Participatory Natural Resource Management for Enhancing Water Productivity in Drylands




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Foreword

Increasing water scarcity and competition for limited water from many sectors necessitates improvement of water productivity in agriculture to ensure adequate food for future generations with the same or less water than is currently available to agriculture. This is achievable as the available information indicates that there is a wide gap between actual and attainable crop water productivity, especially in rainfed environments. Participatory watershed management projects have been contributing to raising income, agricultural productivity, generating employment and conserving soil and water resources. They have achieved greater success in enhancing livelihoods in an equitable fashion. Field experiences show that innovations for improving agriculture and natural resource management need to address not only technological but also the socio-cultural, economic dimensions such as community response, gender, collective action, property rights, land tenure, policy and governance.

The present book is a compilation of topics covering participatory research and development processes with a socio-technical perspective in drylands. I compliment the efforts taken by the editors in bringing out this book covering different themes like concept and practice of water productivity, community mobilization, participatory processes, and sustainability aspects in resource management. I hope, this work would enable researchers and field practitioners to attune programs to rural realities so that research processes now lead more directly to improvements in the resource base and productivity, improved livelihoods and strengthened social assets for rural communities.

B. VENKATESWARLU
Director, CRIDA

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The publication entitled "Participatory Natural Resource Management For Enhancing Water Productivity in Drylands" is a result of collective efforts and wisdom of a large number of authors. We wish to place on record the cooperation and support received from all authors and staff at the CRIDA who contributed in various ways for timely publication of this book. We firmly believe that this publication will be highly useful for researchers, academicians, extension workers, policy maker, planners, students, NGOs and progressive farmers who are concerned with Natural Resource Management in the drylands in one way or the other.

We profusely thank Dr. G. R. Korwar, Dr. K. L. Sharma for their active support rendered from the publication committee during the process of publication of this book.

Our efforts will be more rewarding if this publication receives the attention of more target readers in different fields of research, development and extension in drylands. We will be very happy to have suggestions or comments on this publication.

Hyderabad,
July, 2009

Editors

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CONCEPT OF WATER PRODUCTIVITY

*M.V. Padmanabhan**

About 40% of the land in the world is under arid and semi-arid climatic conditions (Gamo, 1999). Efficient use of rainwater and optimization of crop water productivity are important in such conditions. In the dry areas, water, not land, is the most limiting resource for improving agricultural production. Maximization of yield per unit of water (water productivity), and not yield per unit of land (land productivity), is therefore a better strategy for dry farming systems. Water deficiency and low availability of nutrient often limit crop growth and production potential in agro-ecosystems because most crops are sensitive to water and nutrient deficits during critical stages. On the other hand, excessive use of water can increase the production cost and pollute the environment (enhancing fertilizer leaching). So enhancement of water productivity (also termed as water use efficiency) in agriculture is very important. It is widely believed that an increase in agricultural water productivity is the key approach to mitigate water shortage and to reduce environmental problems (Ali and Talukder, 2008).

Productivity is a measure of performance expressed as the ratio of output to input. Water productivity (WP), like land productivity, is a partial-factor productivity that measures how the systems convert water into goods and services (Molden et al., 2003). It's generic equation is:

$$\text{Water Productivity (WP)} = \frac{\text{Output Derived from Water Use}}{\text{Water Input}}$$

Water Productivity was introduced to compliment existing measures of the performance of irrigation systems, mainly the classic irrigation and effective efficiency (Keller et al., 1996). Classic irrigation efficiency focuses on establishing the nature and extent of water losses and included storage efficiency, conveyance efficiency, distribution efficiency and application efficiency. These measures are partly useful for managers of water system who use them to (a) assess how much water they were losing in the storage, conveyance, distribution, and application sub-systems; and (b) identify interventions to improve performance.

In assessing the performance of water use in a large system, a basin or sub-basin, classic efficiency fails to capture the water re-use aspect. It ignores the beneficial use put to water re-captured and re-used in one part of the basin as a consequence of deep percolation and/ or runoff losses that takes place elsewhere in the basin. To address this problem, Keller et al., (1996) introduced the concept of effective efficiency, which takes into account the quantity of the water delivered from and returned to a basin's water supply. In irrigation context, effective efficiency is the amount of beneficially used water divided by the amount of water used during the combined processes of conveying and applying that water (Cook, Turral and Gichuki, 2006).

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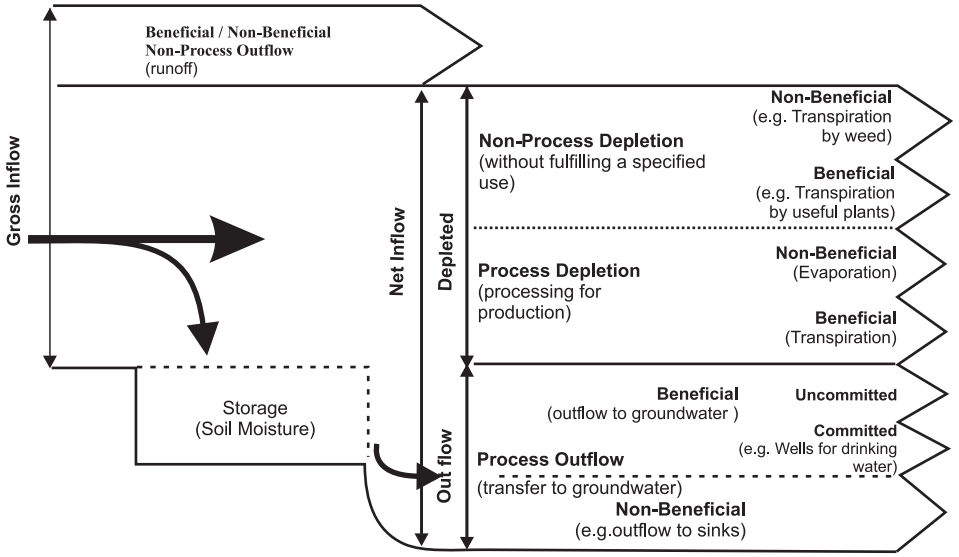

Fig. 1: Water Flow Balance On The Field Scale Of Agricultural Water Use.

Inflows at the field level can be irrigation application, precipitation, subsurface contributions, and surface seepage flows. For the concept at hand, precipitation input is the baseline for the assessment of Agricultural Water Productivity (AWP). Its distribution to the different water fractions is of major importance since it defines whether a user takes or returns water to the watershed. The inflow to the field is further split into gross and net inflow. Gross inflow is defined as the total amount of water flowing into the system, net inflow subtracts water that runs off from the system as well as it includes changes in the storage of the system (soil moisture change). Net inflow subtracts water from gross inflow if water is added to storage, and it adds water to gross inflow if water is removed from storage. “Storage change” hence is expressed in soil water storage change. If storage change is positive, it is beneficial for the subsequent time. A positive storage change further improves soil quality since salts can leach through.

Depleted water comprises that share of net inflow, which becomes unavailable for further use by the system due to certain users' utilization. Molden distinguishes between process depletion and non-process depletion. Non-process depletion comprises depletion of water from the system without fulfilling a specified function. It is further subdivided into beneficial and non-beneficial. A beneficial non-process depletion may be transpiration by useful plants. A non-beneficial non-process depletion can be caused by weed using water for evapotranspiration. Hereby, the consideration of how beneficial the depletion may be depends on the stakeholders in the system. According to Molden, non-beneficial nonprocess depletion also comprises water flowing into the sea or into saline groundwater, which makes it unavailable to the system. But as

understood from the perspective of a farming system, since water actually is not depleted, this water fraction belongs to its outflow. This differentiation further will be of importance when it comes to the valuation of water fractions. “Depletion” will always enter into a product. Even if it enters into weed, its product could further be used. An outflow to sinks however does not return a product.

Process depletion refers to water, which is rendered unusable to the system for the production of a certain good or to fulfill a certain function, e.g. crop growth.

Whereas Molden splits non-process depletion into non-beneficial and beneficial flows, he does not do so for process depletion. Beneficial process depletion in the case at hand is understood as the portion of water that is lost to the system during the accomplishment of a certain function, e.g. transpiration by a crop. Non-beneficial process depletion comprises the fraction of water, which is used during the processing for a certain function, but which does not fulfill the respective function, e.g. evaporates from the soil surface. Often, process depletion is considered as “evapotranspiration”, i.e. a crop is regarded together with its management practices under which a certain amount of water evapotranspirates. Although, in practice, a difference between evaporation and transpiration at times may hardly be possible, on a conceptual level, it needs to be made. A split of evaporation and transpiration can indicate how a reduction in process depletion may be achieved; whether it may be through a change to a different crop (in case of high transpiration), or whether effort may be better spent in crop-, water- or soil-management practices (in case that evaporation is high).

The outflow from the field in above figure is water running off from surface, as well as water percolating to groundwater when soil moisture exceeds field capacity. This distinction also differs from that of Molden who defines outflow as outflow to groundwater only. But from the perspective of a farming system, runoff actually is not a depletion fraction since it does not make use of it. Whereas runoff flows out of the system without being part of the depletion process, drainage to groundwater is. This is why we divide outflow into process outflow and non-process outflow. Non-process outflow (runoff) is split into beneficial and non-beneficial, depending on its further use. In practice, run-off may above all be non-beneficial (e.g. since erosion can occur). However, on a conceptual level, we have to provide a variable for the beneficial non-process outflow that e.g. feeds into dried out rivers. In the balance, non-process outflow has to be subtracted from gross inflow since it is not part of the depletion process. Process outflow is the remainder in the soil after a farming system's water use, i.e. the fraction that drains to the groundwater after water storage surpasses field capacity. It can be beneficial and non-beneficial. If it is non-beneficial process outflow, it will flow to sinks, e.g. degraded or saline groundwater, and cannot be further used. If it is beneficial process outflow, Molden's

differentiation is taken of committed and uncommitted outflow, but for the case at hand, it is referred to committed and uncommitted beneficial process outflow. Committed beneficial process outflow comprises the fraction of water, which is allocated to further uses in the hydrological system, e.g. households' groundwater use. Uncommitted beneficial process outflow has no further use, whereas in water scarce basins, to which concepts of productivity and efficiency most likely apply, this may hardly be the case. (Molden *et al*., 2003).

Based on this modified terminology, the concept of agricultural water productivity will be developed.

The Concept of Agricultural Water Productivity

The water fractions of agricultural water use in above figure show that a farming system fulfils more than one function. They unlikely have the same importance and will be endowed with different values. The AWP of a farming system therefore needs to be assessed in the context of a watershed whose general and spatially explicit water resources availability contributes to the value of the farming system's water fractions. The total value of a farming system's water use then is the sum of values attributed to the different water use functions, i.e. the water use product of a farming system.

The concept of AWP will be developed by first outlining a farming system's water related functions. The sum of these functions constitutes an agricultural water use's product. In order to inquire about a farming system's AWP we first have to analyze its actual distribution of water fractions to the respective functions. For this reason, we need efficiency indicators. The actual distribution returns the actual product of a farming system. With the help of efficiency indicators, we know whether there is still room for a reallocation to the highest valued fractions. It is here that the concept gets operational. This reallocation would return the potential product of a farming system (Bettina, Hong Yang and Claudia, 2007).

Techniques to Improve Water Productivity

The term 'increasing or improving water productivity' implies how we can most effectively improve the outcome or yield of a crop with the water currently in use. The answer lies in three main pathways (Passioura, 2006): i) transpire most of the supplied water (minimization of unwanted loss), ii) exchange transpired water for CO_2 more effectively in producing biomass, and iii) convert most of the biomass into grain or other form of harvestable product.

Among the most promising and efficient proven techniques are: i) limited supplemental irrigation for optimizing the use of the limited water and ii) water harvesting for improved farm

income in drier environment. Water harvesting may be defined as "the process of concentrating precipitation through runoff and storing it for beneficial use" (Oweis and Hachum, 2006). Improving crop water productivity, however, requires exploiting not only water management but also other inputs such as improved cultivars, fertility management and cultural practices, which influence yield (Ali and Talukder, 2008).

Water productivity of agricultural production is surprisingly low in many parts of the world. At present, engineering technologies for water-saving agriculture, such as prevention of channel leakage (through channel lining), water-saving irrigation scheduling, water delivery with low-pressure pipe, sprinkler and drip irrigation systems, and optimized water allocation strategies in irrigation areas have not been advocated or adopted in most parts of the world except in research or field experiments. Most of the irrigation channels (mainly in the third world countries) are unlined and earthen, which causes considerable water loss in the conveyance system (about 30-50%) (Ali, 2001; Talukder *et al*., 2006). Even today, the farmers use traditional furrow or border (flood) irrigation method in dryland crops and standing water in rice crop, which indicate that there is a considerable potential for improvement in agricultural water productivity.

AWP has a broader scope than the improvement at on-farm level and can be considered on watershed, basin, irrigation district or catchment scale. Some studies showed that approaches for integrating fish into rice culture systems are feasible, thus enhancing total water productivity. Faced with a continuous large gap between globally potential and attainable water productivity, adoption of multiple options would play a promising role in enhancing WP and satisfying regional food requirement for the current as well as the future centuries. On-farm water productivity technology if coupled with genetic make-up, improved irrigation management options, better crop selection, and appropriate cultural practices will help to achieve the objective (Ali and Talukder, 2008).

Conclusion

The main pathways for enhancing WP are to increase the output per unit of water (engineering and agronomic management aspects), to reduce losses of water to unproductive sinks, to reduce water degradation (environmental aspects), and to reallocate water to higher priority uses (social aspects). Promoting water-saving agriculture will not only increase WP, but also facilitate the structural adjustment needed for agriculture. Combining biological water saving measures (drought tolerance by genetic improvement and physiological regulation) with engineering solutions, and soil and agronomic manipulation may solve the problem to a large extent.

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ENHANCING WATER PRODUCTIVITY IN DRYLANDS THROUGH WATER MANAGEMENT, FERTILITY MANAGEMENT AND CONSERVATION TILLAGE

K. Srinivas

The productivity of water used in agriculture increased by at least 100% between 1961 and 2001, thanks mainly to increases in crop yields (FAO, 2003). Irrigated rice yields doubled and rain-fed wheat yields rose by 160% in that period, with little variation in water consumption per kilo of output. Globally, it is estimated that water needs for food per capita halved between 1961 and 2001, a significant saving and an equally significant gain for other water users. By one calculation, a 1% increase in water productivity in food production makes available - in theory, at least - an extra 24 litres a day per head of population, while a 10% increase would equal current domestic water consumption. Investing in agriculture and in agricultural water management, therefore, is an attractive strategy for freeing water for other purposes.

Water Productivity Enhancement - Levels

Improving water productivity - whether under rain-fed or irrigated conditions - requires, first, an increase in crop yields or values, i.e. the marketable yield of the crop for each unit of water transpired. Also necessary is a reduction of all outflows or "losses" (e.g. drainage, seepage and percolation) except crop transpiration, and more effective use of rainfall, stored water, and water of marginal quality. Loss reduction and water control are considered parts of basin-wide integrated water resource management (IWRM), which gives an essential role to institutions and policies in ensuring that upstream interventions are not made at the expense of downstream water users. These three principles apply at all scales, from plant to field and agro-ecological levels, but options and practices associated with them require different approaches and technologies at different spatial scales.

At the plant level, higher productivity will depend mainly on germplasm improvements, such as stronger seedling vigour, increased rooting depth, increases in the harvest index (the marketable part of the plant as part of its total biomass) and enhanced photosynthetic efficiency. Green Revolution wheat, rice and maize varieties that are insensitive to day-length and of short to medium duration (90-120 days) have proved successful in escaping late-season drought that adversely affects flowering and grain development. As a result, modern rice varieties are three times more productive, in terms of water use, than traditional varieties. Traditional breeding has already made progress in extending these achievements to other crops, and genetic engineering is expected to overcome long-standing obstacles to development of higher-yielding, drought-

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tolerant crop varieties. In farmers' fields, higher water productivity requires changes in crop, soil and water management. Strategies include selection of appropriate crops and cultivars, use of improved planting methods (e.g. on raised beds), minimum tillage, synchronization of water applications with the most sensitive growing periods, and improved drainage for water table control. All cultural and agronomic practices that reduce water evaporation - such as variable row spacing and the application of mulches - improve water productivity.

Improved nutrient management raises the yield proportionally more than it increases evapotranspiration. Deficit irrigation, in which less water is applied than that required to meet the full crop water demand, results in a small yield reduction that is less than the concomitant reduction in transpiration.

At system and river-basin level, options for improving water productivity include better land-use planning, use of medium-term weather forecasts, improved irrigation scheduling, and use of various sources of water. But increases in water productivity may not result in greater economic or social benefits - water in the rural areas of developing countries has many uses, a fact that complicates value calculations. At this larger scale, the effect of agriculture on other water users, human health and the environment becomes at least as important as production issues.

The many uses of water include production of timber, firewood and fibre, aquaculture and animal husbandry, domestic consumption and environmental servicing. Not all measures to increase water productivity are appropriate in all circumstances. It is essential to consider the various uses of water in agriculture before measures are introduced that would increase water productivity at the expense of other benefits from the same source of water, especially those benefits that accrue to the local poor and landless people.

There is a need to identify the types of policies and incentives that will work best in promoting adoption of new agronomic and cultural practices and, with them, higher water productivity: Experience with conservation agriculture indicates that the short-term interests of the farmers often differ from society's long-term interests, and that the financial benefits that accrue from changes in cultural practices often take a long time to materialize. The inconsistent and sometimes contradictory results from studies on the adoption of new practices suggest that the decision-making process of farmers is highly variable and often unacceptably long considering the urgent character of water-scarcity problems. Experience from participatory research and extension could help reduce this delay.

Irrigated agriculture has long been synonymous with high productivity, the 20 per cent of farmland that is irrigated producing 40 per cent of current food supply. But, surprisingly perhaps, the greatest potential for meeting further burgeoning food demand lies in rain-fed agriculture. In rain-fed agriculture, bridging crop water deficits during dry spells through supplementary

irrigation stabilizes production and increases both production and water productivity dramatically. While investments in water harvesting -. e.g. construction of ditches that take the runoff to a storage reservoir - are relatively small, its effectiveness depends on many factors, including topography, soil characteristics and fertilizer availability, and - not least - the involvement of the beneficiaries in design and operation.

Soil and stubble management, by increasing infiltration and water storage in the soil and decreasing evaporative losses from the surface, can improve water productivity. Timeliness of sowing, evenness of establishment, use of herbicides, management of nutrients, management of disease, crop rotation, choice of crop or plant variety, and breeding for particular traits all play a part. In short, skilful farming and good crop science save water.

Conservation Tillage

In drylands water productivity is often very low, and evaporation rates often very high. Effective redirection of water vapour evaporating from the soil by: intercropping, better use of leaf canopy cover, conservation tillage, and increased use of fertilizer to improve yield and water productivity are some of the many approaches to bring about better crop and water efficiencies. Conservation tillage (CT) or reduced use of the plough by drilling seed in stubble of the previous crop is another saver of water, which can give water saving from reduced evaporation, runoff and deep percolation. CT covers a spectrum of non-inversion practices from zero till to reduced tillage, which aim at maximizing soil infiltration and soil productivity, and minimizing water losses while conserving energy and labour. Even though CT is not new, its recent success in Latin American countries (Derpsch, 1998) has inspired research and development efforts in Africa and Asia. Zero tillage research using direct planting drills on wheat in Pakistan have shown water savings of 15-20% through reduced evaporation, runoff and deep percolation, while increasing yields and saving on fuel (Hobbs et al., 2000).

Supplemental small-scale irrigation of rain-fed agriculture is a particularly important tool to provide improved crop productivity for resource poor farmers. Even small volumes of stored water can be used very effectively when dry spells occur at times, when harvest yield is especially sensitive to water stress (such as at flowering in maize). Water use efficiency enhancements up to 38% have been observed with water harvesting and supplemental irrigation combined with fertilizer application in Africa (Rockstrom et al., 2001). For resource poor smallholders in water scarce areas even small volumes of stored water for supplemental irrigation can significantly improve household economy. In the Gansu Province of China, small (10-60 m^3) sub-surface storage tanks are promoted in large scale. Research using these tanks for supplemental irrigation showed water use efficiency increases of 20% in wheat and wheat (Li et al., 2000). Combined with drip irrigation, this can be effective in improving water efficiency (Ngigi et al., 2000).

Conclusion

The immense challenge of doubling food production over the next 25 years in order to keep pace with population growth requires increased attention to water productivity and rainwater management, making the best use of the local water balance. Even in water scarcity prone tropical agro-ecosystems, there is no hydrological limitation to doubling crop yields in rainfed smallholder farms. There are several appropriate technologies and methodologies to enable a development towards improved soil and water productivity. However, apart from water management, general crop management principles such as choice of variety, time and method of sowing, application of fertilizers and control of weeds, pests and diseases have to be followed to maximize crop water use efficiency.

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WATER PERSPECTIVES IN NATURAL RESOURCE MANAGEMENT

*A. Ravindra **

The conventional perspectives of water conservation and watershed development gives primacy to treatment structures. It is assumed that the conserved water and soil directly contributes livelihoods and income of farmers. However, with the ground water exploitation leading to a crisis even in the treated watersheds, and the lack of sustainability of the structures created has questioned this notion of 'automatic' translation of benefits of conservation into livelihoods. Also, the conventional perspective on water and its use (irrigation) excluded 'improved moisture regimes' as an application of water and have only focused on applied water through surface or ground water storage.

The limited conventional perspective on water has created larger biases in the public investments related to 'water' / irrigation. While the surface and ground water application received large amount of subsidies, they have bypassed the rainfed areas as 'moisture management' as an area of application of water is never considered under public investments. The mounting subsidies on surface irrigation and power subsidies have perpetrated inefficiency and recklessness in the usage of water resulting into substantial wastage and problems like salinity.

It is against this backdrop that the present paper attempts at elaborating an alternative perspective on water.

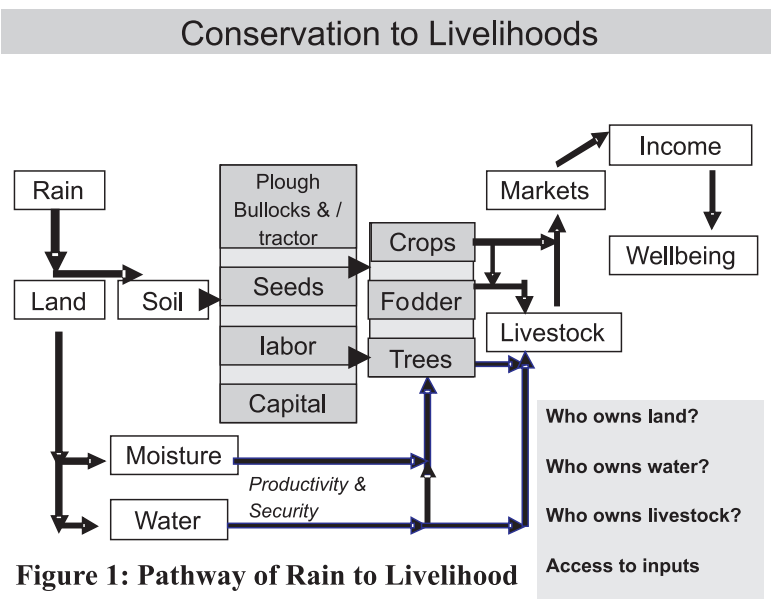

Figure 1: Pathway of Rain to Livelihood

**Director, WASSAN. Tarnaka, Secunderabad.*

Figure one provides a simplistic 'pathway of rain to livelihoods'. The rainwater in its two forms viz., moisture and water are useful to farmers (for livelihoods and incomes) only when the primary and secondary production systems (crops, fodder, trees, livestock etc.,) are in a healthy shape and the quantum of income- benefits depends on their access to markets. The production systems depend heavily on the arrangements of inputs like seed, labour, capital etc., The property regimes of land, water, livestock matters significantly as they determine the choices in the production systems. Access to water and moisture provides security of the production system and also helps in improving the productivity.

For the livelihood and income benefits to be maximized for farmers, it is important to address all the issues along this pathway -from rain to livelihoods. We are more concerned about water perspectives in rainfed areas in this paper.

The crisis in water management:

The following graph depicts the investments on bore wells over time in a watershed in of Andhra Pradesh. The private investments increased sharply from the 2nd year of the watershed program when farmers saw ground water increasing. They have invested more than Rs.20 lakh on borewells- a figure almost equivalent to the public investment in watershed program in the village. Such steep escalation in groundwater use nullifies the benefits of recharging ground water and may eventually precipitate seasonal scarcity of water.

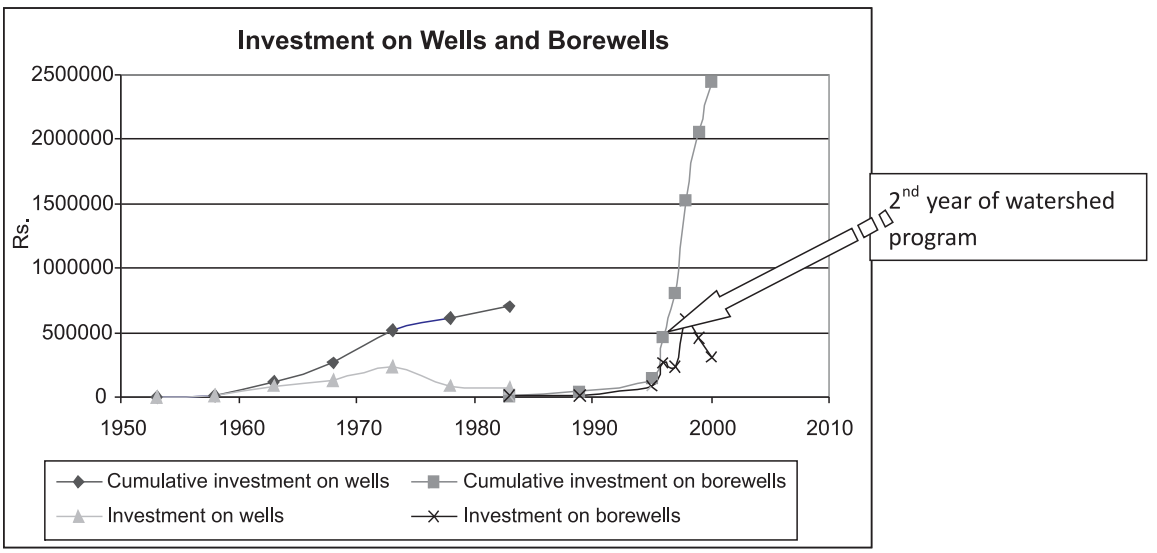

Figure 2: Investment on Wells and Borewells in A.P.

It is important to understand why such trends occur. It is a general phenomenon that input usage i.e. quality seeds, power, fertilizers and pesticides are generally higher in irrigated agriculture. The price support and market procurement is also well streamlined for paddy, wheat and other such irrigated crops. The government subsidies on these inputs flow along with water; these subsidies are often sizeable. To the contrary, there are hardly any support systems for rainfed agriculture. The overall system incentivises irrigated agriculture which partly explains the clamor for it. This larger urge for irrigation is precipitating an unprecedented crisis in ground water depletion, which is now the major source of irrigation in the country.

Seeing water as moisture:

In the path ways of rain to livelihoods soil assumes a greater significance as a medium of storing water in the form of moisture to supply to crops, when it needs. Soil moisture provides security to crop. Organic matter in the soil is an important element in holding the moisture. It is said that each particle of soil organic matter holds moisture sever times of its volume. Increase in organic matter in soils during the crop season will harvest large amounts of water and stores them in the form of soil moisture.

There is tremendous potential to harvest water by increasing soil organic matter during the crop season; without displacing people! In spite of such huge potential, we see water use efficiency only in drips and sprinkler irrigation systems alone! Each tractor load of additional compost may increase the water holding capacity of the soil by more than 500 cu.mt. As organic matter addition to soils equally qualifies as a measure of increasing water use efficiency, subsidies meant for improving water use efficiency (such as drips and sprinkler systems) must be extended to organic matter addition to soils.

Similarly, if we see the consumptive use of water there is substantial difference between rice and millets. For example, a 25% shift in the national consumption basket from rice to millets saves enormous amounts of water. Water use efficiency must therefore, also seen as percentage of shift in the consumption basket from rice to millets. Water allocation for national food security can be drastically reduced by such shifts.

These alternative perspectives on water in rainfed areas are important for public policy and for restructuring the public investments. How to shift towards such a new paradigm is the challenge.

Shift to protective irrigation:

The investment requirement on creating irrigation potential through canal systems is enormous. Even after such expensive irrigation potential is created (in case of canals) or the electricity is subsidized (in case of borewells) the application of water is grossly inefficient. As against irrigated or irrigated dry crops, if there is a shift towards a protective irrigation system of water use, the benefits would be multiple. Investments on pipe-lines to reach to the extensive rainfed areas for protective irrigation and improving water use efficiency are twi strategies for securing large tracts of highly vulnerable rainfed areas with protective irrigation. In this way,

crops and livelihoods of farmers can be secured. The experience in AP Drought Adaptation Initiatives in Mahabubnagar is a case in point.

Where is the biomass?

This is the typical question one would ask! If public investment support is available, it is easier to build soil organic matter; a sum equivalent to the subsidies on fertilizers and irrigation would enable a large scale organic matter addition to rainfed lands. As emerging from the AP DAI program experience, the following table illustrates various sources of biomass availability for increasing soil organic matter during the crop season.

Table1. Options in increasing soil organic matter during the crop season

Biomass option	Units	QTY	Biomass Production in Kg/1acre	Type of biomass	Method of cultivation
Planting around compost pit	Nos/ pit	50	150	wet weight	Two rows all round the compost pit, with 0.5 m plant to plant spacing
Bund plantation	Nos/ acre	100	300	wet weight	Plan o n border /internal bunds of the plot with 1m plant to plant spacing
Horsegram as inter crop (3:1) for biomass	Kg/ acre	10	1000	wet weight	Inter crop in Redgram, Cotton and Castor. Ratio of rows are (3:1) three rows of horsegram to one row of main crop
Sun hemp for biomass	Kg/ 200sqm	2	1000	wet weight	Allocate an area of 200 sq.m per acre plot for bio mass purpose
Pigeon pea crop residues (1m spacing row to row)	Nos/ acre		500	Dry weight	Pigeon pea stock residue can be used as compost in the rainy season in pit method.
Crop residual – biomass (inter crops)	Nos/ acre		400	Dry weight	Residual sorghum stalks can be composted in the winter season in pit method.
Weeds	kgs/acre		500	wet weight	Can be cut and used as compost in rainy season

Such options do exist that farmers would adopt on a large scale if subsidies are available, at least on par with the fertilizer and irrigation subsidies.

Conclusion

To conclude it is important to freshly re-look at the policies and practices in rainfed farming and with a new perspective on water resources management the rainfed farming can be revitalized.

SOIL AND WATER CONSERVATION

*K. S. Reddy**

Soil erosion

Soil erosion is the process of loosening soil particles and transporting them from one place to another. Basically, weather agencies like water and wind in motion are responsible for effecting soil erosion by dislodging the soil particles and transporting them.

Types of soil erosion

Soil erosion can be categorized into two types viz., geologic erosion and accelerated erosion.

1. Geologic erosion

It is the erosion, which takes place in undisturbed natural conditions of soil. In undisturbed conditions, and equilibrium is reached between climate and the vegetative cover which protects the soil from erosion. It is slow erosion process and is compensated by the formation of soil under natural weathering process.

2. Accelerated erosion

When the land is put under cultivation, the equilibrium existing between the soil, climate and the vegetative cover is disturbed. As a result, the removal of surface soil due to natural agencies like wind and water takes place at faster rate than that of soil forming process. Such an erosion process is known as accelerated erosion whose rates of soil loss are more than geologic process. It also depletes the fertility of agricultural lands.

Based upon the agency causing erosion, it is classified as water erosion, wind erosion and coastal erosion. Water and wind erosions are more predominant in agricultural lands. Here, water erosion and its types are discussed below as it is more prevalent and damage is severe when compared to other types of erosion.

Water erosion

This may further be classified based on the stage of erosion process by flowing water as:

Raindrop or splash erosion

Water in the form of rainfall is responsible for rain drop erosion. The raindrops falling with the considerable velocities strike the soil particles and detach them by impact force as splash. This primary stage is called raindrop or splash erosion.

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Sheet erosion

Subsequent to the splash, a thin layer of top soil is detached and transported by the flowing rain water (runoff) on land surface. This type of soil erosion is known as sheet erosion. Lands subjected to sheet erosion will loose a thin layer of top fertile soil every year.

Rill erosion

It is the advanced stage of sheet erosion forming finger like rills on land surface. These rills are smoothened every year by farming operations. But, in subsequent years of rill formations, rills slowly increase in their number as well as shape and size affecting crop production.

Gully erosion

It is the advanced stage of rill erosion. When water flows through the unprotected hills the further develop in size and shape and form deep cuts in the form of gullies on land surface or in hills. Gullies so formed if not treated, will expand year after year. Ravines are a form of gullies.

Stream bank erosion

The erosion of stream banks by flowing water is known as stream bank erosion in certain areas where rivers or streams change their course, stream banks are eroded in an accelerated pace. It damages adjoining agricultural lands, highways, roads and bridges.

Slip erosion

It is another natural phenomenon like land slides and slips caused due to saturation of steep hills and slopes. This process is referred to as slip erosion. It not only disturbs the natural landscape but also cause damage to highways and add additional sediment load to streams and rivers.

Water erosion control measures

The water erosion control methods can be grouped into two types.

I. Agronomic farming

A. Contour farming

Contour farming is the practice of cultivating land along the contours laid across the slope of the field. It reduces the flow velocity of water and retards soil erosion. Row crops like maize, sorghum, and pearl millet are well suitable for contour cultivation.

B. Strip cropping

It involves growing of different crops in alternate strips across the slope of land. They serve as vegetative barriers to control erosion. Strip cropping can be practiced in three ways. They are control strip, field strip and buffer strip cropping.

Contour strip cropping consists of growing alternate strips of erosion permitting and erosion resisting crops along the contours. In field strip cropping, the strips are laid across the slope in uniform width without taking exact contours into consideration. This is useful on uniform slopes with high infiltration rates in buffer strip cropping, permanent strips of grasses are located either in badly eroded areas or in areas that do not fit into a regular rotation. The width of strips of erosion permitting and erosion resisting crops depend upon the factors like slopes, soil texture, rainfall characteristics, type of crops. In general, sleeper the slope, the greater is the width of erosion resisting crop and smaller the width of erosion permitting crop. However, strip cropping is not followed in India on large scale.

Table 1: Crop widths for strip cropping

Slope (%)	Width of erosion permitting crop (m)	Width of erosion resisting crop (m)
1	50	10
2	30	6
3	15	5

C. Conservation tillage

It is any tillage system, which leaves at least 30% of the soil surface covered with residues after a crop, is planted. It implies that a greater quantity of plant residues would be present at all times during the interval between crops. It may also be any tillage sequence that reduces loss of soil or water relative to conventional tillage, which is a form of non-inversion tillage that retains protective amounts of residue on the surface. Different conservation tillage methods for row crop and small grain agriculture are given in Table 2.

Table 2: Mechanized conservation tillage methods

S. No.	Row crop agriculture	Small grain agriculture
1.	Narrow strip tillage	Stubble mulch farming
•	No tillage	Stirring machines
•	Zero till	• One way disk
•	Slot plant	• Offset disk
•	Strip rotary tillage	• Tandem disk
2.	Ridge planting	Chisel plows
•	Till plant	Field cultivators
•	Planting on ridge	Mulch treaders
3.	Full width-no plow tillage	subsurface tillage
•	Fall and/or spring disk	• Sweepplows
•	Fall or spring chisel	• Rod weeder with semi chisels
4.	Full width-plow tillage	Ecofallow
•	Plow plant	Direct drill
•	Spring plow-wheel-track plant	

II. Engineering or Mechanical Measures

A. Contour bunds

Bunds constructed along the contours or with permissible deviation from contours are called contour bunds. Bunding is preferred over the areas where annual rainfall is <500 mm and soil moisture is limiting for crop production. Mostly, bunds are constructed on the land slopes varying from 2 to 10%. For the lands below 2%, agronomic measures can be adopted for in-situ moisture conservation. Contour bunds are preferred in the permeable soils like alluvial, red and shallow black soils. However, bunds are not preferred in the dry soils or deep black soils.

Design of contour bunds involves fixing vertical interval and horizontal interval between two consecutive bunds, their deviations from actual contour and the cross-section of the bund. Vertical interval (VI) can be calculated by using the formula.

$$VI = (s/a + b)$$

Where,

S=land slope, %

a, b= Constants depending upon the soil, and rainfall characteristics. Cropping programme of the area.

