Abstract

Harnessing Wisdom for Managing Watersheds: Honey Bee Perspective on Innovations, Institutions and Policies for Marginal Environments

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Participatory approaches for watershed management are now considered essential for sustainable natural resources management and yet there is very little opportunity for intellectual participation by the people. This requires understanding of the local knowledge systems and their institutional context.

In this paper, we provide an overview of the conceptual framework which can facilitate such participation. The full report being published separately includes case studies of farmers' innovations in natural resources management.

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Household survival in marginal environments such as mountains, dry lands, and flood prone regions require tremendous creativity. As was noted in Alice in Wonderland, you have to move very fast and work very hard even to remain where you are. The choice for large number of households is to sustain the livelihood support systems such as the catchments, biodiversity, other natural resources, etc., in a manner that they do not get trapped in a downward spiral of erosion of resources, self-esteem, and of course, economic opportunities. The fact that despite various odds, including lack of policy support, so many communities and individuals manage not only to conserve resources but also augment them is something that this monograph is all about. The Honey Bee perspective builds upon what poor people are rich in i.e. their knowledge, creative potential, and institutional heritage. The discourse on participation often is restricted to the concept of either physical participation in terms of labor or social participation in implementation of externally designed policies and programmes. In this study, we draw attention to the scope of intellectual, moral, and institutional participation of local communities in reconceptualizing the watershed approach and implementation process. The greatest irony of watershed projects is that they founder after they are 'handed over' to the people by the project implementation authorities. If the watershed projects are designed, owned and implemented by the people, why should the question of handing over arise at all? Unless we, the external facilitators, learn to participate in peoples' own plans (Gupta, 1995), the possibility of building upon peoples' knowledge is very remote.

It is extremely opportune that international and national institutions are recognizing the need for incorporating indigenous knowledge and institutional heritage in the design and implementation of modern watershed projects. This blending of traditional knowledge and contemporary innovations developed by people without outsiders help will not take place unless we understand the policy and institutional context of technology generation and diffusion for rain fed, mountain, and dry regions. The macro policy and the framework for organizing incentives to ensure peoples' participation in design and implementation of watershed are discussed in part one. In part two of the paper we critique the formal models of technology development and transfer. We argue that technology development process in highly ecologically heterogeneous environments cannot take place in the classical lab to land framework. It will require land to lab to land, and land-to-land approaches (Gupta, 1987; 1989a; Richards, 1985). Part three deals with the framework for institution building in watersheds. The contention here is that self-regulating behavior is essential for managing natural resources in the long run. We deal with the institutional aspects of watershed development. Here we focus on two particular aspects,

(a) institutional triggers for technological solutions and
(b) technological triggers for institutional innovations.

This is a relationship, which has not been adequately appreciated while designing policies and programmes for watershed management in various countries. Part four, provides illustrations of more than fifty technological and institutional innovations from the Himalayan region as well as western Indian dry regions.

1. Reconceptualizing Technology Development and Transfer Process: Honey Bee Perspective

The traditional models of on-station development of technology and its transmission to farmers are no longer feasible, since high ecological variability demands niche-specific solutions. Local solutions developed by farmers themselves need to be identified and their scientific bases understood. The value-added scientific principles have to be shared back with farmers, who would then be able to develop technologies through their own research and experimentation. Thus transferring 'science' and not just technology (Gupta, 1989a; 1994b). Supporting and developing such experimentation is an important task for scientists and outsiders. Perhaps the most crucial challenge is for scientists to realize that how they can participate in people's programs rather than asking how people can participate in formal outside initiatives.

This change in outlook, within less than three decades of the onset of the green revolution, is a result of the increasingly complex interactions between local socio ecological and institutional conditions, and externally induced technological change. In other words, the challenge technology designers face today is how to move away from delivering fully-tailored cloth towards supplying semi-stitched cloth which may be tailored by users themselves, keeping local specifications in mind (Kumar, 1985 p c). This requires both an understanding of the tailoring process on the part of the people, and an understanding of local preferences, criteria and specifications on the part of researchers.

Another reason for seeking participation is that it provides opportunities to scientists to recalibrate their scales of measurement and co-ordinates of perception. Perhaps what is more important is developing in scientists the ability to learn how to participate in the plans, programs, experiments and missions of farmers themselves (Gupta 1980; 1987a; 1987b; 1987e; 1989b; 1995d; Anonymous, 1995, Atte, 1992). Ashby *et al*. (1987) had rightly criticized the excessive emphasis on the so-called diagnostic research methods that treated farmers as objects of investigation and in the process lost the farmers' voice. She emphasized that participatory research should involve farmers as co-investigators and researchers, and demonstrated, through farmer-managed trials, creative ways of understanding farmers' criteria for selecting varieties. Gupta (1987d), while describing the dynamics of homestead utilization by women, provided examples of the criteria used by poor women in the management of sweet potato seedlings, that had never formed a part of formal scientific research. There are many other examples, including the excellent research of Richards (1985; 1987) that demonstrate the need for scientists to participate in farmers' own research programs.

However, any process of collaborative learning can be meaningful and mutually enjoyable only when the classificatory schemes or taxonomies used by the partners are matched. It is not necessary to synthesize these taxonomies, but it is essential to understand the various vectors on which each knowledge system organizes information and generates patterns of knowledge. Does it matter in a dialogue between farmers and scientists in Peru whether the potato is distinguished by its local name, Puka suytu, or only by its Latin name, *Solanum tuberosum* (Vasquez, 1996)? It does not when two classificatory schemes are mere tools to highlight the strengths of the knowledge systems on which

they are based. But when one system's superiority is asserted, or when the scientists use scientific language to mask their inability to understand the richness of the vernacular, there is a problem.

A second aspect of matching taxonomies is the need for formal science to realize that an indigenous taxonomy would be extremely rich when the variance in any phenomenon critical for the survival of that community is high. The community breaks down the phenomenon into a larger number of discrete categories, and characterizes each category by a different name. Thus, for instance, Eskimos have a large number of words for snow, and fisher folk many names for varieties of waves. Each category symbolizes not only a pattern but also a theory underlying the classification and interrelationship of different categories.

1.1 Reciprocal Framework of Research: Contingent Perspective on Participation

Often, uncovering the farmers' own experimental approaches and heuristics may be sufficient to help them to redefine the problem and devise appropriate solutions (Gupta 1987c, 1989c; 1989d; Pastakia, 1995). But in some cases, farmers cannot devise solutions on their own. On-station research becomes necessary and farmers will have to merely participate in evaluating results or monitoring the experiments for any counter-intuitive observations. Normatively, we should not consider one form of participation superior to the other. Thus, farmers' participation in the scientists' own experiments need not necessarily be superior to scientists' participation in farmers' research. Both forms have their own advantages and limitations. In order to evolve a contingent framework, it is necessary to match the different methods of participation with the different approaches to defining the purpose of participation. The same method, say on-farm research, may not address all kinds of problems.

1.2 Defining the Problem

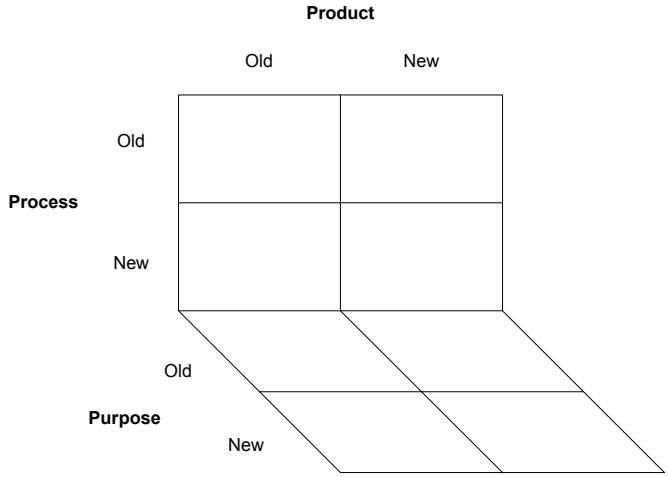
It is a truism that the proper definition of a problem is half the solution. And yet, very often, we do not know whether our definition of the problem is correct or not. Let us take the case of weeds, which are considered to be a menace in rain fed crops. In the conventional definition, weeds are plants out of their place. But in nature, no plant can truly be out of its place. It is possible that we may not know the significance or role of a particular weed as a companion plant. For instance, the distribution of minerals in a field may help certain plants grow faster or slower. Thus, weeds may act as indicators of soil mineral properties (Hill & Ramsay, 1977). If we know the variability in the soil nutrient profile, we can follow precision farming that will lead to economy and efficiency in input use. Once the existing heterogeneity of nutrients is known, it is possible to study the reasons and take remedial action. Another way to look at weeds is to ask ourselves why farmers are selective in removing weeds. They obviously must be recognizing the allopathic interactions of various plants. A good example is a weed (companion plant) called *Sama* (*Echinocloa colonum*), which grows on its own in paddy fields, or is cultivated in certain parts of the country. Why would farmers conserve a 'weed'? There may be several reasons: (a) it is an extremely nutritious grain suitable for consumption during fasting (b) a review of literature shows that it provides an alternative host for a few insects including leaf roller which do not affect paddy crop but get attracted to *Sama* and (c) some other ecological function which we are not aware of as yet. It is not without significance that farmers have conserved this weed through socio cultural mechanisms such as a particular festival, *Sama pancham*, when only grains like Sama are eaten. If sustainability requires a long time frame and a wide variety of

