainfall can still be made effective.

3. Position of land: A piece of land, which is situated at the foot of some larger plot that receives runoff water from the upland. Thus water supply to this lowland is increased is assured in most rain events. Land below some water harvesting structures also gets the benefit of rain than other lands.

4. Stage of crop growth: Quantity of rain that will be effective during boot-leaf stage or tillering stage is far less than an effective rain for transplanting period.

The rain received in May, apart from raising nursery also helps in preparing land, especially uplands for direct seeding of paddy. While early-May rains are used for land preparation, rains in the second half of May helps in sowing of seeds, its germination and subsequent growth or inter culture (continues to June).
Effect of erratic (unevenly distributed) rain:

If there is no rain during the third week of May, farmers wait till there is a good rainfall at least an amount equal to more than the perceived effective rain. Delayed rainfalls for up to one week or so is not so harmful if subsequent rains are in time and well-distributed during the crop settlement period.

On the other hand, if it rained prior to sowing, dependent on which farmers undertake sowing, and the rain ceases for prolonged duration (more than 15 days) during and after germination of the seeds, the paddy nursery ends up in a disastrous state not being able to recover from acute moisture stress. In situations like this farmers give up on the crop and incur heavy losses in their seed investments. Very few farmers who have access to water from either wells or a nearby river try to save the nursery. Rains prior to the germination cannot be stored on farm as soil moisture since bunds are not properly maintained at this stage. Some who maintain bunds have also experienced breached bunds due to heavy rain incidences. Breaching of bunds also occurs due to cart tracks formed during the earlier harvest, rat-holes, etc. To keep the bunds well maintained prior to rainfall would be a simple approach to this issue but quite a few farmers out migrate for other livelihood occupations during dry season and move back just before the rain starts.

Farmers do not preserve moisture on farm or store in the nurseries since excess water during nursery stages is detrimental to the growth of seedlings. Also soil becomes relatively compact, hence increasing labor costs for the farmer. Removing seedlings from nursery becomes difficult due to compacted soil further increasing losses.

Longer spells of heavy rainfall during nursery raising also causes problems of drainage as they fail to drain and dry the field adequately. Farmers are compelled to practice the wet bed method, which they don’t like. It has been farmers experience that seedlings raised in wet bed are generally weaker and can’t tolerate either saturated or complete dry soil moisture conditions after transplanting.

Thus we see that in the existing condition and with present infrastructure of land resource management, farmers neither can cope with the situation of heavy rain, nor low rain: delayed rain or early rain. Unless there is adequate rain during appropriate time farmers tend to loose their crop and incur heavy losses.

Rain during June and at the time of transplanting:

Generally farmers start raising nurseries in May hoping that monsoon will break in the second week of June. So keeping in mind the optimum age of transplantable seedling, good rain in the second week of June is very important. Rain amounting to 50 to 100 mm during the second week of June facilitates easy transplanting.

A similar quantity of rain in the first week of June does not come to any use since it is too early for the seedlings to be ready for transplanting. Farmers do not care for this water
and it runs off through natural outlets. Presently, no worthwhile measures exist to preserve this water for future use.

So, in absence of other alternatives, if there is no rain in time (second week of June or around it) farmers have to wait till there is a heavy rain (50 mm or more). If rains are delayed seedlings get older and over-mature causing further damage during transplanting and lower yields eventually. Experience says that in some years this rain is delayed by more than a month or so. Farmers continue transplanting till mid-August.

**Situation in the aftermath of delayed rain:**

Seedlings when over aged in the nursery lose their inherent power for vegetative growth. After plantation, they do not produce enough tillers. Size of ear-heads also becomes shorter resulting in reduction of output. So, in case of delayed transplanting, farmers as a safeguard transplant more number of seedlings per hill so as to compensate for the reduction in tillering. Thus there occurs a shortfall in the number of seedlings required. Farmers then have to leave a part of the holding uncultivated, generally the less productive upland.