Horizontal interval (HI): $\frac{VI}{s} \times 100$

The criterion for spacing of contour bunds is to intercept the water before it attains erosive velocity. This depends on slope, soil, and rainfall, cropping programme and conservation practices adopted. The non-erosive velocities one 0.5 m/s for sandy soils and 0.6 to 0.75 m/s for clay soils. The cross-section of bund can be determined based on the volume of water impounded between on contour bunds, and the seepage line across the bund.

Graded bunds consist of constructing wide and shallow channels across the slope very near to the contour ridge. These channels induce and regulated the excess runoff water and remove the same with non-erosive velocities. Graded bunds are preferred in the areas whose channel rainfall area is >800 mm. The grade of the channel varies from 0.2 to 0.4% depending on soil type.

Bunds with growing of vegetarian along sides and top of the bund to protect from raindrop impact, biotic interference etc are called live bunds. Generally, grasses like khus-khus. Cenchrus ciliaris and legume like gliricidia are preferred for the above purpose.

B. Terracing

i. Broad based terraces

They are also called as ridge terraces or broad bunds. The terrace consists of a channel with a ridge on its lower and whose function is to drain surface runoff or it absorb runoff Thus, these are called drainage or absorption terrace. These can be adopted in slopes < 10%.

ii. Bench terraces

Bench terraces are preferred in the land slopes varying from 10 to 33% on hill slopes the cost is limiting factor in adoption of bench terraces, they are adopted where intensive culture is practiced on hill slopes. Bench terraces consist of constructing step like fields and contours by half cutting and half filling. Original slope is converted into level fields nominating all hazards of soil erosion.

iii. Level or table top bench terraces

Bench terraces with level tops are adopted in the medium rainfall, having deep and highly permeable soils. As there is no slope given to the benches, most of the rainfall falling in the area is to be absorbed by the soil and very little water goes as surface drainage terraces can be used for paddy cultivation where irrigation facility is available.

iv. Inward sloping bench terraces

Terraces with benches sloping inward are adopted in the high rainfall areas where a major portion of the rainfall is to be drained as surface runoff. In such terraces, a suitable at the inward end of each of these terraces is to be provided to remove excess runoff a suitable outlet.

v. Outward sloping bench terraces

Bench terraces with outward sloping are adopted in low rainfall areas with permeable soils. In these terraces, a strong bund with spillway arrangement would suffice remove excess runoff occurring in case of heavy rainfall events. Excess runoff will flow one terrace to another.

vi. Puertorican type bench terraces (California type)

In this type of terrace, the soil is excavated little during every plowing and developing bench terraces by pushing the soil down hill against vegetative barrier laid along contour. Such a terrace is developed over the years above bench terraces.

vii. Stone terraces

They are small embarkments constructed with stones across the hill slopes. These are justified where stones are available in adequate quantities near to the site. These can be used for growing annual crops and perennial tree plantations.

Design of bench terraces

Consists of determining type of bench terrace, terrace spacing, terrace width and terrace cross-section. Selection of bench terrace depends upon the rainfall and soil conditions. Terrace spacing is the vertical interval between two terraces. It depends on the depth of cut. The factors that limit the depth of cut are the soil depth and land slope. The terrace spacing is so selected that depth of cut and fill are balanced. The width of terrace designed such that is enables economic and convenient agricultural operations. As in the case of contour bunds, the vertical interval between terraces can be determined. The width of terrace is calculated from the following formula.

$$VI = \frac{ws}{100-ns}$$

Where,

VI	=	Vertical interval, m
w	=	width of terrace, .m
n	=	batter slope (1/2 : 1 to 1:1)
s	=	land slope, %

Soil and Water Conservation through watershed management

Watershed is a manageable hydrologic unit with common boundary draining runoff from farthest point to a common outlet at the lowest elevation point. The size of watershed can be selected based on the possibilities of developing it with soil and water conservation structures with 3 to 5 years time. Mini or micro watershed can be the basis for planning and execution.

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WATER PRODUCTIVITY IN WATERSHEDS: SCOPE AND STRATEGIES

M. Osman[1] and Y.S. Ramakrishna[2]

Efficient management of any resource requires a balance sheet and watershed exhibits a well-defined hydrological boundary unlike area-based approach. Therefore, watershed is a convenient unit to determine input-output relationship of precipitation and its partitioning into various components in a hydrological cycle. There are about 3200 watersheds of one lakh hectare each, 500 sub-catchments and 35 basins under different agro-ecological regions. Watershed approach offers great promise for rainfall accounting (conservation, utilization, runoff, and groundwater build-up, positive or negative through recharge). Rainwater management on watershed basis is the key for the success of rainfed areas and its efficient management is bound to bring "second green revolution" from grey areas.

Rainfed areas are besieged with several challenges like frequent dry spells leading to drought, low crop productivity, land degradation and overarching stubborn poverty, besides acute fodder scarcity. These areas are highly susceptible to changing climatic scenario particularly the shift and erratic nature of rainfall leading to droughts and floods. The water balance of India indicates a total rainfall receipt of 400 m. ha m per annum, out of which 125 m.ha.m. is lost through evapotranspiration, 170 m.ha.m. is available for irrigation. The skewed nature of rainfall makes it difficult to harvest and most of it goes as runoff. Along with runoff, topsoil rich in nutrients is also lost resulting in further degradation of land. There is enough scope for the harvest of runoff in semi-arid and sub-humid areas, which is about 6 to 7% of total annual rainfall. Runoff harvesting and recycling is possible through farm pond technology. A farm pond of 250m^3 capacity is suitable for semi-arid areas and can supplement the water for one life saving irrigation for half of the cultivated area (0.5 ha) after accounting the losses. The watershed programmes are aiming at in-situ and ex-situ storage of rainwater in the form of soil moisture, ground and surface water. An amount of Rs. 12000/ha has been earmarked for treatment of the area under new guidelines of watershed. Impact evaluation studies conducted by various agencies have clearly indicated that there is a marked improvement in yield and income of the farmers with similar input of rainfall due to efficient utilization. This clearly brings out the importance of watershed development in enhancing more crop yield with given amount of rainfall as an input. Most of the additional water made available through these programmes has gone for water loving crops like paddy, sugarcane and vegetables. Data analyzed for 19 watersheds across nine states indicated only 10% utilization on agriculture, 4% on livestock and the bulk of 59% have gone for water resource development.

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Livestock is considered as most productive option in terms of water use and any higher investment on livestock will lead to improved productivity of water and will also be useful in generating employment round the year. A direct relationship exists among the three components namely land, livestock, and management with livelihoods. Livestock-water productivity research in Ethiopia clearly indicated that rainfed mixed crop-livestock is the next best option compared to water harvesting and drip irrigation to tomato (Table 1).

Table 1: Livestock water productivity research

Comparison of WP		
System & Scale	**Commodity**	**WP (US/m^3)**
Rainfed mixed crop - livestock	Multiple animal products & services	0.68
Water harvesting & drip irrigation	Tomatoes	0.73
	Barley	0.18
	Wheat	0.18

Box 1: What is livestock water productivity?

Livestock water productivity is the ratio of net beneficial livestock-related products and services to the water depleted as a result of livestock keeping. It is a function of several factors, all of which need to be taken into consideration in decision-making:

- Values of all economic and social benefits from livestock-including food, fuel, fertilizer, and labor
- Opportunity costs of alternate water uses
- Water productivity of diverse animal feeds
- Animal productivity
- Watering and grazing practices that affect water depletion and degradation

Source: IWMI, 2007

Box 2: Strategies for improving livestock water productivity

Strategic sourcing of animal feeds Promoting non-grain food sources with high water productivity, use of crop residues and by-products as feed, and practices that encourage more uniform grazing.

Enhancing animal productivity & reducing herd sizes Promoting better health, genetics, nutrition, and animal husbandry practices-thereby enabling livestock keepers to get more from fewer animals.

Reducing negative environmental impacts Managing animals in ways that reduce land and water degradation (e.g. overgrazing).

Strategic provision of drinking water - Providing adequate quality drinking water-strategically placed enables animals to reach otherwise inaccessible grazing areas, keeps them from contaminating domestic water sources, and enhances the production of meat and milk.

In terms of water productivity, paddy stands at the bottom, while replacement of one hectare of paddy enables growing of three hectares of either maize/groundnut/chickpea or finger millet. The water requirement of paddy is 1200 mm while that of maize and groundnut is only 400 mm. The requirement of water for pulses (green gram, black gram and Bengal gram) is still low, 250 mm. Diverting of water from paddy to other crops that require less water will pay rich dividend and it is possible to grow second crop in monocropped areas, thus there is a scope for doubling the productivity of water. Participatory groundwater monitoring and social regulation on water use by individuals will make the watershed, as water surplus or else it will have negative water balance. A study of Kurmapally Watershed in Chintapally mandal of Nalgonda district clearly demonstrated the water balance as negative during four years period of study (2003-2006) except 2005 when the rainfall was above normal indicating more usage and withdrawal of groundwater than the rainfall can support (CRIDA, 2007). Hence there is a need for adjusting of utilization and improvement in ground water recharge to maintain equilibrium. Excessive use of groundwater generally leads to salt deposition on surface and makes the fertile soil unproductive in the long run. In the interest of improving crop production, productivity and retaining of water balance in watersheds in equilibrium, *in-situ* and *ex-situ* measures are important and need to be integrated. If implemented in the right spirit in the conjunctive mode the productivity will go up to several times.

1 In-situ conservation of soil and water

1.1 Contour cultivation:

Contour cultivation is one of the easiest and most effective and low cost methods of controlling erosion and recharge of soil and ground water. With contour cultivation, tillage operations are carried out along contours. It creates numerous ridges and furrows for harvesting

substantial amount of runoff inside the field itself. Simple measures like across the slope cultivation is highly effective in controlling resource losses and enhancing crop productivity.

1.2 Compartmental bunding:

Compartmental bundings are usually practiced in deep black soil areas for interplot harvesting of rainwater during rainy season. The field is laid out into compartments of 6m x 6m to 10m x 10m using bund former. The harvested water in these compartments facilitates high infiltration resulting in high moisture retention. This system helps in better crop production during the post rainy season.

1.3 Broad bed and furrows:

Broad bed and furrow system implies shaping alternate bed and furrows. This technique is especially suited to black soils, where crops are sown on pre-formed beds. Under this system, alternate bed and furrows are made before the season and is maintained year after year. The planting is done on the bed. Generally, the depth of each furrow is kept at 0.15 m and the inter furrow spacing is maintained at 1.5 m. This helps in retaining water in furrows as well as in disposing of surplus water in the event of excess rainfall.

1.4 Conservation furrows:

High intensity rainstorms during monsoon season cause high runoff rates, poor soil moisture storage / low groundwater recharge and significant loss of topsoil both in the Alfisols and Vertisols in the semi - arid region. Estimates show that about 10-17% rainfall is lost as runoff from cropped Alfisols in a few storms of high intensity. Therefore, concerted efforts are absolutely necessary to conserve and utilize every drop of rainwater effectively for substantial grain and biomass production in the country, as the probability of success of dryland agriculture lies more in rainwater conservation. Conservation furrows have proved successful as a measure of rainwater conservation and runoff management in the rainfed regions. Conservation furrows/ dead furrows are opened parallel to the rainfed crop rows across the prevailing land slope, employing a country plough, 3-4 weeks after the sowing / germination of the main crop. These furrows are 20-25 cm wide at top, 25-30 cm deep and are spaced at 0.9-3.0 m regular horizontal interval depending upon the soil physical characteristics and nature of the crop (close growing, row crops, etc.). During runoff causing rainfall events, the rainwater gets concentrated within these furrows, infiltrates into the soil (root zone) and is available to the crop for meeting the evapotranspiration demand for a longer duration compared to the control. The conservation furrows are temporary and therefore are required to be opened every season / year with *kharif* crops. The conservation furrow fields store additional soil moisture over control throughout the growing season, thereby resulting in 12-23 percent higher crop yields fetching an additional economic return of Rs. 600-800 ha^{-1}. The technology has proved its worth in on-farm studies during the last five years and has been adopted widely in the rainfed regions of India.

2. Ex-situ conservation of soil and water

The surplus rainwater can be safely diverted and can be harvested at different levels. The excessive runoff water from the field can be harvested in the farm pond itself while mini percolation ponds have been found very useful in the first order stream. The masonry check dam is effective at the convergence of second or third order stream.

2.1 Dug-out farm pond:

Rainwater collection through farm ponds is very much essential for efficient utilization of excess rainfall for the benefit of the crops and environment. When designed properly, the stored water can effectively be utilized during the off-season for growing cash crops like vegetables, and irrigating plantation crops. Also, during the season depending on the frequency of filling and availability, the water can be utilized for crops by giving one or two life saving/ supplemental irrigations during dry spells. The farm ponds are constructed at the lower side of the fields. The runoff from the contributing fields is canalized into the pond. In light soil, the dugout ponds can be lined to improve the storage efficiency and eliminate the seepage losses. Considering an average of two fillings in a year the capacity of farm ponds may be designed to store 150 to 200 m^3 of runoff per hectare of contributing area in a semi-arid environment (Mishra and Sharma, 1994), while 250-300 m^3 in sub-humid areas.

The experience at farm level has shown enough potential of farm pond (brick lined) technology in growing vegetables in the off-season by satisfying water requirement at 50% of weekly evaporation. An economic analysis of the above pond with tomato as test crop shows a pay back period of 10 years with BCR 1.5 and IRR 18.9%. This technology will be more viable and economical in *vertisols* where lining is not essential. The BCR will certainly be higher if intangible benefits are quantified and the use of water during the season (if any) is also considered. The poor farmers find it difficult to go for high initial investment to adopt this technology for which institutional subsidized credit support is needed. The spread of bore wells has affected the potential of farm ponds. Farmers get tempted for more borewells; in spite of the fact that many of them prove to be failures.

2.2 Mini percolation pond:

Percolation tank is an earthen embankment to store the runoff for increasing recharge of the groundwater. Mini percolation tank (MPT) is highly feasible in the first order stream and it is cost effective. The shape can resemble to that of saucer with depression in the center with mild inward slope. There is a need to provide a spillway and stone revetment for the embankment. Suitable vegetation can be raised on the embankment.

2.3 Check dam:

Crop failure due to moisture stress/drought is common in drylands. Water harvesting for providing supplemental or life saving irrigation to crops is an important component of watershed

management. The water harvested in such structures can also be used as drinking water for grazing cattle and for agricultural purposes such as spraying of insecticide/pesticide in fields away from village. Depending on the availability of water, they can also be used to grow post-monsoon crops. The water harvesting check dam is essentially a masonry structure consisting of a head wall, head wall extension, cut off wall, sidewall, wing wall, toe wall and downstream apron. The dimensions of various components will depend upon the width and depth of the Nala at the selected site, the type of soil and the foundation conditions. Most importantly, a spillway (generally rectangular) should be constructed as part of the head wall for surplussing the design peak flow from the watershed area above the structure after the reservoir created by the check dam is full. The cost of water harvesting check dam will depend on the dimensions of the structure, materials used and its location. A rough estimate for a pucca check dam is Rs.6,000/- per metre length of check dam. The pay back period is 4-6 years. Depending on runoff and the storage created, assured crops can be taken with supplemental irrigation in a couple of hectares. In Chevella (black soil) watershed in Medak district of Andhra Pradesh, an 18 m long, 3 m high check dam was found to create storage of 1200 cu m in the ephemeral stream. This structure with watershed area of 35 ha has enough water to provide supplemental irrigation for 2.0 ha area in kharif season and 0.5 ha in *rabi*. These structures have found acceptance widely in the National Watershed Programme as farmers have derived substantial benefits from them.

2.4 Groundwater recharge through dried-up and defunct wells:

The technology of diverting runoff to dried up wells is the most cost effective that is less than one paisa per litre per filling, eco-friendly and socially acceptable, easy to construct and replicate, useful in harvesting maximum runoff (about 80%), effective utilization of defunct wells for recharge, provides scope for life-saving irrigation during dry spells and helpful in creating awareness on water resource management issues and participatory hydrological monitoring.

3. Recycling of harvested rainwater

The harvested water needs to be applied through efficient irrigation methods like drip or sprinkler, which are known for improving the productivity and profitability. State and Central governments are providing subsidy to make efficient use of surface and ground water and to improve water use efficiency (WUE), which is the ratio of economic yield to water use through evaporation and transpiration (WUE = Y/ET). In a study in mango at CRIDA, showed that highest WUE can be obtained by meeting 25% of the atmospheric demand of water. Higher application of irrigation water reduced the WUE and resulted in marginal increase in fruit yield (Table 2). Among various systems of irrigation, drip was found superior to sprinkler and surface method of irrigation.

In case of surface application,furrow method was found superior to floodirrigation and resulted in saving of water by 30% in case of tobacco. A supplemental irrigation in tobacco improved the yield by 25% (250 kg/ha) giving an additional income of Rs. 8000/ha.

Table 2: Effect of drip irrigation on fruit yield of mango (average of 2002& 2003)

Drip irrigation	Fruit yield (kg/tree)	WUE (kg fruits/m3 of water applied)
I_0 no irrigation	19.4	-
I_1 at 0.25 Ep	24.5	40.7
I_2 at 0.5 Ep	26.2	21.6
I_3 at 0.75 Ep	30.3	16.7
S.E	2.9	
C.D.	6.4	

Source: Ramakrishna *et. al*, (2007)

Thus, an integrated approach of rainwater harvesting at micro (field) and macro (watershed) level and recycling through efficient methods to crops which are efficient in converting water to economic product makes the system productive and highly profitable. There is an immense scope to achieve freedom from water scarcity and can meet the emerging challenges from climate change effectively in rainfed areas. But, this calls for convergence of various on-going central and state government programmes and line departments on watershed mode (Fig.1). In this way we are bound to achieve a "second green revolution" in rainfed areas

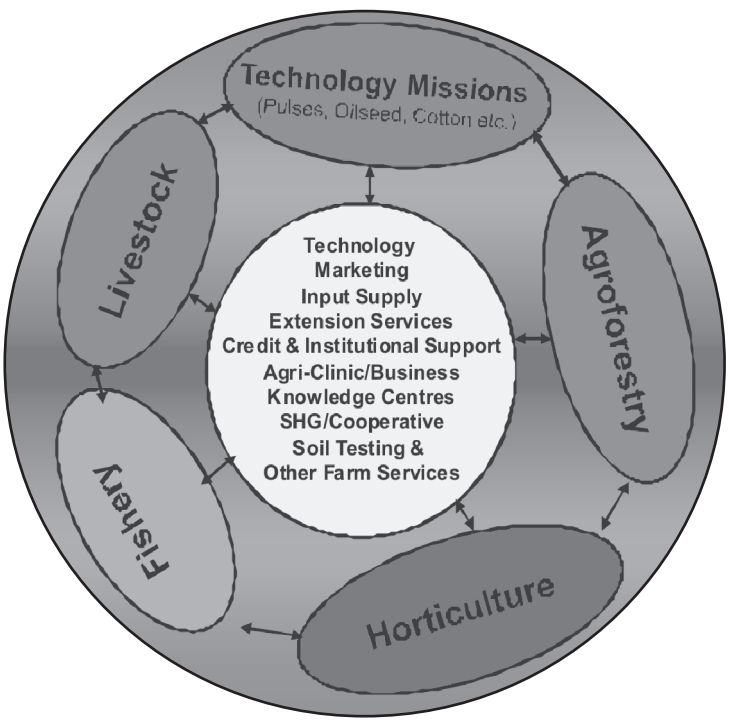

Fig. 1. Convergence of various programmes on watershed mode for improving water productivity and profitability

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EFFICIENT USE OF STORED WATER THROUGH MICRO IRRIGATION TECHNIQUES

K. V. Rao

Introduction

The terms "drip", "trickle" and "spray" irrigation, common in many quarters in the last 15 years, have been supplanted by the term "micro irrigation", recently adopted by the American Society of Agricultural Engineers. Micro irrigation includes all methods of frequent water application, in small flow rates, on or below the soil surface. Ideally, the volume of water is applied directly to the root zone in quantities that approach the consumptive use of the plants. Through good management of the micro irrigation systems the root zone moisture content can be maintained near field capacity throughout the season providing a level of water and air balance close to optimum for plant growth. In addition, nutrient levels, which are applied with water through the system, can be controlled precisely. During the dry season in humid areas, or in arid climates, micro irrigation can have a significant effect on quality and quantity of yield, pest control and harvest timing.

Advantages of micro irrigation systems

Micro irrigation systems have many potential advantages when compared with other irrigation methods.

1. Water savings

Irrigation water requirements can be smaller with micro irrigation when compared with other irrigation methods. This is due to irrigation of a smaller portion of the soil volume, decreased evaporation from the soil are significantly reduced compared with other irrigation systems since only a small surface area under the plant is wetted and it is usually well shaded by the foliage. Since the micro irrigation system allows for a high level of water control application, water can be applied only when needed and deep percolation can be minimized or avoided.

2. Smaller flow rates

Since the rate of water application in micro irrigation systems is significantly lower than in other systems, smaller sources of water can be used for irrigation of the same acreage. The delivery pipes, the pump, and other components of the system can be smaller and therefore more economical. The systems operate under low pressure (5-30 psi) and require less energy for pumping than high pressure systems.

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3. Application of chemicals

Micro irrigation systems allow for a high level of control of chemical applications. The plants can be supplied with the exact amount fertilizer required at a given time. Since they are applied directly to the root zone a reduction in the total amount of fertilizer used is possible.

There is also an advantage to the frequent application of fertilizers through the system in Florida's humid climate. In case of rain, only a small portion of recently applied fertilizer will be washed out and it can be easily replaced through the irrigation system. This application method is more economical, provides better distribution of nutrients throughout the season, and decreases ground water pollution due to the high concentration of chemicals that could ordinarily move with deep percolated water.

4. Water sources with high salt content

A significant advantage of micro irrigation is that water with relatively high salt content can be used by system. For optimum plant growth a certain range of water potential in the root zone must be maintained. The potential defines how difficult it is for a plant to extract water from the soil. Large negative numbers are characteristic of very dry soils with low total water potentials while potentials near zero reflect soils near saturation. The total water potential in the root zone is a sum of the matric potential and osmotic potential. Since matric potential is close to zero under micro irrigation (high moisture content) the osmotic potential component can be a relatively large negative value. Indicating high salt content, without harmful effect on plant growth. This is not true for other irrigation systems.

5. Improved quality of the crop

Micro irrigation plants are supplied very frequently with small amounts of water and the stress due to the moisture fluctuation in the root zone is reduced to the minimum, often resulting in larger and better quality yield.

6. Adaptation to any topography

Micro irrigation systems can operate efficiently on hilly terrain if appropriately designed and managed. Well managed micro irrigation system will not create runoff even on hilly terrain.

7. Additional advantages of micro-irrigation systems

During dry seasons or in arid climates disease and insect damage can be reduced under micro irrigation system since the foliage of the plant is not wetted. With a small portion of soil surface being watered, field operations can be continued during irrigation. The water distribution is not affected by the wind for drip irrigation. However, wind can have some effect on jet spray patterns. Since only the portion of the soil surface is wetted/water uptake by the

weeds between the rows can also be significantly reduced. Micro irrigation systems can also be extensively automated/decreasing labour and operating costs.

Potential problems in micro irrigation

To operate satisfactorily, a micro irrigation system have to be correctly designed and managed to account for the physical properties of soil, quality of irrigation water, and water requirement of the grown plants. This type of system definitely requires a higher management level than other irrigation systems. With all the advantages listed above, a micro irrigation system is not a system without problems.

1. Clogging

One of the biggest problem encountered under micro irrigation is clogging of the emitters. The small openings can be easily clogged by soil particles, organic matter, bacterial slime, algae or chemical precipitates. The micro irrigation system requires very good filtration (most often recommended is 200 mesh screen) even with a good quality water supply.

2.Moisture distribution

Moisture distribution depends largely on the soil type being irrigated by the micro system. In some soils, for example deep sands, very little lateral water movement (low capillary forces) can create many problems. The wetted volume has a shape approaching a cylinder rather than a hemisphere since gravity forces dominate. Under these conditions it is difficult to wet a significant portion of the root zone. It is also more difficult to manage the irrigation without deep percolation since only a small amount of water can be stored in the wetted volume desired. Increasing the number of emitters per plant may improve water distribution in the soil. As a result, coarse sands will require much closer spacing of emitters than fine soils. In general, for any soil, the number of emitters and their spacing must be based on the geometry of wetted soil volume.

It is important to realize that the micro irrigation system wets only a limited portion of the potential soil-root volume. Most of the plants can perform very well under these conditions. However, there is a minimum volume of roots, which has to be wetted, or a reduction in yield will be observed.

3. Salt buildup

Micro irrigation systems can use saline water. However, a problem may occur from salts accumulating at the edges of the wetted zone during prolonged dry periods. Light rain can wash these salts into the root zone and cause injury to the plants. In arid climates, where the rainfall is less than 10 inches per year, an additional irrigation system (sprinkler or surface) may be necessary to leach accumulated salts from the soil between growing seasons. In areas with

heavy rainfall the salts will be washed out of the root zone before significant accumulation occurs.

4. Initial cost

The initial investment and maintenance cost for a micro-irrigation system may be higher than for some other irrigation methods Filters, chemicals injectors and possible automation components add to the cost of a micro irrigation system. Actual costs will vary considerably depending on the selection of a particular micro system, required filtration equipment, water quality, water treatment and selection of automation equipment.

Components of micro irrigation system

A. System components for drip irrigation scheme

1. Head control unit

a) Non-return valve
b) Air valve
c) Vacuum breaker valve
d) Filtration unit (Screen / Disc / Sand / Hydrocyclone)
e) Fertigation unit (Fertilizer tank)
f) Throttle (Gun metal valve)
g) Water meter (optional)
h) Pressure gauge
i) Other fittings & accessories

2. Water carrier system

a) HDPE/PVC pipeline for main
b) HDPE/PVC pipeline for submain
c) Control (PVC or PP valve)
d) Flush valve
e) Other fittings & accessories

3. Water distribution system

a) Online dripper
b) Plain lateral
c) Emitting pipe
d) Spaghetti (for connecting emitter to lateral)
e) Grommet
f) Nipple
g) Start connector
h) End cap

B. *Sprinkler irrigation system*

HDPE Pipes with quick action coupler of 6m long
Sprinkler coupler with foot batten assembly
Sprinkler nozzles (1.7 to 2.8 kg/cm^2)
Riser pipe 20mm diameter & 75cm long
Connecting nipple
Bend with coupler 90^0
Tee with coupler
End plug

C. Gravity fed family drip system

Control valve
PE pipe for main/submain
Emitting pipe
Filter
Tank (200 L and above)
Grommet
Start connector
End cap
Fittings & accessories

Head control unit

Non-return valve

Check valves are also called non-return valves, permit flow in one direction only and prevent reversal flow in piping by means of an automatic check mechanism. They come in two basic types: the swing check, which can be installed in horizontal or vertical piping: and the lift check, for use in horizontal lines only. Water flow keeps the check valves open, and gravity and reversal of flow close them automatically. They are placed in-line at the head control unit immediately after the pump. Swing checks are used with gate valves, lift checks with disk valves. Check valves are made of several metal materials and brass, and are screw type (female joints) quoted in inches from - 4 in, at a PN of 16.0 bars.

a) Air valves.

These valves are of great importance as they protect the pipe network from damage by trapped air in the system or from collapse due to a vacuum. If improperly chosen or located in a wrong place, it can also cause severe functional problems.The presence of free air in water installations causes many difficulties in the piping system at start-up, during operation and when draining the system. Air valves are needed so that air can be either released from or admitted into the pipelines. It operation and air flow rate cannot be influenced either by the system operator or by the performance of any other appliance. There are three main kinds of air valves.

In addition to the above air valves, small vacuum breakers of ½ inch are available for preventing vacuums in drip laterals laid on the soil surface, thus protecting them from clogging.Air valves are manufactured for high working pressures of at least 10.0 bars PN. They are installed on-line with threaded internal or external joints.

Filtration unit.

The filtration of the irrigation water is essential in order to avoid blockage damage to the micro-irrigation emitters. The type of filter used depends on the kind of impurities contained in the water and the degree of filtration required on the emitters. Their size should be the most economical with the lowest friction losses ranging from 0.3-0.5 bars. The following kinds of filters are available

A. Gravel filters.

These filters, also called media filters, are closed cylindrical tanks, which contain a gravel grain of 1.5-3.5 mm or a basalt sand filter bed. Where the irrigation water source is an open reservoir, they are installed at the beginning of the head control of the system. Water entering the tank from top passes through the gravel bed, which traps the large particles of unbroken organic matter, mostly algae, and exits through the outlet at the bottom of the tank. They are equipped with the necessary inlet, outlet and drain valves, and a back-flushing arrangement. The filter body is epoxy coated metal, minimum 8.0 bars PN, and is 50-180 cm high and 40-100 cm in diameter. They are available in threaded connection sizes of 1-8 in.

B. Hydrocyclone (sand separator) filters.

These are closed conical metal tanks placed at the beginning of the head control unit where needed. They separate sand or slit from well or river water through the creation of a centrifugal force by a vortex flow inside the filter. This force drives the solids downward to collecting chamber attached below and lets the clean water out. They are epoxy coated, PN 8.0 bars, and are available in threaded connection sizes of -8 in.

C. Screen type filters.

These are used for final filtration as a safeguard for either moderate quality water or following a primary filtration with gravel or hydrocyclone filters. They are installed at the end of the head control before the main pipeline. They are made of epoxy coated metal or high engineering plastics in various cylindrical shapes (horizontal on-line, vertical angle, etc.,) and are equipped with interchangeable perforated filtering elements, inlet, outlet and drain valves and pressure inspection gauges. They can withstand a working pressure (PN) of 8.0 bars. The degree of filtration ranges from 60 to 200 mesh (75 microns). They are available in sizes of _-4 in. Smaller sizes are made of reinforced plastic.

Disk type filters.

They are cylindrical, made of reinforced plastic, horizontal in line or vertical angle-

shaped. The filtering elements consist of stacks of grooved plastic rings with multiple intersections providing a three dimensional filtration of high level. They are very effective in removing all kinds of impurities of inorganic and organic origin, algae included. The degree of filtration can range from 40 to 600 mesh (400-25 microns). They are available in all sizes (_-6 in), PN8.0 bars, with threaded joints. They are placed at the end of the control unit before the main pipeline.

Fertilizer tank

Fertilizers are applied with the irrigation water through the system using special devices called fertilizer injectors installed at the head control. There are three main types of fertilizer injectors: closed tank, Venturi type and piston pump. All of them are water driven by the operating pressure of the system.

A. Fertilizer (closed) tank.

This is a cylindrical, epoxy coated, pressurized tank, resistant to the system's pressure, and connected as a bypass to the supply pipe of the head control. It is operated by differential pressure created by a partially closed valve, placed on the pipeline between the inlet and the outlet of the tank. Part of the flow is diverted to the tank entering at the bottom. It mixes with the fertilizer solution and the dilution is ejected into the system. The dilution ratio and the rate of injection are not constant. The concentration of fertilizer is high at the beginning and very low at the end of the operation. However, this apparatus is still in service on a very small scale in some countries because of its low cost and easy manufacture.

B. Venturi type

This is based on the principle of the Venturi tube. A pressure difference is needed between the inlet and the outlet of the injector. Therefore, it is installed on a bypass arrangement placed on an open container with the fertilizer solution. The rate of injection is very sensitive to pressure variations, and small pressure regulators are sometimes needed for a constant ejection. Friction losses are approximately 1.0 bar. The injectors are made of plastic in sizes from 2 in and with injection rates of 40-2 000 litres / h. They are relatively cheap compared to other injectors.

Drippers

The drippers are small sized emitters made of high quality plastics. They are mounted on small soft PE pipes (hoses) at frequent spaces. Water enters the dripper emitters at approximately 1.0 bar and is delivered at zero pressure in the form of continuous droplets at low rates of 1.0-24 litres/h. Drippers are divided into two main groups according to the way they dissipate energy (pressure):

- Orifice type, with flow areas of 0.2-0.35 mm^2;
- Long-path type, with large flow areas of 1-4.5mm^2

Both types are manufactured with various mechanisms and principles of operation, such

as a vortex diode, a diaphragm or a floating disc for the orifice drippers, and a labyrinthine path, of various shapes, for the long-path ones. All the drippers now available in the market are turbulent flow ones. Drippers are also characterized by the type of connection to the lateral; on-line, i.e. inserted in the pipe wall by the aid of a punch; or in-line, where the pipe is cut to insert the dripper manually or with a machine.On-line multi-exit drippers are also available with four to six 'spaghetti' type tube outlets.

Drip tapes

These are thin-walled integral drip lines with emission points spaced 10,20,30,45 cm or any other distance apart, delivering lower quantities of water than the usual drippers at very low pressure, i.e. 0.4-1.0 litres/h at0.6-1.0 bar. They are integrated drip lines where the drippers are built in the pipe walls at the desired spacing during the manufacturing process. They are ready-made dripper laterals with a very high uniformity of application. Drip tapes are made of LDPE or other soft PE materials in various diameters from 12 to 20 mm and in several wall thicknesses (0.10-1.25 mm). They are less susceptible to mechanical and biological blockages than conventional drippers are.

Pressure compensated emitters

Several sprinklers, drippers and other water micro-emitters are available with built-in flow regulators. These emitters deliver a constant flow of water at any pressure exceeding the fixed operating one. Uniform rates of discharging are achieved along the laterals regardless of the number of emitters, spacing, length of line or elevation, where excessive pressure is available. Therefore, pressure variations in the laterals due to friction losses can exceed 20 percent. Thus, less expensive smaller diameter pipes can be installed in certain cases. However, the self-regulated emitters, called pressure compensated, are normally operated under pressures exceeding the fixed operational pressures and cost more than the conventional ones.

Sprinklers

Most of the agricultural sprinklers are the hammer-drive, slow rotating impact type, single or twin nozzle. The sprinklers shoot jets of water into the air and spread it to the field in the form of raindrops in a circular pattern. They are available in various nozzle sizes, flow discharges, operating pressures and wetted diameters or diameter coverage, full circle or part circle. They are classified as low, medium and high pressure/capacity, as shown below; according to the height of the water jet above the nozzle, they are divided into low angle (4^0 - 11^0), or high angle (20^0-30^0). They are made of brass or high engineering plastics with internal or external threaded connections of _-1_ in. They are installed vertically on small diameter riser pipes, 60 cm above ground, fitted on the laterals. The sprinkler spacing in the field is rectangular or triangular at distances not exceeding 60 percent of their diameter coverage. Filtration requirements, where necessary, are about 20 mesh.

Sprinkler classification

Agriculture sprinklers	Nozzle size mm (two nozzles)	operating pressure (bars)	flow rate (m_/h)	Diameter coverage (m)
Low pressure	3.0-4.5x2.5-3.5	1.5-2.5	0.3-1.5	12-21
Medium pressure	4.0-6.0x2.5-4.2	2.5-3.5	1.5-3.0	24-35
High pressure	12.0-25.0x.5.0-8 0	4.0-9.0	5.0-45.0	60-80

Micro Sprinklers

These water emitters are small plastic sprinklers of low capacity with flow rates less than 300 litres/h. Their main characteristics are their rapid rotation/whirling, less than a minute per rotation, the very small size of the water drops and the low angle of the water jet above nozzle. They have only one nozzle, of about 2.0 mm. They discharge 150-250 litres/h at 2.0 bars operating pressure. They are full circle and the wetted diameter is only 10-12 m. Mounted at a height of 60 cm on metallic or plastic rods inserted into the ground, they are connected to PE laterals (25 or 32 mm) through small flexible tubes 7 mm in diameter and 80 cm long. The spacing arrangement in the field is the same as for conventional sprinklers. The spacing does not exceed 6.0 m, i.e. 50 percent of the wetting diameter. The filtration requirements are about 60 mesh (300 microns.).

Spitters, micro-jets and sprayers

These are small plastic emitters with a low water discharge at a low angle in the form of fine drops in a sectorial or full circle pattern. They are mainly used for tree crops. They are of various mechanisms with a wide range of flow rates and water diameters. They have a small passage diameter, thus filtration of the water is essential. Their main performance characteristics are:

- Operating pressure: 1.5-2.0 bars;
- Flow rate: 35-250 litres/h (generally 150litres/h);
- Wetting diameter: 3-6 m;
- Precipitation rate: 2-20 mm/h (generally 4-8 mm/h):
- Filtration requirements: 60-80 mesh (250-200 microns).

Their heads are fixed to small plastic wedges 20-30 cm above ground and they are connected to the PE laterals with 7-9mm flexible plastic tubes 60-120 cm long and a barbed plunger. They are placed one per tree, 30-50 cm apart.

System design

The engineering and hydraulic design procedure is almost the same in all kinds of pressurized irrigation systems. It consists of a series of interlinked calculation. The various stages are outline below:

Selection of the water emitter

(sprinkler, dripper, mini sprinkler, bubbler, hose, etc.) according to the crop, irrigation method and requirements:

- Type, flow rate, operating pressure, diameter coverage;
- Spacing and number per lateral line.