heuristics through which our choices should be processed, then a strong case exists for understanding how farmers define a particular problem (Gupta 1981; Gupta *et al.*, 1995).

1.3 Widening Alternative Choices

Primarily drawing upon the Honey Bee database, Pastakia (1996) studied grassroots innovators involved in sustainable pest management in order to understand their decision-making processes. He identified two particular heuristics which were not reported in the formal scientific repertoire: (i) use of insect and plant material for repelling pests and (ii) increasing the growth of a crop to minimize economic damage by a pest instead of controlling the pest itself. The heuristics that the innovators used to derive such solutions included various combinations of materials (or products), methods (or processes) and products, each of which had a sustainability dimension determined by the renewability of the resources involved (Figure 1). An analysis of a farmers' heuristics in these three dimensions of Product, Process and Purpose as shown helps us in understanding firstly, where the innovation was actually done and secondly, how best modern science can intervene to improve upon.

Figure 1. Combinational heuristics



Source: From an unpublished paper presented by Anil K. Gupta and Kirit K. Patel to scientists at Gujarat Agricultural University, Anand in 1994.

[I] Old methods, old material and old products: Old methods, old materials and old products signify the traditional wisdom, which may have relevance even for the contemporary context. For instance, Virda is an age-old technology for conserving rainwater in a saline arid region with saline ground water. In a predominantly flat region, rainwater gets stored in minor depressions or tanks. Within these tanks, the pastoralists dig shallow wells lined with frames of wood of *Prosopis juliflora* and grass. Just ten inches of rainfall provide sufficient fresh water, which remains above the saline ground water inside the wells. The *Virdas* are covered with silt and sealed. They are opened, one at a time, depending upon the need. The water remains sweet for two to three months, after which it turns

saline due to the upward movement of saline water. This technology has enabled the pastoralists in Banni pastures to survive for several centuries. The season's rain may fall within a few days, hence the need for a robust, efficient and adaptive strategy (Chokkakula & Gupta, 1995; Ferroukhi & Suthar, 1994).

In such a case, modern science does not merely help explain the functional viability of the technology, but also provides a basis for abstraction and generalization. For instance, once the properties of wood and grass, the pressure that the walls will need to cope with, the infiltration rate and the functions of the saline soil in holding the salts are explained, the search for other materials and methods for similar outputs may begin. There is very little advantage that the prior art of knowledge in modern science can provide while dealing with such complex questions of survival in difficult regions.

[ii] Old methods, old materials and new products: The hair, which constitutes the mane of camels, is known to be very hardy and resistant to corrosion. Traditionally, the pastoralists make different kinds of ropes, carpets and bags out of this hair. Once science figured out the use of these carpets as oil filters in oil refineries, a new product was developed from the old method and material. Similarly, sisal rope has been used in various activities, both for commercial and domestic purposes. It was found that these ropes could withstand corrosion better than any other material in the sea. Thus a new use for material grown in poor soils is generated. The processing of sisal is very painful because of the various tannins released into the water in which sisal plants are immersed for some time. When the fibre is taken out, these tannins cause blisters on the hand. Simple technologies have been developed to take the fibre out without hurting the hands. Modern science can blend in with the traditional methods while leaving other choices intact.

[iii] New methods, old materials and old products: In many of the cumin-growing regions, farmers had observed that the plots on the roadside were more productive than the ones in the interior. They figured out that the dust which settled on the plants saved them from certain pests and fungal diseases. Some other farmers observed a similar phenomenon near brick kilns. Dusting with ash or fine soil thus became a new method for controlling pest and fungal diseases in this crop. In many other crops, the use of ash as a dusting material is well known.

Similarly, the case of termite control using cut immature sorghum stalks in irrigation channels, reported earlier in this paper, opens up a new field of research. So far, sorghum breeders had been looking for landraces with a low hydro cyanide content. This innovation opens up the opportunity for selecting high hydro cyanide content sorghum lines. If this technology works in different parts of the world, dry farmers may very well grow a small patch of such sorghum for pest control purposes.

[iv] Old methods, new materials and new products or uses : Some innovative farmers have used a drip of castor oil (a tin box with a wick hanging over an irrigation channel). The oil drips into the water and spreads into the soil, adding luster to the banana crop. This drip is also used in other crops for soil-based pest control.

Examples for other combinations are listed in the table below. What these examples show is that farmers can be extremely creative in solving local problems. But the issue is whether their knowledge systems can be blended with formal scientific research. One block may possibly be the tension

between the farmers' interest in solving the problem and the scientists' interest in developing a new theory. For instance, a farmer, Khodidasbhai, after reading about three different practices for controlling a pest in a local version of Honey Bee, used all three on the same crop, in the same season, but sequentially. It is quite possible that scientists would not attempt such an experiment in order to avoid a complicated design with confusing results. Learning to break old rules, which formal training does not easily permit, can be a useful purpose of participatory research.

Process	Product	Purpose	Example
Old	Old	Old	Virda
Old	Old	New	Inter-cropping with ar har dal to protect Maize from frost
New	Old	Old	Virda with lateral pipes
New	Old	New	C V Raju's tree-based dyes
Old	New	Old	Uplenchwar's herbicide
Old	New	New	Drip of castor oil to add lustre to the banana crop
New	New	Old	Mansukhbhai's cotton stripper
New	New	New	Amrutbhai's Auruni

1.4 The Threats to Local Knowledge: The Case of Honey Bee Network

Erosion of knowledge is as much, if not a more serious problem than the erosion of natural resources. We can probably reverse the declining productivity of natural resources like soil through watershed projects or other resource conservation strategies. However, erosion of knowledge cannot be easily reversed once lost. The regeneration of resources and knowledge associated with these resources has to be seen in a single as well as multiple generation framework (Gupta, 1990, 1992, 1996, Gupta *et al*, 1994).

Consider first the single generation situation. The ideal sustainable situation occurs when both resources and knowledge have been conserved, but what happens when one or the other is eroded.

When the resources are conserved and the knowledge is eroded (as in the case of state-controlled conservation of resources through parks or sanctuaries keeping people out of the resource), the sustainability of the system becomes endangered. If knowledge is eroded, the erosion of resource cannot be far behind.

When the knowledge is conserved but the resources are eroded, the sustainability of the system is more likely if local knowledge is incorporated in strategies of regeneration. The knowledge will also be eroded, however, if it is not used.

The least sustainable single generation situation occurs when both the resources and the knowledge become eroded. The folk knowledge once eroded may be almost impossible to reconstruct or rejuvenate. Erosion of knowledge was never so rapid as in our generation because of declining inter-generational communication.

As bleak as the single generational picture is, consider now the multi-generational situation. Again, the ideal situation occurs when both knowledge and resources have been conserved.

The situation where knowledge has eroded and resources have been conserved is not a likely scenario. This is so because a re source cannot be sustained over generation without drawing upon local knowledge at all. Under conditions of no human intervention or access, certain resources like forests may be conserved over generations without incorporating local knowledge. But with the increasing influence of human-made factors on the survivability of forests through acid rains, global warming, and erosion of upper catchments etc., as well as increasing population pressures, we doubt such a situation could occur.

The case of erosion of resources and the conservation of knowledge over several generations leads to a possibility of sustainability if knowledge has been documented through efforts like the Honey Bee network and is available to people, regeneration of resources is possible within a long time frame.