In case of short duration paddy varieties and in case of delayed sowing, the plants start flowering within a short period after transplanting virtually without any worthwhile vegetative growth leading to a sharp reduction in output.

Short-duration and medium duration paddy varieties have two broad categories. One is photosensitive period, during which flowers after being exposed to a certain critical day-length (shorter nights for a certain number of days). Most of the indigenous short and medium duration paddy varieties used in the region are of this type. The second is photoinensitive period, which does not respond to duration of night and flowers after a fixed time depending on the variety. Commonly used and recently introduced *Japonica dwarf* varieties belong to this category.

Once the nursery has been sown in the second week of May, both the types of short duration varieties suffer in case of a delayed rain. The *Japonica* varieties however suffer more due to ageing of seedlings and lack of time for vegetative growth, as reproductive phase starts one month before the grain matures.

Example: Seedlings of a variety with 90 days duration is right for transplanting when it is 21 days old. A thumb rule in this regard most commonly used amongst farmers is: The number of months required for a paddy variety to mature i.e. from seedling to seeding, should be equal to the age of seedling in number of weeks when it should be transplanted. So, seedlings of a paddy variety of three-month duration will be ready for transplanting at three-week age.

Its panicle initiation will start at 50 days and the remaining 40 days is reproductive phase. So normally the seedling will get \([90 - (40+21)]\) or 29 days for vegetative growth after transplanting. If the rain is delayed by 2 weeks transplanting is also delayed by that
amount of time. The seedling will also get about \((29 - 15)\), i.e., 14 days for its vegetative growth after transplantation. Again, at least seven days is required for its establishment after transplantation. Practically in such a case, the seedlings will get only a week for vegetative growth after transplanting. Thus within a short time after transplanting it will reach flowering stage.

In case of *deshi indica* (a local variety) type of medium and short duration varieties, the flowering time is not guided by number of days of its age but by critical night length. For example, a variety which will flower after getting an exposure to a critical night length of say eleven hours for consecutive thirty days will flower around 22\(^{\text{nd}}\) of September irrespective of when it has been transplanted. So, when rainfall occurs at the optimum time (say, 10\(^{\text{th}}\) June) and transplantation takes place, the plants will get enough time (from 10\(^{\text{th}}\) June to 22 August) before it is exposed to the critical (minimum) night length of 11 hours. So, until then the seedlings can increase leaf cover producing more number of tillers before they enter reproductive phase.

But if rain is not received in time (it gets delayed, say, till first of August), in that case even if farmers transplant seedlings of optimum age (say, 3 weeks old) the plants will enter reproductive phase by 22\(^{\text{nd}}\) of August (with a tendency to be late by a few days in comparison with early transplanted crop of the same variety). In such a case (delayed transplanting because of delayed rain) farmers get little time for inter-cultivation resulting in sharp reduction in production.

Effect of uncertain (erratic) rainfall during the months of June and July: Discussion on June and July will be clubbed together because there is little difference in paddy cultural practices as far as *deshi* paddy cultivation of this area is concerned.

The quantity of rain that is received in June varies from 20.5 mm (1987) to 894.3 mm (in 1984). Monthly average is in the order of 298.45 mm. Number of rainy days varies from 7 to 24, the average being 16 days. Rain depths per day vary from less than one millimeter to as high as 130 mm. In a consecutive three-day period the maximum rainfall in last 10 years was 250 mm.