Design of the laterals

- Length, direction, spacing and total number of lateral lines (in solid systems) or lateral positions (in semi-permanent installations);
- Flow of the lateral=number of emitters per lateral x emitter flow rate:
- Number of laterals operating simultaneously = system flow/flow of lateral;
- Number of shifts to complete one irrigation = total number of lateral lines or positions Number of laterals operating simultaneously; Duration of application=irrigation dose in millimetres application rate in millimeters per hour, or irrigation dose in cubic metres per hour system flow in cubic metres per hour.

Determination of the size of the pipelines

Lateral lines

It is important to understand the water emitter's functions and principle of operation before commencing the design process. One of the main characteristics of all types of emitters is the relationship between flow rate and operating pressure, which is usually expressed by the empirical formula. $q=k\ d\ H^*$ where q is the emitter discharge, k and d are coefficients (constants), H is the pressure at the emitter and * is an exponent characterized by the emitter flow regime and the flow rate curve as a function of the pressure. The lower the value of *, the less the influence of pressure variation on the emitter flow rate along the lateral line. Most of the water emitter flow regime is fully turbulent with an exponent value equal to 0.5. Thus, the difference in discharge is half the difference in pressure, when the ratio of the two different pressures is < 1.3/1.0. In order to ensure a high uniformity of water application over the field, the differences in the discharge of the emitters should be kept to the minimum possible and in no case exceed 10 percent. These criteria were established by J. Christiansen for sprinklers and are now applied in all pressurized systems. As a general rule, the maximum permissible difference in pressure between any two

emitters in operation should be no more than 20 percent. The lateral lines with emitters must be of a size that does not allow a loss of head (pressure) due to friction of more than 20 percent.

The loss of head due to friction (friction losses) in lateral pipes is taken from a graph or a table. It is not the true figure as the flow is distributed en route through the emitters. In order to compute the actual losses the above figure is multiplied by Christiansen's reduction coefficient, F, to compensate for the water delivered along the lateral line. The F values depend on the number of the outlets uniformly spaced along the pipeline. Three different series of F values exist corresponding to the Q exponent (m) of the three main friction loss formula: Hazen Williams, 1.85; Scobey, 1.9: and Darcy Weisbach, 2.0. Moreover, lower values are taken if the distance of the first outlet is half the spacing of the outlets, etc. However, the differences between the various F values are almost negligible.

Due to the multiplicity of emitters with variable flow regimes and other factors affecting the pressure/discharge relation along the laterals in the field, such as local minor losses that occur at the connection of the emitters on small-sized pipes and temperature fluctuations, the manufacturers should always provide charts for the optimum length of emitter laterals, based on the size of pipe, emitter spacing, operating pressure, flow rate and slope.

Manifolds, sub main and main pipelines

On the manifolds, whether these pipelines are the submains or the mains as well, a number of laterals are fed simultaneously. The flow of the line is distributed en route, as in the laterals with the emitters. Consequently, when computing the friction losses, Christiansen's reduction coefficient, F, is also considered. The mains, submains and all hydrants are selected in such sizes that the friction losses do not exceed approximately 15 percent of the total dynamic head required at the beginning of the system's piped network. On level ground, these friction losses amount to about 20 percent of the emitter's fixed operating pressure. This is a practical rule for all pressurized systems to achieve uniform pressure conditions and water distribution at any point of the systems. The above figure should not be confused with or related in any way to the maximum permissible friction losses along the laterals. Another important element is the flow velocity in the mains, submains and hydrants. This value should always be kept below 1.7 m/s_ in plastic tubes and a maximum of 2 m/s_ in other pipes (steel, aluminium, etc).

Head control

The component parts of the head control and their size are in accordance with the system requirements. In micro-irrigation systems the units are complete with filters and fertilizer injectors. While in sprinkler and hose irrigation systems the head controls are simple with the minimum of equipment. The friction losses in the various component parts vary accordingly

from 3 to 10 m. The friction loss formulas are empirical and include many variables and correction factors. In calculating the pipe friction losses from equations, extensive practical experience is needed. In view of the fact that great accuracy is not possible due to the unpredictable changes in pipe roughness, water viscosity, nozzle wear, clogging etc., the use of friction loss tables and nomographs is recommended.

Table 1: Some of the recommended irrigation system type for various crops

S.No	Crop	Irrigation system	Spacing	Lateral spacing (m)	Dripper spacing (m)	Drippers per plant	Dripper discharge (LPH)
1	Mango	Drip-online	10m x 10m	10m	---	4	8
		Drip-online	9m x 9m	9m	---	4	8
		Drip-online	8m x 8m	8m	---	4	8
		Drip-online	7m x 7m	7m	---	4	8
		Drip-online/ online	5m x 5m	5m	---	4	8
2	Sapota	Drip-online	8m x 8m	8m	---	4	8
3	Coconut	Drip-online	8m x 8m	8m		4	8
4	Cashewnut	Drip-online	6m x 6m	6m	---	4	8
5	Sweet orange	Drip-online	6m x 6m	6m	---	4	8
6	Acid lime	Drip-online	6m x 6m	6m	---	4	8
7	Guava	Drip-online	6m x 6m	6m	---	4	8
8	Custard apple	Drip-online	6m x 6m	6m	---	4	8
9	Ber	Drip-online	6m x 6m	6m	---	4	8
10	Pomegranate	Drip-online	4.5m x 2.7m	4.5m	---	4	8
11	Grapevine	Drip-	2.7m x 1.5m	2.7m	0.4m	---	2
		Drip-online	2.7m x 1.5m	2.7m	---	2	4

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FARMING SYSTEMS APPROACH CONCEPTS, SCOPE AND APPLICABILITY IN RAINFED AGRICULTURE

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Introduction

Rainfed agriculture occupies 68% of India's cultivated area and supports 40% of the human and 60% of the livestock population. However, aberrant behaviour of monsoon rainfall, eroded and degraded soils with multiple nutrient and water deficiencies, declining ground water table and poor resource base of the farmers are principle constraints for low and unstable yields in rainfed areas (Singh, et al, 2004). Increasing crop productivity to meet food requirements of teaming millions in our country poses a greater challenge. In this context, there is a need to enhance the productivity of rainfed crops from at least 1 to 2 t to meet the food requirements by 2020 AD. Hence, the situation calls for efforts to intensify the production in both time and space. This could be possible by developing appropriate cropping and farming systems in rainfed agriculture.

Rainfed farming systems

Traditionally rainfed farmers are small subsistent land holders integrating livestock with crop production. With continuing population growth, intensifying crop and livestock systems continue to play vital role in maintaining rural livelihoods. Farming systems refers deliberate raising of crops, forest and fruit trees, animals including fisheries, piggery and duck farming, sericulture, mushroom, on a given unit of land to increase the productivity and profitability, to upgrade natural resource base and to achieve overall improvement in the environment. The philosophy behind shifting from cropping system to the farming system mode involves (i) *in situ* recycling of organic residue including farm wastes generated at the farm to reduce the dependency on chemicals (ii) decrease in cost of cultivation through enhance input use efficiency, (iii) effective use of bye-products/wastes of one component for the benefit of other component/components (iv) nutritional security through minimizing chemical residues in soil plant animal human chain, and (vii) environmental security by moderating flow of green house gases from the soil to environment. Farming system provides a vast canvas of livelihood gathering, a better risk coping strategy, continuous flow of income and employment throughout the year for small landholders. It involves utilization of primary and secondary produce of one system as a basic input of other system through making them mutually integrated.

Concept and principles

The modern agriculture emphasize too more dimensions viz., time and space concept. Time concept relates to increasing crop intensification in situation where there is no constraint for inputs. In rainfed areas where there is no possibility of increasing the intensity of cropping, the other modern concept (space concept) can be applied. In space concept, crops are arranged in tier system combining two or more crops with varying field duration as intercrops by suitably modifying the planting method. Income through arable cropping alone is insufficient for bulk of the marginal farmers.

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Activities such as dairy, poultry, fish culture, sericulture, bio-gas production, edible mushroom cultivation, agro-forestry and agri-horticulture, etc., assume critical importance in supplementing their farm income. It should fit well with farm level infrastructure and ensures fuller utilization of bye-products. Integrated farming system is the only answer to the problem of increasing food production for increasing income and for improving the nutrition of small scale farmers with limited resources.

Integrated Farming System

Integrated farming system (IFS) a component of farming system research (FSR), introduces a change in farming techniques for maximum production is a cropping pattern and take care of optimal utilization of resources. The farm base is better recycling for productive purposes in the integrated farming system. Unlike specialized farming system (SFS) integrated farming system activity is focused round a few selected, inter-dependent, inter-related and often inter-linking production systems based on few crops, animals and related subsidiary professions. Integrated farming system as basic input of other system, thus making the mutually integrated as one whole unit. There is a need to effective linkages and complementarities of various components to develop holistic farming system.

Predominant components in rainfed systems

Crop based farming systems

In this system, animals are raised on agricultural wastes and animal power is used for agricultural operations and voids are used as manure and fuel. In rice based production system at Orissa, *in situ* conservation of rain water by optimum weir height, conserving excess water in the refuges constructed at the down stream of rice field and rearing of fish in the refuges in the medium land enhanced the total productivity (James et al., 2005). This system recorded the highest net returns (Rs.2197/ha) with BC ration (2.78) as compared to the growing of rice along (915294/ha). The average fish yield in this system was 1107 kg/ha in six months. The cropping intensity was increased from 100 to 131%. At Ranchi, the improved rice (IR-64) + fish (mixed carps), wheat (PBW-443) enhanced the net returns (Rs.58557/ha) as compared to the farmers practice of rice fallow (Rs. 2270/ha).

Under nutritive cereal based production system, the cropping pattern with 35.39% of food grains and 25.71% of oilseeds, 17.3% of commercial crops and 1.17% of fodder crops in total holdings of small farmers with backyard poultry (6 birds) helped the farmers to stabilize the farm income at Dharwad. The animal component (poultry bird) helped the farmers during the drought year to stabilize the farm income as compared to crop alone. At Hyderabad, a marginal farmer having 0.5 ha grown cotton (Bunny) and maize + pigeon pea systems recorded the BC ration of 3.47 and 4.43 respectively. One milch animal on an average gave the additional net

benefit of Rs. 380/year. Thus, the net income from the marginal farmers could rise to the tune of Rs. 3275/ha with investment of Rs. 1460/- in the farm (TAR-IVLP,2003). At Bangalore, the crop diversification involving 60% of area under finger millet (GPU 28) and 40% area under drumstick gave additional net returns by 16 and 48% respectively as compared to the sole fingermillet alone (Rs. 11266/ha).

Agri-sheep farming with 10 lambs and growing crops and use of farm by products in one ha of marginal lands gave the net returns of Rs. 8700/ha as compared to growing cotton alone at Warangal in Andhra Pradesh (Rs. 27500/ha) under cotton based production system. Employment generation to the tune of 550 man-days was possible in dairy cum poultry based integrated farming system whereas cropping alone generated 245 man days in a year. In North Telengana zone, farming system with agriculture and dairy generated more than 200% additional employment over agriculture alone. The net returns were higher in agriculture and dairy followed by agriculture and poultry and agriculture and sheep. In Oilseed based production system, Groundnut cake is the most important by-product used as protein source and cattle feed at Ananthapur. Groundnut haulms are used for feeding cattle and sheep. Integration of sheep production in groundnut farming systems offers gainful employment in rainfed areas. In this scarce rainfall zone of Andhra Pradesh, the highest net returns were recorded with farming with the poultry broilers (Rs. 43360) followed by farming by dairy with three buffaloes having 2 ha (Rs. 40606) while sole crop of groundnut (2.6 ha) recorded the net returns of Rs. 14872/ha.

Agro forestry based farming systems

Perennial grass components, besides imparting stability to crop production in arid areas, also act as vegetative filter strips for prevention of wind and water erosion. Moreover, the grass component improves the soil organic matter and starts giving production from the establishment year onwards. Growing of grasses and legumes reveals that moth bean and mung bean in the ratio of 2:1 with grasses like *Lasiurus sindicus, Cenchrus ciliaris, Cenchrus setigerus and Dicanthium annulatum*, gives the bonus yield of grain (1.3 to 2.8 q/ha) and fodder (3.5 to 6 q/ha). However, intercropping of grasses and dryland crops is often not feasible under a farmer's micro-farming situation and, hence, a strip cropping of grasses and *kharif* legumes in 1:2 ratio is recommended, with a strip width of 5 m. The grass component in agri-pasture and silvi-pasture system was more profitable than the areable farming. Economic evaluation was carried out by CAZRI, Jodhpur, taking 18 years as an effective period. The entire tree based systems showed higher benefit-cost ration over the pure arable farming.

The Agri-silviculture system is recommended for land capability class IV with annual rainfall of 750 mm. A large number of tree-crop combinations, particularly of N, fixing trees with sorghum, groundnut,castor and pulses were evaluated in Alfisols and Vertisols. Short duration dryland crops such as pearlmillet, blackgram and greengram, combined with widely

spaced tree rows of *Faiderbia albida* and *Hardwickia binata*, have been found compatible in semi-arid tropical areas.

At CRIDA, the horti-pastoral system with *Cenchrus/stylos* in rainfed guava and custard apple, *Cenchrus* yielded dry forage 7 t/ha with 17.5% of crude protein during the first year while *stylos* recorded 5.6 tonnes of dry fodder during the second year of plantation. In ber based agri-horti system, Pearlmillet + pigeonpea (Solapur), Pigeonpea + balckgram (Rewa), Castor (Dantiwada) and Clusterbean (Hyderabad) showed promising results in rainfed environment. Ber on an average gave 40 kg fruits/tree along with the 100 kg of horsegram and 450 kg of cowpea cultivated in interspaces (Osman *et al,* 1989). Radhamani (2001) reported the additional employment gains (314 man-days/year) through integrated farming system with crop+goat under rainfed vertisols. In 21st century, stability in crop production and income is likely to occur because of land use diversification. A matrix of possible land uses as influenced by the resource carrying capacity is recommended for future.

Livestock based production system

The livestock farming system in rainfed agriculture are complex and generally based on traditional socio-economic considerations. An understanding of production factors (livestock, capital, feed, land and labour) and processors (description, diagnosis, technology design, testing and extension) that effect animal production is pre-requisite for livestock integration. The productivity of livestock in farming systems in rainfed agriculture can be improved by increased fodder production as an intercrop with cereals, relay and alley cropping, forage production on bunds, improving the feeding value of stover by chopping, soaking with water, urea treatment, strategic supplementation of concentrate, urea molasses mineral block for enhanced utilization, improvement in productivity of grasses quantum and distribution decides the effective growing season and it becomes critical in selecting cropping systems for a given reason.

A beneficial effect of 15-25% in yield was and legumes in degraded lands, establishment of fodder banks in areas where surplus fodder is available, artificial insemination with semen approved bulls, removing low-grade animals through health camps. At CRIDA, field studies indicated that urea treated straw increased the milk yield ranging from 0.47 to 1.2 1/day with an average increase of 0.8 1/ccw/day in IVLP villages of Ranga Reddy district. The paddy straw consumption was also increased with 1-1.2 kg/animal due to this intervention. Urea molasses mineral block (UMMB) enhanced quality and quantity of milk by 25-30% in cows and buffaloes. It helped in maintaining the overall health and productivity of animals particularly when fodder scarcity was acute in drought period. Mineral supplementation gave higher milk yield (58%) and net returns (Rs. 816) compared to the farmers practice of grazing alone which gave milk yield of 1.8 lit/day with net returns of Rs. 2156. Supplementation of rice bran @ 1.5% of body weight significantly improved the growth rate of sheep and goats.

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ROLE OF LIVESTOCK AND THEIR MANAGEMENT FOR ENHANCING PRODUCTIVITY AND INCOME FROM DRYLANDS

D.B.V. Ramana and A. Vijay Kumar**

Livestock is an important livelihoods providing segment of traditional farming systems in India. It contribution is substantial (about 23%) to the agricultural gross domestic product in the country. Traditional, resource-driven and labour intensive ruminant sector, which produces a multitude of services to subsistence agriculture in general and multi-faceted contributions to socioeconomic development of the dryland areas in particular. Livestock are consistently and widely owned by small farmers for a variety of advantageous reasons (Devendra, 1983; Chantalakhana, 1990):

- Diversification in the use of production resources and reduction of socio-economic risks
- Promotion of linkages between system components (land, crops and water)
- Generation of value-added products (e.g. meat, milk, eggs and skins)
- Income generation, investment, insurance and economic security when a berrant weather conditions prevail
- Supply of draught power for crop cultivation, transportation and haulage operations
- Contribution to soil fertility through nutrient cycling (dung and urine)
- Contribution to sustainable agriculture, and environmental protection
- Prestige, social and recreational values, and
- Development of stable farm households.

Further, increased human population growth and increasing urbanization, will significantly drive the demand for animal foods. Over the last two decades, the country evidenced with significant increase in expenditure share (from 10.01 and 3.43 in 1972-73 to 15.03 and 5.22 in 1993-94, respectively) towards milk and meat consumption. This trend is also consistent with the fact that consumers have been obtaining an increasingly greater share of calories and protein from animal food products.

Potential for productivity enhancement:

The non-ruminant poultry industry continues to contribute the major share of meat and egg production to meet projected human needs. The application of major advances in non-ruminant nutrition enables maximum per animal performance as well as high efficiency of feed

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conversion. With ruminants by comparison, overall meat production continues to come mainly from the slaughter of numbers rather than improved animals having good growth rates, optimum slaughter weights, and short duration to slaughter. Without exception, this is the trend especially with meat from goats and sheep. Considerable opportunities exist for increasing productivity in the ruminant sector in tandem with the need to increase food security, reduce poverty and efficient natural resource management (NRM).

The continuing evolution, contribution, and future of animal production systems will be associated with a number of interrelated factors, together with the demand-driven factors for animal proteins. Among these, the issues below are considered to be especially important.

Strategies for Enhancing Productivity of Livestock:

1. Feed and fodder resources:

Feeding and nutrition are the major constraints to animal production in drylands. Animal production within the mixed farming systems is predominantly dependent on the efficiency of use of the available coarse crop residues and grazing resources. The level of efficiency will dictate to a very large extent improved per animal performance and increased productivity from different livestock resources. Primarily four categories of feed and fodder resources exists in drylands

a. Pastures on mostly grazing lands these include native and improved grasses, herbaceous legumes and multi-purpose trees

b. Crop residues these include such examples as coarse cereal straws, groundnut haulms and sorghum stover (the dried stalks and leaves of the crop)

c. Agro-industrial by-products (AIBP) good examples are cereal bran, ground nut cake and cotton seed cake and

d. Non-conventional feed resources (NCFR) this category includes diverse feeds that are not traditionally used in animal feeding; examples are palm press fibre, spent brewer's grains, sugar cane bagasse (the residue from crushing the canes) and sweet sorghum stalks.

The fibrous crop residues (FCRs), mostly sorghum, millet, paddy and maize straws, ground nut haulms and dry grass form the basis of feeding systems for ruminants in drylands. The green feeds available were weeds, forest grass, tree leaves, and cultivated forages such as napier, lucerne, and maize. Complementary to FCRs are those crop residues that have higher protein content, and can therefore be used judiciously to improve the overall diet. This category includes a variety of oilseed cakes and meals, such as groundnut cake, palm kernel cake, cottonseed cake, coconut cake and brans, damaged grains, and chuni (broken pulses with kernels), which are often used as dietary supplements.

Feeds are generally plentiful for use by various animals during rainy season, but chronic feed deficits exist during winter and rainy season in drylands. In order to ensure nutritional efficiency, priorities for use of the available feeds are important. With ruminant production systems, there are three categories: extensive systems; systems combining arable cropping (roadside, communal and arable grazing systems, tethering, and cut-and-carry feeding); and systems integrated with tree cropping (silvopastoral and hortipastoral). There will however; be increasing intensification and a shift within systems, especially from extensive to systems combining arable cropping, induced by population growth. The principal aim should therefore be improved feeding and nutrition, maximum use of the available feed resources, notably crop residues and low quality roughages, and various leguminous forages as supplements.

a). Management issues in rangeland-based systems: It is estimated that 60% and 5% of the total feed requirements of small ruminants and large ruminants respectively are met by the rangelands (Devendra et al., 2000). There are three major concerns about rangeland-based systems.

- Appropriate strategies to use of common property resources (CPRs): As there is no control over the number of animals allowed to be grazed, causing severe damage on the regrowth of no. of herbaceous species in grazing lands (Table 2). Thus causing severe impact not only on herbage availability from CPRs but on the productivity of livestock

- Communal management of these lands: CPRs need to be reseeded with high producing legume and non-legume fodder varieties (Table 3) at every 2-3 years intervals as a community activity. Further, grazing restriction till the fodder grows to a proper stage as community decision would improve the carrying capacity of CPRs.

- Lean season feeding: It has severe impact on the productivity of livestock as the herbage availability comes to all most negligible during summer months. Hence, supplemental feeding becomes essential to maintain optimum productivity in livestock

b). Fodder production from arable lands: Non-availability of arable land has been severely affecting the area under fodder cultivation. As a result, the green fodder availability both qualitatively and quantitatively is much lower than requirement and leading to many nutritional deficiencies ranging from energy, protein to micronutrients like minerals and finally lowered production from livestock. Hence, each farmer should at least allocate 10% of his or her land for fodder production.

c). Development of integrated production systems: It is an efficient and integrated land use management system of agricultural crops, horticultural/forest tree species and or livestock simultaneously on the same unit of land, which results in an increase of overall production. The potential importance of this system and successful examples has been reviewed (Table 1). Future development of these integrated systems will require policy support concerning land use and also to encourage the introduction of ruminants and to increase unit land productivity.

Annual and perennial crops: Relatively more attention will need to be given to mixed (crop-livestock) farming systems that involve annual crops, not only because of the importance of rice and wheat as food staples, and the opportunity to integrate annual legumes into the cereal cropping to develop foodfeed systems.

Trees: The decreased availability of arable land in many areas and the need for more food from animals could encourage further integration of ruminants with trees in the form of silvopastoral (Forestry + Pasture + Livestock), agrisilvipastoral (Agriculture + Forestry + Pasture + Livestock) and hortipastoral systems (Orchards+ Pasture+ Livestock).

***d). Alley Cropping*:** Alley cropping is a system in which food/fodder crops are grown in alleys formed by hedgerows of trees or shrubs (*Leucaena leucocephala, Gliricidia, Calliandra, Sesbania etc.)*. The essential feature of the system is that hedgerows are cut back at planting and kept pruned during cropping to prevent shading and to reduce competition with food crops. The main objective of alley cropping is to get green and palatable fodder from hedgerows in the dry season and produce reasonable quantum of grain and stover in the alleys during the rainy/cropping season. This necessarily calls for cutting back (lopping) of hedgerows during the dry season fodder requirements. A welcome feature of alley cropping is its ability to produce green fodder even in years of severe drought. At Rajkot in 1985, rainfall received during the season was only 30% of normal precipitation. There was total failure of 3 legume crops tried in the system. In sole crop plots, production was limited to 0.5 1.7 t/ha of green fodder. However, in alley cropped plots, *Leucaena* hedgerows produced over 5t/ha of green fodder (Table 4). Similar was the experience at the Anantapur Centre in 1984. The cropping season rainfall was only 144 mm as against normal of 495 mm. All crops (groundnut, pigeonpea and sorghum) failed, and even stover production was severely affected. However, the *Leucaena* hedgerows produced 2t/ha of dry leaf material. Thus, alley cropping systems if properly planned, can remove a part of the risk faced by the small farmer in India.

e). Tank beds- Common Pool Resources for fodder production: Due to silt deposition, tank beds are fertile and retain adequate moisture in the soil profile for cultivation of short season fodder crops like sorghum and maize fodder. Cholamarri village***, Anantapur District*** has several tanks (45 tanks) but remained unfilled and was in the grip of severe drought during 2002 resulting in distress sale of livestock. This motivated the youth and organized the community for cultivation of fodder on the tank bed of Cholamarri village in early 2003. The farmers could produce substantial biomass worth Rs. 4.75 lakh by cultivating 184 ha of tank bed area and the fodder produced could support the livestock for entire summer (Ramana et al, 2007).

f). Efficient feed and fodder utilization Strategies: Cost of feeding accounts for 60-70% of the total cost of production in any livestock production systems. The limited purchasing power forces farmers to manage livestock by carefully adjusting the resources and production factors of their farms. Hence, capacity development of the stakeholders about feeds and their efficient use

should be imparted with self-reliance and on farm demonstration of different mixed farming systems. Potential promotion of linkages between rural and peri-urban areas in the use of production inputs, intensification, nutrient flows, and marketing of produce that is consistent with environmental integrity should be created. The final objective should be the development of sustainable all year round feeding systems that increase feed supplies to overcome shortages, seasonal constraints and expanded production systems. Examples of such approaches include foodfeed cropping (Devendra et al., 2001), forage (para grass) production on rice bunds and under trees and alley cropping.

Based on the use of crop residues, combining or utilizing available resources at rumen level, e.g., supplementation with critical nutrients (bagasse/cakes/bran/minerals) or extracting more from existing resources by physical means (chopping/soaking etc.) and chemically treating (urea molasses treatment of straw) would help in meeting nutritional requirement of livestock and efficient utilization of available resources. Other technologies, such as modified cropping patterns (ley farming/perennial fodder cultivation in arable lands/Lucerne and horse gram cultivation in winter etc.,) might also contribute to increased feed availability and/or quality. Feeding interventions, such as use of concentrates, Leucaena leaves, urea-treated straw with limited concentrates, could benefit farms with crossbred cows. Tree leaf feeding is feasible for farmers with access to tree leaves and slack labour, such as for tribal and landless farmers. However, urea-treated straw with limited concentrate supplementation may not be suitable for non-descript cows and/or landless farmers due to limitation of straw availability and low milk yield of the cows. The feed deficiencies can be corrected by adjusting the feeding practices. Feeding additional concentrates, such as bran plus urea/cakes, can compensate for both the TDN and CP deficiencies in all breeds. Urea treatment of straws can help to correct the CP deficiencies, particularly in the monsoon season and in zones where high amounts of straws are fed. The CP deficiencies in the dry season are too high to be corrected by feeding leguminous tree leaves/ cakes.

2. Health management strategies:

Diseases reduce the production potential of livestock. There are a number of diseases such as foot and mouth disease (FMD), hemorrhagic septicemia (HS), black quarter (BQ), entero toxaemia (ET), blue tongue, peste des petitis ruminitis (PPR), sheep pox, pneumonia, calf scores, mastitis, brucellosis, tuberculosis etc., affect livestock production and cause enormous economic losses. An estimated livestock output worth more than Rs 50 billion is lost annually due to various diseases. Most of the diseases affecting livestock in general and small ruminants in particular were due to lack of awareness, supply constraints in availability of vaccines and deworming drugs and insufficient manpower with animal husbandry department to tackle the problems in time. Hence, animal health camps and prophylactic vaccination campaigns needs to be conducted at regular intervals to create awareness among farmers regarding the adoption of better livestock health management practices and containment of endemic diseases. Capacity

building of local youth as service providers and participatory involvement of stakeholders while streamlining the animal health services, as community activity would better facilitate in this process. Further, developing linkages with animal husbandry and other rural developmental departments would help in promoting the innovative livestock health management practices and providing sustainable rural livelihoods.

3. Reproduction management strategies:

Increased prevalence of reproductive problems especially in high yielders and crossbreds is becoming a potential threat to the profitability of livestock farming by bringing down the production and income. Reproductive problems like delayed onset of oestrus, anoestrus, abortion, failure of conception etc are more common in buffaloes and crossbred cows under village conditions because of deficiency of micro minerals and some fat-soluble vitamins due to under feeding and or sole feeding of roughages. The other reproductive disease conditions like prolapse, retained placenta and metritis in the early postpartum period, a sequel to the nutritional stress in the lactating animals will reduce the production efficiency and reproductive performance. Supplementation of top fodder, concentrate mixture, mineral mixture, vitamin premix, and synchronization of oestrus etc., inaddition to the individual animal managemental practices like timely identification of oestrus and insemination will improve the life time productivity of livestock. Incase of small ruminants, changing the breeding ram for every 2-3 years (ram lamb exchange from other district herd) or artificial insemination with proven breed semen will help in enhancing the productivity.

4. Breed improvement strategies:

Cross breeding of indigenous dairy cattle and upgradation of buffaloes had tremendously improved the productivity of animals, augmenting milk production. This is an important development option for landless farmers (Patil and Udo, 2006). A case study of Gujarat farmers show that remote farmers with local cows under the assumed price conditions hardly benefit from feeding concentrates, however, farmers with better market access and crossbred cows may consider feeding of concentrates in all situations. This explains farmers' preference for crossbreds in conditions with a favorable milk/concentrate price ratio, and it illustrates the limitations of concentrate feeding where concentrates/milk ratios are unfavorable, due to prices, management and/or genetic potential.

5. Technology transfer issues:

Livestock development is affected by many factors, such as farmers' access to resources, availability of knowledge and skills, consumer demands, national and international policies and social aspects. As a result, a large number of technologies (Table 5) are not readily accepted by the stakeholder. Indeed, low adoption rates of technologies by stake holders are at least partly due to differences among farmers in terms of their access to resources, such as land, water, livestock and credit and personal values, status, food habits, and to cultural barriers. Many

development programmes lack a proper perspective on the local resources, the environment and the needs of the farmers (Van den Ban and Hawkins, 1988; Chambers *et al*., 1989; Röling, 1996). What is useful for one farmer may not be useful for another, and certain technologies can even have negative trade-offs. Hence, basket of technological options with site specific and problem targeted should be made available to the stakeholders, so as to choose according to their resources and environmental conditions.

6. Policy issues:

There exist major opportunities for the use of improved policy issues. These relate to institutions, services and delivery systems that affect animal production systems. In view of the biophysical focus among the ruminant production systems, despite the economic benefits of added value, integrated systems with trees remain underestimated. Policy interventions are required to stimulate more integration with animals, for example through tax incentives, and also encourage increased private sector investments. The market chain involves rural, urban and international markets. In an era of globalization and improved marketing, presently, the ruralurban market linkages are weak, and closer integration is very necessary. Rural markets are especially important to rural communities and their households, and are also used for the sale of live animals for slaughter in the urban areas. Appropriate policies are required to provide good links between rural and urban markets, infrastructural and communication facilities that must be in place, as also collection and processing centres. Horizontal and vertical coordination and the development of cooperatives are also important initiatives. Because of the greater market demand for animal products in urban areas, such facilities become more essential. Urban markets are the outlets for exports, and promote international trade, and have opportunities for foreign direct investments and growth benefits (Otte et al., 2005).

Conclusion

Capacity building and participatory involvement of stakeholders while streamlining the animal health services, as community activity would better facilitate containment of animal diseases in rural areas. Animal health camps and on-farm trials creates awareness among farmers regarding availability of basket of options for productivity enhancement in livestock. Further, use of technological advances along with appropriate management practices would help in providing healthier livelihoods and income from large and small ruminants. Improved cultivars along with efficient fodder utilization practices and integrated systems would augment fodder resources substantially in rural areas and reduces distress sale of animals during lean season. Improvement in services and delivery system along with creation of market linkages and better polices would drive the stakeholder for adoption of latest technologies. Thus results in higher productivity, more stable livelihoods and income.

Table 1. Summary of examples of extent of benefits from animals in improved cropanimal systems in India

Type of crop-animal system	Estimated profitability/net income (Rs.)	Source
Crops-dairy-poultry	Net farm returns increased by 148-165% in marginal and small farms	Sirohi et al. (1980)
Crops-dairy farming	Dairying increased farm income and farm employment	Devadoss et al. (1985)
Crops-dairy farming	Cost per litre o f milk was lowest compared to specialized dairy or arable farming	Rekib and Rajpali (1987)
Rice-duck-fish	77.2% more income over arable farming (Rs.50/day)	Ganesan et al. (1991)
Coconuts-crops-livestock	More profitable than coconut alone	Das (1991)
Crops-cattle/buffaloes-fish	99.7% more income over arable farming (Rs.30,400)	Kadian et al. (1992)
Rice/wheat-buffalo	Increased net returns	Sheokand et al. (2000)
Coconuts-dairy-poultry	Increased returns with livestock by 59%	Maheswarappa et al. (2001)
Cereals-pulses-oil seeds - vegetables-dairy	Increased farm income by 47.8%	Kumar et al. (2002)

Table 2. Number of herbage species and production as influenced by management of CPRs

Management type	Herbage production (t/ha/year)	No. of species
Open grazing lands (CPRs)	0.9	13.0
2 years protected CPRs	2.4	21
3 years protected CPRs	3.0	25

Table 3. Identified constraints to low productivity of CPRs

Problem	Causative factor	Remedial Measures
Poor regeneration of forages species	Severe d amage due to over grazing and stampede	Rotational and restricted grazing
Low forage production	Low yielding annual grass species and competition by unpalatable shrubs and trees	Reseeding of high yielding perennial grass species and bush clearing
Low nutr itive value of the forage	Lack of legume forage species	Seeding of legumes like Stylo just before onset of monsoon and application of P as basal dose
Non-availability of green fodder during lean period	Very few tree species suitable as top feed in CPRs	Development of silvopastoral system

Table 4. Risk reduction in poor years through alley cropping at Rajkot

Treatment	Leucaena green fodder (t/ha)	Crop yield (t/ha)	
		Grain	Stover
Sole crops			
Leucaena*	5.75	-	-
Groundnut	-	0	1.67
Mungbean	-	0	0.68
Urdbean	-	0	0.47

* 1.5 m rows
Note: Rainfall 177 mm (120 mm in cropping season), vs. 625 mm average
(Source: Annual report, AICRPDA Rajkot, 1985)

Table 5. Technologies available for enhancing productivity of livestock

Technology	Advantage
Fodder production	
Availability of high yielding multi cut cultivars	Year round higher green fodder production
Silvi/agrisilvi/horti-pastoral systems	Higher income per unit land and efficient utilization of available resources
Drought/stampede/water logging resistant fodder varieties	Increased fodder availability
Feeding technologies	
Concentrate mixture feeding	Better growth and production
Urea molasses mineral blocks	Useful during drought conditions
Balance compound feed	Improvement in animal health
Mineral mixture feeding	Proper growth and production
Use of industrial by -products and crop residues	Reduction in cost of production
Urea-molasses treatment of straw	Better animal health and production
Chopping/soaking	Efficient utilization of available resources and more digestibility of available nutrients
Bypass protein/fat feeding	Higher production and proper reproductive activity
Heath care technologies	
Vaccines against endemic and contagious infectious diseases	Prevents the out break and reduces the production losses
ELISA kits for diagnosis of different diseases	Early detection of diseases
Medicines acting both ecto and endoparasites	Saving money and time

Technology	Advantage
Breeding technologies	
Artificial insemination	Genetic potential improvement leads to higher production
Oestrus synchronization	Production of animals according to the demand
Early pregnancy diagnosis kits	Higher life time production of animal
Oestrus detection instruments	Better conception
Embryo transfer technology	Production of improved livestock
Management technologies	
Regular control of parasites	Better health, growth and production
Milk replacer feeding	Reduced cost of calf rearing
Clean milk production	Controls mastitis problem
Castration of males	Faster weight gain
Weaning of young ones	Higher profitability
Proper feeding of different livestock	Better growth and production
Livestock products processing technologies	
Preparation of meat balls/ sausages/patties/nuggets etc	Livelihoods creation leads to additional income
Preparation of various milk products (paneer, ghee, yoghurt etc.)	Livelihoods creation leads to additional income
Preparation of various egg products (egg powder, egg roll, cakes etc.)	Livelihoods creation leads to additional income

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PARTICIPATORY APPROACHES TO SUPPORT BOTTOM UP PLANNING

G. Nirmala

Participatory Approaches - Concept and Relevance:

Development professionals in the context of rural development operate on a basic presumption that they are judge of any situation and that the welfare of any situation and that of rural masses rests on them. Hence, with best of knowledge, resources and motives they remain oblivious of the fact that majority of their rural clienteles are passive spectators of their magic wand of development (Neela Mukerjee, 1993).

There is huge gap existing between rural perceptions of development professional at 'top' that are involved in planning and implementation of conventional models of rural development. In conventional models of rural development, the beliefs, attitudes and values of rural people involved remain under-perceived, under valued and simplified. In top-down model, the plans are conceptualized and formulated at the national level and then made to percolate down to lower levels. Moreover, the rural people struggle day in and day out with meager resources at their disposal and poverty, which makes life harder for them to survive and have very little interest to participate in the developmental programmes. The presumptions of the 'top' have done considerable damage to the pursuit of rural development. Top-down approach, has failed to address the issues of poverty, unemployment, inequalities, ecological degradation, etc. This has lead to discrepancies in planning and implementation resulting in unrealistic and unsustainable in the long run.