The worst case of all occurs when both knowledge and resources have become eroded over several generations. Only rare repositories of knowledge may exist among some bypassed communities.

Whether the analysis is performed in a single or multiple generational setting, the key is the same. The conservation of knowledge is as important as the conservation of resources, if not more so. Thus, any system of conservation should be directed not only at rewarding communities for the conservation of resources, but also at rewarding them for the valuable knowledge they hold, create and recreate.

In the context of the biologically rich, low-mean/high-variability income areas discussed earlier, emphasis is placed on providing short-term relief, employment, and other means of subsistence in high-risk environments in order to alleviate poverty. The economic stress on the community erodes their self-respect and dignity. The will of the people to struggle and innovate gets subdued. Both the resource and the knowledge around this re source get eroded.

1.5 The Evolution of the Honey Bee Network

In order to stem knowledge and resource erosion, the Honey Bee network, a global voluntary initiative was launched nine years ago. Its purpose is to network the people and the activists engaged in eco-restoration and reconstruction of knowledge about precious ecological, technological, and institutional systems used by other people.

This network aims at identifying the innovators (individuals or groups) who have tried to break out of existing technological and institutional constraints through their own imagination and effort. What is remarkable about these innovations is the fact that most of these require very low external inputs, are extremely eco-friendly and improve productivity at a very low cost.

It is necessary to note here that organizations of creative people, which take the form of networks or informal cooperatives or just loose associations, would generate a very different kind of pressure on society for sustainable development. The spirit of excellence, critical peer group appraisal, competitiveness and entrepreneurship so vital for self-reliant development, may emerge only in the networks of local ‘experts’, innovators and experimenters. It is true that every farmer or artisan does experiment. But not every one is equally creative and not in the same resource-related fields. The transition of the developmental paradigm from ‘people as victim’s perspective to that of the people as

potential victor's is the answer. Former may generate patronizing and externally driven initiatives where as the latter may spur endogenous initiatives by people themselves.

Honey Bee network newsletter is brought out in seven languages in India (English, Hindi, Gujarati, Kannada, Tamil, Punjabi and Telugu) and Dzonkha in Bhutan so that dialogue with the people takes place in their own language. The creative people of one place should be able to communicate with similar people elsewhere to trigger mutual imagination and fertilize respective recipes for sustainable natural resource management. The Honey Bee network is head quartered at SRISTI (Society for Research and Initiatives for Sustainable Technologies and Institutions c/o Prof Anil K Gupta, Indian Institute of Management, Ahmedabad), an autonomous NGO.

It is realized that the technological innovations cannot survive without institutional innovations and support structures. Hence we have been documenting the ecological institutions, which have been evolved by the people to manage knowledge and resources as common property.

Honey Bee insists that two principles are followed without fail: one) whatever we learn from people must be shared with them in their language, and two) every innovation must be sourced to individuals/communities with name and address to protect their intellectual property rights.

It is possible to take the current global debate on biodiversity and peasant knowledge beyond rhetoric. Our network extends into 75 countries at present. Some of the colleagues have started similar documentation in their respective regions. Offers have been received from Nepal, Sri Lanka, Uganda, Paraguay and Mali for local language versions.

Honey Bee also appeals to fellow researchers, activists and planners in other developing countries to identify native wisdom both to inspire and also to provoke the young minds to explore. In every country a very strong oral tradition of knowledge generation, validation, scrutiny and diffusion exists. Honey Bee strongly believes that boundaries between formal and informal knowledge systems may often be false. The informal system may have formal rules waiting to be discovered. The formal system may have informal beliefs, accidents, or conjectures providing impetus for further inquiry.

Honey Bee has already collected more than five thousand innovative practices predominantly from dry regions to prove that disadvantaged people may lack financial and economic resources, but are very rich in knowledge resource. That is the reason we consider the term 'resource poor farmer' as one of the most inappropriate and demeaning contributions from the West. If knowledge is a resource and if some people are rich in this knowledge, why should they be called resource poor? At the same time, we realize that the market may not be pricing peoples' knowledge properly today. It should be remembered that out of 114 plant-derived drugs, more than 70 per cent are used for the same purpose for which the native people discovered their use (Farnsworth, 1988). This proves that the people in majority of the cases had done basic research linking cause and effect successfully. Modern science and technology could supplement the efforts of the people, improve the efficiency of the extraction of the active ingredients or develop them from natural resources, there by improving effectiveness (Gupta, 1991a).

The scope for linking scientific search by the scientists and the farmers is enormous. We are beginning to realize that peoples' knowledge system need not always be considered informal just

because the rules of the formal system fail to explain innovations in another system. The soil classification system developed by the people is far more complex and comprehensive than the USDA soil classification systems. Likewise, the hazards of pesticides residues and associated adverse effects on the human as well as entire ecological system are well known. In the second issue of Honey Bee out of ninety-four practices thirty four dealt with indigenous low external input ways of plant protection. Some of these practices could extend the frontiers of science. For instance, some farmers cut thirty to forty days old sorghum plants or *Calotropis* plants and put these in the irrigation channel so as to control or minimize termite attack in light dry soils. Perhaps hydro cyanide present in sorghum and similar other toxic elements in *Calotropis* contributed towards this effect.

Honey Bee in that sense is an effort to mould markets of ideas and innovations but in favor of sustainable development of high-risk environments. The key objectives of SRISTI thus are to strengthen the capacity of grassroots level innovators and inventors engaged in conserving biodiversity to

(a) protect their intellectual property rights,
(b) experiment to add value to their knowledge
(c) evolve entrepreneurial ability to generate returns from this knowledge and
(d) enrich their cultural and institutional basis of dealing with nature.

Of course no long-term change in the field of sustainable natural resource management can be achieved if the local children do not develop values and a worldview, which is in tune with the sustainable life style. Thus education programs and activities are essential to perpetuating reform. That is also the reason why we have organized biodiversity contests among school children to identify little eco-geniuses.

2. Institution Building in Watershed Management Projects

Sustainability of some of the traditional soil and water conservation structures in many mountain regions, dry regions and other areas has come under stress in recent times. And yet, there are few contemporary institutional models that have survived one generation without any decline in the quality of leadership or management of resource. Many of the traditional institutions have worked successfully for several generations and through small innovations - or improvements from time to time in technology as well as institutional processes. Many of the modern projects seem to be designed for failure after the project management team withdraws from the scene. How do we avoid spawning failure and ensure not just success but a sustainable success in watershed project is the purpose of this note.

Our contention is that there are time-tested processes of institution building, which somehow have never received adequate attention in watershed projects. The results are obvious. Extremely good and effective watershed projects have faltered when external interventions or incentives are withdrawn as if people were implementing somebody else's project. In some cases when projects have indeed sustained their effectiveness, the cost at which the success has been achieved has been ignored. In still other cases, the innovations in the process underlying the successes have never diffused even to the neighboring villages. This evidence puts the question mark on the very strategy of establishing demonstration watershed projects. Nobody ever expected in the canal irrigated regions that after looking at the advantages of canal irrigation, farmers will on their own design and manage secondary

and tertiary irrigation channels (Gupta, 1996). And yet, in watershed projects such an assumption is made despite considerable evidence to the contrary. This paper therefore also suggests the limits of institution building processes and need for complementing between internal and external incentives for managing watersheds in stressed environments.

2.1 How do Institutions Evolve?

About eight years ago in an action research project in dry-land regions of Karnataka, we asked a question in a village meeting, "What were the activities which the villagers have done collectively without any outside help?" The answers were very instructive as expected. Different villagers had a strong tradition of collective action in religious, cultural and socio-economic fields. In one village, the people had organized a rotating saving and credit association. The discount money from the chits was not distributed as dividend. This was used to build a temple and buy necessities for the local primary school. In many other villages, people have managed common breeding bulls, a tank, common land for compost pits, common drainage, temples, etc. And yet, when we design watershed projects, we never look into the processes and the dynamics of these existing institutions.