In July, total precipitation varies from 188.4 mm to 512.9 mm with an average of 331.6 mm. Number of rainy days varies from 16 days to 27 days with an average of 20 days. One should not however try to get the total rain of the month calculated, by multiplying the aforesaid average rain per day with the average number of rainy days because these are the average values for the last ten years. Another noticeable aspect of this rainfall is that, if the nature of rain in June is compared with that of July we find that June rains are more erratic than rains in July. Again, if one attempts to find out the effective rainy-spell (for the purpose of transplanting, more than 50 mm at a spell of three days can be good) available. In some years, no effective rain spells occurred in June. Due to availability of moisture in the soil as a result of rains in June the possibility of effective rain-spell increases even if the precipitation rate is lower. Thus in July, quantity of rain required for an effective rain spell drastically reduces. According to Pradan, a rainfall of 25mm may be considered as effective in the month of July. Hence July is more reliable than June.
It has been observed that the above effective rainfall may occur in the first half of July, with lesser probability of the same during the second half. In such cases farmers are usually unable to complete transplanting within the first half of the month. Transplanting operation stops halfway and they are forced to wait until August. Rains during the month of first 2 weeks of August are the last opportunity for farmers for transplanting.

This type of sudden cessations of rain causes other trouble apart from difficulty in transplanting. Fields that are already transplanted suffer from shortage of water while top soil layer develops cracks loosing moisture from deeper layers to atmosphere. Crops tend to whither and weeds compete for moisture and nutrients. Under such circumstances intercultural operations cannot be practiced due to lack of sufficient water to make the soil soft. This results mostly in crop failure in the upland transplanted paddy.

The direct-seeded paddy crop on uplands is relatively less affected. Farmers tend to neglect and manage upland paddy poorly hence leaving rains of June-July unutilized. June-July is the time for vegetative growth of paddy particularly for those, which are of short duration. Any stress condition during this period results in sharp reduction of yields.

**August rain and paddy cultivation:**

Observed minimum rainfall in August is 213 mm with a maximum of 512 mm and an average of 320 mm. The number of rainy days varies between a minimum of 16 to a maximum of 25 days with an average of 20 days. August rain is generally considered as subsistence and maintenance rain. But continuous rain accompanied by cloudy weather conditions cause considerable harm to paddy growth. Enough sunshine hours during this month plays an important role affecting crop establishment, which in turn affects production. Cloudy weather increases possibility of insect and disease attack. Crop cannot recover from any damage during the latter part of the vegetative growth phase and cannot be compensated by any means (water or fertilization).

September rain and paddy: September rains are crucial in determining the outcome of paddy crop on uplands and midslope lands, which constitutes sixty percent of paddy-lands of this area. Lowlands normally do not suffer due to failure in September rain. One normal rain of 25 mm usually ensures good harvest from uplands and medium uplands. If this does not happen, whatever progress might have been made eventually leads to drastic crop failure.

Quantity of rainfall received during this month varies from 46.2 mm to 448.2 mm with an average of 201 mm. Number of rainy days varies from 5 to 21, the average being 15 days. But number of effective rainy spells (more than 25 mm) is more important than more number of rainy days in September. In 1988, the entire upland rice cultivation failed to produce any grain in Purulia due to no rains in September. This suggests the ultimate test for farmer and indicates total dependence on September rains. One can realize the truth behind the farmers saying, "Just one rain during the Visvakarma Puja can save our Baid dhaan".
Usually, a rainfall of 25 mm at seven-day intervals or equivalent amount of cumulative rain in seven days during September can assure the survival of paddy. Last ten years’ data for Purulia reveals that in the year 1981 there were no rains between 11th September and 25th September. In 1982, there was a dry spell of 38 consecutive days until 21st October. In 1984 and 1986, there were dry spells of 13 days starting from 12 September and 12 September respectively with very little rain not enough to meet the effective rainfall needs in the latter. Situation in 1988 indicates a rainfall of 58.4 mm for September but, spread over number of days resulting in almost zero effective rainfall during the month. Maximum rain on given any day was 9.9 mm with total rainfall of 5.5 m during 8th September and 19th September, the most crucial period to salvage paddy crop.