People's participation is found very important in the rural development programme in general and farmers participation in agricultural development programmes in particular. The fruits of green revolution was relished by the rich farmers and the conditions of the resource poor farmers was deteriorated over the years as it has not addressed the well being of the poor farmers. It was realized that the components of interrelationships of people and the socio-economic processes be introduced in the developmental programmes.

The focus, as a consequence of shift in paradigm to bottom-up approach of the rural perceptions can be better revealed and understood by following these aspects:

❖ Indigenous technical knowledge (ITK)

ITK has been more recognized as valid and useful. Many social and biological scientists have increasingly gone to farmers to understand reasons for non adoption. Farming systems research has made a huge contribution by revealing the complexity of farming systems and farmers have increasingly been recognized as themselves as innovators and experimenters and are found to be more rational and right in behaviour, which at first seemed irrational.

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- ❖ Incorporate rural diversity
- ❖ Make rural communities involved in pursuit of their well being
- ❖ Make professional's task more worthwhile and rewarding in the process of collecting, analyzing rural information base for development

Many development programmes, particularly Natural Resource Management insist on community participation as a tool to conserve land and water considered precious resources, which are fast being depleted and need enough care and measures to conserve them. Watershed programme is all about management of soil, water, vegetation and human resources effectively. Participation of people is stated as an important factor to ensure effective management of natural resources. This component is being debated all over the world. Many legislations and byelaws were brought into force in all rural development programmes in general and watershed programmes in particular. The National Watershed Programme for Rural Areas (NWDPRA) implemented by the Ministry of Agriculture, which was put to criticism for want of participation. Policy makers on the recommendations of Prof. Hanumantha Rao Committee, introduced people's participation in the Watershed implemented by Ministry of Rural Development through DPAP programmes, which is better known as Integrated Watershed Development Programmes (IWDP).

Success of any watershed programme depends on the active involvement of community. Instituting such systems of participation ensures sustainability and maintenance of watershed even after the withdrawal of the interventions. Rakesh Prasad *et al* (2002) reported community participation also bring indigenous knowledge of the local people which helps in understanding the local problems and thereby design workable solutions.

Factors that have been mentioned as part of getting the participation right include, appropriate decision-making processes (Webler and Jules, 1999), a paid coordination (Holland 1996; Pinkertan, 1994), effective leadership (Sellin and chavez, 1995; USEPA 1998) and formalized responsibilities (Pinkertan, 1994).

Getting the right participation and the participation right may not be sufficient for effective watershed planning and implementation. Other factors may be critical for success, such as effectiveness of Institutional structures (Margerum, 1996); sufficient resources for implementation (Schenler, 1996) manageable size of watershed or sub watershed and socio political factors and economics (Napier, 1997).Participation now has a long history in development projects, and most, if not all, development agencies national and international have tried to involve in some aspect of their planning and implementation. But these attempts, usually known as people's participation or popular participation are not enough. There are three types of community mobilization/participation (Sylvie I Cohen, 1986)

i) Participation as a contribution made by the community:

a) Participation as a contribution in a simple form is sharing about which includes carrying pipes, digging holes, performing construction work and maintenance costs.

This is quite often seen in most of the rural and watershed development programme, which is a tertiary level of participation and is less sustainable once the project staff has withdrawn from the site.

b) Community is asked to contribute through cost sharing. In the watershed development programmes the cost involved in the construction of bunds has to be borne by the farmers on fifty-fifty basis.

ii) Participation as an organizational process of the community:

Community participation is defined as a process of establishing a minimal institutional infrastructure to manage and maintain the system. In this approach, project managers may concentrate on the following structure:

- Getting local leaders to legitimize the project
- Forming committees to promote, manage and monitor local contributions

  and usage of services and infrastructure

Example: Formation of co-operatives, water committees, Women's groups, credit associations, co-operatives, local religious groups, branches of political parties and unions, neighbourhood associations, literacy groups, etc.

iii) Participation as empowerment of the community:

It is participation of high order where the people/farmers to make decisions and planning of programmes. It is achieved through creating sense of local ownership of resources and regular involvement to make decisions and planning. Once this feeling of ownership is created all other requirement in terms of cost, management and monitoring can easily be worked out. This leader-centered approach clearly demonstrates the relationship between participation and power. Not only men but women, local leaders as well as the poorest and marginal social layers of the community share the power to be active participants in all stages of planning resource mobilization and allocation, acting and maintenance of the system.

Critical elements of this empowering process are:

- To enhance awareness
- To strengthen local organizations
- To create pressures from below to bring about changes in existing arrangements

Therefore, projects that seek to promote participation must be clear as to the nature of the participation that they expect to promote. This clarification will help determine the appropriate methodology for mobilization.

A host of methods emerged over time as a consequence to promote “bottom up” model of development where the clientele needs and priorities are assessed for programme planning and

implementation. All aimed at understanding the intricacies of socio-economic and ecological environment within which the resource poor farmers operate and to resolve their problems. Some of the popular methods are listed below:

I. Farming Systems Research

It was evolved in the 60's whose objective was to further research in the area of farming system, analyse problems and plan research and extension activities. This concept was planned differently in different institutions. However, the common theme in the evolution was a field oriented and comprehensive approach of a multi-disciplinary team through repeated farm trials with same degree of farmer's participation.

II.Rapid rural appraisal

This methodology was evolved in 1970's influenced by Farming System Research (FSR) and other methods. Same of the pioneers who develop this methodology were Robert chambers, Peter Hildebrand, Robert Rhodes and Michael Collinson. The concept spread through literature and by 80s there was a wide experience from applications of RRA in different situations.

Rational for using Rapid Appraisal

- Cost involved is less because of smaller sample size.
- It is made focused in nature.
- It helps in programme managers to optimize the use available resources.
- It reduces time spent on data collection as that counts project setting administrative deadlines rather field research requirements.
- It is flexible and open ended and be changed as per requirement.

Rapid Rural Appraisal Methods

1) **Key informant interviews**

(Specialists in subject matter) widely used method. It is unstructured in nature and qualitative interview carried out with interview guides that list topics and issues to be covered in a session. The interviewer frames the questions in the course of interview and subtly probes the informants to elicit information. The number of key informants ranges from 10 to 25. The interviewer takes extension notes on the subject.

2) **Focus group interview**

Focus group interview are conducted to discuss a specific topic in group session. Basic premise underlying this method is that free discussions generate free ideas and insights because the participants stimulate each other. Groups of 8 to 12 members are carefully selected for discussion. Session lasts for 1 to 2 hours.

3) **Community interviews**

Participants discuss subject among themselves in focus group discussions. But, in community interviews, investigator asks questions, raises issues and seeks responses from the participants. The primary interactions are between the interviewer and participants rather than among participants.

4) **Structured direct observation**

One of the successful methods employed in developing countries. It involves careful gathering of data based on well-designed observation sometimes it also involves individual or group interviews. It is better conducted by a team of experts than by a single individual. It deals with physical objects such as agricultural production, dams and roads rather than social phenomena.

5) **Informal surveys**

Informal surveys have emerged as an important tool in rapid appraisal studies of agricultural rural development interventions. Sample size range from 25 to 50 people who are contacted and interviewed in markets, shops, public meetings, organizations, selected on easy accessibility basis. It is based on the open-ended questionnaire. Example conducted to understand the problems faced by the owners of micro enterprises.

Limitations of Rapid Rural Appraisal

- Reliability and validity of the information generated by rapid appraisal methods may be questionable.
- Data, opinions and arguments that do not support the existing frameworks of the investigator are not fully presented in groups.
- Qualitative data, by their nature are difficult to record, code analyze objectively
- Quantitative data cannot be generated through RA methods and so generalizations cannot be made for a whole population.
- Credibility of the finding as relatively low.

Participatory Rural Appraisal (PRA)

PRA is both an attitude and a methodology. It is one of the tools of surveying that helps outsiders to understand the village systems, dynamics, and politics by using various techniques as well as by methods of direct observation and discussion. (GR.Desai and SK.Arora, 1995)

Need for Participatory Rural Appraisal

- It advocates that the people themselves are 'solution agents' for their problems.
- Sustained change and the need for accurate and timely information.
- It cuts down the 'Normal professional bias' and antipoverty bias towards people.
- Reduces the normal time consuming long methods of survey which consumes the much needed resources and that gives results after a long time. The method is cost effective, fairly accurate and timely.

Purposes of Participatory Rural Appraisal

- To use farmers criteria, chances and understand the local environment with clear local priorities.
- To learn farmers indigenous technologies.
- To achieve for triangulations, using different methods and involving various people to check and re-check the findings.

General guidelines for Participatory Rural Appraisal implementation

1. Meet the villagers with an open and frank mind.
2. Build up personal rapport with villagers.
3. Ask general questions to relieve tension.
4. Select a suitable place for the interview. Sit down with villagers on the same floor.
5. Listen carefully
6. Show empathy
7. Be patient
8. Intense and careful observations is most important
9. Do not lecture
10. Respect villagers as human beings
11. Take detail note of the answers and on the process of discussions and information gathering.
12. Try to find out different villagers for different tasks.
13. At the end of the interview all the interviewers must be thanked individually for giving time and sharing their experiences.
14. Sit down with all the members and record all the information collected and the process of information generation.

PRA techniques are used in agricultural development projects. PRA normally has eight clearly defined steps though procedures can vary greatly, depending an local need preferences of the team. These are:

1. Site selection and clearance from local administration.
2. Preliminary visit.
3. Data collection, spatial, time related, social and technical, focusing especially on problems of the community.
4. Synthesis and Analysis
5. Setting problems in priority order and exploration of opportunities to resolve them

6. Ranking opportunities by priority and feasibility and preparing a village resourcement plan (VRMP)
7. Adoption of VRMP
8. Implementation

Several methods were developed in the context of PRA. They are categorized according to its representation with space, time and rank.

Mapping

This is the construction of a map of a village area using rangoli powders or chalk on the ground or a cement floor for understanding the village layout, main features such as housing, temples, stores and other resources like forest, land, watersheds etc., it helps to understand land use pattern, problems and prospects of the area.

Transect Walk

A transect walk is a kind of exploratory walk which is undertaken by the team along with the villages to observe and send in minute details or the differences of a particular area. The area under study is systematically traversed together with villagers e.g. from north to south, east to west or from the highest to the lowest point. Everything encountered or noticed by the villagers is discussed and recorded.

Purposes

1. It gives an idea about farming practices, cropping patterns and the physical layout of irrigation facilities etc.,
2. To know the agro-eco system of the village

Timeline

Timeline refers to a calendar of historical events from as far back as one can remember up to the present, in the life of a person, community, village, area or institution depending on what we wish to construct. Timelines and historical profile are used as a simple means of visualizing key historical events and major perceived changes etc., with regard to resources and factors such as soil, erosion, population growth and climate changes.

Preference Ranking

Preference rankings can be used to quickly problem areas and the preferences of individual and compare them with assessments of others. Preferences can be identified by assigning scores (eg. when comparing 5 different foods and problems, 5-favourite/most important, 1=least delicious/least important). The units or objects to be ranked can be effectively collected by means of brainstorming session, or by first interviewing key informants. Afterwards each individual or the group as a whole performs the rankings.

Matrix Ranking

In matrix ranking a class of objects is evaluated by applying different criteria and assigning value to criteria. Villagers' preferences and attitude towards a particular topic of interest is revealed to us by this technique. It helps us to understand farmers' priorities in crop varieties, vegetables, tree species, livestock categories, soil and water conservation techniques, irrigation methods etc. They provide us an opportunity to think and look things from a new angle and perspective.

Seasonality

Seasonality calendar is an important and useful exercise to determine seasonal patterns in rural areas as related to rainfall, farming practices, employment etc. In seasonality, an attempt is made to determine the seasonal calendar as understood and practiced by the villagers. It is to get insight into the seasonal variations in a number of parameters relevant to farmers.

e.g. Work, employment, income availability of food, fuel, fodder and health.

Venn Diagram

A venn diagram shows the key institutions and individuals in a community and their relationships and importance for decision-making. Intersecting sets in the form of circles of different size, the links between key institutions and/or persons within communities and organizations can be represented apart from their importance for decision-making processes. The size of the circles depicts the relative importance attributed to them, the closeness depicts the sort of relationship, and the institution has got with the community.

The purpose of the venn diagram is to get villagers perspective on the impact/influence of the local and outside institutions in a particular area.

The PRA methods appear versatile and adaptable. PRA also enhances capabilities. It can entail not just shared knowledge but also shared analysis, creativity and commitment.

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ROLE OF KRISHI VIGYAN KENDRAS IN TRAINING AND OUT REACH ACTIVITIES TO BUILD LOCAL CAPACITY FOR SUSTAINABLE NATURAL RESOURCE MANAGEMENT

*M.S. Prasad**

Agriculture continues to be the backbone of Indian economy. A vast majority of India's population depends on agriculture for subsistence. However, ever increasing population and decreasing resource base are posing severe challenge for enhancing agricultural production and productivity. Out of an estimated 142.2 million ha, net cultivated area of our country, about 33 percent (47.4 million ha) is irrigated. The irrigated area produces about 56 percent of India's total food requirements. The remaining 44 percent of the total food production is contributed by 95.8 million ha (66.7 percent) which is rainfed. Most of the coarse grains like sorghum, pearl millet, finger millet and other millets and 75 percent of the pulses and oil seeds are grown in drylands only. In spite of best efforts to increase the irrigated areas by the turn of century about half the net cultivated area will continue to remain rainfed. In order to meet the projected needs of 250 million tones in the first decade of next century it would be necessary to increase production from the drylands manifold.

Constraints in increasing production limited resources

The problems of dryland agriculture are so many and multifarious. Most of the drylands are degraded and low productive and are subjected to serious erosion. The soils are shallow with limited moisture storage capacity and undulating topography. Rainfall is not only low and uncertain but also erratic in nature.

Land holdings are fragmented. The milk yields are poor and there is fodder shortage occurrence of frequent droughts, problem of pests and diseases and low draught power are some of the problems faced by the farming community. The rural women folk are facing poor livelihood conditions and left with no employment opportunities for earning additional family income particularly during off-season. Increasing pressure on natural resources coupled with degraded land and water and other problems as mentioned are posing serious challenges to food, social, economic, livelihood and environmental securities. Development of rainfed areas by sustainable management of natural resources is one of the foremost priorities of the Government. In order to achieve this, the Govt. of India, has initiated several programmes like DPAP, DDP, Watershed development etc., Out of all these programmes, Krishi Vigyan Kendras (KVKs) initiated by the Indian Council of agricultural Research (ICAR) in the early seventies is an important one. This is one of the major techniques or technology with the active involvement of farmers. The was established as an innovative institutions to organize need-based and skill oriented training on the basis of work experience for the practicing farmers, farmwomen by the principles of 'learning by doing' and 'teaching by doing'. Subsequently the mandate of the KVK was revised by adding various other activities viz; conducting frontline demonstrations (FLDs),

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on-farm testing of technologies (OFTs) and extension educational activities. In order to transfer the appropriate technologies based on the actual needs of farming community participatory rural appraisal (PRA) methods are employed in the villages for identification of technological gaps.

These surveys form the basis for formulation and implementation of various KVK programmes. The clientele by their participation in these programmes are well equipped with essential skills and information for increasing production in a qualitative manner through optimum utilizations of natural resources.

The following are some of the activities being undertaken by the KVK:

1. Training programmes
2. Frontline demonstrations
3. On-farm trials
4. Extension education
5. Livelihood activities

1. Training programmes

Capacity building of farmer is crucial and pre-requisite for any KVK programme. Need based and skill oriented practical training is being imparted to clientele as on-campus (2 days to 10 days and above) as well as off-campus (1 day). Practicing necessary skills (learning by doing), visiting research fields / demonstrations sites, observation and group discussion through A.V.aids like video, OHP, Slide projector etc., are the essential ingredients of any KVK training. The following are the thrust areas:

- Crop production (including S&WC, INM, IPM etc)
- Farm implements and machinery
- Dryland horticulture
- Livestock production and management
- Women empowerment through livelihood programmes for income and employment generation.

Some training courses lay special emphasis on imparting specific skills to trainees.

They are:

- Making & use of 'A' Frame
- Calibration and operation of CRIDA drill plough
- Operation and maintenance of Plant Protection equipment
- Collection of soil samples
- Preparation and use of bio-pesticides (like NSKE)
- Plant propagation techniques
- Nursery management skills
- Feed mixing and feeding practices for livestock management.

2. Frontline Demonstrations

The main objective is to demonstrate newly evolved crop production techniques and management practices in the farmer's fields under different agro-climate regions and farming situations. The emphasis is on introduction of new crop genotype along with practices like IPM, INM etc., The KVK through FLDs is providing feed back to research scientists and policy makers about the performance of technologies in terms of their potentiality and marketability. The FLDs are concentrating on oilseeds crops, pulse crops and other than oilseed & pulse crops like cereals and horticultural crops. The demonstrations other than crops includes S&WC methods, use of improved implements like weeders, seed drills etc., and new production systems like SRI etc.,

3. On-farm trial

Availability of technological solution for a field problem encountered by farmer does not end there. If often requires testing on-farmers fields for a specific location (field) for its suitability in soil / season etc., the on-farm trials are conducted based on the status of technology i.e. if a recommended technology is working well or not. If not, it has to be refined to solve the field problem. Otherwise if the technology is well tested and it requires testing only for a particular area, this can be done by 'assessment of technology'. If a technology passed through all above situations, it will be recommended for large-scale demonstration n farmer's field.

4. Extension education

The KVK is serving as knowledge bank for spreading the useful information to the needy farmers in different corners of the district. In order to fulfill this, it is conducting a number of extension activities like field days, kisan mela, exposure visits, radio / TV, seminar, exhibition, animal health camp, special days like world food day etc.,

5. Livelihood enhancement

The KVK is giving emphasis on improving the livelihood conditions of rural women and empowering them with the help of appropriate technologies for improvement of farm and home conditions. The KVK is conducting appropriate training programmes for them. Their programmes are specially designed for income generation and to meet the additional family expenditure. The nature of such programmes are both farm and non-farm oriented.

Activities on-farm

- Plant propagation techniques
- Preparation and use of bio-pesticidal as like Neem Seed Kernal Extract (NSKE)
- Vermi-composting
- Backyard poultry
- Maintaining dairy animal
- Raising vegetable nurseries

- Use of improved implements for seedlings, weeding / interculture etc., for drudgery reduction.
- Value addition products, fruit and vegetable preservation etc.,
- Candle making

Activities non-farm

- Smokeless chullas / biogas
- Preparation of detergents, phenyl, Vaseline, pain balm etc.,
- Candle making
- Bakery products
- Tailoring and embroidery
- Adda leaf making
- Production of mushrooms

Besides, the women are trained in activities like scientific storage or food grains, rural crafts, nutrition and childcare, health and sanitation, watershed management etc.,

Future thrust and Conclusion

With rising input costs and declining returns, farmers are facing many challenges to produce crops competitively and meet their livelihood needs. Therefore more preference for low cost technologies like INM, IPM through intensive use of bio-fertilizers and bio-pesticides is growing. This is necessary to decrease the cost of cultivation and improve the crop productivity and profitability. The KVK is at present concentrating more on these aspects through its core programmes.

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ORGANIZATIONAL AND MANAGEMENT ASPECTS FOR SUSTAINABILITY OF USER GROUPS

N. Loganandhan[1] and N.K Sanghi[2]

Watershed development programmes are adjudged as one of the most effective means of bringing livelihood security among rural mass. Whole lot of development projects and studies conducted at the level of government and civil societies stood as testimonies for this fact. Like every other rural development programme, success of watershed programmes also solely depends on the strength of its community-based organizations.

Community based organizations (CBOs) are very much essential to execute both the technical and social oriented activities in a watershed. Unless they are established with sound principles, structure and men, it will be almost impossible to achieve the success, leave aside the sustainability.

In a typical watershed, there is a need for different kinds of CBOs like Self Help Groups (SHGs), User Groups (UGs), Watershed Committees (WCs) and Watershed Associations (WAs). Among these, UGs are those that comprise the farmers or stakeholders of that community, who are directly influenced by the field level activities. Almost all the existing guidelines, including the recently developed common guidelines for watershed programmes, consider them as the most important role players. In fact, it is highly recommended to devise the watershed plan by considering the suggestions put forth by the UGs, as per their demands at local level. So, for a successful watershed sustainability of these institutions are very much essential.

This paper attempts to analyse the issues with regard to sustainability of these CBOs, especially the UGs in terms of carrying out the watershed activities. The experiences derived from the civil society organizations working in this arena reveal that the endurance of these CBOs differ among themselves, as shown in the table 1.

Table 1. Sustainability of Different CBOs under Watershed Programmes

CBOs	Sustainability level
SHGs	High
UGs	Low
WCs	Medium
WAs	Low

As seen in the table, the experiences show that the sustainability of UGs is comparatively low among different CBOs. For a successful model watershed, it is crucial to make the UGs more sustainable.

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The UGs are normally governing the assets like water harvesting structures (check dams, nala bunds, farm ponds etc.) in common and private lands and perennial biomass in common lands. In order to have a smooth functioning of watershed activities, sustainability of these UGs is important. There are different strategies for improving the sustainability of UGs as given below:

I. Enhancing participation
II. Structural refinement
III. Adequate investment on capacity building

I. Enhancing the participation of UG members:

Under this strategy one can consider the following options:

- Advance contribution for construction of structure / plantation of biomass
- Participatory approach in deciding location and type of structure / biomass
- Multiple technological options regarding type of structures / biomass
- Construction of structure / plantation of biomass under the supervision of UGs (with or without their labourers)
- Collection of user charges of the common resource
- Repair and maintenance of structures / measures through user charges and cost sharing by participants
- Operation and maintenance of the resource / structure through local entrepreneur (on contractual basis)
- Formal / interim allocation of users right over the asset (after registration of land and the asset)

Advance contribution for construction of structure / plantation of biomass

The members of UGs may be requested to contribute their share in advance to actual construction of the structures or development of plantations. This would generate and ownership' among them and ensure a better participation in the initial execution and further maintenance stages.

Participatory approach in deciding location and type of structure / biomass

In the planning stage, members of UGs may be taken on a transect walk along the watershed in order to decide the location and type of structures or biomass. Though technical survey help in appropriate location and type of structures, considering the local knowledge and demands of the UGs would definitely improve their confidence and hence their sustainability in later stages.

Multiple technological options regarding type of structures / biomass

In a similar manner, members may be asked to choose a suitable technology among the multiple options in order to address a specified issue. Some befitting PRA tools may be used to help the members to arrive at an appropriate solution for a particular need.

Construction of structure / plantation of biomass under the supervision of UGs

Under this strategy, UGs may be entrusted with the job of supervising the construction of structures with or without their labourers. This would surely improve their participation level, as they get the chance of intervening in the process of project implementation.

Collection of user charges of the common resource

This is a widely followed strategy for ensuring the effective participation of members. As the UG members possessing land around a particular structure or a perennial biomass are directly benefitted from that common resource, they can be easily coerced to pay the user charges. In addition to the benefits like involvement of members, the contributed fund can be used for the watershed development fund.

Repair and maintenance of structures / measures through user charges and cost sharing by participants

The user charges collected from the members can be used to repair or maintain the structures. In case of well-managed watershed villages, the participants can share the cost of such maintenance.

Operation and maintenance of the resource / structure through local entrepreneur

The work of maintenance of water harvesting structures can be entrusted with the local entrepreneurs on contractual basis. This will not only benefit the local population, but also enhance the credibility among stakeholders.

Formal / interim allocation of users' right over the asset

The users' rights can be allocated to different institutions after the proper registration of land and the asset. The following approach may be pursued in allocating the rights.

- Ownership right over the asset (to Gram Panchayat)
- Management right (to Watershed Committee / Federation of UGs, etc.)
- Users right (to concerned members of the UGs)

In this fashion, participation at all the levels can be assured in a watershed project.

II. Structural refinement

Refinement in the structural pattern of UGs can be achieved by following the principles like:

Facilitating democratic functioning in the group

In this case, the leadership role can be rotated among the participants, so that everyone will get a chance of expressing their ideas and implementing the same with the cooperation of other members.

Integrating the concept of SHGs with UGs

In this method, UGs can be conceptually converted into SHGs in a gradual manner. The members of UGs can be organized into number of smaller SHGs. Members of small sized UGs can form a SHG. Likewise, large sized UGs with heterogeneous members can be emerged into different SHGs, depending on their socio-economic homogeneity and affinity. Similarly, UG members may be allowed to emerge out of different SHGs. The UGs and SHGs thus formed can carry out the technological aspects and financial transactions respectively.

III. Adequate investment on capacity building

To sustain the UGs in the watershed setup, it is equally important to invest in the capacity building aspects of them. This can be achieved by providing training in technological, management and institutional aspects as given below:

Technological aspect: Members may be trained on how to choose the relevant interventions and locations of structures or measures according to their needs.

Management aspect: They may be shown the different ways and means of using their resources in a sustainable manner.

Institutional aspect: Further emphasis can be given to make them aware about the sustainability issues of their UGs as described above.

Summary and Conclusion

Success of any watershed development project depends on the sustainability of its institutions. Among all the institutions, User Groups play a vital role as they directly involve in the execution of field level activities. Hence, their functioning for longer period is very much essential for the betterment of the project. So, methods of improving their sustainability are to be studied in deep in order to execute them in field level. There are various strategies like enhancing the participation of UG members, structural refinement and adequate investment on their capacity building, which can be tried by any government or civil society organization involved in

watershed development programmes. If they follow these strategies in a systematic manner, it is certain that they would achieve success in their endeavors by improving the sustainability of the User Groups.

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COMMUNITY BASED NATURAL RESOURCE MANAGEMENT IN INDIA

Jun Takeda[1], P.Muthuraman[2] and K. Ravi Shankar[3]

Introduction

The search for sustainable methods of land use goes back to the 1950s when planned community development trusts were introduced but later abandoned in the 1960s. In the late 1960s to early 1970s the concept of equity and participation re-emerged, to be buttressed a little later by concept and approaches based on integrated rural development projects. In the late 1980s, large international conservation organizations began to work closely with the local organizations and communities to support creation of protected areas and strengthen the conservation of endangered ecosystems. These efforts led to much community based integrated conservation and development programmes, which attempted to provide local benefit through wildlife and ecosystem protection programmes.

Community Based Natural Resource Management (CBNRM) grew out of attempts to find new solutions for the failure of top down approaches to conservation. The approach was based on the idea that communities residing adjacent to game reserves would derive benefits from wildlife in order to motivate them to look after the resource and reduce human-animal conflict. The difference with CBNRM is the starting point with recognition that local communities must have direct control over the utilization and benefits of natural resources in order to value them and desire to utilize in a sustainable manner. This implies finding ways of increasing the participation of rural communities in resource management for it's a fact that rural communities have a more intimate knowledge of their location than state agencies. They too have a greater stake in managing resources sustainably as their livelihoods depend on it. CBNRM thus as a construct emerges as a conservation and rural development strategy, involving community mobilization and organization, institutional development, comprehensive training, enterprise development, and monitoring of the natural resources.

Variations of what can be collectively termed community natural resource management (CNRM) have exerted significant impact on the organization of natural resource management during the past decades and more. Various expressions of CNRM included social and community forestry, community wildlife management, cooperative or co-management, buffer zone management, participatory multipurpose community projects, communal area management for indigenous resources and others (Western and Wright 1994). Despite all these differences, all

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these expressions of CNRM share certain characteristics, including**,** a commitment to involve community members and local institutions in the management and conservation of natural resources, An interest in devolving power and authority from central and /or state government to more local and often indigenous institutions and peoples.

A desire to link and reconcile the objectives of socio-economic development and environmental conservation and protection.

A tendency to defend and legitimatize local and/ or indigenous resource and property rights, and A belief in the desirability of including traditional values and ecological knowledge in modern resource management. In the mixture of political, organizational, socio-economic, epistemological and institutional features of CBNRM has been rationalized and promoted (HED 1994; Western and Wright, 1994; Lynch and Talbot, 1995; Kothari *et.al* 1997; Uphoff, 1998). CBNRM has been advanced as a way of improving the social and economic standards of local and rural people (Wells and Brandson, 1992). An emphasis on power participation and property rights of frequently marginalized peoples also represent a prominent objective (Gilmour and Fisher, 1991; Little, 1994; Lynch and Alcorn, 1994; Strum, 1994; Sarin, 1995). An additionally compelling aspect of CBNRM is its stress on achieving conservation goals through economic and social incentives, and by incorporating the traditional knowledge and wisdom of local people accumulated over generations of intimate participation with the natural resource management (Berkes *et.al* 1994; Kleymeyer, 1994).

CBNRM can be viewed as a modern attempt to revive often quite established and traditional local and indigenous cultural and institutional mechanisms for managing and conserving the natural environment (Croll and Prakin, 1992; Bwerkes *et.al* 1998). The reality for much of the world, however, is that many traditional practices for regulating nature have eroded as a consequence of expanding markets, industrialization, urbanization, state power, economic globalization and profound alterations in property rights, life styles and consumption patterns. The desire to revive, at least in modified form, traditional resource management practices often originates in the belief that it may better achieve and reconcile two persistent and rarely attained objectives: the alleviation of rural poverty and the conservation of biological diversity. CBNRM initially gained attention during the early 1970 when many became disenchanted with the results of large-scale capital intensive and centrally planned conservation and development projects (Horowitz and Painter, 1986). Interest particularly developed in agriculture, water management and forestry, centering on promoting the participation and enhancement of the power and decision making role of local communities (Little, 1994). Community approaches further developed national park and protected area management, with many believing the combined efforts of ecological insularization and chronic conflict with local peoples jeopardized the long term sustainability of protected areas.

There are six major variables, which constitutes the economic, social and environmental domains that make the CBNRM as a successful one, these six variables are equity, empowerment, conflict resolution knowledge and awareness, biodiversity protection and sustainable utilization.

Equity- the distribution and allocation of socioeconomic benefits and resources.

Empowerment- the distribution of power and status, particularly among local peoples, including authority devolved from central and state governments to local peoples and institutions; as well as participation in decision-making, sharing of control, and/ or democratization.

Conflict resolution the handling and resolving of conflicts and disputes over resources among local peoples and among local, state, and national entities and interests.

Knowledge and awareness- the consideration, incorporation, and production of traditional and modern ecological knowledge in managing natural resources.

Biodiversity protection - the conservation and protection of biological diversity and associated habits, including the preservation and recovery of rare, imperiled, or flagship species, or imperiled populations or stocks of species.

Sustainable utilization the consumptive and no consumptive utilization of natural resources in ways intended to maintain the long-term availability of these resources in a nondiminished manner for present and future generations.

Challenges in Community Based Natural Resource Management

1. Reluctance to change is perhaps on of the greatest challenge to CBNRM. Most CBNRM constructs attested to government line ministries holding on to the classical top down planning and remain reluctant to consider or at least the promising approach.

2. With the introduction of micro-enterprises and communities establishing their own rules and regulations to govern sustainable resource use, there is enormous weakness over power at the dispensation of communities to enforce therules and regulations.

3. Management and leadership functions remain mostly closely intertwined within most CBNRM projects. This creates over what the community does, and the role of the project manager or facilitator. For instance, should the project manager hand over when the programme or project winds up? And if so what is he/she suppose to hand over and to whom?

4. There is a notion that community based development initiatives are only about micro-level interventions a notion held by even a number of CBNRM proponents. More robust notions

could better highlight its potential and contribute to restructuring broader development practices, power relations and distribution of economic benefits at the macro-level. Such a stronger and nuance concept of community is, therefore, an essential element of more effectiveness in development work. The micro-level stereotypes inhibit the potential in promoting rural livelihood.

5. Instituting relationship between government agencies and rural institutions, as catalyst for success is quite elusive during CBNRM constructs development. The question is how CBNRM constructs can be developed inside instead of outside government. In the presence of complex relationships that involve divergent parties. Moreover, many CBNRM initiatives continue to be relegated to the informal sector thereby inhibiting participation of local private and formal sectors.

6. Communities in drylands represent fragile ecosystems that need continued effort to be sustained. This in essence, implies that programs/ projects need longer periods of support to guarantee sustenance. Thus this often discourages potential supporters or those who move in for shorter periods and end up facing challenges with sustaining outputs often in post evaluations.

7. Communities rightly feel conservation should justify its existence within their land areas and have renewed interest in benefit sharing mechanisms both within CBNRM constructs, and government programmes. Although proponents claim it's a clear challenge to even the classical natural resource management paradigms, CBNRM constructs are not spared. It still remain a challenge and can probably be worked out through 'learning by doing' to device modalities to equally distribute benefits and specifically guarantee percolation of the same to majority if not all facets of the community with specific emphasis on the lower cadre.

8. High poverty levels that force people to over exploit the natural resources so as to provide food to their families.

9. Local community change agencies are commonly a target of interference from politicians and few economically powerful at the expense of the majority. It is not only to be savvy enough to understand the different interests that exist in local communities and avoid being hijacked by the agencies of the rich and the powerful even among community representatives that sit in elective positions. This early leads to activities leaving out, neglecting or forgetting women, youths, and vulnerable.

10. Organization of local communities into legally recognized entities to participate in collaborative management with other stakeholders like government and the private sector is not easy.

Opportunities

In CBNRM, communities are considered as development actors. With very different perceptions and motivations from external interveners, but who nevertheless have a significant, albeit recognized capacities. It concomitantly lays much greater emphasis on the perspectives of the local people and targets the infusion of indigenous knowledge in informing decision, policy and scientific understanding of natural resources and guide local interventions in environmental management. Therefore, in situations where entire communities or villages do not have a secure property rights, such insecurities are better resolved through community based collective action than land reform. CBNRM is an effective vehicle for tapping positive synergy to address poverty and natural resources degradation trap. When supported with appropriate policies and incentives it offers a viable options in generating employment in the rural sector, improving the conditions of women, youth and the poor, and reducing the pressure on natural resources. The synergy expands and improves marketing of primary products to small town and urban areas, for which a particular area has comprehensive advantage. CBNRM if well structured, can develop ties between rural communities and the state. Structures so developed, work out a repertoire of practices and institutions that can make sense both to villagers and to the government officials, enabling cooperation even where objectives may differ.

Five community based natural resources management institutions with in the Indian context is discussed in detail i.e., Pani panchayat (water users association), van panchayat (forest users association), community based watershed management, the biovillage approach and the Village Forest Joint Management (VFJM)

I. Pani Panchayat (Water Users Association)

After independence the problem of inadequate water management and maintenance involving the farmers in the irrigation system is one obvious remedy for addressing the management problems, thereby entrusting responsibility of irrigation to a village or a group of villages if the farmers were willing to take up cooperative irrigation. Efficient use of available water has, therefore become extremely important and it is in this context that the participatory Irrigation management (PIM) has an important role to play. The first step made in this process of reformation was to hand over part of the irrigation network for its operation and maintenance (O&M) to the farmers or the beneficiaries through the “Pani panchayats” (Water User Associations or WUAs). The Pani panchayats are registered as legal bodies to provide the required identity. Pani panchayat is very simply a group of water users, such as irrigators who pool their financial, technical, material and human resources for the operation and maintenance of a water system. A WUA usually elects leaders, handle disputes internally, collects fees, and implements maintenance. In most areas, WUA membership depends on one's relationship to a water source (such as canal, tank or ground water).

Pani panchayats are successful in overcoming the poor O&M of their irrigation systems and have improved their agricultural productivity. The formal handover of the systems has taken place in many Pani panchayats allover India. The Pani panchayats have now become enthusiastic in taking up the control and management of the irrigation system in their respective jurisdiction. Most of the state governments with a view to providing equitable, timely and assured irrigation have introduced the concept of Pani panchayat for participatory Irrigation management. The concept finally led to the transfer of tertiary irrigation networks to registered Pani panchayats. The responsibility of operation and maintenance of the reservoir/ diversion weir, dam, spillways, sluices, primary and secondary distribution networks etc rests with the department of Water Resources or Public works Department, whereas the responsibility of O&M of the tertiary system i.e., (below minor irrigation / sub-minor) will be with the Pani panchayat.

The primary objectives of the participatory Irrigation management through Pani Panchayat are:

i. To create awareness among farmers in the irrigated commands towards the benefits of formation of Pani Panchayat,

ii. To create a feeling of unity and brotherhood among fellow members,

iii. To create a feeling among farmers to visualize the created irrigation potentials as their own rather than that of government,

iv. To build up confidence among farmers regarding better returns once equitable, timely irrigation supplies are assured,

v. to convince farmers to go for cash crops under crop diversification programme to get better returns on their investments, and

vi. To arrange trainings and workshops of state, district, block and panchayat levels with the help of experienced resource person on PIM.