2.2 Grafting and not just Crafting Institutions

There is a considerable research done on crafting institutions (Ostrom, 1992). And very little on 'grafting' institutions. Whenever we initiate a collective institution in any village we obviously do not begin in vacuum. There is a history of people working and sometimes not working together and watershed project must deal with this history explicitly. The so-called participatory techniques by missing the issue have failed in generating an organic fusion or blend between traditional and modern institutions. Fifteen years ago we came across an interesting example of this fusion in a village in Ahmednagar district of Maharashtra. In a dry land village, people had planned planting of tree seedlings on an auspicious day as a part of a watershed project. They wanted to carry the seedlings in a cradle, normally used for carrying the idol of the local deity on religious festivals. Important dignitaries had been invited next day for the function. However, during the previous night when discussions were going on in the temple premises about the arrangements, somebody raised the issue of impurity of soil and thus impossibility of using the cradle meant for deities for this purpose. Everybody was perplexed. They did not know what to do in the available time. A carpenter's son belonging to a lower caste was standing at the gate of the temple and listened to this question. Being a person of lower caste, he was not allowed to participate in the discussions. However, he pleaded with the people to be given a chance to solve the problem. He knew of a cradle lying in somebody's house unused. This cradle originally meant for the children was in a bad shape. However, he could repair it during the night and thereby make it available before the function so that people could carry the seedlings in this cradle in a procession without changing any programme. Everybody liked the idea and accordingly an excellent function was held and tree seedlings were planted. Such a fusion sometimes takes place serendipitously. But can it also be planned? (A volunteer of the Social Centre, Ahmednagar during an institution buildup exercise there narrated this incident in 1985).

2.3 Fusion of cultural and modern institutions

Sometimes grafting of tradition and modern cultural and institutional values can be planned. In Gujarat, a very large-scale movement of water recharge has been triggered by Swadhyaya Move-

ment, building upon people's cultural and religious values without any injection of external resources. In many traditional situations, the place of origin of a natural spring or a stream in mountain areas is considered a sacred site and sometimes would have temple to signify it. There was an interesting case in Bhutan, which went to the court on the ground of violation of sacred space. A farmer had cut a tree from a sacred space from the upper reaches of a stream. When people protested, he did not confess his fault or do anything to atone for the mistake. Eventually, the case went to the higher court where the judge held the offender guilty and asked him to plant trees as a part of the punishment in the sacred space and take care of them regularly till the trees were established. Incorporating respect for such institutions in modern jurisprudence may help in recognizing that sustainability without involvement of the spirit was not possible in the long term. The functional attributes of a technology were not sufficient to generate the kind of respect that is called for in an inter-generational time frame.

2.4 Inter-locking of Resource Management Institutions

Institutions seldom evolve in isolation. Links across resource and property regimes evolve to generate cross-sectoral incentives for sustainability of institutions. During our recent visit to Himalayas, we came across an excellent institution in Belehra, a remote village in the Kangra district of Himachal Pradesh. Way back in 1954, the then Punjab government offered the villagers usufruct rights of grass on a 80 acre degraded forest land in order to provide them with regular supplies of grass for their livestock. However, the government insisted that the farmers would have to generate the necessary funds to regenerate the degraded land and also maintain it. The farmers agreed and on the advice of the government, they pooled one tenth of their individual land holdings and formed a joint farming society. They decided that the land pooled would be cultivated collectively and the revenues thus generated will be used to regenerate the degraded forestland as well as manage it. The forestland was thus regenerated and the fodder from the forest distributed among the farmers. The surplus funds are deposited in the name of the joint farming society and are spent on common facilities such as school, a dam on a nearby stream, guest house etc. Unless a farmer participates in the joint farming of the land, he is not allowed to claim a share in the grass from the forestland. Grass is an important resource for the livestock during dry seasons and a farmer cannot afford to lose his share. The institution is particularly interesting because of the inter-locking arrangement between two resource management systems actually contributing to its sustainability. Thus fusion between two or more institutions can generate generalized reciprocities (Gupta, 1989e; 1995) among the communities- a step considered necessary for generating cooperation among heterogeneous communities.

2.5 Portfolio of Institutions across property right regimes

The institution building process also involves recognizing the boundaries of the common properties and the relationship between common, public and private properties within and outside the watershed areas. During 1988, Prof. Gupta was invited by the state planning board to look at the dry land development programmes of the state. During the visit to Mittmerri watershed in a dry-land region, it was noted that several farmers had experienced increase in the water table in their private wells in the downstream of a water storage structure. This was to be expected. The project design and management structure, however, did not discuss how would the gains from the rise in water table to private individuals be shared with the community. The gains were obviously not a consequence of

the contribution by well owners alone. Large number of non-well owning dry farmers and land less pastoralists had also contributed to the conservation of the catchment area by not grazing their animals. The benefits were restricted to only a few. In the same watershed several second-generation problems of maintenance of waterways, weirs and spillways had arisen. The common fund that did exist did not require contribution from such individual well owning beneficiaries and therefore was limited in its scope.

Let us extend the same example to look at how resource utilization is affected by the technology used vis-a-vis the change in property right regimes. In one of the watershed projects in Andhra Pradesh, an open tank was converted into a percolation tank in order to increase water table level. But the result in the next few years was exactly contrary to the expectations, a drastic fall in the overall ground water table level was experienced. The reason being that, once the level in the private wells began rising due to the recharging of the ground water, farmers started over-extracting water from the wells. In other words, once the regime under which the control of access to water shifted from a common property in a tank to a private property in a private well, the sustainability of the resource itself was at stake.

There are many cases where we have looked at the issues in management of common property right regimes with the framework of commons ignoring the interface of such regimes with private and public resources (Gupta, 1985a, 1990).

2.6 Organizing inequity

A successful project can come under stress by neglecting the component of institution building processes across social classes. The implication for the project designers is to recognize that in any collective project everybody cannot gain equally in every subset of the project. By using portfolio approach, inter-locking of the institutions and inter-sectoral incentives could be so designed that unequal distribution of resources in each sector could generate equitable distribution at the portfolio level. Organizing inequity at the sectoral level may thus be a key to organize equity at the portfolio level. Those who depend upon grazing alone should get a higher share of the biomass from the common land so that those who get the benefit of water table in the private well lose in some resource market just as they gain in the water market. Likewise, those who gain substantially should make larger contribution to the common fund in such a way that maintenance of common structures and activities can take place regularly. Such a possibility of organizing equity / inequity may require the inter-locking of institutions across resource regimes.

2.7 Augmenting voluntary spirit

In large number of hill areas, particularly in the Himalayan region, ranging from Hunza region in Pakistan to Kashmir, Himachal Pradesh, UP, Sikkim, Bhutan and some parts of North-East India, there is a long standing tradition of voluntary labor, partly obligatory and partly paid for maintenance of irrigation streams called *kuhls*, *guhl*s or *nalas*. Every household is supposed to send one or two members depending upon the need for cleaning the channel and repairing it before the on-set of rains. The decisions to distribute the water and also to deal with any violations are also taken collectively. Similarly, during the contingency of any landslide or a breach there are well-established norms for contributory labor to repair the structures (Gupta and Ura, 1992). The concept of people's

participation in many watershed projects and national policies ignore the subtlety of local arrangements. Disregarding the local endowments and needs in a given terrain, uniform principles are applied across different socio-ecological regions. There are instances of extreme distorted interpretation of participation. For instance, the statistics of the number of women working as paid labor have been used to show high participation of women (Chokkakula, 1997). The extent to which they participated in decision making and generating agenda for the project was totally ignored.

On the other hand, an interesting dilemma arose in a watershed programme in dry regions of Gujarat when one of the participating NGOs wanted to change norms of people's participation. Premjibhai who had planted through his own resources more than 400 tonnes of tree seeds in different parts of the state during last ten years (Chokkakula, 1997) took up the implementation of watershed programme near his village. However, he devised his own norms and rules. He would ask a farmer who wanted to participate in the programme as to how much cost he or she could bear through one's own resources. He would offer to provide only the gap, which would rarely be more than 60 per cent of the cost. Thus as against only ten or fifteen per cent contribution required under the government norms, he managed with as much as 40 per cent contribution from the people. He also changed the parameters of the programme and focused on only a few anchor activities instead of focusing on all the components of the watersheds. The result was that other NG0s and government institutions wanted to exclude Premjibhai from the watershed team and the programme. This is not an isolated example. Public policy does not put premium on either innovation or flexibility in the way programmes are implemented by different people in different regions.