**October rain and paddy cultivation:**

Minimum rainfall during the month was zero with a maximum 203.9 and an average of 80.6 mm. Number of rainy days ranged from 0 -12 averaging 5 days. October rain is specially important for long-duration (Aman) paddy varieties particularly for those, which flower in the middle or this month. But in these areas due to undulating topography, the lowland Aman paddy gets enough water for its survival through seepage from the adjoining upper catchments. So, October rain is not so important in these areas as compared to flat areas outside the plateau. One or two rains, however is beneficial as far as medium-low land paddy is concerned. However, October rain is very important as the moisture source for the ensuring a Rabi crop in this area. Rains in October increase the possibility taking up Rabi cultivation such as vegetables, etc. Most October rains occur due to low pressure formed in the Bay of Bengal. Severe storms formed out of the low pressure may also cause damage to the standing paddy crop such as premature lodging leading in reduced yields.

**November – December rain and paddy crop:**

Rain in November and December is not at all desirable. This creates trouble in harvesting and post-harvesting operations. However, these rains are of significance to farmers who cultivate long duration paddy or some who cultivate rabi crops such as vegetables and pulses.

An alternative approach of integrating soil and moisture conservation:

The methodology suggested by Pradan is to conserve moisture along with soil conservation and land husbandry where the existing skills of villagers and local labor has been utilized keeping the amount of expenditure low to be affordable to the poor, small and marginal farmers. The approach combines two of the pradan’s promoted models:

1. Jaladhar model, which is practiced on unbunded and unterrated uplands.
2. Five percent model on lands below that could be bunded or terraced.
The Jaladhar model is practiced in the upper slopes that are degraded or can be classified as wastelands to primarily harvest rainwater in trenches that would eventually feed in to the 5% pit downstream of it. Pradan recommends that the micro watershed be treated to an extent not less than 20 hectares.

RAINWATER MANAGEMENT FOR SECURING KHARIF PADDY

This section describes Pradan's approach to better rainwater management to protect paddy crop (particularly upland paddy) of Purulia district and similar agro-climatic region of Chotanagpur region. This section includes implications of the rainfall analysis discussed in the previous section and an assessment of kharif paddy crop for 5 months beginning in May and ending in September. Issues related to runoff, subsurface flow, and existing modes of external water sources for irrigating crops is also discussed.

![Diagram of land types]

**Figure: Typical distribution of land types in Chotanagpur region**

The land is generally sloped with upper most slopes quite barren. This land patch is closer to the ridge line is occupied by homesteads, small tanks and open wells that are mostly used for domestic and livestock purposes. Portions of land immediately below constitute the Baid uplands where short duration paddy is cultivated. This portion of the slope is less fertile with shallower topsoils and gravelly (morum) or rocky layer within 3-4 feet from surface. This portion of the land is mostly owned by small and medium farmers. Almost all farmers own some patch of land in Baid area. The land then rolls down gradually up to the lowest land (Kanali and Bahal) where topsoils are deeper and more fertile. Kanali area captures most subsurface flow from upstream and its subsoil is
moist for longer periods after the monsoon ceases. Bahal land, which is mostly the drainage channel, constitutes of flatter slopes and is owned mostly by large farmers. Long duration paddy is mostly cultivated in this portion due to assured water flowing into it during most part of the year.

When there is sufficient rain and a consequent run-off, it starts flowing from the upper catchment; flows through the medium-up, medium-low, and lowlands and finally reaches a local natural outlet that ultimately drains to a river. As the runoff passes through medium-up, medium-low, lowlands it is joined by the runoff from intermediate lands and consequently increases in volume. Parallel to surface flows of excess rainwater, however, their subsurface flow the flow area for which also gradually increases downstream. Subsurface portion of the flow is more crucial as compared to the surface flow when growth of vegetation in the middle and lower patches of the slope are concerned.

When excess amount of rainwater flows above surface it not only causes soil erosion but also carries away soil nutrients including those from manures and fertilizers applied making the land poorer, and decrease the pH of soil. Farmers believe that many of the barren uplands that exist now were occupied by forests and other kind of vegetation with good depth of topsoil. Over time due to human occupation of land for converting them into agricultural lands without practicing good soil conservation has resulted in to barren lands. So long the upper catchment was in a position to hold moisture (due to presence of vegetation), even if these lands were not cultivated, they were helping by supplying subsurface water to compensate for the moisture loss from the cultivated lands down below. As upper catchment lost this ability, need for external irrigation to crops in cultivated lands became more felt.