Characteristics of Pani Panchayats (Water Users Associations)

The major characteristics of enduring and self-governing Water Users Associations are as follows:

i. Clearly defined boundaries: The membership of the institution must be well defined. It must be clear who has legitimate access to the resource, who is under the authority of the association, and who the others are that must be prevented from access. Additionally, the boundaries of the resource must be defined. In case of the WUAs, the membership would likely be all landowners that receive water from a main canal and the resource would be the flows. This is known as a hydrologic organizing structure. However, some groups choose to organize in ways more familiar in their culture. There are cases of organization by village or kinship, which also have had success.

ii. Appropriation, rule and local condition congruence: It is necessary for the resource appropriations and rules to be adapted to local areas. Ostraom stresses that it is not specific rules, which are necessary for strong institutions, but rather rules to which the members agree. Rules made by locals will inevitably make sense with local conditions.

iii. Collective choice: It is necessary that all members have the opportunity to play role in changing the rules. All those directly affected should be able to voice their opinion and vote. While officials are elected to execute duties, the real authority rests with the general assembly of water users.

iv. Monitoring: In order for all users to make a credible commitment to one another and fully cooperate, they must know their fellow users are not stealing. Monitoring may take the form of water guards or more sophisticated gadgets.

v. Graduated sanctions: the members must impose penalties for those breaking the rules of the organization. The penalties should be commensurate with the infraction and could even lead to expulsion from the WUAs. Such severe penalties deter user from attempting to steal.

vi. Conflict-resolution mechanisms: One of the beauties of WUAs is the ability to handle disputes on the local level. This avoids the tortuous legal processes in the judicial system and adds to the accountability among the group. The members are apt to make equitable decisions for disputes knowing they may be in a similar situation in the future.

vii. Minimal recognition of right to organize: Members must have ability to organize without being challenged by external government authorities. In other words, they must be given true authority over their resource and members in it.

Functions and Responsibilities

Pani panchayat will assume full responsibility for operation and maintenance of the minor/sub-minor and all structures turned over to it. It will also ensure constructive/ maintenance and repair of all the watercourses, field channels, and field drainage in the said area as covered under the agreement jurisdiction of the water users association. For this purpose Pani panchayat will establish its own operation and maintenance fund (O&M) to meet the operation and maintenance expenditure. The following items of work are included in repair and maintenance work, namely removal of silt from minor / water courses/ field channel and field chains and proper upkeep of the same, repair and maintenance of inspection path and service road to keep them in good conditions, removal of grass, shrubs and bushes from the canal embankments and canal beds, repairs and maintenance of all structures to the distribution system so handed over for operation and maintenance to keep them in good working conditions, earth work to restore embankments to proper shape and profile, repair to lining painting, planning and replacing damaged portions, repairs to masonry and other structures etc. Pani panchayat will ensure construction, maintenance and repair of all the watercourses, field channels, field drains and other drains structures within the jurisdiction of the Water Users' Association. The

Pani panchayat will protect the entire system covered under the said area within the jurisdiction from any damage whatsoever. Pani panchayat will receive water from the Government and shall distribute it among the water users, whether members or non-members according to the requirements of their area under crop. It will observe economy and equitability in this regard. Wherever possible water shall be supplied for water users association on volumetric basis. It will organize better and improved water management methods at the farm level. It will decide for internal distribution of water. The panchayat will have the right to decide its own cropping pattern within the allocated water.

The Pani panchayat may ask for and obtain from the Department of Water Resources information on planned operation and maintenance activities in the entire system. It may also request and obtain assistance from the concerned Assistant Engineers Department of Water Resources and the plant for operation and maintenance in the concerned distributaries, minors/ sub-minors for proper asset management. The Pani panchayat will facilitate collection of water rates from the members and non- members of the Association as per the rate prescribed by the government in accordance with provision of the irrigation act and Rules made there under. The rates charged shall vary from time to time as determined by government.

Advantages of Pani Panchayat

i. Guarantee of getting full share of water through "quota of water'.

ii. Right for suggesting improvements in the main system management, water delivery schedule etc at the project level.

iii. Participation in operation, maintenance and management of the system,

iv. Freedom of deciding own cropping pattern within the allocated water.

v. Thorough and timely maintenance for guarantee of drawing full allocated water,

vi. Concession in water goes for collective and bulk water supply.

vii. Better service and amicable settlement disputes in the use of water.

viii. Better assistance from department of Agriculture in all aspects of crop husbandry.

ix. Own bank account for carrying out need based maintenance.

The prolonged prevalence of government-managed systems has restricted the initiative of the farmers and made them dependent on the government. Farmers are reluctant to adopt participatory approach. There are apprehensions in the minds of farmers that under the new system they might have to incur expenditure on operation and maintenance, in addition to increased water rates. There is often lack of homogeneity in the composition of farmers' population and they are reluctant to come together, because of differences of castes and classes, to form an association. On the basis of the experience gained over past four decades, it is now need of the hour to undertake all required corrective measures for the management of irrigation systems with more emphasis on farmers' participation.

II. Van Panchayat

Van Panchayats in Uttaranchal were born out of conflicts and compromises that followed the settlements and reservations of forests in the hills at turn of the last century. The first government approved Van Panchayat was thus formed in 1921. According to recent estimates, there are 6,069 Van Panchayats managing 405,426 hectares of forests (13.63% of total forest area) in the state. Most of these have been carved out of civil (protected) forests under the jurisdiction of the Revenue Department. The area under each Van Panchayat ranges from a fraction of a hectare up to over 2,000 hectares.

It may be mentioned here that Community forests managed in accordance with Van Panchayat Act is a hybrid of state ownership and community responsibility, in its efforts to mange and control community forest use. Forest committees are guided by Revenue Department rules and by the technical advice of the Forest Department. In contrast to civil forests, community forests or panchayat forests as they are popularly known are not 'open' forests. Access and use of forests is guided by rules elaborately designed and implemented by the communities. In fact four identifiable working rules exist relating to Use, Monitor, Sanctions and Arbitration. Though only notionally or nominally owned by the communities, community forests are in a very real sense common property with an identifiable user group, have finite subtractive benefits and are susceptible to degradation when used beyond a sustainable limit. However what is more important is that the local users consider them as their collective property and in real sense they are not actually divisible. These forests though are not completely immune from misuse and the condition of the forests varies from poor to very good.

The main functions of Van panchayats are as follows:

a) To develop and protect forests by preventing indiscriminate felling of trees and to fell only those which are marked for by the forest department and are useful from the point of view of silviculture.

b) To ensure that there is no encroachment on Van Panchayat land and that no rules are being violated that are being enacted under Kumaon and Sodic Land Act of 1948 and that no land should be encroached without prior permission for agricultural practices.

c) To construct and fix boundary pillars and to maintain them 18(c).

d) To carry out the directives of the Sub-Divisional Magistrate in developing and protecting forests. 18(a)

e) To distribute its produce amongst right holders in an equitable manner. 18 (e)

f) 20% of the area of the forest must be closed for grazing every year.

New Van Panchayats

Though the Van Panchayats managed to survive these multiple obstacles and challenges to their authority in many villages, they are faced with two additional threats in the recent years which may further weaken or bring about their demise as relatively democratic and self-governing forest management institutions. Ironically, these new threats have been state initiatives that are presented as 'devolution' policies: the rapid formation of new Van Panchayats under the direction of the Revenue Department; and the introduction of 'Village Forest Joint Management' by the Forest Department. Their practical effect has been to transfer still further authority to the state at the expense of communities. In the recent years there has been an increase in the demarcation of remaining civil lands as village forests and this has converted the demand driven process into a supply driven one. Instead of the villagers collectively applying for a village forest, the administration have imposed their decisions, irrespective of the fact whether panchayats are required or not as well as ignoring other aspects like ongoing boundary disputes, existing community management arrangements etc. For example in Nainital district itself there were only 61 Van Panchayats at the time of independence, which increased to 495 by 1999.

Further some multi-village Van Panchayats have been re-organized without consulting the villagers, in ways that exacerbated inter-village conflicts, Traditionally, villagers had developed an effective multi-village governance system that was both democratic and equitable. Reorganization of Van Panchayats has in fact destroyed the traditional culture of resource sharing. Moreover with the division of forest councils neither the forest area nor the species composition could be evenly distributed among the villages, some are now left with small forest patches with only *Chirpine*, while others have all the fodder bearing areas. It has also failed to address any of the major problems plaguing the existing Van Panchayats - the lack of effective and easily accessible dispute resolution mechanisms, inter-village inequity in availability of forest areas, erosion of panchayat authority and limited control over forest based livelihoods and income. The rapid formation of Van Panchayats, rather than expanding space for local forest management, seems to be reducing it still further. It is too early to predict the effects of state-driven Van Panchayat formation might have on local livelihoods, social relations and forest management practices. The process of their formation, however, gives reason for concern.

III. Community Based Watershed Management (CBWM)

A watershed can simply be defined as any surface area from which rainfall is collected and drained to a common point. Watershed is synonymous with a drainage basin or catchments area. A drainage basin, however, can involve several villages and regions and even counties. There is no definite size of a watershed as it may vary from a few hectares to several thousand hectares. Generally watersheds are classified into three groups namely, micro, mini and macro

watersheds. A combination of micro watersheds make mini watershed, which forms part of the macro watershed before finally discharge into the sea or ocean. Watershed management is the integration of appropriate technologies and strategies within the natural boundaries of a watershed or drainage basin for optimum development through conservation, regeneration and judicial utilization of all resources: land, water, animals and human. Integrated watershed management is the process of coordinating conservation, management and development of water, land and related resources across sectors within a manageable hydraulic unit in order to maximize the economic and social benefits derived from water resources in an equitable manner preserving and, where necessary restoring the ecosystems. Community based watershed management is the process of involving local communities to identify problems as well as solutions towards formulating and implementing a course of action involving the water and land resources of their watershed, with emphasis on linkages between the upstream and downstream parts and the respective human and bio physical endowments.

Community based watershed management - Why is it required?

i, Eighty percent of the rural communities meet their requirement of food, fuel, and fodder from the local environment. Where farming is the main source of income, differences in local farming conditions are the main determinants of variation in local food security system.

ii. The breakdown of traditional institutions for managing common property resources and failure of new institutions to fill the vacuum has been major factors responsible for denudation of natural resources.

iii. Each watershed is different as humans and environment influence it in a varied manner according to local situation and culture. Therefore, matching availability of resources with the needs of humans and animals can best be carried out at a micro level or in a community but based on ecological units in conformity with natural law.

iv. Increasing concern about why other community based natural resources management approaches fail to achieve expected levels of equity and sustainability.

v. Increasing need to treat natural resource management as a socio-economic and political issue rather than a technical and administrative one.

Operational Framework

Community based watershed management is a multi-objective and multi-disciplinary approach to solving natural resources management and food security problems with the rural communities. These communities can exist in dry and semi-arid regions. The economic and social well being of any community affects its decision making with regard to the use of land and water resources. And these decisions or actions can affect the production potential of the natural resources base either favorably or adversely. Thus, watershed management is a reflection of

social, economic and political relationships amongst the watershed dwellers. This argument makes watershed management as a societal technology and not just a mere technical approach to solving problems of food security and natural resource management**.** As a social and technical approach it has its own process and aims of development, which can be divided into three goals: first, the socio-economic development, which is responsible for creating opportunities for additional income for the farmers and ensuring equity for all the concerned. Second, the institutional development, which is responsible for bulking capacities and capabilities of the community for the effective and efficient use of their resources. And third, enhancing the ecological integrity of the watershed area, which is vital to food production and maintenance of the overall productivity of the territorial ecosystem. Thus, the overriding aim of community based watershed management is to ensure sustainable natural resources use, agricultural growth, and development of farming communities. Therefore, an appropriate operational framework model would be one that considers these aims in the watershed development process.

Watershed Management Plan

Watershed management plan generally include the following elements viz., definition of the area of concern, the purpose of the plan, and who was involved in developing the plan, description of the physical, ecological, and social characteristics of the watershed and the communities within its boundaries, description of the problem that affect watershed functions, identification of responsible parties and of planned activities for addressing identified problems and responsible parties and explanation of how the progress will be measured once implementation of a plan begins.

Challenges associated with Community based watershed management

Community based watershed management is not easy; no it is always effective of protecting or restoring watershed functions. Some of the challenges faced by those who adopt a community base approach include the following. Watersheds may cover thousands of acres of public and privately owned land. Developing even basic understanding of how human activities affect watershed functions a major undertaking. Some of the key stakeholders may lack time, motivation sills, or resources to participate effectively throughout the management planning process. Resource management professionals may be reluctant to give up their role as experts and to share authority with laypersons regarding resource management issues. Conflict between stakeholders over management and the means to accomplishing those goals are inevitable, and resource management are often ill-prepared to facilitate constructive dialogue to resolve these conflicts. Community based approaches require time to generate interest and to build relationships between stakeholders. Funding agencies and stakeholders may grow impatient with the lack of observable outcomes.

Keys to Success

There is no easy formula for successful community based watershed management. However, experience gained from most of the earlier projects suggests that several key factors such as those of listed below are common to many successful projects viz.,

i. Involve stakeholders in the management planning process in a way that is meaningful to them and that allows them to use their particular skills and knowledge most effectively.

ii. Don't be discouraged if some stakeholders choose not to participate initially. Begin by educating and informing key audiences about the value of watershed to the community as a whole, the watershed management process, and specific actions they can take to get involved.

iii. Determine the appropriate scale of addressing watershed problems. Actions aimed at changing land-use practices are easiest to implement at the local level and become more difficult to manage on a larger scale.

iv. View watershed management plan as starting point and not the end product. Be prepared to adopt the plan as conditions change and groups learn from their mistakes.

v. Make management decisions, when possible, based on consensus of a broad range of stakeholders. Efforts to resolve conflicts before management decisions are made pay dividends in the long run.

vi. Focus on desired outcomes, which can often be more helpful and motivating for participants than emphasizing problems and who is causing them.

IV. The Bio village Approach

The Bio village approach initiated in 1991 by the M. S. Swaminathan Research Foundation in collaboration with the Pondicherry administration is being implemented in the Union Territory of Pondicherry, South India with assistance from the United Nations Development programme (UNDP). The support of the UNDP extended is to test and demonstrate the bio village paradigm in 19 villages spread over 4000 hectares inhabited by a population of 25,000 people, which if found successful could be replicated elsewhere, within and outside the country. The approach is being conceptualized through the integration of the best in traditional wisdom and technologies with the best in modern biological technologies. It is a Pro-nature, Pro-poor and Pro-women developmental paradigm. It seeks to address concurrently the twin concerns of sustainable development of the present times viz. Degradation of the resource base and persistence of rural poverty. The former is addressed through integrated resource management systems of both the biophysical resources (Land, water and natural vegetation) and the human resources to which the rural households have access individually (farm households) and communally (Common Property Resources). This would maximize

income and employment per unit of resource land and water and not a specific commodity per unit of land. Similarly alleviation of rural poverty is sought by accessing the resource poor to technology through technological empowerment for income and employment generating activities and skill up gradation, and assessing to the Usufruct of the Common property resource by the resource poor. The approach is based on the identification (micro level planning) and promotion of market driven micro enterprises (with Micro credit) and fostering group action, which lend them selves to decentralized production supported by a few key centralized services.

V. Village Forest Joint Management (VFJM)

VFJM, implemented by the Forest Department, in 1997 is even more problematic for villagers. Whereas Joint Forest Management (JFM) in other states enables villagers to participate in the management of forestlands under the Forest Department's jurisdiction, in Uttaranchal, the VFJM Rules enables the department to become the dominant partner in the management of Van Panchayat and civil forest lands. The land being brought under VFJM falls under the Van Panchayats or the Revenue and not the Forest Department's jurisdiction. The latter is managed in collaboration with Gram Sabhas, the democratic institutions of local self-government at the lowest level.

The VFJM Rules also provide for forming Village Forest Committees (VFCs) where there is no Van Panchayats. This is an effort to link VFJM with local self-government through Gram Sabhas. These forest committees are expected to be representative of key local interests, with one seat each designated for women, scheduled castes/tribes, backward castes, and for persons with a particular interest in forests. The Parthian (head) of the Gram Sabha is to be the President of the forest committee and the forest guard its member secretary, the two also jointly holding the committee's account. As many Gram Sabhas in the hills cover more than one village, neither the president nor the secretary of the Village Forest Committees may be residents of the village whose forest management institution they head. Whereas linking community forest management institutions with those of local government is highly desirable, the order for constituting Village Forest Committees is a top down, mechanical prescription. It says nothing about strengthening participatory governance by the Gram Sabhas and forest committees or their respective roles and responsibilities within the local governance structure. Simply prescribing the Gram Sabha Head to also be the forest committee's President vests further power and responsibilities in one elected individual, an institutional norm, which has already weakened collective decision-making within Van Panchayats. Making a Forest Department functionary the member secretary of a local government committee similarly violates the objective of democratic decentralization of governance by vesting power and authority in a non-elected representative of the bureaucracy.

Notification of the VFJM rules, together with the issuing of other orders for 'participatory' forestry, was a condition of the World Bank $65 million loan for the Uttar Pradesh Forestry Project over the period 1998-2002. JFM is to receive priority under the project, accounting for about 30% of the total budget. The Bank's appraisal document does not provide any analysis supporting the introduction of village forest joint management instead of strengthening autonomous functioning of existing Van Panchayats in the unique historical context of Uttarakhand. Neither does it specify any process ensuring multiple stakeholder participation in framing the 'participatory' orders. In the event, the responsibility for framing them rests with the Forest Department with no history or experience of working with Van Panchayats. Exclusion of long standing Van Panchayats from any role in the matter is conspicuous by its absence. Van Panchayats and other community institutions are treated as the objects of attention, not active participants in redefining their future destiny. The World Bank project simply assumes the desirability of importing the standard JFM model from other states into Uttarakhand, with all its shortcomings, instead of exporting a strengthened Van Panchayat framework to them.

The impact of Village Forest Joint Management on communities in Uttaranchal

Though, it is too early to see the impacts of VFJM on forest based livelihoods and forest quality, the content of the VFJM Rules, however, suggests a loss of decision-making space for local villagers. Despite claims to empower local forest users, the rules do much to achieve the opposite. Collective control over decision-making Prioritization and selection of villages for VFJM is done by the Forest Department in accordance with several selection criteria, making it a supply, rather than a demand driven process. 'Spearhead teams' communicate with and develop micro plans for selected villages. These teams consist of: one ACF; one ranger or deputy ranger; one forester or forest guard; and two NGO 'social motivators', at least one of whom should be a woman. The social motivators are recruited under contract with NGOs and the teams imparted 3 weeks training. Experienced Van Panchayat leaders with decades of experience of community forest management have no role as facilitators and technical advisors. Instead they are being motivated to protect forests. The agreement to be signed by the participating villagers refers to them as beneficiaries rather than as equal partners.

In Uttarakhand, NGOs and civil society groups have historically played a strong advocacy role. Chipko, for example, was triggered by protests led by the NGO, Dasholi Gram Swaraj Mandal. Today, the NGO movement is split into different camps and factions. The vast majority has been co-opted to work as 'private service providers' for the several donor funded projects in the region, including the forestry project. Once they have accepted working on project terms, they effectively lose their critical and questioning voice. The overall impact is that today the NGO and civil society movements have been considerably weakened with hardly any concerted public action for protecting people's forest rights.

The World Bank funded forestry project has provided an average of rupees 20 to 15 lakhs for implementing a micro plan in each village brought under VFJM. Besides promoting inequity between neighboring villages, the sudden offer of large sums of money to selected villages with high unemployment and limited opportunities for cash incomes, however, had led to the eruption of major conflicts to gain control over the funds. Even where existing Van Panchayats were functioning well, small groups of elite men, with the least dependence on the forest, had often made alliances with Forest Department field staff to pervert the requirement of obtaining general body resolutions accepting VFJM. The majority of the genuinely forest dependent women and men were neither aware of the content of the VFJM Rules nor of the fact that the Van Panchayat Rules had become inapplicable. Their main involvement had been reduced to that as wage laborers.

Conclusion

Despite being an excellent example of state-people partnership which has been relatively successful in managing forest resources in the region, the institutions are facing challenges from unrealistic and target driven policies which would affect its democratic functioning. There is a need to replicate such institutions in other areas rather than interfering with the existing ones. Moreover Non-governmental Organizations need to play more active role in keeping these institutions alive by bringing the communities to the center stage of decision-making. In order to strengthen such community-oriented institutions, one needs to identify such similar institutions and undertake comparative studies on the same so that anomalies if any can be removed.

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GENDER AND NATURAL RESOURCE MANAGEMENT

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This paper reviews the linkage between gender and its role in natural resource management. It outlines several strands of environmentalism to explain different approaches to environment management in general and role of women in particular. The paper begins with a overview of different approaches to both women and environment (with specific focus on NRM) with the development context.

There is a clear progression towards recognition of the problems and attempts to redress the imbalance. Approaches to development, women within development and environmental management have moved to empowerment at local level, with community management of resources.

Development has had a very large impact on both women and the environment. Many authors have made a strong link among women, the environment and development seeing the three as connected. Consequently, they have advocated action to help both women and the environment for development to be successful. In most societies world wide, throughout most of their lives and most settings women have fewer opportunities than men to gain education or to become economically self-sufficient (World Resources Institute 1994). These statistics on poverty and illiteracy reflect discrimination in inheritance and land ownership laws, employment and development policies, resource allocation, and the traditional division of labor (Power, 1992). Discrimination varies depending upon the country, culture, class and locale; but in general, women are considered inferior and are treated as such (Anderson and More, 1993).

Social and economic conditions in developing countries are rapidly changing as a result of the worldwide multi-sectoral development process. Development impact on women and men differently, and the past few decades of development have seen an alarming degree of feminization of poverty. Development in many cases has had the negative impacts on a large proportion of women in particular (Heyzer, 1985). The main thrust of development has been economic improvement. In most developing countries this has been focused on agricultural development with varied impacts for women. Most important have been increased workload (Singh and Kelles- Viitanen, 1987; Mukhopadhyay, 1984; Ramamurthy, 1991); reduced access to land, water, firewood and finance (Moser, 1989; Harcourt, 1994; Young, 1993); and decreased power and decision making (Ramamurthy, 1991, Mellor,1992, Sen and Grown, 1987).

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Five Major Approaches to Development

Any review of the perspective adopted by researchers and development agencies reveals a variety of approaches to development, and a variety of assumptions about women and the impacts that development has on them. The major approaches have attempted to address are:

1.The Welfare Approach

2.The Equity approach

3.The Anti-Poverty Approach

4.The Efficiency Approach and

5.The Empowerment Approach

1.The Welfare Approach

Moser (1989, 1993) describes the welfare approach as being based on three assumptions:

i. Women are passive recipients of development, rather than participants in the development process.

ii. Motherhood is the most important role for women in society.

iii.Child rearing is the most effective role for women in all aspects of economic development.

The welfare approach claims to be 'family centered' in orientation, but it focuses on women in terms of their reproductive role and identifies the motherchild dyad as unit of concern. At the same time it assumes men's role to be productive.

The main method of implementation is through 'top-down handouts' of free goods and services or through training in those skills deemed appropriate for non-working housewives and mothers.

While welfare programmes identify women rather than lack of resources as the problem, and place the solution to family welfare in their hands, without questioning their 'natural' role (Moser, 1993).

During the 1970s, criticisms of the welfare approach prompted several alternative approach to women; namely equity, anti-poverty, efficiency and empowerment. Though these approaches share many common origins, were formulated during the same decade and are not mutually exclusive, there has been a tendency not only to confuse them, but also to categorize them together as human in development approach.

2.The Equity Approach

By the 1970s, studies showed that although women were often the predominant contributors to the basic productivity of their communities, particularly in agriculture their economic contribution was not referred to either in national statistics or in the planning and

implementation of development projects (Boserup (1970). At the same time, new modernization projects with innovative agricultural methods and sophisticated technologies were affecting women negatively, displacing them from their traditional productive functions, and diminishing the income, status and power they had in traditional relations.

The original Women in Development Approach (WID) were in fact the equity approach, which recognizes that women are active participants in the development process. Through their productive and reproductive roles, women provide a critical, if often acknowledged contribution to economic growth. The approach starts with basic assumption that economic strategies frequently have had a negative impact on women and acknowledges that they must be brought into the development process through access to employment and the market place. This change in emphasis from the family to the economic arena has been a step in the right direction; but economic independence has been seen, erroneously, as synonymous with equity. Like many of the WID approaches, this approach focuses on women in isolation, both from their daily lives and the relationships through which inequalities are perpetuated.

3. The Anti-Poverty Approach

The essential difference between equity and anti poverty approach is that unless employment leads to greater autonomy, it does not address the equity needs of women. The anti poverty approach also identifies the economic inequalities between men and women, but sees the cause as poverty rather than subordination. The operational emphasis is on reducing economic inequality. This approach to women focuses mainly on their productive role on the basis that poverty alleviation and the promotion of balanced economic growth requires increased productivity of women in low-income households. Underlying the anti-poverty approach is the assumption that the origin of women's poverty and inequality which men are attributable to women's lack of access to private ownership of land and capital and to sexual discrimination in the labor market. Therefore it aims to increase the employment and income generating options of low-income women through better access to productive resources.

4. The Efficiency Approach

The Efficiency approach is now the predominant approach for those working within WID framework and evidences a shift away from women and towards development, on the assumption that increased economic participation for the Third World is automatically linked with increased equity, and recognizes that 50 percent being wasted to increase their labor in both their reproductive and community management roles. However, in most cases this approach fail to reach any strategic gender needs and seriously reduces the number to practical gender needs that are met, because of the reductions in resource allocation.

5. The Empowerment Approach

Empowerment approach appears synonymous with the equity approach, especially with frequent references in the literature to a combined equity-empowerment approach; but the empowerment approach is markedly different in its explanation of the causes, dynamics and structures of women's oppression, and in terms of the strategies proposed. Although the women's empowerment approach acknowledges inequalities between men and women, and the origin of women's subordination in the family, it also emphasises that women experience oppression differently according to their race, class, colonial history and current position in the international economic order. It therefore maintains that woman have to challenge oppressive structures and situations simultaneously at different levels.

By emphasizing women's organizations, the empowerment approach appears similar to the welfare approach. However, the welfare approach recognizes only the reproductive role of women and uses women's organizations as a top-down means of delivering services. The empowerment approach recognizes the triple role of women. It aims to raise women's consciousness and encourage women to challenge their subordination, by using bottom up processes through women's organization. Many (Steady, 1993; Shiva, 1989) have considered that sustainable development will not be possible without the central and beneficial participation of women to incorporate their needs. Concerns, aspirations and perspectives in all sectors, and at all levels of society and political process. This approach has not gained a great deal of support from either national government or bilateral aid agencies. This is despite the widespread growth of Third World groups and organizations whose approach to women is essentially of empowerment.

Approaches to Environmental Management

There is an enormous gap in understanding environmental change, which result from development. Environmental thinking and sustainability became central to development policy of the 1990s. From the earliest decades of development, there has been a trend from conservation of the environment, to local control, participation and management with the current emphasis to sustainability, paralleling this, there has been a trend from the obvious exclusion of women in environmental management to an emphasis on their direct involvement.

The world's natural resources, particularly land, biomass and water supplies are so degraded by the development process and that 'development' itself is at risk (Ramakrishnan, 1992; Adams, 1990; World Bank, 1992; Kramer 1985; Redclift 1992). Development has impacted negatively on land, water and forest resources, causing a complex range of biophysical, economic and social effects. Serious environmental problems are invariably part of socio-biophysical systems characterized by both complexity and high level of interaction,

causing a dynamic situation (Carley and Christie, 1992). The recognition of their dynamic complexity led to the formation of the United Nations Research Institute for Social Development in 1988. The UNRISD's research on the environment stresses social and political economy dimensions because conservation and sustainable development programmes will only succeed if they address the social factors influencing in the way people interact with the environment (Ghai, 1994).

Conservation: Managing Natural Resources For Sustained Use

The World conservation Strategy (IUCN) defined conservation as the management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generation(s), while maintaining its potential to meet the needs and aspirations of future generations. They saw conservation as positive, embracing, preservation, maintenance sustainable utilization, restoration and enhancement of the natural management. IUCN described conservation as a process to be applied cross sectorally, not an activity sector in its own right. In the case of sectors directly responsible for the management of living resources, conservation was seen as that aspect of management, which ensures that utilization, is sustainable and which safeguards the ecological process and diversity essential for the maintenance of the resources concerned.

In both developed and developing countries, government often reacts, to severe environmental destruction and pressure from environmentalists by designating national parks or reserves. However, the establishment and management of national parks and reserves is a reflection of a actually derived valuation of the landscape and its elements, and in some cases sets land aside, restricting or preventing use by local people. In many cases this creates conflict.

Management systems are needed that can minimize social conflict utilizes natural ecosystems on a sustainable basis to maximize the flow of important products to communities, and generate income and employment opportunities. Successful management of natural resources does not happen unless the people associated with the resource actively participate in designing and executing the various ventures indented to improve their welfare.

Local communities often play a key role in natural resource management; therefore, the support of the entire community is a critical element for its sustainability. Men and women use natural resources in different ways and at different rates and have different allocation and conservation measures. Understanding the different roles and responsibilities on men and women in the natural resource management system is critical to understanding how changes to that system will affect food security, resource management practices (e.g., land, livestock and fisheries) and hence productivity and sustainability.

NRM requires participation, management and commitment from both the sexes. Women's participation in community organizations that manage natural resources is not just an equity issue, but also one that affects efficiency and effectiveness. In general women have a high degree of responsibility of natural resources in performing their daily household tasks, as women are the ones involved in subsistence activities such as collection of fodder, and wood for fuel and construction.

Women are also actively involved in the management, conservation and maintenance of natural resources for individual and collective consumption and often have detailed knowledge of their local environment, which is critical to strategies for development and change.

The World Bank funded projects have shown the importance of gender issues in NRM. Particular areas of concern, with a strong need for future improvements, are benefits for vulnerable groups, gender inclusion and property rights with a strong need for future improvements. In terms of sustainability, on average the projects with NRM components demonstrate sufficient design and implementation schemes to ensure economic, and environmental sustainability.

Women's role in Environmental Management

Most writers support local control and management of resources. Jackson (1993) expressed strong concern that local control will lead to environmental degradation. She believes, contrary to many others such as Steady (1993) and Shiva (1989), that women's apparent concern for the environment is really livelihood concern. This does not explain the many actions taken by women on environmental issues worldwide in both developing and developed countries.

In contrast to Jackson (1993), Dankleman and Davidson (1989) strongly advocated women's inclusion in environmental management. They state: 'The tragedy is that remedial programmes of environmental rehabilitation often ignore women's needs and fail to build upon their capacity to conserve'. They gave four reasons supporting women's inclusion in environmental management:

1. Women have knowledge and skills in natural resource management that can be built upon.
2. Women have a remarkable ability to zwork together.
3. Women have a powerful influence over changing attitudes to the environment, in caring for their children.
4. It is likely that restoring women's capacity to care for the environment will be associated with improvements in their independence and their status.

A major shift in focus has taken place. There has been a convergence of interest between environmentally sound and sustainable development, and the development of women. Their empowerment and participation in environmental management are seen as necessary precursor to sustainable development.

Arguments for excluding Gender Aspects

The most common arguments for excluding gender aspects that we have heard are the following:
It is a slow process that takes patience and time.
Indigenous men don't want it.
Gender equality and equity issues destroy the traditional indigenous way of life as the women are the cultural bearers and guardians.
It is too difficult to get in contact with indigenous women
Indigenous women don't speak the common language.
Women do the cooking, look after their children and sweep around the house.
And for what purpose, anyway?

Reasons for including Gender And Indigenous Concerns

There are three main reasons for including gender aspects in natural resources management in indigenous communities areas and territories. One is that traditionally both indigenous women and men have valuable knowledge of the natural resources and of how to manage them. Another is that they are both necessary and essential partners and agents in sustainable natural resources management and development work. And the last one is that indigenous families traditionally survive on the basis of both men's and women's integrated work and effort in daily life.

Rationale for integrating Gender into Agriculture and Natural Resource Management

Strategies for sustainable agriculture and NRM stress participation and empowerment of farmers and communities, as well as partnership development among all stakeholders. Gender relations at community and family levels play a crucial role in the success of their efforts to harmonize agricultural intensification with environmental integrity and promote social equity while maintaining economic production objectives.

Uttar Pradesh Sodic Land Reclamation project, India : A classic Example

The project sought to reverse the trend in productivity decline in vast stretches of sodic lands through a land reclamation process. It also aimed to make the process sustainable by preventing further increases in sodicity through the effective management of programs with strong community participation and NGO support. Not only has the project used the latest technological methods, but also it has emphasized social aspects to ensure stakeholders commitment in sustaining the activities to manage the sodic lands.

The project is ahead of its target thanks to the motivation and participation of men and women farmers. Some of the highlights are i) 45,000 hectares of land have been reclaimed and brought under cultivation, ii) Cropping intensity has gone up, iii) 58,000 landless laborers have been allocated land and the need to seek off-farm employment has been reduced. iv) Women's groups have been formed which have become important centers of economic activity, v) access

to institutional credit has improved: banks now extend group credits to women for related activities such as dairy farming, nursery raising and trading, vi) The overall social and economic well-being in the villages has improved.

The project's enormous success is based on using social and institutional mechanisms to coordinate community efforts. Some important lessons are:

Correct sequencing of project activities: first, establish property rights and land titling, then create groups and organizations and finally, bring in the technical solutions and resources. Encouraging equal participation of men and women in problem solving, and developing local capacity among local people for decentralized management of degraded lands. In a remarkable development, the project initiatives have resulted in a new legislation in land titling requiring joint registration in the names of both husband and wife for allocation of reclaimed land.

Systematic Integration of Women in a National Program: IPM Training Project in Indonesia.

The IPM Training project is implemented in 12 main rice producing provinces to stabilize agricultural production, particularly rice, and promote environmentally sound crop production systems. Using farmer's field-school (FFS) methodology, the project trained farmers and farmer trainers had built awareness about the health and environmental hazards of continuous use of pesticides in rice production.

Project outcomes had a far-reaching impact on rice production systems in the country. At the implementation in 1999, a total of 900,000 farmers and 23,000 farmer-trainers, of which 160, 000 were women, had been trained in IPM. Crop yield was maintained although pesticide use was reduced and the project improved the environment and farmers' health.

In spite of strong social, cultural and religious barriers, a significant number of women beneficiaries participated in all project activities. Women farmers were successfully trained in IPM, and leadership developed among women farmer-trainers. Women became very active in post field school activities and in farmers' networks and associations. The following gender-related activities led to the success in integrating women in project activities all around the country.

i. A national target of 30% participation of women farmers in IPM field schools.

ii. Gender analysis by farmers' field schools (FFS). Guidelines were issued also to match the percentage of women farmer-trainers with the percentage of female participants in the FFS.

iii. Annual gender studies on women's participation in individual field schools.

iv. Monitoring and evaluation of women's participation in individual field schools.

v. Women's participation as IPM alumni and leaders in post field schools' activities played a big role in networking among women farmers and in the informal spread of IPM.

Checklist of Gender Related issues and Activities during project Cycle

	Identification and Preparation	Design and Appraisal	Implementation and Supervi	Implementation Completion
Socio-economic	→ Division of Labor between men and Women in farming activities in project area. → Constraints in men and women farmers face in improving productivity. → Men's and women's access and control over resources at household level. → Men and Women farmer's understanding and capacity to adopt sustainable practices.	→ Gender inclusive project activities geared towards meeting specific needs of men and women. → Interventions to improve women's access to productive resources with existing local and cultural context. → Community mobilization in adoption of sustainable practices and NRM.	→ Women's farm productivity and their role in decision making. → Quality of participation of women in agriculture and NRM. → Awareness among men and women about sustainability in farming practices.	→ Women's role in agriculture and NRM strengthened. → Improvement in women and men farmers' income and overall social well being.
Policy and Institutional	→ Prevailing system in land tenure security and women's land rights. → Existing capacity of Institutions to provide support to farming needs of men and women.	→ Project initiatives to address gender differences in land rights. → Capacity building in extension and other services to address gender.	→ Women farmer's access to land. → Training of staff trained in gender. → Gender balance among staff. → Gender focus in extension activities.	→ Gender equity in access and management of land resources.
Technology Development	→ Farmer's knowledge of sustainable and NRM. → Gender specific technology needs to improve productivity and sustainability.	→Technological support in conservation approach by community women's groups. →Focus on woman and the les privileged – productivity increase in degraded lands and post harvest technology.	→ Information dissemination on farmer oriented sustainable practices in agriculture and NRM. → Women's participation in field demonstrations and technology adoption.	→ Improved management and sustainability of land resources. → Increase in productivity and fertility of degraded land.

Notes to Task Team	→ Collect background information on men and women's dynamics in agriculture and NRM to identify gender analysis.	→ A preliminary gender study or an engendered PRA is advisable to help identify specific areas of emphasis on the project.	→ Emphasis should be given to assessing improvement in the quality of women's participation.	→ Impact of women's participation should be seen in overall context – social, economic and environmental.