Kerr *et al*. (1996) discusses in detail how high subsidies and incentives undermine the success of a watershed project. People's interest in receiving subsidies can lead to many unintended consequences. They also suggest that the subsidies or incentives are desirable to be directed more towards group of families rather than individual families. Such interventions directed towards common benefits may not only improve the effectiveness of the subsidies but also generate incentives for collective action. In this context, the experience of Premjibhai's is illustrative if we want the structures to be maintained once the external agency withdraws from the project. Another implication for institution building process thus is explicit reliance on voluntarism in any watershed project and attention to variability in the process and structure and norms.

2.8 Physical and institutional boundaries: Should they be same?

In many watershed projects, the implementing agencies focus on only the farmers within the watershed boundary even for those technologies, which would show results -may not be as spectacular -in non-watershed areas. For instance, a new variety of oil seeds or a cereal might show better performance if all the watershed principles are followed, but might not do very badly in the absence of these measures provided the existing level of resource degradation was not very high. In such a case, to generate good will and demand for comprehensive treatments through one's own resources, diffusion of such a variety among non-watershed project farmers may be quite appropriate. If there were no differences, the project would founder. And if there was, the farmers outside the watershed area might also either demand watershed projects in their micro catchment or take measures to organize it on their own. The implication is that deliberate design of controls that help people to compare and contrast various components and their efficacy might be a useful spur for the watershed projects.

In fact, very few watershed projects actually take into account the presence of individuals other than farmers who might depend indirectly on the natural resources in that area. Particularly in the case of landless labourers. Hinchcliffe *et al*., (1995:11) observed, "The landless tend to be marginalised in watershed programmes since the major thrust of investments is on land. Although, the landless do get work and income during implementation period, this is not necessarily sustained". This is also the case with artisans and other groups of families relying on common property resources for their livelihood even from out side the watershed boundaries or even the village. It is possible that all these families may be interacting with those identified members of watershed with regards to other institutions and networks in a village system. Such differences in appropriation of funds to specific groups may cause tensions and deteriorate the process of institution building. To a large extent, this may be avoided if the agenda for a watershed project is built in consultation with all sections of the people in and around the watershed during the planning stage itself. That may give rise to multi-functional institutions instead of single purpose institutions. This realization is dawning on many women's saving and credit groups organized in watershed projects.

Similarly, the inter-linkages between the uncultivated common lands or public lands and the cultivated lands is between the uncultivated common lands or public lands and the cultivated lands is also ignored. Deshpande and Nikumbh (1993:11) observed, "the failure of inter-dependence between commons and cultivated lands, between owners of forest pastures and consumers and the dominant role of `time productivity' under the pressure of poverty have created conditions leading to failure of certain village institutions". In a comparative study of four watershed projects involving uncultivated lands, they also concluded that caring of uncultivated lands and degraded forests in some watershed projects have strengthened other institutions.

2.9 Sequential synergism

Unfortunately, in most projects the emphasis has been on physical structures. The concept of 'sequential synergism' (Gupta, 1980) has not received adequate attention. This concept implies that the same components in a different sequence may have different kinds of synergy in different regions. In some areas, one might begin with livestock, in another area with water recharge wells and in still another area with ridge basin treatment. Without violating the sanctity of watershed project, one can devise different entry points at different sequences except soil conservation where ridge basin sequence cannot be changed. Implication is to recognize that focusing on the same resource in every region cannot generate motivation for participation. Depending upon what is the source of maximum stress, the appropriate intervention will have to be devised. If drinking water were the problem, then without waiting for all the investments that improve the recharge or harvesting of water, steps would have to be taken to improve storage facility for available water and simultaneously initiating efforts for long term sustainability. Otherwise, the poor people might even migrate out by the time watershed project is completed or in other cases might contract loans in informal credit market such that all the gains from the enhanced productivity, if at all, would be liquidated by the interest burden of accumulated debts.

It has been the experience of several agencies that the farmers become receptive to the watershed development projects when their immediate needs and problems are addressed in the initial stages (Kerr *et al*., 1996). Instead of restricting the interventions only to the framework of the watershed

project, if some flexibility is allowed and addressing the immediate problems in the watershed area could identify the best entry point, the chances of sustainability may be increased.

2.10 Skill based leadership

The variability in socio-ecological conditions requires the each watershed becomes a site of on farm research and builds upon local excellence in different sectors. Leadership based on skill is often qualitatively quite different from the leadership based on political connections, social influence, economic power or cultural coercive power. And yet, no guidelines for watershed project have ever required identifying and building upon local excellence. Variability in the design probably will not come about unless variability in the process and structure of leadership is brought about.

Building upon local knowledge and experimental ethic can be designed between watershed projects and thereby ensure sustainability of spirit, structures and social and ecological networks.

2.11 Internalizing externalities: How do institutions help?

Institutions help in internalizing the externalities and vice-versa in a watershed. For example, adoption of soil conservation measures by the farmers in the upstream may help the farmers in the downstream by reducing the sediments in the dams. On the other hand, if the upstream farmers do not adopt the soil conservation measures and the downstream farmers attempt to build vegetative barriers on the upstream lands, it may be seen as an attempt to encroach on their lands. Arrangements for benefit sharing and resource allocation through institutions may help in internalizing the externalities (Gupta and Prakash, 1993, Prakash and Gupta, 1997).

2.12 Replicability of institutions

A large literature exists on the indigenous knowledge systems related to social and cultural institutions for managing wide range of resources. The possibility of replicating the institutional arrangements in watershed development projects is a subject worthy of separate research. While it is understood that the local institutions are extremely specific to local cultural and social values, the replicability cannot be conceived without rigorous understanding of these institutions. Though, the replicability may be restricted to the principles learnt from an institution rather than just the structures. Sengupta (1985) narrates his experiences while doing a detailed case study of *ahar-pyne* irrigation system in Bihar. *Ahar-pyne-ayacut* is the hierarchy of the irrigation system, *ayacut* being the lowest level which feeds fields with water through distributaries to small plots owned by as many as sixty families. It was in the second stage of analysis that Sengupta was struck with the evidence about actual incentive for generating equitable distribution arrangements among the families. The total landholdings under each *ayacut* are fragmented and each family owns plots at the head, middle and at the tail of the *ayacut*. Thus all the families are interested in water in all parts of the *ayacut*. At the same time, every family can have some amount of water in case of limited availability of water in the *ayacut*.

In different regions, excellence of varying kind exists without which survival would not be possible. Blending culture with environment and technology with institutions, viable models have evolved both in traditional and a few contemporary institutions. Technology has been considered like words

whereas institutions have been conceptualized as grammar (Gupta, 1992). One could not organize words without grammar but grammar alone cannot create the message without words. This part aims at merely widening the thesaurus and dictionary of such 'words', which can enable institution builders to exercise a wide range of choices.

2.13 Institutional and Technological Cycles

Technological constraints can be precursors of institutional innovation and vice versa. In fact the process may even be cyclical, with an institutional constraint providing a spur for technological solutions, which in turn lead to an institutional innovation. Sometimes, both technological and institutional change may take place simultaneously. It has been argued that technology may be likened to words and institution to grammar (Gupta, 1991c; 1995c; Gupta *et.al.,* 1995). We cannot make much sense of one without the other. In the literature on participatory watershed development, the interface of institutions with the process of technology generation or adaptation has not been adequately addressed. Therefore, we will provide illustrations from the Honey Bee database in order to strengthen the case for modifying the framework for participatory watershed development (Tables 1 and 2).