**Common practices of developing sources of water:**

Farmers with their age-old experience built water-harvesting structures in the form of check-dams and small earthen tanks. Large number of these structures were constructed decades and centuries ago mainly by landlords or zamindars. These check-dams and tanks are built along the drainage channel of the topography and harvest runoff from the upper catchments. These structures store water and are still primary sources of water for drinking, livestock and irrigation of paddy lands immediately downstream of it. During acute scarcity of water needed for saving paddy, water is also lifted using indigenous devices such as swinging baskets or more recently diesel operated portable pumps.

Farmers and implementers clearly understand the impacts of increasing pressure on land and water resources. More and more lands of the upper catchments mostly rain fed, were brought under cultivation due to increasing food demands. These lands, having lesser access to irrigation sources became more vulnerable to dry spell. Dependence on rainwater for successful harvest from these lands thus was much more.

Conventional water harvesting structures are normally of a size varying from one acre to ten acre or even more constructed at comparatively lower areas of the valley so as to get sufficient water either from a perennial source (e.g. oozing water out of the cut-off
seepage line) or from a sufficiently big catchment above. These structures can supply water to the lower lands by gravity-flow or water from them needs to be lifted. These by gravity-flow or water from them needs to be lifted. These type of water harvesting structures however can retain very less runoff water as compared to what it receives from the catchment.

Finding a solution to the problems

There are a few common alternatives considered by a large section of farmers, experts and many development agencies. These are

1. More water harvesting structures
2. Lift irrigation schemes—small or big
3. Introduction of short duration and drought resistant paddy varieties
4. Promoting intercropping to reduce risk
5. Crop diversification or change of crop to less water intensive (i.e. from paddy to some other pulses)

Pradan seems skeptical in promoting practices that are less water intensive. This may be primary due to problems associated with access to markets for both acquiring inputs and selling the produce. Present approach of paddy saving water management is derived from the fact that paddy grown in most of this region especially small and medium farmers is primarily for domestic consumption. Pradan’s argument is that upstream lands from where the water is coming however never get the benefit of these structures. Water from these do not meet the irrigation requirement of the medium uplands to save the paddy crop there. Replication of these structures on a widespread basis in the present day situation will be difficult due to:

a. Technical prerequisites which can not be met in a majority of places
b. Fragmentation of land-holdings that has led to issues related to land reallocation, collective farming or management of these resources that have failed in the region.
c. Limited land resources available for cultivation.

Some of the other concerns of Pradan in promoting other alternatives are as described below.

The lift irrigation system itself restricts its replicability with the absence or inaccessibility of water sources in or near a vast majority of uplands. It also has a comparatively high recurring cost, which many poor farmers cannot afford. Particularly when it comes to the question of saving the upland paddy during September (a difficult period of the year for the poor families to sustain) an LI system is difficult to think of unless it is supported y an LI system is difficult to think of unless it is supported by an organization of farmers (something like that of a cooperative) and availability of timely finance is assured. It also increases dependence on outside inputs. Because of unavailability of fuel in remote areas
in time or uncertainty of electricity, a flowering crop may die, as the pump set remains idle.

Introducing early maturing varieties is thought of as another alternative. These varieties mature in the first half of September and thus escapes the possibility of risks during September rains. But dry spells do not occur every year. In many years sufficient rain is received during September and beyond. Harvest and post harvest operations become difficult in a rainy and cloudy weather. There is much probability of losing a mature crop because of rain. For threshing and drying, a reasonably long dry and sunny weather is needed.