Gender Related Indicators for Natural Resources Management projects

Sub-Sector Indicators	Input Indicators	Out Indicators	Impact Indicators
→ Changes in the role of men and women in project area. → Increase in number of female headed households, women as land owners, etc → Increase in awareness about conservation - oriented practices among men and women.	→ Incorporation of women farmers/landless laborers in project activities. → Women's level of participating in extension program's planning and implementation. → Mass media materials on technology and practices available. → Support for technology adoption– research, training, inputs. → Amount of funding for gender specific activities.	→ Improvement in access to resources by men and women farmers. → % of men and women adopting sustainable practices. → Increase in number of women participating in field training and farmers' group's activities. → Increase in productivity of degraded lands.	→ Improvement in land management practices, reduction in land resource degradation. → Improvement in productivity of degraded lands and Improvement in women's income. → Women's empowerment and overall well-being nutrition and health.

Environmentalism

Underlying environmentalism is the belief that environmental factors, both physical and cultural have paramount influence on the development of animals and humans, both individually and socially, and that the natural environment should be protected and conserved. The way in which people view their environment influences the way they manage it and the kind of environmental actions they will encourage. Many theorists have attempted to explain the exploitation and human induced degradation of the natural environment,. Some have linked this with the exploitation of women. Within the development literature there are some clear parallels of patriarchalism and androcentrism between environmentalism and women.

Environmentalism has influenced the process of environmental management. It is through the environmental movement that governments and people of the world are altered to environmental problems. In many instances environmental groups and grassroots people have been instrumental in creating government policy.

Environmentalism has had a considerable impact on development, and has different origins and emphasis in developed and developing countries. Unlike the upper middle class of the developed countries the poor countries and poor people are not interested in environmentalism. However, many authors have disputed that the poor are not interested (Strong, 1993; Shiva, 1993; Ghai 1994) and maintain that are many example of underprivileged groups of women within the developing countries who have taken concerted and decisive action to halt environmental degradation. Some examples cited include the Chipko Movement, the Greenbelt Movement and Bhopal.

Distinctions have been made between two major strands in Western environmental thinking. These strands are "techno centric" and "eccentric": environmentalism. Ecocentric environmentalism is characterized by environmental regulation, reformism rather than radicalism, the scientific approach, belief in economic rationality and in the possibility of environmental management. Techno centric environmentalism has been the dominant paradigm for centuries with women instrumental and managerial resource-use planning and conservation interventions: the aim has been to gain control of resources to benefit mankind.

Conversely, ecocentric environmentalism considers nature to have a value apart from its usefulness to humankind and is viewed by some as a utopian approach. Though ecocentric environmentalism is as yet a secondary stream of environmentalism it is gaining strength. This can be seen by the diverse array of ecocentric environmentalisms which are gaining support include green theory, deep ecology, social ecology and ecofeminism.

a). Green Theory

It is based on the belief that the cause of environmental problems is anthropocentrism. Vance (1993) considered that even the environmental movement, which aims to rectify the degradation, is a self-centered anthropocentric movement since it advocates saving the rainforest in case it holds as yet undiscovered valuable medicinal plants, preserving wilderness areas as part of "national heritage" and conserving resources for future generations.

Anthropocentrism, if not the direct cause of environmental problems, legitimizes the exploitation of nature. These anthropocentric values are deeply rooted in modern culture, and therefore require social transformation if they are to be overcome.

b). Deep Ecology

Deep ecology embraces a philosophy of the relationship between humanity and the natural world. Like green theories, deep ecology attributes environmental degradation- such as environmental pollution, extinction of species of plants and animals, clear felling of rainforests, over population and genetic engineering to anthropocentrism.. Deep ecologists extend the notion proposed by green theorists that human need to change their relation to nature. They believe that humans need to expand their perceptions or identification of self to encompass all life.

Zimmerman (1987) believed that exploitation occurs because humans see themselves as separate from and superior to the rest of nature. Deep ecologists advocate a holistic view of nature and suggest an ethical stance emphasizing interdependence, relationship, and concern for the community in which we live. They propose a bioregional approach practiced by a non-hierarchical grassroots democracy.

Deep ecology rejects the exploitation of some by others, of nature by man, and man by man, but it has ignored the crucial role played by patriarchalism in shaping the cultural categories responsible for western humanity's domination of nature. By denying the importance of gender and feminists analyses, deep ecology perpetuates the dualistic thinking that it seeks to transform.

c). Social Ecology

Social ecologists consider the origins of the exploitation of nature to be in hierarchical social institutions, including patriarchy. They reason that dominance relationships among humans lead to objectification, control, and manipulation of others, resulting in similar attitudes to non-human nature.

d). Ecofeminism

Ecofeminism disagree with social ecologists, who consider that social reform is the only answer to environmental problems. Ecofeminists believe social reform creates a hierarchy of oppressions.

Both the environmental and women's movements have gained enormous support during the latter half of the twentieth century. Both movements focus on the domination and exploitation that has occurred, and both are liberal and democratic in outlook. Connecting feminism with environmentalism allows many to see the relevance of both whereas; they may not have been able to consider either issue alone. Ecofeminism has arisen as a response to these connections and tempts to address a number of shared problems. Despite these parallels and connections there are dangers in ecofeminism if it reinforces traditional forms of oppression.

The most striking parallel is that the traditional role of both women and nature has been conceived as an instrumental one. Similarly, both the movements are based on the dualism- nature/ humanity, reason/ nature. In environmental movement the concern is a distancing between human and non-human, in the women's movement it is a distancing between sexes. These dualisms tend to maximize polarity and should not be seen as mere dichotomies. The dualisms tend to be seen hierarchically, without having a higher value than the other. They have also been attributed with instrumentality, some being seen to serve others.

No one version of ecofeminism encapsulates the assertions of all ecofeminists since each is rooted in a particulate intersection of race, class, geography and conceptual orientations. Some considered this diversity to be the strength of ecofeminism and encouraged pluralistic models. Despite the diversity and controversy, there are basic claims with which many ecofeminists agree:

1. The domination of women and domination of nature have important connections.
2. It is necessary to understand the nature of these connections in order to understand the domination.
3. Feminist theory and practice need to include an ecological perspective.
4. Solutions to ecological problems need to include a feminist perspective.
5. The human self is interconnected with all life.

Underlying much of ecofeminist literature is the view that the cause of the oppression of women and nature is the prevailing patriarchal conceptual framework. This framework is a set of beliefs, values, attitudes and assumptions, which shape, reflect, and explain our view of our world and ourselves. And this case is characterized by dualism organized through a value hierarchy. Chief among the dualisms is the " feminine" / "masculine" dualism with the masculine the superior form. The deviation of the feminine has been a fundamental basis of domination and many ecofeminists advocate the universal adoption of the 'feminine principles' as a way of relieving the oppression of both women and nature. However, as Cheney (1987) pointed out, 'feminine ' and ' masculine' are gender categories which refers to culturally created roles, attitudes, and modes of thought implicitly or explicitly understood as appropriate to one or the other sex, and therefore cannot be attributed to males and females universally.

One of the basic tenets of ecofeminism is the twin domination of women and nature due to the pervading influence of a patriarchal conceptual framework, but there is some debate amongst ecofeminists as the extent of this influence. As more men support ecofeminism, they realize that the patriarchal structures limit opportunities to improve equity and reinforce environmentally damaging attitudes and perspectives.

Future Directions

Environmentalism, whether in the developed or the developing countries has had a considerable impact on development. Distinctions have been made between two major strands in western environmentalist thinking technoentric and ecocentric. Technocentric environmentalism is characterized by environmental regulation, reformism, scientific approach, beliefs in rationality and the possibility of environmental management. Conversely, ecocentric environmentalism considers nature to have a value apart from its usefulness to humankind. Technocentric environmentalism has been the dominant paradigm using instrumental and managerial resource -use planning and conservation interventions.

In terms of patriarchalism and androcentrism there are clear parallels between environmentalism, especially ecocentirc environmentalism and the women within development literature. Though ecocentric environmentalism is as yet a secondary stream of environmentalism, it is gaining strength. Some of the more popular theories include green theory, deep ecology, social ecology and ecofeminism. Underlying much of ecofeminist literature is the view that the cause of oppression of women and nature is the prevailing patriarchal conceptual framework. This has been exacerbated through the development and colonialism process.

Approaches to development, women within development, and environmental management have undergone considerable change since the 1940s. Current developmental thinking in all these areas is centered on the empowerment of women and ways of devolving power to local people so they can participate in natural resource management for their own benefit. However ways of implementing the issues are not described in the literature. How do development workers encourage local community members to participate meaningfully, and how do they enable the empowerment of women? Strategies, processes and methods to operationally empowerment need to be developed and defined.

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INFORMATION TECHNOLOGY BASED NATURAL RESOURCE MANAGEMENT

Nagasree.K *

Agriculture is one of the most crucial economic sectors as well as the main employer in rural areas of developing countries, yet this sector is under increasing pressure due to rising population, limited natural resources with dwindling resource base, pressure from globalization, escalating prices of inputs with marginal returns. Different approaches are functioning to redefine agricultural extension from a process of technology diffusion to a process of facilitation through a wide range of communication, information, and advisory services (demand-driven, multifaceted and decentralized extension). In the midst of this change, extensionists are grappling with the question of how best to harness information and communication technologies (ICTs) to improve rural livelihoods.

Basheerhamad Shadrach (2006) said that India's agricultural renewal has brought the sector to a crossroads and there is an urgent need for an integrated approach towards solving the economic, social, ecological and technological problems facing the farmers, where he stressed the uses of ICTs in ensuring farm prosperity. At this juncture, it is essential that ICT's are promoted as a general solution to tackle farm problems. Moni (2004) stated that Agricultural development, along with village and cottage industries, tiny and micro enterprises, are the cornerstone for promoting sustainable rural livelihoods. On the other hand over the decades, natural resource research institutions have amassed an unprecedented amount of data, which has become increasingly complex. These conditions have rendered conventional resource management tools and methods less effective and led to the necessity of more advanced information technology for help. An agricultural knowledge and information system for efficient NRM resulting in rural empowerment and improved livelihoods is the need of the hour.

Access to information, knowledge about interventions, technology that conserve natural resources is prerequisite for any NRM activity. People must be aware and they should feel and want to be more sustainable, the intention which mobilizes them to acquire capacity. But prior to that of all they need to know is what to do and how to do it. At this juncture IT applications play a crucial role to support learning and method of application through which more sustainable management of land, water and other resources could be done. The following are indicative of types of the information to be accessed by employing information technology as a tool.

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- Land use planning
- Alternate land use systems
- Integrated farming systems
- Soil management
- Water conservation and management
- Simulation models
- Field based technologies with integrated information on soil, water, weather, nutrient and pest management models;

Some examples of NRM based Information technology:

International:

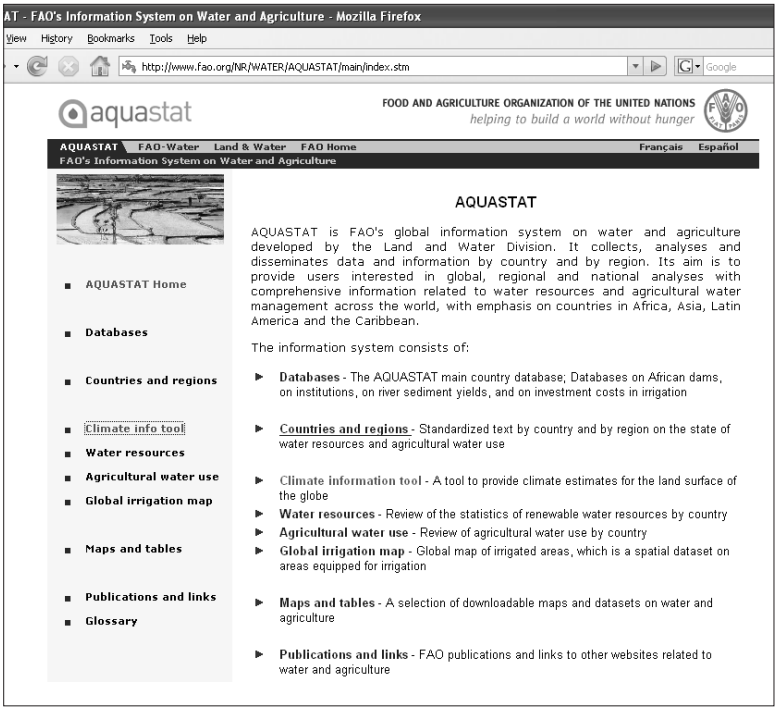
The Natural Resource Management Virtual Knowledge World

Chrishtopher Petitt *et al.* (2008) developed a platform which is user friendly to access NRM information by different stakeholders. According to them there is a wealth of natural resource management information available to land managers, farmers, researchers and the public via a plethora of websites and portals. But suitable methods through information technology could be used as a tool, which explores the development of an online virtual world for presenting natural resource information to diverse audiences. The Natural Resource Management (NRM) Virtual Knowledge World has been created using the Virtual Reality Modelling Language (VRML). Visitors to this virtual world can explore the Bet Bet sub-catchment in North Central Victoria and learn about such natural phenomena as biodiversity, climate and soil health. It can also facilitate to access information on simulated landscape processes such as flooding, erosion and salinisation. Point and click functionality of this initiative enables the visitor to download objects from a three-dimensional object library which includes a number of built structures, trees, shrubs and grass species. By navigating further into the virtual world the visitor can enter a natural resource management virtual shop and access a range of information products pertaining to landscape models, tools, frameworks, workbooks and reports. The experts told that next step in this research is to evaluate the value of such virtual worlds for enhancing the understanding of natural resource phenomena across a diverse range of user groups from policy makers to school students.

AQUASTAT

AQUASTAT is FAO's global information system on water and agriculture developed by the Land and Water Division. It collects, analyses and disseminates data and information by country and by region. Its aim is to provide users interested in global, regional and national

analyses with comprehensive information related to water resources and agricultural water management across the world, with emphasis on countries in Africa, Asia, latin america and the caribbean.the information system consists of databases - the aquastat main country database; on institutions, on river sediment yields, and on investment costs in irrigation, countries and regions - standardized text by country and by region on the state of water resources and agricultural water use, climate ,water resources ,agricultural water use, global irrigation map which is a spatial dataset on areas equipped for irrigation, maps and publications and links



Aquastat homepage with information on its services

The Forest Service Natural Resource Information System (NRIS) combines a standard corporate database and computer applications designed to support field-level users. NRIS databases contain basic natural resource data in standard formats built to run within the Forest Service computing environment. This system provides employees, our partners, and the public with access to essential natural resource data needed to support the management decisions that form the core business of the Forest Service.

Natural Resource Information system

Montana State Library meets the information needs of Montana citizens through NRIS. It provides access to information through a wide range of services, from mapping applications to reference services, from statewide databases to plant and animal field guides

Home page of Natural Resource Information system maintained by Montana state Library

Center for Natural Resource Information Technology (CNRIT) serves as an institution for research and development that takes a holistic and interdisciplinary approach to information and decision support systems for planning, monitoring and assessing management paradigms, new technologies and policy relative to the economic well-being of landholders, society and the natural resources supporting future generations using the softwares BRASS, GAAT, LINKS, NUTBAL, Pendleton Records PESTMAN etc,.

National :

Public sector IT initiatives in agriculture sector:

Several ICT initiatives are planned and developed by The Ministry of Agriculture and National Informatics Centre (NIC) which stressed the need for informatics in agriculture that lead to integrated rural development. The information provided by the initiatives is gaining importance among the stakeholders like subject matter specialists , researchers, students, academicians besides farmers. The information is being provided to farmers with a motive of improve their labor productivity, increase crop yields, and realize a better price for their produce. Some of these initiatives are described below :

AFPINET: Agricultural and Food Processing Industries Informatics Network	AGMARKNET: With a road map to network Agricultural produce wholesale markets and rural markets nation wide.
AGRISNET: An infrastructure network upto block level agricultural offices facilitating agricultural extension services and agribusiness activities to usher in rural prosperity	APHNET: Animal production and Health Informatics Network networking about 42000 Animal Primary Health Centres
ARISNET: Agricultural Research Information System Network	ARINET: Agricultural and Rural Industries Information System Network to strengthen Small and Micro Enterprises (SMEs)
CoopNet: To network Agricultural Primary Credit Societies (PACS) and Agricultural Cooperative Marketing Societies to usher in ICT enabled services and rural transformation	FERTNET: Fertilisers (Chemical, Bio and Organic Manure) Informatics Network facilitating "Integrating Nutrient Management" at farm level
FISHNET: Fisheries Informatics Network	HORTNET: Horticultural Informatics Network
LISNET: Land Information System network ("Agricultural Resources Information System")	NDMNET: Natural Disaster Management Knowledge Network
PPIN: Plant Protection Informatics Network	SeedNET: Seed Informatics Network
VISTARNET: Agricultural Extension Information System Network	Weather NET: Weather Resource System of India

A Webpage View of Agricultural Resources Information System

Agricultural Resources Information System consists of Agricultural resources management which include, Agro-climatic data, Agro-economic data, Agro-forestry resources data, Animal resources data, Capital resources data, Crops and Cropping Systems data, Environment resources data etc.

Other successful examples of Information and Communication Technologies in agriculture:

Crop weather outlook

Central Research Institute for Dryland Agriculture (CRIDA) which houses the All India Coordinated Research Project on Agro-meteorology (ACRPAM) has launched a web site Viz. CROP Weather Outlook (CWOL) for providing value added agro-advisories to the farmers in Collaboration with National Centre for Medium Range weather Forecasting (NCMRWF) of Govt. of India. AICRPAM has a network of 25 centres distributed all over India, located in State Agricultural Universities (SAUs) which supply the weather conditions and agro-advisories offered in different crops based on weather conditions. CRIDA has also gives advises on contingency crop plan based on weather which are put up in the website

e Sagu

eSagu is an IT-based agro-advisory system . It is personalized where agriculture expert advice at the farmer's door-step,query-less that farmers need not ask a question, continuous where advice is provided regularly (once in a week) from sowing to harvesting .It saves the time as it provides the advice within 24 to 36 hours and cost-effective.The eSagu system functions starts as the farmer registers into the system by supplying soil, water capital, crop details. Coordinator visits each farm once in a week and takes problematic photographs who also fills-in feedback form and takes its photograph. The data is written into CD at the village computer center. CD is sent to main eSagu lab by courier/post. Agriculture scientists at eSagu main lab prepare advice based on photographs and other information.The advice is downloaded at the village center through a dial-up Internet connection.The coordinator delivers the advice to the farmer

aAQUA: An archived multilingual multimedia Question Answer based communication system (www.aaqua.org)

aAQUA (almost All QUestion Answered): aAQUA is a smart effectively online, yet archived, web-based discussion forum, allowing users to create, view and manage content in their native language. It provides easy and fast retrieval of contextual information, documents and images using various keyword search strategies with the help of query expansion and indexing techniques. Using this, a farmer can ask a question on aAqua from a kiosk (cyber-café); experts view the question and answer back, providing solutions to the problem. aAQUA has been deployed at many kiosks in Pabal and Rajguru, Shirur, and Haveli taluka region in Maharashtra. It is available in English, Hindi, and Marathi. Being Unicode compliant system, it can support other languages also. It has been developed at Media Lab Asia research hub at IIT Bombay.

Digital Ecosystem for Agriculture & Rural Livelihood (DEAL)(www.dealindia.org)

The project is creating a platform for creation, sharing, and dissemination of agricultural information to various stakeholders. It has created an ontology based agricultural vocabulary database in Hindi with more than 28000 agricultural terms with a graphical browser interface tool. An audio blog has been developed for voice based user interface for knowledge base. The agro extension scientists at Krishi Vidyan Kendras have been trained on the use of this system in the Lucknow-Kanpur area. The system is planned to be field tested in collaboration with Krishi Vigyan Kendras and NGOs.

JAGRITI: The Jagriti model

Jagriti e-Sewa (www.jagriti.com) is a social enterprise that has pioneered the concept of development of 'Rural Models of IT'.

Role of Information and Communication Technologies in agriculture initiatives of Jagriti

- Reduction in the cost of communication and improvement of the response time to the queries.
- Creation and fast replication of training material for the farmers.
- Efficient management of inputs, stocks and the produce.
- Maintenance of the master database of the producers, agro- climatic data and farm data.
- Market demand/prices data.

Functions of Information Technology based Natural Resource Management

- The tools would serve as repository of the information on location specific natural resources (renewable and non renewable)
- It will provide information guidance and general awareness about the features of natural resources
- Helps in knowledge and information management of the natural resources
- Maintains the electronic collection of the NR related documents
- Can function as a point of reference to the students, researchers and other stakeholders

Integration of emerging tools with Information Technology for sustainable Natural Resource Management

Advent of information technology hastened the process of delivery of information to targeted clientele. The services are redefined as enabling tools in accessing information about natural resources. Efficient management and sustainable use of natural resources needs planning, devising strategy specific to the needs of a region. However accuracy and clarity are the most important criteria in providing information about natural resources management. In this context reliable, valuable true information with the use of tools like GIS, remote sensing could be provided to the end users. Nair *etal.,(*2003) stated that to accomplish a task of sustainable NRM reliable, accurate spatial and non spatial information on the land and water resources and various processes involved in the evaluation, up gradation and degradation of these resources is a basic

requirement. This information constitutes the geo information, which has a wide spectrum of application in resources evaluation, development and management. There is also a need for collection, processing and dissemination of the information in the desired manner and usable form

Remote Sensing as Information and Communication Technology tool in accessing Natural resources information

NageswaraRao (2004) stated that using the remotely sensed data from Indian Remote Sensing Satellite (IRS) having capability of resolving what is grown in one tenth of an acre. Hence it is possible to estimate the cropping area under agriculture, field crops, pulse crops horticulture and commercial crops of neighbouring states and countries. A sort of agriculture intelligence and market information can be supplied to the farmers. Similarly, the remote sensing payloads from geostationary satellites like Kalpana-I, INSAT etc. can provide hourly information on weather systems.

Geographic Information Systems

Basheerhamad Shadrach (2006) suggested the use of Geographic Information System (GIS)-assisted water management information system for the entire nation with village level disaggregated data. Such a system will enable assessing the status and quality of ground and surface water resources, and various water harvesting methods ranging from ground water aquifer recharge structures to roof top rainwater harvests. This can be followed by an intensive ICT-based mass media campaign for water literacy and development of a community learning modules for encouraging the efficient use of water resources .Combining the satellite technology with the tools of ICT, it will make possible to develop knowledge kiosks at the village level that can sell information and advisory services as commodities

Summary

Information technology would facilitate NRM information by functioning in various modes like software tools and applications, form of information or decision support systems, expert systems, networks for sharing information etc,. Access to NRM information through information technology hastens the technology adoption and enhances the productivity of natural resources used in agriculture. It also increases the efficiency of Natural Resource Management systems among the rural communities. Proper use and sustainable management of resources further mitigate the pollution effects due to indiscriminate use of natural resources

Conclusion

One of the key challenges faced by extension professionals is to transfer technology in an integrated manner suitable to the rural poor for promoting proper management of resources, sustainable technology use which requires the active participation of rural communities in communication processes . Information is a prerequisite to empower the farmers in terms of

technology utilization. Access to information will also reduce burden on the traditional extension system where man power is a major constraint the developing countries like India . With ICTs access agriculture can be improved to be more sustainable, economically viable and ecologically balanced. In the light of aforesaid facts, the real ICT's would need to be measured not only in terms of communicating to farmers, but also in terms of knowledge acquired, utilized and adapted to local needs. However with the advent of novel tools and approaches like remotes sensing, GIS, precision farming etc,. in combination with information technology would play key role in productive and sustainable natural resource management.

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OPERATIONAL ASPECTS OF POST NATURAL RESOURCE MANAGEMENT PROJECT SUSTAINABILITY AND WITHDRAWAL STRATEGY

J. Venkateswarlu

Introduction

The Natural Resources (NRs) include soil, water, vegetation and living systems (human, livestock, soil biota). Economic prosperity is achieved by running up ecological deficits. This ecological "overshoot", if not addressed, can become disastrous by 2050. We need to realize that man, despite his artistic pretensions; his sophistication and many accomplishments owe the fact of his existence to a six-inch layer of topsoil.

Thus in the watershed development programmes, retrieving the NRs to their pristine glory has been the main goal. This axiomatically leads to better productivity of crops and livestock. But what is more relevant is sustainability of the retrieved NRs after the withdrawal of the watershed development programme. On the other hand, in a recent report The Hindu (18.07.2008) states that Rs 19,200 crores have been spent on the watershed programme but the impact is "invisible". In fact the treated areas are reverting back to "original status". But NRSA (2005) states that degraded area of 63.8 Mha (upto 2000) has now come down to 55.7 Mha, a decrease from 29.19 % to 17.45 %. 'One possible reason could be the large scale implementation of watershed programmes in the country, covering an area of 45.56 Mha upto March 2005 (Anonymous 2006a). However it needs verification.

In the following pages, the present methods of retrieving the NRs, related externalities, the concerns in sharing of the usufructs and other post project lessons are presented.

Methods of retrieving the NRS

Soil conservation not only connotes water / wind erosion of the soil, but also includes conserving soil productivity. Briefly the soil and water conservation methods are both mechanical and biological. Among others, these include

Mechanical measures

- Land leveling
- Contour bunding
- Graded bunding
- Contour trenching (CCT; SCT)
- Terracing
- Contour cultivation
- Stabilized drains

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Biological measures

- Strip cropping
- Seasonal land rest
- Mixed cropping
- Cultivation of fast growing trees and early maturing crops
- Mulches
- Agroforestry
- Agropastoral systems
- Vegetative barriers
- SALT (sloping agricultural land technology)

The water harvesting systems

They can be grouped into

- *In situ* systems
- Surface runoff collection
- Diversion of perennial surface / sub surface water
- Roof top water harvesting

Water in any form (soil moisture, groundwater, surface water and rainfall) has to be frugally used. Watershed development, no doubt, enhanced recharge of groundwater. But it also triggered overexploitation of the same, leading to uneconomical, inefficient and exploitative use. The exploitation is quite alarming. Of the 7928 blocks / mandals in the country are shown to be under threat Table 1 (Anonymous 2005).

Table 1: Categorization of blocks / Mandals/ Taluks / Watersheds as over exploited and dark on all India basis

Sl. No.	States	No. of blocks / taluks / watersheds	No. of blocks / taluks / watersheds			
			Overexploited		Dark / Critical	
			No.	%	No.	%
ST						
1.	Andhra Pradesh	1157	118	10.20	79	6.83
2.	Arunachal Pradesh	59	0	0.00	0	0.00
3.	Assam	219	0	0.00	0	0.00
4.	Bihar	394	6	1.52	14	3.55
5.	Chhattisgarh	145	0	0.00	0	0.00
6.	Delhi	6	3	50.00	1	16.67
7.	Goa	12	0	0.00	0	0.00

8.	Gujarat	180	41	22.78	19	10.56
9.	Haryana	111	30	27.03	13	11.71
10.	Himachal Pradesh	69	0	0.00	0	0.00
11.	Jammu and	69	0	0.00	0	0.00
	Kashmir					
12.	Jharkhand	193	0	0.00	0	0.00
13.	Karnataka	175	7	4.00	9	5.14
14.	Kerala	151	3	1.99	6	3.97
15.	Madhya Pradesh	312	2	0.64	1	0.32
16.	Maharashtra	2316	154	6.65	72	3.11
17.	Manipur	29	0	0.00	0	0.00
18.	Meghalaya	39	0	0.00	0	0.00
19.	Mizoram	12	0	0.00	0	0.00
20.	Nagaland	5	0	0.00	0	0.00
21.	Orissa	314	0	0.00	0	0.00
22.	Punjab	138	81	58.70	12	8.70
23.	Rajasthan	237	86	36.29	80	33.76
24.	Sikkim	4	0	0.00	0	0.00
25.	Tamil Nadu	385	138	35.84	37	9.61
26.	Tripura	38	0	0.00	0	0.00
27.	Uttar Pradesh &	819	2	0.24	20	2.44
28.	Uttaranchal					
29.	West Bengal	275	0	0.00	61	22.18
	Total States	**7910**	**671**	**8.48**	**424**	**5.36**
UNION TERRITORIES						
1.	Andaman & Nicobar	1	0	0.00	0	0.00
2.	Chandigarh	1	0	0.00	0	0.00
3.	Dadar & Nagar Haveli	1	0	0.00	0	0.00
4.	Daman & Diu	2	1	50.00	1	50.00

Source: MoWR, GoI

The maximum exploitation of groundwater is in the states of Rajasthan, Punjab followed by Tamil Nadu and Haryana. Gujarat also is under threat of overexploitation.

The SWC works along with water harvesting structures enhance groundwater recharge. As seen in a recent study, Sastry *et al* (2004) the groundwater rise was 1.05, 1.57 and 1.38 meters in arid, semiarid and humid ecosystems, average being 1.51 m. (Table 2).

Table 2: Agro-climate-wise analysis of water-related parameters

Parameter / Agro climate	Arid	Semiarid	Humid
Rise in water table (m)	1.05	1.57	1.38
Reduction in runoff (%)	35.0	33.2	30.5
Reduction in soil erosion (%)	15.0	28.8	25.6
Surface water resources developed (%)	9.0	18.0	20.5
Increase in afforestation (%)	10.0	11.3	21.7

The data include:

(i) The rise in groundwater was high in semiarid region. It was relatively less in the humid zone. This could be due to high and variable slopes in this zone

(ii) The runoff and soil loss are expected to be high as the rainfall increases. However, with the intervention in the programme, there is considerable reduction in both the parameters. But the percent reduction in runoff decreased as the rainfall increased. This calls for improving systems of rainwater management in areas with increasing rainfall

(iii) Similarly, the reduction in soil loss was lesser in humid areas as compared to semiarid situations. This also points out the need for better R&D efforts in humid areas

There is the urgent need for participatory irrigation (groundwater) management (PIM). An attempt is being made by GoAP based on the work done by some of the civil societies (to name, CWS is one such) to introduce PIM in particular relation to groundwater use. Hoering (2008) discussed in detail on water to the people, drinking water and water livelihoods in three case studies in Andhra Pradesh, Tamil Nadu and Orissa. He concludes that water cannot be tackled as an isolated issue. It is an integral part of resource distribution and allocation in any given society. So water-based social movement could be uniting force for building alliance with other initiatives working to defined common property resources such as public land, forests or biodiversity.

Water (upto 85%) is used mainly for agriculture. But drinking water is the top priority in our Water Policy. It is known by every 3 decades the drinking water for humans and livestock increases by two-fold (Batchelor *et al* 2000). And the drinking water in hinterlands is largely

from groundwater. So water us efficiency in agriculture is a must. SRI (System of Rice Intensification) cultivation rice is one such example. Besides this, GoI is encouraging use of pressurized systems of irrigation (drip, micro-sprinkler, sprinkler) for enhancing WUE.

Maintenance of Soil Productivity

Management of soil productivity includes maintenance of soil organic matter (SOM) for sustainable productivity in the centre stage.

Let us realize that soil is a living system. A teaspoonful of soil would contain a billion of the micro-flora and fauna. There are several types habitating in the soils. Some are autotrophic which draw upon atmosphere for their carbon supplies. On the other hand there are quite a large number of useful organisms that are heterotrophic deriving their energy from organic sources. And it is these useful heterotrophic organisms that need organic matter in the soil as their source of energy (Broadbent 1957).

Further, organic matter also drives several other chemical processes and physical properties (Fan *et al* 2005). Thus SOM contributes considerably to increasing soil stability and resilience that are so important in food supply stability (Niggli *et al* 2007). Pimentle *et al* (2005) argues that enhanced SOM leads to better aggregate stability and biologically more active soils, increasing water retention. In fact, they reported 28 34 percent high maize yields in the Rodale experiments in the organically managed plots in years of drought. This is what the author used to see in Anantapur district during 1955-56 in the farm fields where mixed cropping had been the practice contributing more and more leaf litter on to the soil. Even runoff and nutrient losses would be reduced (Niggli *et al* 2007; Thorup Kristensen 2007). However the level of SOM that can be maintained in soil depends on its texture, the way it is managed and the climate. Thus SOM is always in equilibrium with the environment (Broadbent 1957).

For maintaining SOM, one way is on-farm turnover of organics @ 2t/ha annually is the doable system that not only provides energy to the heterotrophic organisms but also improves the soil structure leading to better aeration and water retention. Further the micro dosing of the micronutrients will not be required. There are several other opportunities for incorporating organics in some form or the others. They include

i) Preparation of bulky organics (FYM, compost, vermicompost)

ii) Incorporation of weeds

iii) Leaf litter from tree farming

iv) Leaf litter from crops

v) Turnover of legumes

vi) Green leaf manuring

vii) Integrated crop livestock farming

viii) Ley farming

ix) Mixed cropping

Improvement of Vegetation

Vegetation in any form is a moderator in erosion control. The vegetation includes, among others, crops, cropping systems, tree component, silvipasture systems and forests. It also includes soil biota.

A few of the important issues include

- Forest is the foster mother of agriculture
- Water is an important by-product of forests
- Vegetating the catchments is the best way to control siltation of water bodies
- Silvipasture systems provide the much needed feeds and fodder to livestock
- MPTs provide the fuel besides feeds, fodder and NTFPs.
- Change in crops and cropping patterns largely suggest shifts to commercial crops *in lieu* of food crops, threatening agrobiodiversity as well as ecological access to food
- As mentioned earlier all the heterotrophic soil biota need external energy. And that comes from SOM. So, turnover of small amounts (say 2 t/ha) annually is suggested either through green manuring, green leaf manuring, composts) (including vermicompost), sheep penning, etc
- The government provides subsidy to chemical fertilizers @ Rs 8/kg urea N. It has been our pleading that this subsidy should be extended to organics as well
- Moreover inorganic fertilizers are very high energy consuming and create pollution in the biosphere (e.g. N_2O atmosphere and NO_3 in groundwater). On the other hand organics are internalized systems and eco-friendly. They are low energy needed products. But their production needs more labour. And this should be met from the NREGA, which is now functioning in all the districts in the country.

We like to emphasize that good crop husbandry itself could be the best option in soil conservation. The vegetal cover provided by the crops itself is a good control measure of soil erosion. To strengthen this argument let us see the data of Hudson

(1992),which suggests that a good crop (maize) husbandry is as good as a good soil conservation measure.

Treatment	Plot A	Plot B
Plant population/ha	25,000	37,000
N (kg/ha)	20	100
P_2O_5 (kg/ha)	50	80
Crop residue	Removed	Ploughed in
Crop yield (t/ha)	5.0	10.0
Runoff (mm)	250	20
Soil loss (t/ha)	12.3	0.7
Rainfall (mm)	1130	1130

In other words a good crop husbandry is a good soil conservation measure.

From Soil Conservation To Land Husbandry

Lundgren *et al* (1993) quoted Hudson's work on Land husbandry. They said the study of soil conservation is relatively new; it only began to be taken seriously in the early part of the 20th century. So we should not be surprised that it is still in a state of rapid development with new ideas arising and earlier concepts being replaced. Current changes include even the term soil conservation, which will probably fade away to be replaced by land husbandry, because that better describes the fundamentals of the new approach. The idea of the care of crops, and their management and improvement, has for years been called crop husbandry, and animal husbandry has described the care and management of livestock. Soil conservation was appropriate when we were mainly concerned with increasing the knowledge and awareness of soil degradation, and learning how to decrease the process. But that was mainly a defensive strategy, and what we now seek is a positive approach where care and improvement of the land resource comes first, and control of erosion follows as a result of good land husbandry.

Managing externalities

An externality is said to occur when the activities of one person affect the welfare of others who have no control or influence over those activities. Externalities can be positive or negative (Anonymous 2006b).

For instance poor land use practices in upper watersheds cause increased water runoff and land degradation for downstream farmers. Changing those landuse practices in ways that

benefit people downstream could impose costs on upstream land users who would be providing positive externalities for others. Thus there is a need to compensate for the costs imposed on the upstream farmers.

This could become feasible only with and advance agreement to share the benefits of enhanced natural resource productivity. One way is to treat water as common property in the watershed areas.

Similarly gully erosion leads to deposits into downstream water bodies, which are a negative externality. On the other hand trapping silt from upstream soil erosion is a positive externality.

The externalities that occur in the development of NRs were examined by the World Bank (Anonymous 2006b). Some examples are

- *Pani Panchayat*: Salunke's approach of harvesting water from hilly catchments near Pune with an agreement to treat the water so harvested as a common property. Unfortunately the downstream land owners exploited groundwater leading to reduced storage in the water bodies (Negative externality)
- Sukhumajri: The water harvested in the reservoirs as well as the vegetation protected in the catchments treated as common property. Landless also are benefited (Positive externality)
- Water rich *Jhola*: In the KBK districts of Orissa, *Jhola* system of water harvesting is a positive externality to the *jhola* beneficiaries. On the other hand, it is a negative externality to the upstream farmers.
- Jhum cultivation: It is a negative externality to the environment; but a positive one for the practicing farmers. Orissa government (GoO) offers land rights in exchange for halting *jhum* cultivation.