Table 1. Technological triggers of institutional innovations

No.	Problem	Technological need	Institutional innovation
1	Pasture degradation due to trampling of grasses and grazing of seedlings by small ruminants	Either grasses should withstand trampling or they should regenerate in spite of damage	In Takuva village of Gujarat, farmers persuaded sheep and goat owners not to graze their animals for two months after rains when grass/ seedlings are tender
2	Locust attacks	Use insecticide, antifeedant or repellent to minimize damage	Farmers beat drums or bang vessels collectively to prevent locusts from settling on their fields
3	Silting of ponds	Mechanical desilting or catchment treatment	Collective action through religious or other motivation to manually desilt ponds (Saurashtra and Golden Temple)
4	Salinisation of soil in Gujarat	Soil reclamation and drainage	Pooling of private fields and agro-forestry with salt-tolerant species
5	Red rot of sugarcane and sorghum	Control of fungal spores in the crop residue	Burning of residues on a particular day in all the fields
6	Foot and mouth disease in cattle	Develop effective control agents	Quarantining diseased animals; separate grazing and watering
7	Pasture degradation due to excess grazing	Grasses should regenerate under any amount of stress	*Kuhlwalas*, a group of farmers elected to maintain irrigation channels guard the grazing land and donot allow any grazing in the restricted periods. People shift upwards or downwards in the hills and thus change the pasture patches
8	Conserve seed diversity	Exchange of seeds among	Farmers in Madhya Pradesh have a cultural practice where, they bring handful of varieties of seeds and

No.	Problem	Technological need	Institutional innovation
		farmers to prevent same seed being grown on the same plot every year for possible disease build up	submit to a deity before sowing season. The priest exchanges these seeds among them and give them back. The farmers are supposed to begin their sowing operations only with those seeds.
9	Collective needs of irrigation water and other facilities	Construction of check dams and divert water from stream	Revenues from cooperative farming society were used to construct the check dam
10	Irrigation water supply	Construction and maintenance of irrigation channels	Rotation water supply for specific durations, monitoring through peer pressure Rotational water supply, but monitored by a group of members elected as *kuhlwale*
11	Planting trees	Plant trees or sow seeds	Premjibhai mobilised students and rural youth to sow seeds and monitor plantations
12	Taking care of cows for grazing	Individual households take their cows for grazing in the *Gauchar* land	A care taker working under a committee takes care of the cows as well as the *gauchara*

Table 2. Institutional triggers of technological innovations

No	Problem	Institutional need	Technological innovation
1	Protection of crop from animals of migrating graziers	Evolving agreements between pastoralists and farmers to respect respective boundaries	Farmers treat seed of castor with butter milk which induces toxicity in leaves, requiring animals to be kept away
2	Protection of trees planted by individuals in common lands	Community action for protection of seedlings from grazing animals	A tree-planting entrepreneur devised machines to scatter seeds of tree species not touched by animals
3	Red rot disease of sorghum and sugarcane	Non-cooperation of farmers for burning residues on a particular day	Evolution of indigenous seed treatment for preventing disease
4	Fair distribution of water	Difficulty in supervising each other's withdrawal of ground water	In the *Zuni* community, sticks are provided to every user who cuts a particular portion after every use so as to keep a record of water used
5	Pooling of bullocks becomes difficult	How to generate incentives for pooling	Development of single-bullock drawn farm equipment
6	Regular supply of grass for livestock in Belehra village	Pool revenues for buying rights over forest land/ regenerate available degraded land	A joint-farming society has been encouraged where farmers contribute one-tenth of their land-holdings. The pooled land is cultivated collectively and the revenues out of this land is used to regenerate the degraded land offered to grow grass for the village.
7	To make people responsible for large scale afforestation and protection	Generate incentives and easy way of planting trees	Premjibhai's suggestions (i) Sow seeds instead of planting saplings before monsoon (ii) Spray seeds through a mechanical device (iii) Specific choice of tree species' seeds
8	To modify consumer preference for tree-based dyes and stem erosion of local skills	To pool the efforts of the artisans to produce high quality products and reduce transaction costs	C V Raju developed tree-based dyes capable of mixing with lacquer. Being eco-friendly, they fetched better prices

The cases presented in Tables 1 and 2 show that technology and institutions are interdependent and trigger changes in each other. The changes may be simultaneous or may follow a sequence. For instance, the failure of village institutions to protect crops from grazing animals led to the innovation of seed treatment with buttermilk. This treatment, however, led to another institutional change, the development of a sanction against the innovator, since there was a risk of death of animals due to accidental browsing on the treated plants. Again this sanction may encourage innovative pastoralists to find out some way of identifying the treated crops. This sequence of constraints in one subsystem leading to innovation in another may continue till the limits of ingenuity are reached. The challenge

is to determine whether one should adapt to a given technological constraint through an institutional innovation or evolve a technological solution to what may essentially be an institutional problem.

In many villages in North Gujarat, farmers had to give up commercial hybrid seed production because of the failure of institutional support for isolation from other farmers. In such cases of participatory technology development, we may need to emphasize the institutional requirements. The technological response to this problem can be the incorporation of the apomixis gene in hybrids so that they can be grown every year like a self-pollinated crop.

In participatory development processes there is generally a tendency to underestimate institutional problems and to invest more resources in solving technological problems. The watershed research program is a classic case of such a bias. Many natural scientists do not pay attention to institutional dynamics and the management of common property resources. Institutional analysis may require an understanding of boundary rules, resource allocation rules, governance rules, and conflict resolution rules, which is usually not in the province of natural scientists. Sustainable pest management, management of groundwater as well as surface water, are other areas, which require group action (Gupta, 1985b; Gupta, 1992; Sinha *et al*., 1996).

A key factor in understanding institutional dynamics is uncovering the actual preferences vis-à-vis the articulated ones at the level of the individual as well as of the group. For instance, Sanghi and Rao (1982) and Sanghi (1987) tried to relax each of the constraints that farmers reported for not trying a dry land technology (Warren and Rajasekaran, 1995). When each constraint had been relaxed, and the technology was still not being tried, it became obvious that farmers were skeptical about the suitability of the technology. Sanghi and Rao (1982) provide a good example of how institutional dynamics can be facilitated by incorporating traditional knowledge in the technology development process. They found that sowing the crops with the pre-monsoon rains, as practiced by some farmers, ensured the efficient utilization of mineralized nitrogen, avoided pests like shoot fly and ear bug in sorghum, and ensured the timely sowing of subsequent crops. In summary, the understanding of the interaction between technology and institutions is an essential aspect of developing sustainable watershed management projects.

3. Knowledge-intensive approach to watershed management

Sustainable development has been defined as widening the range of choices for people and increasing the time frame (Gupta, 1981; 1985a; 1995). In this part we argue for what we called ‘solution augmentation’ rather than ‘problem solving’ approach so that we increase the range of choices of solutions (Gupta *et al.*, 1996 CIAT). It implies that we augment and optimize the solutions generated by farmers on their own for similar problems instead of trying to solve the problem afresh ignoring earlier developed local solutions, even if they were sub optimal. In order to illustrate the approach, we use a hypothetical watershed and discuss the wide range of solutions that local knowledge systems offer for watershed treatment. We take the particular case of soil and water conservation and review local technologies from across the world.

Drop to Drain: Conserving Watersheds by People

Let us assume a typical watershed that extends from high mountains to the plains with all possible configurations of ecological parameters. We begin from the top with steep slopes and look at the variety of local technologies for soil and water conservation developed by people.

3.1 Innovations at System Level

3.1.1 High altitudes (> 3500 m)

At the highest altitudes, where human habitation is found (above 3500 m), the household economy is dependent on livestock and communities are mobile pastoralists. There are examples of innovations where people (in Ethiopia) make use of frosty winds by putting up polythene barriers to harvest water for domestic consumption. These altitudes are prone to natural hazards.

There are several traditions among people to face or prevent these hazards through collective action. For example, there are specific norms in Bhutan among the pastoralists about their movement of livestock. As the cattle arrive from sub-tropical regions, the yak herds must vacate the pastures at about 4000 feet height to avoid transmitting of diseases by cattle to the yaks and allow recovery of the grazed pastures to regenerate (Gupta and Ura, 1992).

In the highland plateaus like the Ladakh region and Jammu, water from glaciers is diverted and collected in structures similar to tanks called zings (Agarwal and Narain, 1997). The water from zings then is used for domestic and irrigation purposes.

3.1.2 High hill dry zone (2000 m - 3500 m)

In the high hill dry zone, the household economy primarily depends on the livestock and dispersed rain fed farming The soil and water conservation technologies available at these altitudes are not much diverse and narrow down to bench terraces (Refer 1.2). The steep slopes at these altitudes make it impossible for any temporary storage of water. The rainfed terraces are generally outward sloping. There is an interesting observation made by the Ives and Messerli (1989) in their monumental work, “The Himalayan Dilemma”. They quote a report by ADB (Asian Development Bank), which assess the outward sloping terraces by farmers as poorly constructed whereas the outward slopes are actually desirable to avoid landslides in this region.

3.1.3 Mid hills and high hill wet zones (650-2000 m)

Bench terraces are of two types as we move into the high hill wet zones and mid hills; (I) rain fed terraces and (ii) irrigated terraces. Small streams feed the irrigated terraces or irrigation channels called ‘*guhl*s’ or in some area, called as *'Kuhls'*. It is interesting to note that the rainfed terraces continue to be outward sloping whereas the irrigated terraces are inward sloping. The reason may perhaps be that it is possible to control the inflow of water into the irrigated terraces and thus is possible to avoid any likely landslides. In the rainfed terraces, it may not be possible because of the erratic and unexpected inflows of water.