5% Model – A Measure For Assured Kharif Paddy Crop In Chotanagapur Area

The term ‘5% technology’ refers to a technique for harvesting rainwater and excess runoff initiated by PRADAN in the late 1990s in the Purulia district of West Bengal. It essentially consists of a pit dug usually at the most upstream point on farmers’ plots and represents roughly 5% of the total area of the plot. It is a risk reducing technology primarily implemented to mitigate the weather-related risks that affect the rain fed paddy crop on which the small farmers of this poor region depend for their subsistence and food security. Average annual rainfall in this region is about 1200 mm. Most of the precipitation is received during four months of monsoon (June–September). But even during this period, the distribution of precipitation is often erratic and drought-like conditions could occur during critical crop growth stages. The pits are usually about 1.5 meters deep and farmers lift and apply the stored water with the help of buckets. According to PRADAN, the 5% area of the pit is not a sacrosanct figure, and farmers can make bigger or deeper pits depending on the land availability and soil type. Generally, 5% appears to be the minimum for supplying the required irrigation to upland paddy during dry spells. For best results over large contiguous areas, PRADAN advocates the application of a complete package consisting of farm pond + field-bunds (constructed using the excavated soil) + plantation of selected tree species. Water availability is improved and soil erosion minimized.

Physical features of 5% Model

i.) Consider a patch of bunded upland used for kharif paddy cultivation in a terraced terrain of Chotanagapur area where average rainfall is to the tune of 1200 mm or so of which most of which most of the rain (say 70% or more) occurs in four months (from June to September).

ii.) Consider a single such upland. Select 5% of the area in one of the corners of that single land, preferably towards the slope of the terrain.

iii.) Three and half feet depth of earth is excavated from that selected area and the excavated earth is put on the field bunds for strength them.
iv.) The excavated portion of that plot of land looks like a micro water harvesting tank. In local language it can be called “happa”, Chota Jorabund” Chota pukhur”, “Talab” etc as it will store water in rainy (Kharif) season.

v.) This kind of micro water harvesting tank can be constructed in each and every ploy of the area (watershed).

vi.) The expected benefit of this structure is that it will both directly as well as indirectly maintain required moisture regime through out Kharif season and thus assure upland Kharif paddy crop.

**Underlying assumption for which 5% model is suggested**

2.) Agricultural drought of Chotanagpur region is mostly due to erratic nature of rainfall and not due to shortage of total rainfall amount during the Kharif season the area received.

3.) Total amount of rainfall received during the upland paddy growing in Kharif is never less than the minimum requirement.

4.) Dry spell in the month of September (during Hatia Nakhastra) ultimate determines the yield of upland paddy. More than seven days dry spell causes drastic reduction in the crop production. Farmers treat this as failure of crop.

5.) There are vast areas of upland in Chotanagpur region- approximately 70% of total agricultural land is upland-which is fully dependent on rainfall for any crop to be grown and have no access to irrigation.

6.) Total replacement of traditional duration varieties with short duration varieties with short duration verities to avoid dry spell in September is not desirable primarily for any crop to be grown and have no access to irrigation.

   a.) Rainy season is expected to continue in September also and there every possibility of rain during harvest and thus post harvesting processes of short duration variety paddy will be very trouble-sum and will lead to loss of production.

   b.) Traditional varieties are time tasted over the years and to be more reliable and are to be more reliable and are better matched with socioeconomic and agro-ecological situation of the area.

Phenomena in 5% Pit Paddy cultivation – farmer’s practices and failure of kharif paddy during the dry spell:
Farmers raise separate paddy nursery. Then they transplant paddy seedling on puddle field. During puddling, Physical properties of the soil mass undergo considerable changes as follows.

a.) Compactness/bulk density
b.) Porosity decreases
c.) Water holding capacity decreases
d.) Permeability/deep percolation rate reduces

Farmers practice puddling method of land preparation for translations as against direct seedling mainly because of more paddy yield. Puddling directly is not responsible for more paddy yield but indirectly helps in the followings.

a.) Lesser weed growth
b.) More ensured water retention by reduction of water loss
c.) Reducing nutrients loss through leaching But puddling method has also its risks and limitation
   - Unless there is sufficient water one can’t go for puddling
   - When a dry spell occurs puddle soil starts drying up to a deeper layer (may even exceed root zone depth) and gets cracked.