Some of the more frequent externalities observed in the name of development are:

- Groundwater depletion: Deeper bore wells while benefiting the owners, deprive the shallow well as well as shallow borewell owners, particularly in the hard rock areas
- Green revolution: It is a negative externality to the ecology leading to depletion of SOM and deterioration of soil health
- Intensive commercial cropping: This led to loss in biodiversity, so important in the sustainability, particularly for the smallholders

Natural Resource Management Related Post Project Lessons

Sastry *et al* (2004) examined the lessons learnt in their NATP study on 31 completed watersheds spread allover the country. Among others, the lessons include

- Participatory, bottom-up approach ensures sustainable development in WDPs
- SCW are largely field bunding and land leveling, but not contour / graded bunding
- The institutional water harvesting structures like CDs and PTs become dysfunctional unless handed over to users for upkeep and maintenance
- The quality of SC & WHS works are not upto mark due to several slippages, damage varying from 10.6 to 49.9 % (being less in watersheds managed by the civil society)
- Groundwater tables are receding *(vide supra)*
- Shallow bore wells are drying up
- Deep bore wells are on the rise, exploiting static water (leading to a point of no return)
- WUE is poor, more so with high water requirement crops, varying from 35 % with flow irrigation to 50 % with groundwater
- With pressurized systems of irrigation, the WUE is 75% with sprinkles and 90% with drip irrigation (Patel 1999). However the draft of groundwater is on rise as the area under fruit trees, in particular, is on rise. In fact quite a few orchards are drying up and farmers are purchasing water for irrigation @ Rs 200-300 per 5000 litres
- Inspite of watershed programmes instances are seen where drinking water for both humans and livestock is becoming scarcer (Batchelor *et al* 2000)
- Large landowners are more benefited than smallholders. They also could improve their production base, the advantage being 50% more in all the socio-economic indicators
- Landless and smallholders have earned more through wages (the increase in employment being 14% over non-watershed area)
- New crops and cropping patterns have come up (e.g. sunflower, agroforestry, intercropping)
- There is a felt need for precision in use of inputs, particularly the external ones to minimize cost of production
- Soil health needs specific attention calling for turnover of organics on annual basis In sump up unless there is some common economic interest, people would not be together in development activities on a sustainable basis.

Sharing of Usufructs

The large and medium farmers (LMF) generally gain more from watershed programmes compared to the small and marginal farmers (SMF). The ideal could be gain to both LMF as well as SMF. An example comes from Andhra Pradesh (Anantapur). The APPS involved the landless and the poor in retrieving the deforested areas in several villages with a right on the usufructs. With the vegetation in the upstream, the farmers below are benefited with increased groundwater recharge. In Sukhomajri, the harvested rainwater is treated as a common property as in the case of *Pani Panchayat*. The share of landless can be sold to land owners or bartered with some economic goods. However for upscaling such an approach, advance agreements in (a) sharing and (b) not to overexploit the augmented water supply are needed.

In practice, only the landed peasantry are benefited at the cost of landless and smallholders. The evaluation study of Sastry *et al* (2004) on share of usufructs indicated the following.

Particulars	**Comparative share (%)**	
	Smallholders (SMF)	**Large farmers (LMF)**
Improved CPRs	56	78
Usufruct sharing	63	94
Fuel availability	56	83
Fodder availability	62	80
Stall feeding	31	46

It is clear that the usufructs from CPRs are more accessible to the large farmers than smallholders. Other examples come our field visits in different locations.

- In Kandi (Himachal Pradesh) landless were to take a share in green fodder grown by the landed peasantry *in lieu* of the irrigation provided to them. But in reality the landless worked as labour in the irrigated farm and got green fodder as part of their wages
- Similarly in Relmajra (Punjab) the area adjacent to the water body was to be with the fruit trees for the landless. But in reality the watchman knocked away most of the produce
- In *Pani Panchayat* (Maharashtra) the landless are to sell their share of water to the landowners. But in reality bore wells are coming up lead to increased share of water by the land owners
- Similarly in Sukhunajri (Punjab) the *babbar* grass and *Acacia catechu* grown in the catchments were to be auctioned by the habitants for sharing the money thereof. But in reality due to in-fighting recently, the same was handed over for auction to the Forest Department

In sharing the usufructs, there cannot be a universal approach. The CPRs, in particular, need a separate dispensation. The poor may be given the responsibility retrieving the CPRs to their pristine glory with an implicit understanding that the benefits so accrued are only shared within themselves. Thus, unless a properly committed advance agreement is taken up, the distortions as above will be apparent.

Requirements for Post Project Sustainability

Several studies were taken up on the issue of sustainability. It is generally found that water (rainwater harvested leading to increased groundwater recharge) and money (provided from Banks / thrift of SHGs) that hold the CBOs together. Then it would be lot easier to sustain many, if not all the components completed in the watershed programmes. Coming to the requirements, they include, among others.

- Handholding for 2-3 years even after completion of the project.
- Participatory SWC and water harvesting works
- Treating harvested water as LIQUID GOLD, establishing WUAs in managing the retrieved tanks, *talabs, johas,* etc, enhancing WUE and encouraging PIM in groundwater use and adopting SRI cultivation under tanks and wells
- Paying specific attention to the drinking water needs of humans as well as livestock
- Accepting the farmers idiosyncrasies insofar as tree component is concerned. Also ensuring biodiversity and ecological farming (crop-tree-livsetock-soil continuum).
- Establishing the pro-poor usufruct sharing through MoU in enhancing biomass in the CPRs (vegetation and water bodies), but without 'free-riding'.
- Providing compensation to the farmers who contribute part of their holdings to water bodies, tree farming, etc. In other words those who are benefited with positive externalities must accept that the project funds may be apportioned as compensation to those who are affected and/or not benefited due to negative externalities
- Road connectivity is an important requirement for sustainability in the production systems. And that is what is inadequate particularly in the hilly regions of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Chattisgarh, Jharkhand and the seven north-eastern sister states
- Treating revolving fund (RF) and watershed development fund (WDF) as recyclable fund for ensuring livelihood support systems with differential interest and loaning systems across different economic groups in the watershed
- Further training and capacity building be on continual but on payment basis
- Internalizing production systems through non-chemical / LEISA systems of farming by establishing the needed infrastructure locally in relation to seed, nutrient and pest management

- Providing proper marketing and product processing facilities including ware housing facilities on cluster village basis besides reviving local *shandys* for efficient in-ward marketing
- Establishing CIGs for marketing products directly to the dealer avoiding middleman, that too through proper MoU with a third party (Panchayat / Government) assurance
- Ensuring credit through SHGs and VOs at low interest rates

End Note

A) Action plan

With the lessons learnt, action plan for the future WDPs should be based on participatory demand driven approach. Input use efficiency (including water) must be uppermost priority so as to reduce the costs of production. Further the action plan may be on the following lines.

• Thrust programmes are needed on

a) Retrieval of degraded lands,
b) Improvement of pastures,
c) Enhancing productivity of CPRs (soil and water),
d) Recharging groundwater,
e) Mitigating drought effects,
f) Enhancing production systems,
g) Ensuring livelihood support systems for the poor and landless
h) Involving women as equal partners

- The stakeholders may be encouraged to manage slight and moderate levels of degradation while severe to very severe degraded NRs may be retrieved at the cost of budget. For this purpose, the stakeholders need to come out with proposals for funding by the WDP
- For areas covered under social fencing and controlled grazing, the needed external inputs (e.g. improved seed of grasses, fodder legumes and multipurpose trees; phosphatic fertilizer, opening up of the soil for intake of rainwater and for spread of seed and fertilizer) may be met for the budget on cost sharing basis
- Wherever self control / self sharing mechanisms are adopted, funds may be provided on cost sharing for enhancing groundwater recharge (e.g. SCT and vegetating in the commons, smaller WHSs and growing of MPTs in private ands)
- Dysfunctional tanks may be repaired on a cascade basis as should be degraded CPRs across a cluster of watersheds. Cost sharing and self management should be ensured for sustainability through sharing of both bounties as well as shortages

- Drought mitigation cannot be achieved only by SC works and WHS works. Several short as well as long term strategies are needed leading to the four banks seed, feed, grain and water, giving due priority to drinking water. The project must find funds for developing the needed infrastructure.
- The training and capacity building should ultimately by a self financing system. The project, at the initial stage, may provide funds with the needed infrastructure to the clients, who can subsequently, finance the needed training from GO / NGO on cluster basis
- By adopting the scientific norms, equity can be achieved better of course through cost sharing. Examples include

a) SC works only in lands with slopes higher than 0.75 % in heavy soils and 1.5 % in light soils

b) WHSs be small in size

c) Introduce trees only in soil classes beyond III

- Cost of production can be reduced by internalizing the production systems to the maximum extent (mixed farming, INM, NPM, village seed production). being labour intensive the two options open to achieve the above are

a) Extending the subsidy in their adoption to the extent it is available with chemicals and seed supplied by external agencies

b) Make the production systems a part of the wage employment scheme (NREGA) and provide the additional labour costs

- Find ways and means to extend handholding at least till the production and livelihood support systems are stabilized. Make / provide revolving fund in these two systems.

B) Need for innovations

Continuous flow for innovations is needed for avoiding routinization. To achieve this, a PTD approach is needed where the farmer and researcher (GO or NGO) need to work together in various production systems (crops and livestock). Rainfed farming being site specific such efforts have to be made in different agroecological niches. And separate fund must be provided for the purpose for use by all these agencies. Presently the funding is for the NARS system only.

This is more so when we consider the NRM. Earlier we used to be a part of the nature. Today we are trying to alienate from them and attempting to conquer it! So the disaster. They ray of hope is that the smallholders still hold NRs dearer to them as they essentially make a living on the NRs. And that is the reason why we still see biodiversity at the farm level of the smallholders. Let us protect the biodiversity.

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NETWORKING AND ROLE OF RURAL INSTITUTIONS FOR SUSTAINABILITY OF NATURAL RESOURCE MANAGEMENT PROJECTS

*K. Ravi Shankar**

Sound networking is sound resource management. It is to enable dialogue, share ideas and planning.

Networking and Linkages

A network is a group of people sharing a common interest or enterprise. Effective networks maintain relationships and information flow. Networking is an important linkage between research on the one hand, and analysis and knowledge production on the other hand. The growing emphasis on networking plays an important role in analysis of community based NRM activities and in producing community based NRM knowledge.

Steps in Networking

1) Form a working group of researchers, stakeholders, representatives from organizations who can identify community networks and personnel. Conduct community mapping to identify social organizations and key people in each of them. This is to know the frequency, importance and mutuality of contacts with other organizations.

2) Invite them to community workshop aiming to identify networks, trends in social context, and goals that strengthen alliances on activities which benefit NRM.

3) A network map shows the main stakeholders and the informational and material flows within the network with a view to assessing the degree of importance of the stakeholders for potential engagement. The map identifies key players and critical connections within the network and relationships between stakeholders. It reveals who lies at the center of the network, who is on the periphery and who is isolated. This process allows for a community to move in directions they think need attention for sustainability, be it social, economic or environmental without confining the agenda to environmental issues.

4) Identify strong and weak linkage patterns from social network analysis and provide feedback to the communities on opportunities for alliances. Dendograms (tree diagrams) show degree of closeness or distance among organizations. Common 'resolves' that could become the basis for collaboration between organizations, including those with previously quite weak ties, would be discussed.

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Issues in linkages

Linkages and partnerships across issues of infrastructure, research, policy, training, and institution building would constitute a bridge between external opportunities and local initiatives. Thus, linking evidence from farming households and communities to policy makers thereby influencing their decisions. Scaling up vertically is from village communities to policy makers and horizontal scaling is across people covering large areas.

Role of Rural Institutions

Many cultural, economic and political barriers effectively prevent the poor from having any real stake in development activities. Without appropriate approaches and policies to overcome these obstacles, the voices of the poor will not be heard and transfer of technology will at best be token. In this context, the approaches adopted by rural institutions become pivotal in improving the livelihoods of the poor and in enabling sustainability of NRM programmes. This article throws light on some of the successful strategies adopted by both Government and Non Government Organizations (NGOs) managed NRM projects in Andhra Pradesh, Maharashtra and Karnataka.

Key Issues in Natural Resource Management

- Complex problems and conflicting objectives
- Requires integrated multidisciplinary expertise
- Spatial variation
- Economic and equity issues

NRM activities are likely to fail, if they divide benefits unevenly but require nearly universal cooperation to make them work. A good technology that can be introduced on individual farms is likely to give better results than an excellent one that requires significant cooperation among farmers (Kerr and Sanghi, 1992).

Approaches enabling sustainability of Natural Resource Management projects

1. Segmentation or homogenization of clients

Rolling (1988) and Rogers (1995) have argued that segmentation or homogenization of the clients constitutes one of the strategies to efficiently achieve the objectives of an extension programme. Lack of social harmony undermines the success of community-based approaches (Barrett *et al*, 2005).

2. Forming farmers' groups

Self Help Groups (SHGs) provides an entry and practical form to the programme.

Successful social interventions of some watershed programmes like *Ralegan Siddhi* in Maharashtra on a participatory mode also provide clue on organizing groups. Also, change is best guaranteed when change agent is one among the clients (Anna Hazare in case of *Ralegan Siddhi*).

It Utnoor watershed, near Adilabad in A.P. managed by NWDPRA, women are empowered by making them leaders of working user groups with a concept of saving while earning through executing different works.

3. Repeated exposure

Benefits of soil and water conservation catch prominent attention through eye-catching slogans at common meeting places viz., temple, school etc. They capture the attention and interest of people as seen in *Mallapuram* watershed near Ananthapur in A.P. implemented by Rural Development Trust (RDT).

4. Transparency of activities

Physical and financial targets achieved and to be achieved are kept open for public which helps in gaining the trust of people as seen in the watersheds managed by RDT in Ananthapur.

5. Economic contribution

At *Kadiridevarapalli* watershed near Ananthapur, peoples' participation through economic contribution is compulsory both for individual and community works (Ravi Shankar *et al*, 2002). With this people become responsible when they become aware, agree upon and involve in NRM programmes, which creates a sense of ownership and control over their resources.

6. Exposure visits

Visits to successful watershed farmers' fields can also be used for training and motivating the farmer-farmer extension concept as seen in the case of *Manjunathapura* watershed (tree based farming systems) near Tiptur in Karnataka implemented by BAIF Institute of Rural Development (BIRD).

Social reformation

In *Kenkhara* watershed, Karnataka implemented by BIRD, a perceptible social change among village people was observed with activities like HRIDAYA SAMMELANA (food sharing by all village people on first Monday of each month) and SATYAVRATA (meditation by all villagers in the evenings) were being organized.

Sequence of events in NRM

Conclusion

NRM should be holistic. This process of building partnerships among local groups and external agencies links micro activities and macro structures as well as transcending individual agendas, turf struggles and entrenched roles. Groups especially women groups in the mode of self-help groups provides a promising reality in achieving sustainability of NRM projects. The success lies in achieving a fusion between the physical resources and the all-important sociocultural concerns of the people. Prioritizing gender issues, narrowing socio-economic gaps between 'haves' and 'have-nots', striking balance between individual benefits and developing community resources, and a slow but sure withdrawal strategy will pave way for sustainability of NRM programmes. Sustainability is directly linked with community participation and results only when people form into a cohesive force as a single community, raise their voices in achieving their due.

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ECONOMIC AND EQUITY ISSUES IN PARTICIPATORY NATURAL RESOURCE MANAGEMENT FOR DRYLANDS

*C A Rama Rao**

The growth in Indian agriculture has been commendable since independence. Production of different agricultural commodities increased significantly and the growth in food grain production has been faster than the population growth (Ahluwalia, 1991). The country is now better placed in terms of ability to meet the growing food needs of its teeming millions. Such a growth in agriculture has its roots mainly in investments in irrigation development, agricultural research and extension, input supply, favourable policies and the farmers' ingenuity and diligence.

However, not all the crops and regions are benefited equally by advances in agricultural technologies. The 'quantum jumps' in productivity are limited to a few crops and a few regions. Though these so-called green revolution technologies are 'scale neutral', their adoption and impact is dependent on the access to resources. In this process, a vast part of the cultivated area, the drylands or rainfed regions, are bypassed. Consequently, the disparities between the incomes and living standards of farmers practicing irrigated agriculture and dryland agriculture widened.

Now, it is well recognized that the productivity levels in irrigated crops also have reached plateau and it is becoming increasingly difficult to break the yield barriers. This growth, as it is, is a result of adoption of high yielding crop varieties, chemical fertilizers and pesticides and irrigation water. In many instances, these inputs have been indiscriminately used resulting in huge economic, environmental and social costs.

In order to deal with the growing food and trade needs as well as to make agricultural production more broad based and sustainable, it is imperative to improve the productivity of dryland agriculture. Agriculture as such is a natural extractive process and the role of natural resources in influencing the productivity is too obvious to be explored.

Dryland regions are characterized by less fertile and highly degraded soils, inadequate and erratic rainfall limiting crop-growing period and poor investment capacity of the farmers. There is a strong view that management of natural resources is vital to enhancing the productivity of dryland agriculture and to improve the livelihoods of the dryland farmers.

Land, water and vegetation (forests) are the three key natural resources that influence productivity dryland crops. The optimum management of these resources are key to dryland agricultural growth. The management of water for agriculture was largely concerned with

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development of major and medium irrigation facilities till the 1980s, notwithstanding the community-managed tank irrigation facilities, especially in South India. So during the early decades of independence, growth in surface irrigation was faster.

However, the 1980s marked a clear shift towards bore well irrigation propelled by the policies of highly subsidized power supply and liberal credit through institutional finance. The advances in groundwater extraction technologies also enabled to draw water from deeper layers. As a result, there has been steep growth in the rise of ground water irrigation.

The 'excess' of private benefits over private costs spurred overexploitation of ground water and in effect what is essentially a common pool resource is used as private property resource. Other concomitant phenomena of economic development also led to general deterioration of environment, deforestation and pollution.

Considering all these issues, it was recognized that watershed development is an appropriate approach for development of dryland agriculture and to move dryland farmers out of poverty. Staring in 1980s, investments in watershed development projects grew rapidly and attracted many national and international donors and implementing agencies. To some extent, these programs served to correct the bias in favour of irrigated agriculture though there is still lot to be done in support of dryland farmers. A watershed development programme is supported to be a holistic land use plan where in the land, water and vegetation resources are optimally utilized with participation of all the stakeholders.

These watershed development programmes were initially driven by the agricultural research institutions and gradually gave space to different government departments, NGOs and community participation. The emphasis is moving towards the participation and ownership by the community directly affected by such programmes. However, eliciting and ensuring peoples participation was found to be difficult because of the very nature of these interventions. The interventions will have different economic impact on the lands located at different reaches of a watershed. Further, the land-less and livestock owners either have no or negative stakes in some ill-planned programmes. The experience gained overtime was manifest in the guidelines being prepared by the Government of India from time to time. Many different solutions were practiced in different contexts and these have to be adapted to local situations to replicate the success in terms of watershed implementation through people participation and the sustainability. Largely, it was observed that participation by people is more likely to happen when there is a sizeable gain in terms of income, the region is 'somewhat' developed, there is visible impact in terms of creation of water bodies and the community is relatively homogeneous and where, which is somewhat difficult to replicate, there is strong and committed leadership. In a watershed development programme, besides water management through rainwater harvesting and

recharge, 'joint forest management' groups have also become popular as the conservation of forests is an important source of livelihood for the poor and also for the environmental functions that the forests play. Similarly, development of CPRs by forming user groups accompanied by appropriate technological interventions also assumed importance. Further, success of watershed programmes was found to be positively associated with social mechanisms that regulate demand for water, especially created through rainwater harvesting technologies such as farm ponds, check dams, etc.

To conclude, any programme concerned with management of natural resources for enhancing livelihoods of the farmers must be people's participatory. Stakes should be created for different sections of community so that participation can be maximized and conflicts minimized. Formation of user groups, SHGs etc supported by adequate capacity building is a vital step towards management of natural resources and the government should strive to a create an enabling environment. These should be coupled with general education and awareness among the stakeholders in conserving the resources for current and future use and the role of various instruments, both price and non-price, in obtaining the conservation behaviour from the stakeholders. In any case, all these management interventions need to be ably supported by appropriate technological interventions. In a nutshell, it is the amalgamation of technological and management interventions (institutional interventions) that hold key to sustaining the capacity of resources to be productive now and in future.

Table 1. Factors Influencing The Damage Of Watershed Structures

Independent variable	Regression coefficient	Standard error
Constant	70.529**	15.974
Rainfall	-0.002	0.010
NGO dummy	-18.476@	10.775
Groundwater rise	-9.024*	4.317
Participation	-0.163	0.162
R^2	0.42	

**, * and @ indicate significance at 1 ,5 and 10%, respectively
Source: Rama Rao *et al*, (2007).

Table 2. Estimated Logit Regression Equation For Predicting The Success of Watersheds

Independent variable	Regression coefficient	Standard error
Constant	-1.274	1.869
X_1(Farmers' participation, %)	0.025 @	0.019
X_2(Average rainfall, mm)	-0.001	0.001
X_3(Rise in GW, m)	1.147 **	0.597
X_4(Distance to market, km)	0.034 *	0.020
X_5(Distance to motorable road, km)	0.011	0.109
Percent correct Classification	70.3	
Specificity [a]	78.9	
Sensitivity [b]	67.1	
Pseduo R^2	0.31 *	

**,* and @ indicate significance at 5,10 and 20%, respectively

a percent classification when the watersheds were successful
b percent correct classification when the watershed were not successful
Source: Rama Rao *et al*, (2007).

Table 3. Benefits from Watershed Development Programmes

Parameter	No. of studies	Mean
BC Ratio	128	2.14
IRR (%)	40	22.04
Employment (persondays/ha/year)	39	181.5
Irrigated area (%)	97	33.56
Cropping intensity (%)	115	63.51
Rate of runoff (%)	36	-13
Soil loss reduced (tons/ha/year)	51	-0.82

Source: Joshi *et al*, (2005).

Table 4. Summary of Benefits From The Watershed Studies Associated With People's Participation

Parameter		People's participation	
	High	Medium	Low
BC Ratio	2.37	1.79	1.24
IRR (%)	30.8	38.43	32.43
Employment (persondays/ha/year)	201.75	138.26	176.72
Irrigated area (%)	28.87	41.08	34.03
Cropping intensity (%)	90.84	63.88	53.39
Rate of runoff (%)	12.98	8.51	15.62
Soil loss	0.85	0.8	0.81
(tons/ha/year)			

Source: Joshi *et al*, (2005).

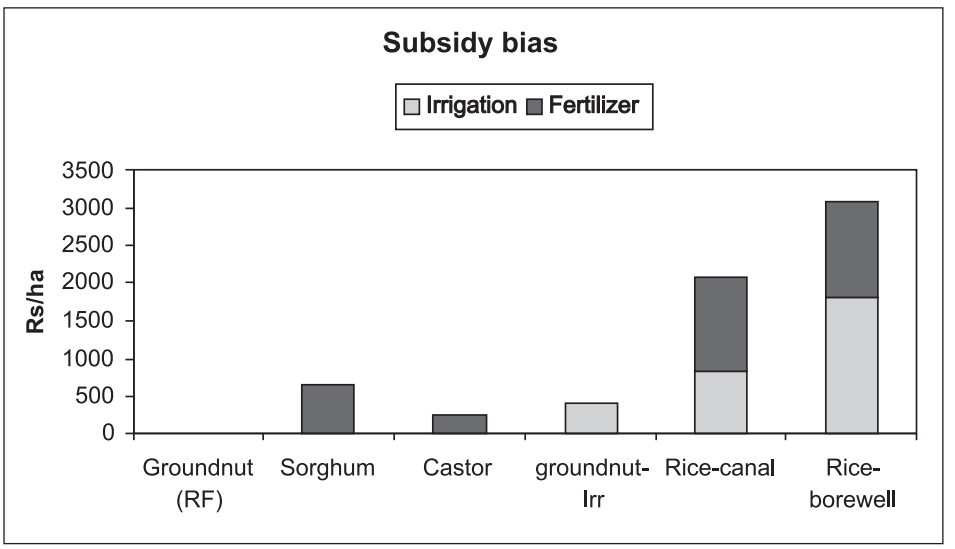

Fig 1. Subsidy bias in crop production

Table 5. Causes and effects of CPR encroachment

Encroachment by	Purpose	Affects whom
Powerful people (rich/politically strong)	Vested interest Status Cultivation	Rural artisans Women Poor
Industry	Mining	Farmers and poor (conflicts)
Pastoral community	Grazing	Pressure on CPR Poor

Source: Osman *et al,(*2001).

Table 6. Costs and Benefits of Community Management. of different CPRs

Resource	BC ratio rank	Costs	Size of benefits	Security of benefits
SW (Tanks/canal)	1	High capital costs may deter communities acting on their own	Higher crop yields Fisheries Environment	Secure Tail farmers?
Forest on forest land (JFM)	2	High cost to forest dept (degraded forests) Low survival rates Transaction and patrolling costs	Low initial returns Wages Higher when resource is poor	Not very secure, especially for timber
Forest on revenue land	3	No costs for natural regeneration Some costs for SWC with benefits	Limited	Uncertain usufruct rights
Village pastures: enclosure and rehabilitation	4	High transaction costs	Limited bi omass benefits Wages from NGO Secured community rights over resource	Certainty only during the period of lease from panchayat
GW recharge thro' tanks, check dams etc	5	Difficulty to impose rules	Dependson aquifer characteristics	Unclear and uncertain 'Free riders' Some SW benefits
Management of GW abstraction	6	Substantial monitoring and enforcement costs		Uncertain to individuals

Source: Osman *et al, (*2001).

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MONITORING AND EVALUATION: CONCEPTS AND METHODS

*S. Rajakutty**

In the study of Monitoring and Evaluation, the following basics, needs to be understood clearly to begin with.

Purpose of a programme is to convert a set of RESOURCES into desired RESULTS.

Resources are INPUTS. Results are OUTCOMES. Inputs to outcomes happens in a sequence as detailed below.

Input:

Goods; Funds, Services, Manpower, Technology and other resources provided in a project with the expectation of OUTPUTS.

Results:

Certain things happen immediately, and certain things ultimately and certain things in between these two. According to this sequence, results can be grouped into three Broad categories.

1) Output:

Specific products or services, which an activity is expected to produce from its inputs in order to achieve the set objectives (increased irrigation, fertilizer use, health facility etc.)

2) Effect:

Outcome of the use of the project outputs above the realization of expected effect in a project will lead to desired impact Intermediate results.

3) Impact:

Outcome of Project Effects (broad long term objectives: Standard of living and reducing poverty both at individual and community level) Ultimate

Monitoring:

In recent years a growing volume of literature on Monitoring and Evaluation has come into existence and fairly clear picture had emerged from them on the concepts and definitions of Monitoring and Evaluation.

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An Example

Let us assume an Irrigation dam has been built and has become operational results in the coming years/month in the Command Area of the dam. In this example, we are trying to see what happens when a dam is provided and therefore –

Sequence of Results		NRM Parameter of Command area of dam
Immediate Results (s)	**INPUT** **OUTPUT**	**Irrigation Dam** **i) Irrigated Area** **ii) Change of Crop pattern** **iii) Use of Agri. Inputs (Seeds,fertilizers, chemicals, labour etc.)**
Intermediate Result (s) (Medium Term)	EFFECT	i) Productivity ii) Production iii) Income
Ultimate Result (s) (Long Term) Agro industries, investment in agri-busin Ess,infrastructure, Social indicators.	IMPACT Development	Overall Socio-Economic

Monitoring defined:

A continuous / periodic review and surveillance by management, at every level of the implementation of an activity to ensure that input deliveries, work schedules, targeted outputs and other required actions are proceeding according to plan**.**

Another way of defining Monitoring is that it is a process of measuring, recording, collecting, processing and communicating information to assist project management decision-making.

To be precise and brief, “monitoring system is an information system for management decision making.”

A project's operation, performance, and impacts are the aspects of concern in monitoring with a view to keep track of the technical and economic 'efficiency' of the project. This is carried out in terms of;

- Whether the various tasks are carried out according to scheduled;
- Whether project results are likely to lead to realization of project objectives
- Whether project objectives / targets / execution needs adjustments

Thus, monitoring is a management function, which begin with the start of a project and ends with the completion of the project but it is a continuous process during the implementation of project. The key requirement for Monitoring is an **ACTION PLAN** without which monitoring is not possible.

Monitoring Functions Involve	Check, review, overview, keep track, observe, control, Guide, correct, inspect, supervise, verify, feed back, follow-up	Progress of programme implement with reference to Action Plan.

An Example of NRM interventions in agriculture project :-

In relation to agriculture, monitoring focuses on the operation, performance and impact of agricultural projects.

i) Project operation embraces the many tasks performed regularly or intermittently, which are essential for the proper functioning of a project. For example, the operation and maintenance of machinery and equipment, the delivery and distribution of project resources including farm inputs; credit and extension activities, and so on.

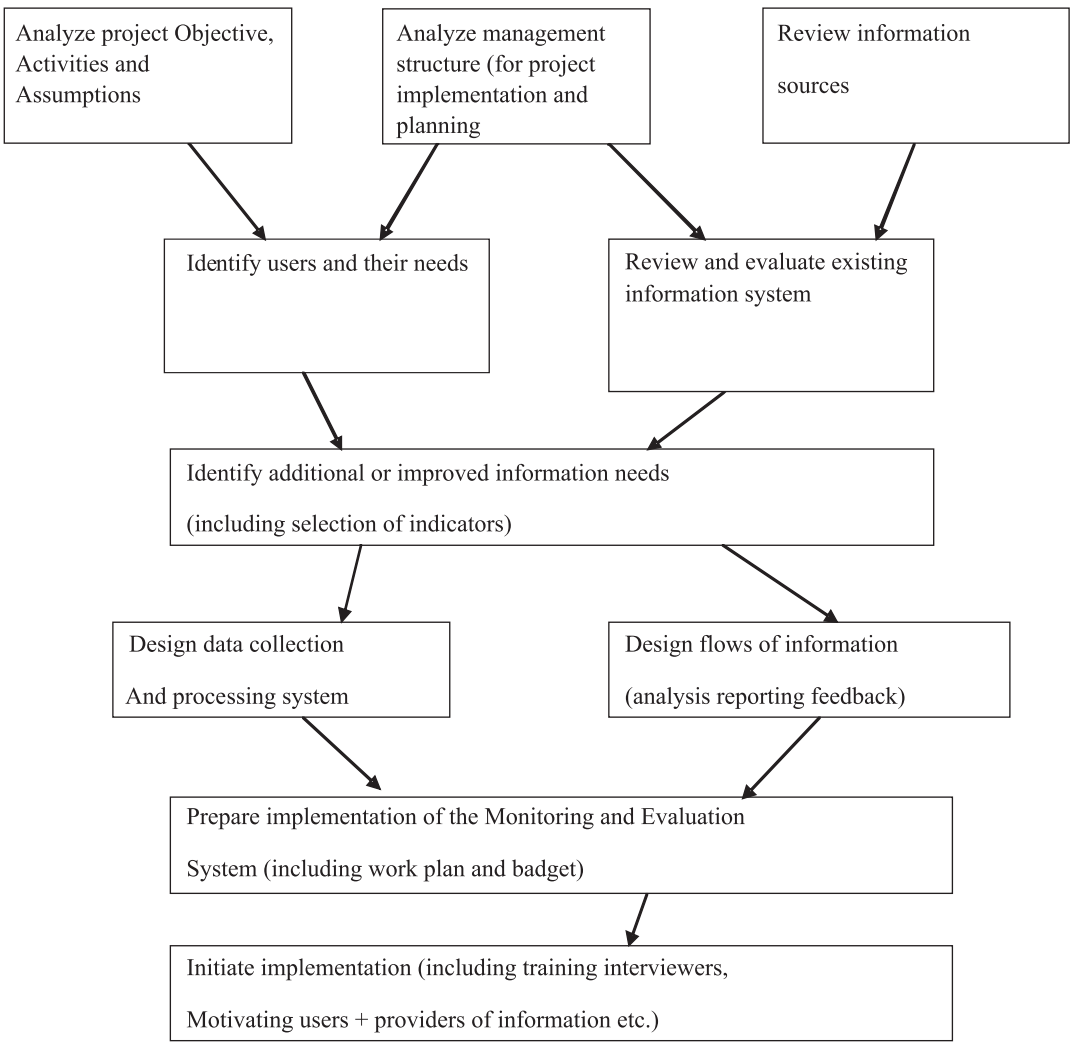
ii) Project performance refers to the level of achievement of project targest such as area of land under cultivation, supply of irrigation water, cropping systems and intensities, extension and adoption rates, project yields and production levels.

iii) Project impact relates to the effect of project operation and performance on the rural people, both on and off a project, as indicated by changes in levels and distribution of farm yields, farm incomes, family nutrition and welfare, etc. It is also concerned with changes in the local environment and economy that arise from project operation and performance (e.g. soil salinity and erosion, changing farm input and product prices.

Monitoring, therefore, is an essential tool for successful implementation of a project. During the process of monitoring, we identify the shortfalls, deviations and problems and causes for the same so as take appropriate remedial/corrective action.

Since monitoring is a management function, all those who are involved in the project implementation (who constitute the project management team at different level/sectors) will do the monitoring. This may include, even the beneficiaries when local groups/organizations have been formed as part of project strategy (e.g. Village Forest Committees and Forest Protection Committees under JFM or Water Users Committee under irrigation projects, watershed associations etc). It is important to appreciate that monitoring is not an individual's function but a collective function. When all stakeholders, including beneficiaries are involved in monitoring, then it paves way for participatory monitoring.

Figure 1: Design sequence of a project monitoring system



Monitoring and progress reporting:

Sometimes monitoring and progress reporting are misunderstood to be one and the same in view of certain common features. The similarities between the two are:

a) Both are organized and systematic flow of data of different technical/administrative operation in progress;

b) Both can be quantitative and qualitative in their approach. But there are distinct differences between them.

Table 1. Differences between Monitoring and Progress reporting

Progress reporting	Monitoring
1. Regular / ad-hoc	1. Regular / continuous.
2. Suitable to smaller projects.	2. Required in bigger and complex projects.
3. Comprehensive and covers all aspects (physical and Financial)	3. Selective|
4. Collection and reporting function. It does not ask 'Why' and 'How'	4. Collection, reporting identifying short falls / bottlenecks and their causes.
5. Required by programme administrator.	5. Programme formulator and controlling authority (Managers).
6. Emanates from primary level.	6. Carried out at multiple level (from primary central-apex)
7. Reporting of fail accompli and therefore passive	7. Regulate the pace of development-not merely records it.

Some Monitoring Techniques:

1. Regular progress report:

Progress reports submitted by field staff and records at District and Block levels should contain physical and financial progress vis-à-vis targets, coverage by blocks, composition of groups (SC/ST/Others), activities etc.

From the financial and physical progress report, it often possible to make a rapid assessment of whether, and to what extent, the original objectives of the scheme have been fulfilled, and whether it is working successfully within the allocated budget. Disbursement of funds for the scheme can be matched against other data/schemes.

2. Monitoring staff performance:

Monitoring staff performance can ensure that individuals are effectively employed to fulfill given tasks. Ideally, all those employed in a project should meet regularly, to discuss their

progress, and match this against targets and objectives, and discuss problems and possible changes.

3. Tour reports by field staff:

Often, the most useful information about qualitative aspects of a programme are obtained from the tour reports submitted by field staff; this is especially true in the case when the project is very small and the participation may posses only low levels of education and literacy.

4. Participant observation:

The field staff may stay in the villages and observe the groups closely so as to obtain sensitive, first-hand insights.

5. Reports from visitors:

The project staff ensure that all visitors to the project area (Project Director, State Level Officials, Researchers, etc.) Provide a short report on their impressions of the schemes. These can provide insights/information on new developments, exchange of experience and help in further developing the programme.

6. Interviews:

Group members and community leaders should be interviewed on their attitude towards the scheme and resultant behavioral changes.

7. Participatory monitoring:

In this latest technique, the beneficiaries themselves are made partners in monitoring evaluation. Project staff and beneficiaries discuss and assess the performance together, in order to understand how they have performed, what the problems are and what the future holds for them.

8. Key informants:

In addition to our regular contacts (as per protocol, Sarpanch/VDO), we must try to interact with other people who may be useful sources of information e.g. Village Teacher, Village Postmaster, and Women Kirana Shop etc.

9. Complaints / grievances petitions:

Many a times, complaints and grievances petition from people in general and target group in particular may throw some light on the actual performance of the scheme. Every project should make provisions for such source of information as part of monitoring mechanism.

Beneficiary contact monitoring:

Beneficiary contact monitoring is the key to successful overall project monitoring. Physical and financial monitoring the first main component of a management information system generally measures a project's provision and delivery of services and inputs. But project managers also need to know whether their services are being accepted and how they are being integrated into, for example, farmers' systems.