*Guhl*s or *Kuhls* are irrigation channels to carry water from sources like springs and glaciers for irrigation as well as domestic purposes. *Guhl*s may be called the lifelines in the hill regions and are invariably found below 2000 m altitude. They may be found at higher altitudes also but when the slopes are comparatively mild. *Guhl*s exhibit great variety in their form, structure and designs across the Hindukush mountain region. Accordingly, the institutions for protecting and managing them also vary. Religious customs and norms sometimes support these institutions. (Husain, 1992) The present compilation carries documentation of some such institutions at the community level (Refer Part II, H.1, H.2, H.3). Some illustrative examples of the kind of innovations by people in their design are also documented (Refer B.7 and section 4.). Variations in irrigation channel networks using locally available material also exists, for example, people use a network of bamboo pipes for diverting water from glaciers in the North-eastern parts of India (Agarwal and Narain 1997). Similar bamboo pipes are used for harvesting drinking water from small streams called *jhurjhuris* in Bangladesh (Bose and Osman, 1998).

At lower altitudes in this zone, we find some diversified water harvesting structures. *Bawri* is a structure constructed around a spring to protect and divert water (Refer part II, B.1). Strong collective institutions still exist to keep them clean and sustain their yield. *Khatri* or *Diggis* are horizontal tunnels dug into the semi-weathered sediment rocks to harvest rainwater for domestic purposes (Refer B.2). *Hoj* or *Hod* is similar to *Bawri* but they are found in hill regions of Uttar Pradesh. *Naulas* are tracts yielding water from sandstone aquifer bodies for both domestic and irrigation purposes (Refer B.5). People collectively clean these structures periodically and maintain them. Water trapped in the sedimentary rocks is harvested through small wells called '*Kua*' in the hill regions of Bangladesh (Bose and Osman, 1998). The institutional arrangements for maintaining the *guhl*s as well as other irrigation structures have evolved all along the high mountain region ranging from Hunza area of North Pakistan to Kashmir, Bhutan, Tibet, etc. Obligatory labour has to be provided by households before the rainy season to remove debris, clean it and repair the breeches.

It will be interesting to note that structures similar to *Khatri* are found in the plains also using the same principle. *Sorangas* in Karnataka (Refer B.3) are found in the lateritic regions and tap the moisture trapped in the large sand depositions. A familiar version of such horizontal wells is *qanat* system found in Iran.

There are several contemporary innovations by individual farmers from which we can draw lessons for watershed management. A.3 provides such an example where, an artisan-farmer, Shaligram literally converted semi-weathered rocky hill into a fertile farm. He used several strategies in the process (Refer 1.3). Other soil conservation structures found in the lower elevations are *bunds* made of different materials like stones and sticks (Andrew, 1987). In Bangladesh, the stick barriers for soil conservation are called *Chikon Thok* (Bose and Osman, 1998).

3.1.4 Low hills and plains (< 650 m)

Towards low hills and plains, the variety of structures increases. Though the conditions are homogenous over fairly large areas, the soil profile and rainfall changes across regions. Innovations emerge to respond to these conditions specific to the region. They may be broadly classified as (I) storage structures and (ii) impounding structures

[I] Storage structures

Most popular among the storage structures are the ponds or tanks. A rich diversity in their form can be seen in different regions of India. Large networks of tanks still provide irrigation to very large area in the Southern parts of India (Reddy, 1989). In Rajasthan, depending on their size, they are called *nadi* or *talab* (not to be confused with the word *nadi* implying river). They invariably are associated with appropriate institutional arrangements for maintaining them. In Rajasthan, people consider the catchment (locally called *agar*) as sacred and religiously protect the catchment areas. Activities like defecation and dumping of debris are strictly prohibited (Agarwal and Narain, 1989). Every year before monsoon, cleaning catchment is practiced as a collective ritual[1]. Such functional rituals are a common feature in most marginal societies. Among the Andean peasant communities, 'Journey to Hualca-Hualca' is an annual event with an explicit purpose to clean the tributaries of the Hualca river (Gelles, 1991).

Wells are another popular structure for harvesting and storing water. While they are wide spread in sub-humid and semi-arid regions, several innovative modifications of this form may be found in response to the location specific conditions as we move towards arid regions. In Rajasthan, *Bawdi, Kundi* and *Tankas* are case in point. While the *Bawdi* is a conventional well found to be on the downstream of a khadin (see Kolarkar,1989), the *Kundi* is an artificial storage structure with protective covering. *Tanka* is a storage structure of a different kind. It harvests rainwater falling on an artificial catchment prepared around it and stores it for scarcity periods (Vangani *et.al.*, 1988).

[II] Impounding structures

Ahar-pyne system is a traditional irrigation system found in Bihar in the form of a network of channels followed by storage structures. Sengupta did exhaustive studies on the institutional aspects of the system. In one of these studies (1985) he explores the incentives for people for collective action. He finds that the farmers own land/parcels at different parts of *ayacut*, such as at the head, middle and tail of the *ayacut*. And thus their need to receive water in all of their fields contributed to strong collective institutions for distribution of water.

Bandharas are found in the semi-arid Jabalpur tract of Madhya Pradesh. Water is impounded in the fields on all four sides till the sowing time approaches. Water is drained before sowing and no water is required later. Rabi crops are grown using the residual moisture in the heavy black soils. It is also believed that the technique prevents the growth of weeds (Pangare, 1992).

Khadins are another form of cultivation based on residual moisture and are important life supporting farming systems in the arid parts of Rajasthan. Extensively practiced in Jaisalmer and Jodhpur districts, *Khadins* are formed by constructing barriers at the foothills to impound the water as well as the silt being carried. Farming is done on the upstream side of the barrier tapping the residual

[1] In South India, for long time, cultivation in the catchment is restricted to avoid silting in tanks. Disregarding such norms, Government gave away *pattas* and encouraged cultivation in catchment areas. It has resulted in silting of tanks and breaking their network (Reddy, 1989).

2 Similar to the initiatives of cleaning the catchment areas of the tanks, the community also cleans the catchment areas of the tributaries of the rivers.

moisture (Kolarkar, 1989, p.c.). An impervious layer of soil found about one to two meters below helps the moisture to be retained in the top layers (Chauhan, Personal Communication).

There are several practices among communities across the world that are based on the simple principle of impounding runoff temporarily so as to increase the moisture content in the soils. *Teras* are earthen *bunds* found in arid plains of Sudan. The earthen *bunds* are constructed across the flow of runoff with perpendicular arms extending towards upstream. The basis, thus created harvested the water and supplied moisture to the crops on the downstream (Reij, 1991; Dijk, 1993). *Caag* and *Gawar* systems in Africa also use earthen *bunds* of different shapes based on similar principles (Reij, 1991).

[III] Other structures

Many other indigenous soil and water conservation systems exist which are yet to be properly studied and understood. They offer a variety of scientific principles, which may not have been considered by the formal science yet to generate solutions. Some illustrative examples have been reviewed below.

Willcocks (1930) narrates what he calls, 'Overflow Irrigation System' extensively practiced in West Bengal. Though extinct, it offers some relevant insights. The channels used to be breached deliberately by people so as to let in the muddy waters into their fields along with rich silt. Willcocks argues that the system not only provided fertile silt but also helped in preventing breakout of malaria as the fish flowing in along with the water predated upon the mosquito larvae.

The ingenuity of people in generating solutions to cope with adverse conditions may be demonstrated using the case of *Virda*. *Virdas* are found in the saline deserts of Gujarat and are the only source of drinking water. *Virda* is constructed on the beds of depressions and tanks where the rainwater stands for fairly long periods after the monsoon. The long-standing water leaches out the salts in the soil around these depressions and thus the water trapped in the soil remains free of salts. *Virda* harvests this water. A further innovation that took place recently in these systems of *Virda* proves the point that innovation is a tradition in these high-risk environments. Farmers in Banaskantha district of Gujarat and in some villages of Rajasthan elaborate these systems. The regions have a saline water layer below at a depth of about 20 -25 m from the ground surface. Farmers dig these wells up to this level and drill lateral holes through the walls just above the bottom of the *Virdas*. These holes extending as long as 20 m tap the fresh water trapped in the layers above the saline water table (Chokkakula and Gupta, 1995; Ferrouki, 1994).