**Phenomena during dry spell**

Fields in upper catchment dry earlier and much faster than the fields at lower catchment because of the subsurface flow phenomena of water through seepage. The flow line goes down comparatively deeper in upper catchment then that of lower catchment. If the flow lines goes down to an extent when upward movement of water through capillary action cannot reach the root zone. The crop cannot compensate the loss that occurs due to evapo-transpiration and it would starts wilting. If this continues for a long period (till permanent wilting) the yield will get reduced drastically.

Longer the dry spell lower down the seepage line dry spell in reproductive stage is more harmful.

**Phenomena of water storage in upper catchment**

When water stored in upper catchment in the form of a tank of Jorebund through seepage it supplies moisture in the root zone of crop of the fields in the down stream. It does not allow the seepage line to go down even during the dry spell through continuous supply of water through seepage. This reveals the need for creating water bodies to provide moisture in the root zone through seepage during dry spell.

**Choice of water bodies to meet the above need:**

Traditional water bodies found in the upper catchments are,
1. Small, medium and large tanks that collect rainwater from upper catchments and water harvested.

2. Dug wells

Constraints and limitations of the traditional structures:
Tanks (small, medium, large): Creating traditional tank in upper catchment demands larger space both for creating the water body and keeping the excavated earth. This is crucial considering the smaller size of land holding among these farmers and access to public land for purposes of collective reaping of its uses. Individual farmers are more willing to invest money (in the order of 10000 INR).
Dug wells: The stored water is available mostly mostly in the deeper columns and thus requiring pumping systems to lift for purposes other than domestic use.

Pradan's definition of an ideal body is the one that can provide moisture to the root zone from a nearby area requiring less labor and investment. This may be of the form:
1. Depth of the storage needs to be shallow and not deeper than couple of feet.
2. The water body should be adequate to supply the critical moisture needed to the root zone for a depth 6-8 inches.
3. Each field/plot should have its own water storage.

**Pradan’s design of an ideal water body**

**Design principle**
1) It will be in installed each and every field.
2) It should provide critical moisture of 2 inches if the area of the field is ‘A’ unit.

Then critical water requirement is \((A \times 2)\) unit-inches. Suppose the area of the water body is one twentieth of the field (5% of the field area) and depth of such storage is \(d\), then:

\[
\frac{1}{20} A.d = (A.2) - A.2. \frac{1}{20}
\]

\[
A \frac{d}{20} = 2A(2 - \frac{1}{10})
\]

\[
d = 40(1 - \frac{1}{20})
\]

\[
d = 38 \text{ Inches (approx. 3 ft 2 inches)} 3 \frac{1}{2} \text{ ft for practical purposes.}
\]

It is desirable that each and every single field in a contiguous patch should have such water bodies comprising of 5% of the total area having a depth of three and half feet.
Expected outputs: Except couple of fields in the top most ridge, all other fields will be assured of critical moisture supply from these numbers of water bodies created in the whole catchment. If the area has common lands upstream with forest or bush cover such treatment can be practiced there, which will enhance the functioning of the pits through out the downstream.

Selection criteria for implementing the 5 % Pit Technology:

Following are the criteria recommended by Pradan for the selection of the land for implementing 5 percent pits,

a. Upland paddy
b. Unbunded, unteraced lands having considerable topsoil depth (atleast 6 inches).
c. Areas having hard rock within 3 feet soil depth could be avoided.
d. Unterraced lands having more than three percent slope can be considered with extra provision made for plot leveling.
e. Other paddy fields which face dry spells during September may also be considered.

Minimum treatment area: The lands should be selected in a contiguous patch of minimum 10-acre area for the technology to be fully functional. The length of the patch along the slope should be more than the width of treatment (ratios questionable?).