As a project is implemented, the perceptions of its intended beneficiaries lead either to a growing demand for its services or to its increasing irrelevance. If the beneficiaries have different motivations than those underpinning the project, it matters little which are more financially sensible. At the very least, satisfactory rates of repeated use of project-supplied inputs let managers know that the project is proceeding steadily, Low rates of repeaters can signal the need for an urgent follow-up study, for there is a chance that the project is based on erroneous assumptions.

i) Is to maintain records for each participant (feasible for credit and similar projects) and to analyze these periodically to monitor the penetration of the service and the establishment of a clientele.

ii) To establish a regular schedule of surveys to enable managers to measure the progress of a project and the response of its beneficiaries. Formal sampling techniques must be used to get statistically significant data from these surveys.

iii) To use informal interviews to alert managers to understanding success stories or problems.

Monitoring staff can develop many useful insights by talking target groups and summarizing their comments. Such interviews can be conducted at project facilities or at beneficiary's work place or residence. This quick, inexpensive method of sampling users can very effectively capture the atmosphere of a project, even if it does not rely on a representative sample.

The Monitoring staff has the primary responsibility for initiating and maintaining contacts with beneficiaries. They must also keep the project records well organized and will usually conduct interviews if sample surveys are needed.

The Monitoring staff also collates and summarized the data from physical and financial monitoring, which is often implemented by officers of various projects units. The monitoring staff then integrates those data with the information on beneficiaries' response.

Beneficiary contact monitoring requires that beneficiary s can be identified; this is possible in most agriculture and rural development projects. Project preparation and appraisal

reports generally specify intended groups of beneficiaries whether by location, type of farm eligibility for services, or willingness to use the project's inputs or techniques and give working estimates of their number.

What to Ask

Beneficiary contact Monitoring should answer the following basic questions:

- Who has access to project services and inputs?
- How do they react to these stimuli?
- How do these stimuli affect their behaviour and performance?

The need to elaborate the answers to these questions guides Monitoring planners in choosing their methods of obtaining data and in analyzing the responses of beneficiaries.

The following questions need to be answered in sequence to gauge clients initial reaction to a project.

- To what extent did persons with access understand the available services?
- To what extent were the services seen as meeting the needs of those who understood them?
- To what extent sere the services tried by those who saw them as relevant?
- Did those who tried the services continue using them?

Beneficiary Contact Indicators

Beneficiary indicators illuminate how beneficiaries are exposed and react to project services and inputs. The indicators progress in sequence from measuring the population in general to measuring beneficiaries directly involved in the project

- What proportion of the target population knows of the project's services or inputs?
- What Proportion of the target population has access to particular project services, or inputs?
- What Proportion of the target population received a particular message, service, or input?
- Of those who received a message, service, or input-who comprise the exposed population-what proportion understood its purpose?
- Of those who received and understood a message, service, or input what proportion regarded it as potentially helpful?
- What proportion of the exposed population adopted elements of the project for the first time? For example, who followed instructions, bought or applied an input according to recommendations, used a project facility, or borrowed the credit?

- What proportion of the adopting population repeated their use of project services in following seasons in a similar manner or on a similar scale?
- What proportion of the adopting population used project services more intensify in following seasons?
- What proportion of the adopting population continued practices promoted by the project even after the project's facilitating services had been discontinued?
- What in the scaled index of adopter satisfaction for example, ranging from very disappointed to very satisfied?
- What is the distribution of reasons that potential beneficiaries did not use project services or stopped participating?

Summary of Monitoring Functions

Sl.No.	Main purpose / Event	Common Technology
1	What is Expected in a project?	Targets (Physical & Financial Quantitative & Qualitative)
2	What has been done?	Achievements (Physical & Financial Quantitative & Qualitative)
3	What is the difference	Variance. (Shortfall, deviating, relative to 1)
4	Why is the observed difference?	Problems and Reasons
5	What is to be done to set right the difference?	Remedi al / corrective Action
6	Is the remedy / corrective Action done and working?	Continuous Monitoring
7	If remedy / corrective action is not working why?	Diagnosis – In depth Monitoring (Consultant / Expert advice)
8	Suggest new corrective Action?	Follow -up Monitoring

This process continue to be the project or programme is put on course;i.e., goes as per Action Plan.

Understanding process monitoring

When a set of inputs are to be converted into outputs, effects and impact theme are certain activities, actions, measure need to be carried so that we are able to more to the next stage in a sequence and in a correct manner. These interviewing tasks / actions are called processes.

Evaluation:

Evaluation is an assessment of END Results or Impact of a project with reference to the objectives set in the project.

Knowing why a programme succeeds or fails is more important than knowing what it has done. Evaluation provides answers to this crucial question and helps us to identify the strengths and weaknesses, merits and demerits. It also established Cause-effect relationship of project outcomes.

By virtue of this, evaluation is generally undertaken after the completion of a project. Evaluation helps to refine our planning tools.

It is a process for determining systematically and objectively the relevance, efficiency, effectiveness and impact of project activities in the light of their stated objective. Since objectives and unbiased assessment of project outcomes are the essential ingredients of an evaluation. It is also an organizational process for improving activities still in progress and for aiding management in future planning/programming and decision making. Evaluation provided information about past or ongoing activities as a basis for modifying or redesigning future strategies.

Some Basic features of evaluation:

1. It is always with reference to stated criteria.
2. It is always with reference to a point of time.
3. It starts where progress reporting/monitoring/estimational surveys end.
4. It establishes relationship between policies/methods and results.
5. It investigates and find out factors for success/failure and suggest remedies.
6. More qualitative in approach and emphasis is in variability than standardization.
7. More purposive and less aggregative.
8. Its problem focus is policy issues, problem formulation, organizational forms, administrative practices, and extension of technical content of programmes, people cooperation, attitude and impact.

Reasons and Precise terms of evaluation

Sl.No.	Reasons	Precise term
1	Seeing what has been.	Record of Achieve
2	Results in accordance with the objectives of the programme	Measuring progress in terms of projects end results / impact.
3	For better management	Improving monitoring
4	To strengthen the programme	Identifying strengths and weakness
5	What difference has the	Effectiveness of effects
6	Were the costs reasonable?	Cost-benefit.
7	To plan and manage programme activities better.	Collecting information.
8	To prevent others making similar mistakes or to encourage them to use similar methods.	Sharing experience.
9	To have more impact programme made?	Improving effectiveness.
10	More in line with needs of people especially at community level.	Allowing for better planning.

Table 2. Basic Differences Between Monitoring and Evaluation

Sl.No.	Monitoring	valuation
1.	Continuous: Starts and ends with a programme.	One shot operation; at a point of time (usually at completion or mid way of programme)
2.	Required for immediate use and mid -course correction.	Used for future planning.
3.	Done by implementing personnel.	Usually by outside agency.
4.	Quick but covers all units	In-depth; covers a sample
5.	Correcting / Managing	Learning process
6.	Symptomatic, early warning system.	Diagnostic.

Evaluation and Appraisal:

Sometimes, evaluation and appraisal are used interchangingly as if they are synonymous.

Appraisal is different from evaluation in that appraisal deals with economic viability, technical feasibility and social desirability of a project that is being contemplated. It is generally undertaken for large but concentrated investment project. Thus, appraisal is basically a planning and project formulation activity. Appraisal may be guided by evaluation findings of similar projects / components, which have already been implemented.

Type of Evaluation:

a) By Focus

Formative Evaluation	**Summative Evaluation**
Done during the programmes developmental stable state of stages (Process evaluation: operation mid term appraisals)	Taken up once (outcome evaluation ongoing Ex-post evaluation)

b) By Agency

Internal	**Independent**
It is a progress and as well as output, effect impact monitoring by detailed assessment (ex. post) the management (ongoing/ concurrent Evaluation)	Unbiased, objective, and by outsider (terminal, the management ongoing/concurrent Evaluation)

c) By Stages

Ongoing	**Terminal**	**Ex-Post**
During the current	At the end of or immediately after completion of project	After a time from completion of project

d)Longitudinal Evaluation: Repeat evaluation to study the sustainable of results

Ongoing Evaluation (Concurrent Evaluation)

When the monitored information is further analyzed and examined by the project management (with the help of some ad-hoc or special studies) on a continuing basis, with a view to determine the casual relationship between project input or activities and outputs and the influence of external constraints on project performance, it is classified as ongoing evaluation. More aptly this is the effect and impact monitoring exercise in programme, which are long term in nature. The idea here is to adjust or redefine policies, objective, and implementation. Since the main purpose her is also mid-course correction, it can be taken by the project staff also and therefore it is also called as internal evaluation. Such evaluation is also termed as concurrent or mid-term evaluation. Generally, this type of evaluation is undertaken in long-term projects.

Table3. Schematic Representation of M & E of a Development Project.

Monitoring	Ongoing Evaluation	Ex.Post/Terminal
Keeping track of progress in implementation of a project (in relation to target, timely control and remove of constraints and correction action	To assess continuing relevance, and present and future outputs; effectiveness and impact during implementation. Major corrections if required.	Assessment of overall output, effects and impact. Drawing lessons for future planning.
Source of Information Periodic Admin., reports observation	In-depth studies participation-observation: Sample survey, rapid reconnaissance.	Socio-economic surveys
Location of M&E Unit With in project	Parent Dept. / Ministry Central Planning Agency (can be interdisciplinary unit)	
Reporting To Project Managers/Supervisor, beneficiaries, Funding Agencies.	Project Management, Policy makers, Funding Agencies	
Monitoring Main Focus Inputs and Utilization timeliness of operation and realization of output against targets. Relationship between inputs and outputs.	**Ongoing Evaluation** Assessment of continuing validity of project design and targets, assessment of effects and review of costs effectiveness (TARGET ORIENTATION)	**Ex. Post/Terminal** Maximum and long term objectives. Differential effect and impacts on project beneficiaries. Draw lessons (BENEFICIARY ORIENTATION) and identifying critical factors
Periodicity Concurrent	Concurrent	Baseline survey before project. Repeat survey (Mid) Annual at end after a time lapse.

Designing a monitoring and evaluation system:

While evolving a suitable Monitoring and Evaluation system for any programme it is suggested that the following questions are asked and answered satisfactorily.

i) What are the purposes of M&E activity?

ii) What type of information should be collected?

iii) How will the information be collected?

iv) What methods will be used?

v) To whom will the M&E findings be presented?. How will they used?

vi) How will be the M&E system be organized and who is responsible?

vii) How many and what type of staff will be involved?

viii) What is the cost of Monitoring and Evaluation? How should it be financed?

ix) What are the likely benefits of establishing a Monitoring and Evaluation to the institution programme?

Evaluation design (How to do evaluation)

Since the primary focus of evaluation is assessment of results with reference to objectives i.e., end results or impact, evaluation would necessarily mean comparison with situation that existed prior to project. This can be accomplished by studying situations as below.

"Pre-Project" versus "Post-Project".

For obtaining pre-project situation, two methods could be adopted.

i) Carryout a sample survey at the end of the project and enquire from the project beneficiaries simultaneously their present situation and the conditions that existed prior to the project. This method, however, suffers from 'Memory or recall bias' of the respondents.

ii) To overcome the memory or recall bias, it is always preferable and necessary that a 'baseline' or benchmark study is carried out at the beginning of the project on selected parameters of likely impact. A similar baseline at mid term and at the close of project will provide us the changes brought about by the project overtime. Unfortunately in most project baseline studies are not undertaken or when available it is inadequate. Hence the pre-post (Before After design) may not give us reliable.

With-Without Project

Under the circumstances, an alternative evaluation design needs to be adopted. This method is called "With and Without" (also called as beneficiary-non-beneficiary (Control Group) design. For this purpose a comparable typical sample of beneficiaries and non-beneficiaries can be selected and studied within the project area. Alternatively, a comparable typical area adjoining the project area where project has not been implemented can also studied along with project area. The key to both the approaches is selection of comparable / typical sample.

Despite best efforts, results may not be reliable or accurate due to certain external factors like environment, policy change or other factors.

In order to obtain the best results in evaluation a combination of both the design will be the most appropriate method.

Situation	Pre (Before)	Post (After)
With (Beneficiary)		
Without (Non beneficiary)		

Six Fundamental Questions in Monitoring and Evaluation

What? What Do you want to find out

Why? Why do you want to find out

When? When do you want/need the information

How? How can I get the information I look for

Where? Where should I gather the information

Who? Who is the information drawn for and from whom should we collect the information we need

A. Certain Guiding Principles of Monitoring and Evaluation

Relevant: Geared to specific need of decision maker

Timely: Available or accessible at the time of decision making

Accurate: Reliable and empirically verifiable

Usable: Is all information used?

Flexible: To meet changing needs

Simple: Ready and easy for adoption

Participation: Management and all persons connected should be involved.

Reference

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SOCIAL REGULATION IN GROUNDWATER MANAGEMENT - EXPERIENCES FROM AN ACTION RESEARCH PROJECT IN ANDHRA PRADESH

R.V.Rama Mohan

Introduction:

Andhra Pradesh is a south Indian state with a total geographical area of 275,000 sq.km. The state is predominantly dependent on South-West monsoon during June to October with average annual rainfall of 925 mm. Rainfall varies from 495 to 1200 mm across state, with lowest reported in Anantapur district in Rayalaseema region and highest reported in Coastal region. *Rayalaseema* in the south and *Telangana* in the north are the two drought-prone regions with predominantly groundwater irrigation from private open wells and tube wells. The state has a net sown area of 10.84 m ha and net irrigated area of 4.4 m ha during 2005-06 (Directorate of Economics and Statistics, GoAP, 2006). Fig. 1 gives area irrigated from different sources in Andhra Pradesh from 1955-56 to 2005-06.

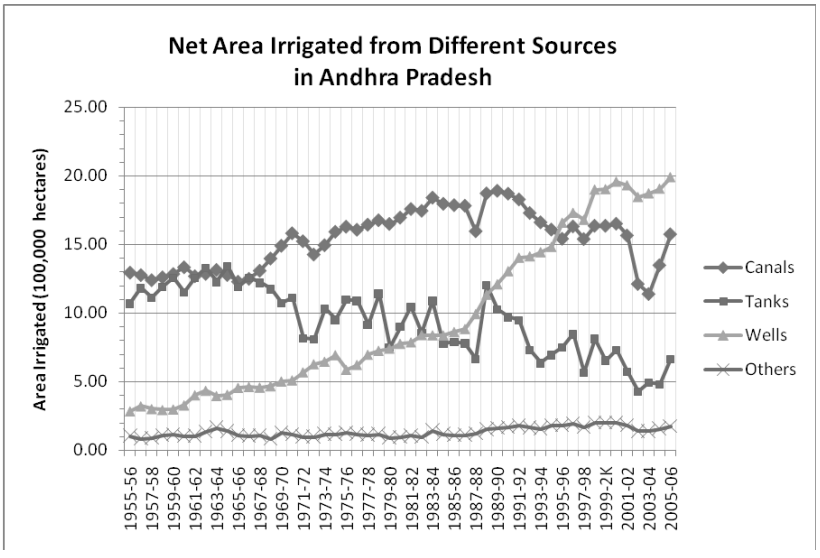

Fig.1: Net Area irrigated from Surface and Groundwater Sources in Andhra Pradesh (Directorate of Economics and Statistics, GoAP, 2006)

The net irrigated area from wells has been increasing (as per Fig.1) up to 1998-99, but later started to stagnate or grow at a slower pace till 2005-06. The net area irrigated by groundwater is about 45.23 % of total net area irrigated in 2005-06. The gross area irrigated by groundwater is reported to be 2.796 m ha out of 5.996 m ha of total gross area irrigated in Andhra Pradesh during 2005-06.

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Classification of Micro-basins in Andhra Pradesh

Andhra Pradesh has 23 districts with 1114 blocks and 28234 villages. During 2004, the Ground water department divided the state into 1229 micro basins, having an average of 25,000 ha. and classified them according to the stage of groundwater development. This classification was based on groundwater levels recorded from selected observation wells and secondary information available on the pumping intensities and cropping patterns in each micro basin.

As per their report, Groundwater Department classified 187 micro basins as over-exploited (groundwater development > 100%); 82 micro basins in critical condition (groundwater development > 90%); and another 203 micro basins as semi-critical (groundwater development > 70%) out of the total 1229 micro basins in Andhra Pradesh as shown in Fig. 2.

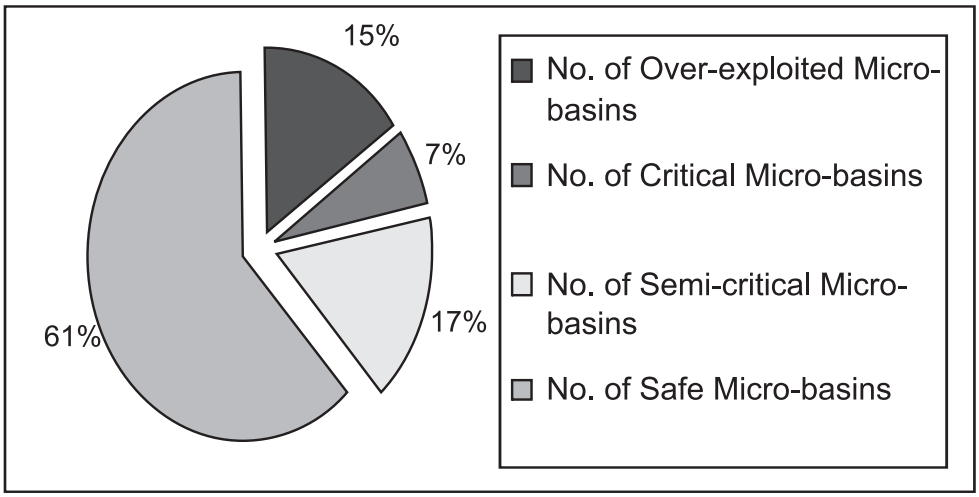

Fig.2: Classification of micro-basins in Andhra Pradesh (Groundwater Department, GoAP, 2006)

Groundwater levels declined by 2.5 m, on average, during the period 1998-2003 in Andhra Pradesh (Department of Disaster Management, GoAP. 2003). Obviously, this decline could be much more in over-exploited and critical basins.

Trends in Groundwater Irrigation Between 1993-04 and 2000-01:

The over-all increase in gross and net irrigated areas under groundwater (as per Fig.1) is only a macro picture and does not reveal the variations in micro trends across the state. While area irrigated by dug wells has been decreasing, the area irrigated by shallow and deep tube wells has increased rapidly over last decade. In over-exploited and critical areas, due to exponential increase in well density, the yield and area irrigated per well has been reducing. Table 1 below reveals temporal variations in number and net area irrigated under different types of wells.

Table1. Number of wells in Andhra Pradesh between 1993-94 & 2000-01

Type of well	1993-94		Gross Area irrigated (ha)	2000-2001		Gross Area irrigated (ha)
	Total	In Use		Total	In Use	
Dug wells	1216412	1018370	1245166	1185216	946393	1040644
Shallow tube wells *(Less than 70 m deep)*	317197	304358	617978	656359	637003	1010388
Deep tube wells *(More than 70 m deep)*	31216	29839	121969	87482	85601	242505
Total	1564825	1352567	1985113	1929057	1668997	2293537

Source: (Ministry of Water Resources, GoI, 1993-94 and Ministry of Water Resources, GoI, 2000-01)

Above table reveals those numbers of total and used dug wells have been reducing with corresponding reduction in gross area irrigated. Shallow tube wells more than doubled between 1993-94 and 2000-01, but the gross area irrigated increased only by 63%. Deep tube wells increased by three times and correspondingly area irrigated doubled.

Area irrigated per well has reduced from 1.22 to 1.09 ha; from 2.03 to 1.59 ha; and 4.09 to 2.83 ha respectively from dug wells, shallow tube wells and deep tube wells. The reduction in area irrigated per well is significant in shallow and deep tube wells. While these are average values taken across over-exploited; critical; semi-critical and safe areas, it is obvious that these values will be on higher side when calculated for over-exploited or critical area categories separately.

Further, following data given in Table 2 indicate alarming increase in number of wells with less water discharge, among shallow and deep tube wells, between 1993-94 and 2000-01.

Table 2. Status of Wells in 1993-94 and 2000-01

Type of well	1993-94		2000-01		% Change in wells discharging less water
	Wells In Use	Wells with Less Water Discharge	Wells In Use	Wells with Less Water Discharge	
Open wells	1018370	440016	946393	376303	-14.5
Shallow Tube wells	304358	68204	637003	177967	+160.9
Deep Tube wells	29839	8020	85601	34216	+326.6
Total	1352567	516240	1668997	588486	+13.99

Source: (Ministry of Water Resources, GoI, 1993-94 and Ministry of Water Resources, GoI, 2000-01)

Reduction in number of dug wells and wells discharging less water are due to further slippage of wells as dry wells over this period. Most of those shallow and deep tube wells that are discharging less might be located in over-exploited; critical and semi-critical areas in that order.

Policy and Regulatory Framework in Andhra Pradesh

Repeated droughts and alarming depletion in groundwater resources during the late 1990s prompted the AP State Government to lay emphasis on efficient water conservation and management. The last decade has witnessed promulgation of various acts and guidelines related to water management. One such measure is the enactment called Andhra Pradesh Water, Land and Trees Act (APWALTA) in 2002. This Act repealed earlier legislations such as Andhra Pradesh Ground Water Act (Regulation for drinking water purposes), 1996 and Andhra Pradesh Water, Land and Tree Ordinance, no.15 of 2000. Table 3 gives the chronology of events in water-related policy evolution in Andhra Pradesh.

Table 3. Key events in water policy evolution in Andhra Pradesh

1996	Enactment of Andhra Pradesh Ground Water Act (Regulation for drinking water purposes)
1997	Enactment of Andhra Pradesh Farmers' Management of Irrigation Systems Act to promote participatory management of irrigation systems in the state
1999	Spelt out Vision 2020, emphasizing the importance of water management and participatory approaches to irrigation management for sustainable growth in the agriculture and fisheries sectors
2000	Andhra Pradesh Water, Land and Tree Ordinance (no.15)
2002	Enactment of Andhra Pradesh Water, Land and Trees Act (APWALTA)
2002	Release of Guidelines for Watershed Development in Andhra Pradesh based on the national guidelines (1994) and recommendations of the reviews done time to time during later years
2003	Andhra Pradesh Water Vision defining a broad policy framework for water management in the state

The APWALTA, enacted on 19th April, 2002 by Act no.10, is a comprehensive act covering surface and groundwater resources. The act aims to promote water conservation, enhance tree cover, and regulate the exploitation and use of ground and surface water. The act empowered the State Government to appoint a state level authority, namely, Andhra Pradesh Water, Land and Trees Authority. The Authority has the mandate to promote water conservation, enhance tree cover, regulate exploitation of ground and surface water, make regulations for the functioning of the authorities at District and *Mandal* level (administrative units within Districts), and advice the Government on various legislative, administrative and economic measures and for the strengthening of public participation.

Various provisions under the Act are broadly categorized under the following four headlines (Government of Andhra Pradesh, 2002 & 2004):

- Groundwater protection measures
- Surface water protection measures
- Trees
- Miscellaneous, including penalties

Provisions related to groundwater listed under 'Groundwater protection measures' are quoted below:

- All groundwater resources in the State shall be regulated by the Authority
- Owners of all wells and water bodies shall register their wells / water bodies with the Authority
- Prohibition of water pumping in any particular area in the State
- Prohibition of and penalty for drilling new bore wells in any particular area in the State
- Any person shall obtain permission for drilling a new bore well (other than drinking purposes) within 250 m of a public drinking water source
- Declaration of over-exploited areas and ban on sinking new wells in these areas (other than drinking purpose). Periodic review of status and provision to revoke the declaration
- Protection of drinking water sources by prohibiting extraction of groundwater from existing wells in the vicinity that are adversely affecting the drinking water source. Compensation to the owner for closure of existing well
- Prohibition of water extraction for sale from an over-exploited water source or aquifer or residential areas or premises of multi-storied buildings in urban areas
- Specification of well spacing and depth for sinking new wells to curb unhealthy competition to tap water from deeper layers of groundwater
- Registration of drilling rigs by rig owners
- Issue guidelines and impose conditions for rainwater harvesting measures in residential, commercial and other premises and open spaces to improve groundwater resources
- Formulate guidelines for recycling and reuse of waste water by industrial, commercial users and local bodies
- Prohibition of groundwater contamination from any source, including industrial, domestic and aquaculture/agriculture
- Regulate sand mining to prevent depletion of groundwater and protect public drinking water supply sources

Specific rules and procedures were issued time to time through Government Orders on the above broad provisions in the Act. APWALTA rules and procedures were revised comprehensively and a single-window approach was introduced in 2004. As per this system, a farmer can submit an application to get a permission to drill a new well to a single office (the Mandal Revenue Office) and the decision would be announced within 15 days.

The State Government came up with a notification in February 2005 listing 4003 over-exploited villages (15%) out of the total 26,586 villages and banned further exploitation of groundwater and sand mining in these villages. Table 4 gives the region-wise classification of these villages in Andhra Pradesh. That implies no new permissions to drill bore wells will be entertained from these villages. It was also stated in the notification that, the status of groundwater exploitation in these villages will be reviewed every six months and necessary modifications done.

Table 4. Number of villages notified as over-exploited in Andhra Pradesh

Region in Andhra Pradesh	No. of *mandals* covered by notified villages	No. of notified villages
Coastal	64	395
Rayalaseema	169	1378
Telangana	232	2230
Total	465	4003

Source: (Government of Andhra Pradesh, 2004)

The Government of Andhra Pradesh introduced well failure insurance scheme for the bore well owners in March 2005. As per this provision, farmers who take permission from the concerned authority and drill a bore well, are eligible to claim the insurance subjected to a maximum limit of Rs.10,000 in case the well turns out to be dry. Farmers were required to pay Rs.1,200 towards insurance premium, in addition to the geological survey charges of Rs.1,000 (Rs.500 for small and marginal farmers) towards the cost of site investigation by a qualified hydro-geologist.

In June 2005, the State Government through a notification defined the minimum spacing to be maintained from existing drinking and irrigation wells, while according permission to new wells. Minimum spacing to be maintained in case of shallow tube wells is 260 m from an existing irrigation well and 250 m from an existing drinking water well. As per this rule, a farmer who sought permission for drilling a new well will not be allowed to do so, if its proposed location is within the specified minimum distance.

From 2006-2007, the Government decided to revise the insurance scheme for failed bore wells through the Commissioner, Rural Development by maintaining a corpus fund instead of being tied up with insurance companies. All those bore wells which were drilled after obtaining necessary permissions under APWALTA are eligible for insurance compensation of Rs.10,000 or actual expenses, whichever is less. In the new system, the farmers need not pay any premium for obtaining the insurance cover (Government of Andhra Pradesh, 2006).

Role of Energy In Groundwater Management

Total installed capacity of electricity generation in Andhra Pradesh is 12330.12 MW (as on 31st January 2008) with 26,027 MU of cumulative energy generation. Maximum electricity consumption takes place during post-monsoon period when agricultural consumption peaks, touching as high as 200 MU per day.

Most of the wells in Andhra Pradesh are energized with electricity supplied free of cost and for about 7 hours per day. As per the reports of Central Electricity Authority, consumption of electricity for agriculture has reached 14,160 Giga Watt hour during 2004-05 in Andhra Pradesh which is about 36% of total electricity consumption in the State.

The Central Power Distribution Company, one of the four electricity distribution companies in Andhra Pradesh, reported an increase of 33% in demand for agriculture between 2003-04 and 2006-07 (CPDCL, Andha Pradesh, 2008-09). Electricity purchase from other sources and States is contributing to the huge revenue deficit to the company. The company projected a revenue deficit of Rs.1150.3 crores for the year 2008-2009. Table 5 gives number of agricultural service connections in the state and increase of connections in 2007-08. The table reveals that there is an increase around 50,000 connections per year, on average, some are due addition of new wells and some from regularization of un-authorized connections.

Table 5: Status of Agricultural Service Connections in 2007-08

Agricultural Services	As on 31.03.2007	2007-08 (upto Jan 2008)	As on 31.01.2008
Distribution Companies (DISCOMs)	2439632	48844	2488476
Rural Electricity Service Corporations (RESCOs)	88168	1578	89746
Total	2527800	50422	2578222

(APTRANSCO, 2008)

In many areas, distribution transformers are over-loaded due to increasing wells; unauthorized connections; use of non-standard motors and use of higher capacity pump-sets. Low voltages at pump-sets are affecting the discharge and the life of pump-sets. This low energy efficiency in transmission and at the pump-set level is also a major contributing factor to the slippage of wells to less discharge condition and further to dry condition.

The new State Government introduced free power to agricultural pump-sets during late 2005, to replace the previous tariff system based on the horsepower of the pump. Though free power was supplied to farmers, the Government has been limiting the number of hours of power supply from 9 hours to 6-7 hours a day due to shortage of power, especially during *Rabi* crop season (the dry season, from November to February). Still the free power scheme was a major trigger for the steep increase in number of energized bore wells (data given in Table 5) and deepened the power crisis during *Rabi* and summer months. Hence, there is a direct conflict between the policy promoted by the APWLTA and the power supply policy in terms of incentives for the farmers to exploit groundwater.

Alternative approach of Social Regulation of Groundwater (Rama Mohan, 2007)

An action research project called "Social regulation of groundwater management at community level" was initiated in 2004 in three villages in Andhra Pradesh by the non-governmental organization Centre for World Solidarity (CWS), Secunderabad, Andhra Pradesh in partnership with local grass-root NGOs RIDS, Jana Jagriti, Nava Jyothi and CROPS. The project covers 715 families in 4 villages in 3 districts of Andhra Pradesh. The project aims to promote local regulation and management of groundwater resources with equitable access to all families in the communities. The project cost was around Rs. 2 million per year, over the last 4 years.

The four project villages, Madirepally (Anantapur district), Mylaram (Medak district), CR Pally (Anantapur district) and Enabavi (Warangal district) are in the semi-arid regions Rayalaseema and Telangana of Andhra Pradesh with repeated occurrence of drought. In all four villages, rain-fed agriculture is the norm, but groundwater is an important contributor to irrigation on 6-35 % of the land. Erratic rainfall and recurring drought conditions prompted farmers to use groundwater, which is more reliable and controllable. Groundwater provided the much-needed life-saving irrigation during prolonged dry spells during the rainy season.

Initially, open wells were dug and electrical centrifugal pumps were used to extract groundwater. Farmers started drilling bore wells from the early 1990s and shallow open wells gradually dried up due to falling groundwater levels. Over the last 15 years, the number of bore wells grew rapidly in these villages. Due to indiscriminate drilling of bore wells and unscientific groundwater exploration, many bore wells failed either at the time of drilling or during later

years. Furthermore, drilling bore wells as deep as 300 ft resulted in drying of shallower open and bore wells. This phenomenon resulted in huge loss of investments to farmers and seriously affected the livelihoods of farmers dependent on irrigated farming.

The project interventions began with a participatory assessment of the water resources status in the four villages. Participatory Rural Appraisal (PRA) methods were used to map the resource status and existing water utilization pattern for different purposes, such as: drinking, domestic, irrigation. Growth of groundwater-based irrigation and trends in groundwater levels over a period of time were thoroughly discussed and analysed in community level meetings, wherein women and men from all households participated. Series of such meetings and interactions helped to arrive at the crux of the issues, i.e., frequent failure of bore wells and increasing debts of farmers due to investment on new bore wells.

The competition between neighbouring farmers often leads them to drill bore wells as close as 2 m apart. For instance, in Madirepally village, three neighbouring farmers dug 13 bore wells in an area of 0.5 acres over a period of four years in competition to tap groundwater (see Fig.3a & b below). The project realized that there is need for changing the mind-set of farmers from "competition" to "cooperation" and to increase the "water literacy" among the farmers for efficient use of water.

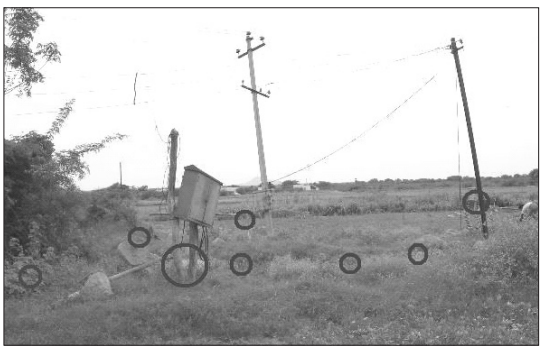

Fig.3a. Bore wells drilled in competition (Before the Project Intervention)

Fig.3b. Neighbouring Farmers Sharing Water (After The Project Intervention)

A number of training programs, exposure visits and awareness raising meetings were organized by the grass-root partner NGO and supported by CWS in the project villages. Further public awareness and education was carried out through posters, pamphlets and wall-writings. Participatory hydrological monitoring of rainfall and groundwater levels in selected bore wells was done regularly and shared and discussed at village meetings to increase the understanding of farmers on the behaviour of groundwater in relation to rainfall. A volunteer from the community measured rainfall from a simple manual rain gauge station installed in the villages and recorded the static water levels in 10 sample bore wells using an electronic water level indicator (Fig.4). This data was displayed on a village notice board and updated periodically.

Fig. 4. Participatory Monitoring Of Groundwater Levels

The last 3 years of intensive grass-root work and facilitation has resulted in the community realizing the ill effects of indiscriminate drilling of bore wells and use of groundwater. The community evolved and agreed on the following 'social regulations' and interventions in the village:

- No new bore wells to be drilled in the village
- Equitable access to groundwater to all the families through well sharing
- Increasing the groundwater resources by conservation and recharge
- Efficient use of irrigation water through demand-side management

Small groups of farmers were formed in all the project villages between a bore well owner and 2 or 3 neighbouring farmers who did not own bore wells. Bore well owners were motivated to share by explaining that drilling new wells in the vicinity of their wells may render them dry due to competitive extraction of groundwater. Instead, sharing a portion of water from his well helps his neighbours and at the same time secures his access to water and thus livelihood. Sharing water with their neighbours will be a “win-win” situation benefiting both the bore well owners and water receivers.

Fig.5: Sprinkler System In Use For Irrigating Groundnut Crop

Small farmers were given priority in formation of groups. Table below gives the number of such sharing groups in each village. Group members were encouraged to save water by using micro-irrigation kits (sprinklers) and share water from the existing wells rather than drilling new bore wells in the vicinity of existing ones. The project linked up with the existing 50% subsidy on micro-irrigation systems from the government scheme and offered additional subsidy of 20% to the groups to encourage sharing practice.

Surface water harvesting and retaining structures were renovated, and existing dry open wells were converted into recharge wells. Regular monitoring and recording of hydrological information, such as rainfall, water levels in 10 sample wells and water storage in all surface water bodies was done since 2004. Groundwater draft (also called extraction) for different purposes, such as irrigation, drinking and domestic was calculated based on the data collected from the villages.

Water sharing in the three project villages* as of 31st March 2008

	Madirepally	Mylaram	CR Pally	Enabavi
No. of functional bore wells	64	60	34	22
No. of bore wells under sharing system	64	39	34	5
No. of farmers sharing the water	135	107	56	15

** The project was initiated in Enabavi village from Jan 2007 only. Hence, only few wells are shared so far*

While creating access to groundwater to around 182 farmers who do not own bore wells, the project was successful in reducing the groundwater extraction in the project villages. The project aimed at bringing all functional bore wells in four villages under the water sharing system by 2008.

Conclusion and Recommendations

The above analysis of groundwater situation in Andhra Pradesh gives the broader scenario in terms of use, management and regulations. Following major observations can be drawn from the above analysis:

- Exponential growth of wells in the state resulted in decline in groundwater levels and area irrigated per well
- The net irrigated area by groundwater increased until 2000 but remained stagnant afterwards. This could be the beginning of declining trend if number of wells and well density tend to increase in future

- The existing regulatory framework failed to check the indiscriminate growth of wells in the state
- Enactment of APWALTA did not help in systematic development and management of groundwater in the State after 2002.
- The free electricity policy of the existing government is in contradiction of the objectives of APWALTA and further deepened the crisis in electricity sector and groundwater situation
- Though limited hours of electricity supply, there is no restriction / regulation on pump capacity or depth of pump or number of wells per person

As per APWALTA, drilling new bore wells is not allowed within a specified distance from an existing irrigation bore well. This restriction denies many farmers access to ground water, while the existing bore well owners continue to enjoy unrestricted access to groundwater. Social regulations and mutual sharing of water is required to address this "disparity created by APWALTA". It is suggested to amend APWALTA and provide measures and incentives for farmers to come together and share from existing bore wells within the stipulated distance from existing bore wells, instead of drilling new bore wells. Introduce differential and higher incentives on micro irrigation systems to groups of farmers willing to share water.

Alternative approaches such as social regulations in groundwater management and sharing mechanisms shall be scaled-up for ensuring equitable distribution of groundwater without stressing the energy and groundwater resources. Local self governments (*gram panchayats*) shall be empowered by APWALTA to manage and regulate the groundwater resources within their area of operation.

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