3.2 Farm level innovations

Grassroots innovations at the farm level are abundantly rich. In the following discussion of farm-based innovations, in addition to examples from literature and the current compilation, we draw upon two major sources. The first one is an annotated bibliography on peasant innovations (Gupta, Capoor and Shah, 1990) and the other one is the Honey Bee database. We took some select practices of farmers whose innovations have been recorded in the Honey Bee database (Refer 1.4).

Following are some of the strategies used by the farmers:

Goal	Strategies
Soil Conservation	Physical barriers
	Vegetative barriers
	Trees or plants as stabilizers
	Manual operations
	Agronomic operations
Conditioning/ Improving micro climate of soil	Inputs to improve specific properties of the soil
	Plants/trees to improve microclimate conditions
	Manual/Mechanical operations
Saline soil reclamation	Treatment with plant and specific soil material
	Manual/mechanical operations
	Physical interaction of trees and plants
Treating degraded soils/ Improving fertility	Application of materials like ash etc
	Application of plant material
	Interaction of animals
	Inputs of organic manure
	Agronomic operations
	Indicators of fertility
Water/Moisture Conservation	Agronomic operations
	Microstructures
	Manual/mechanical operations
Harvesting	Manual/mechanical operations

3.2.1 Soil conservation

Physical barriers are the most commonly found soil conservation measures on the farm. The barriers in the form of *bunds* are made using different locally available materials. Several forms of these are found all over India. Farmers in Burkina Faso use stone *bunds* for conserving soil (Reij, 1986). In Sierra Leone, sticks along with stones are used in constructing *bunds* for preventing soil erosion (Andrew, 1987). Farmers of Bantika build dikes surrounding the paddy fields in order to reduce the possibility of water erosion. In Dogon Plateau, farmers build terrace fields using stone *bunds* on all the four sides so that the soil and moisture can be augmented for cultivation. The *Kana bundi* (refer A.1) in Rajasthan is constructed at right angles to the direction of wind using the crop residue.

Vegetation used as physical barriers is another form of local innovation for soil conservation. Farmers in Karnataka were reported to have been using *Vetiver zizaniodes* grass for centuries for controlling soil erosion . Similarly some farmers in Mancion, Dominican Republic have also been growing the *Vetiver* grass primarily for controlling soil erosion and only secondly for fodder purposes. In the Northern Thailand, farmers grow bamboo on the banks of irrigation ponds to reduce silt-inflow into the ponds (Marten and Vityakan, 1986)

Trees could be important agents of stabilizing soil. Most famous example where the trees are used as stabilizers is the shifting cultivation practiced in many mountain regions like North-Eastern parts of India and parts of West Africa (Richards, 1985). It is observed that large trees are deliberately left without removing the stumps and roots in order to keep the soil intact. A similar practice, jhum cultivation is found in the Northeastern parts of India (Agarwal and Narain, 1997; Ramakrishnan, 1992). A farmer in Gen Nakar (Dominican Republic) noted that the pilinut trees grown on the riverbeds prevent soil erosion and bamboo to stabilize the soil in the highlands (Blomer, 1989).

Bamboo's dense roots help to hold the soil and are grown to prevent down slope movement in many upland regions of South-east Asia (Marten and Vityakan, 1986). In the eastern hills of Nepal, while planning for farmland tree fodder resources, farmers consider various attributes of tress; height, leaf area density, size to predict the impact on crops as these directly influence the splash erosion and shade. For example, trees with long leaves are considered detrimental as the large drops from the leaves lead to severe splash erosion resulting in crop lodging

Farmers carry out some farming operations exclusively to conserve soil. Sanghi (1987) observes that farmers in Andhra Pradesh leave the furrows open after the sowing operation in castor crop and make new furrows during the inter-culturing operations in order to prevent wind erosion.

Some farmers in humid regions prefer planting sugarcane in individual pits instead of furrows in order to bear the stress of high floods. In the Andean mountains, farmers use vertical furrows to drain soils and thus prevent landslides (Rhoades, 1988).

There are certain agronomic strategies used by farmers to withstand floods in the humid regions and thus reduce soil erosion by water. Farmers of Bantika in Thailand sow floating varieties of paddy in the fields at the lowest level . Farmers in Philippines practice combined farming of banana and cassava in order to control erosion and weeds.

3.2.2 Soil conditioning

There are several innovations for conditioning the soil and to improve the properties of soil. The most primary of them is mulching using crop residues and other plant material available in the surroundings. While this is a common practice in India, farmers in West Bengal and Bangladesh use crop residues, dry grasses, water hyacinth and other plant material for mulching. In Tanzania, farmers use banana leaves, grass, straw, chopped maize stalks, pruning remains weeded grass, sisal waste, coffee pulp etc for mulching. A widely practiced method to improve soil fertility is by burning the crop residues/ stems in the field. It helps in improving soil properties and particularly adds phosphates. The method is more prevalent in semi-arid regions and uplands (Richards, 1986). This process achieves other goals also. Burning is a faster and efficient way of clearing the fields and destroying insect-pests and weeds.

In many parts, trees are grown specifically with the purpose of opening up the soil, which helps in draining the salts. An added advantage of having trees in and around the field is that the leaf litter is used as mulch in the soil. In Burkina Faso, farmers grow *Acacia albida* trees for this purpose. In West Africa, farmers grow locust bean trees (Bayer-waters and Farrington, 1990). Tuber crops like sweet potato are specifically grown to improve soil aeration. Their roots swell and shatter the soil below (Randhawa, 1985). In Andhra Pradesh, farmers sow one or two castor seeds along with the pearl millet and finger millet seeds in the regions of alfisols. The millet seeds have weak plumule and cannot break the soil. The castor seed plumules are strong and make way for the millet seed to germinate. The castor is removed after germination.

Agricultural operations for improving soil conditions include the mixing of soil from different sources. Farmers in Tanzania use soil dug from pits and spread over on the neighboring soil after it has been covered with grass (Kees, 1987). One of the strategies that Shaligram used to make the soil fertile is to mix soil (Refer 1.3) from other farms with the clods dug out of the semi-weathered rock.

In Saurashtra region of Gujarat, farmers mix *tas* that is semi weathered rock material from river beds or some other such locations rich in nutrients.

3.2.3 Treatment of degraded soils and improving soil fertility

Degradation of soils is a common problem in high-risk environments. Consequently, innovations for treatment of soils are also diverse and rich. Most elementary of them is to add materials that provide deficient inputs to the soil. Umarabhai Rasulbhai Gandhi of Bharuch district applies ash in the onion fields before sowing to improve the quality of soil. He says that the soils improve over time and he gets better bulbs of onions by following this treatment. Lakhmanbhai Khimjibhai of Surendranagar in Gujarat too believes the same and suggests that the ash is also useful for better growth of tuber crops like carrots and potatoes. Ambavibhai Gokalbhai of Kutch district mixes clay clods from the pond in his village to prepare his land. Farmyard manure (FYM) is a common input to improve soil fertility and it also increases water-holding capacity.

Plants and its derived products are used extensively to improve soil fertility. Farmers in arid parts of Mehsana district in Gujarat use castor cakes to control termite population (Jethabhai Karshanbhai Baraiya, 1991). In Panchmahal district of Gujarat, turmeric and ginger are grown in winter, which require fertile and well-drained soils. Farmers spread leaves and twigs of 'mahuda' (*Madhuca indica*) over the field and burn them. The field is then tilled and irrigated before sowing. Recently farmers have started to use 'khakra' (*Butea monosperma*) leaves also along with 'mahuda' (Manilal Sartanbhai Damor). Farmers of Banaskantha district spread the leaves and branches of khakra over the entire field and burn it before the onset of monsoon. Farmers believe that this helps to improve the water holding capacity of the soil. In some parts of Southeast Asia, degraded and soils with low moisture content are cultivated with trees such as turi (*Sesbania grandiflora*), petai cina (*Leucaena lecocephala*) or other leguminous plants to restore soil fertility (Marten and Vityakan, 1986).

Some farmers use local weeds to improve the soil fertility. '*Fatlo*' is such a weed that grows vigorously in Surat district. Farmers spread the *fatlo* seed on fallow land. It takes about two months for the weed to attain the height of four to five feet. It is then incorporated into the field as green manure (Ramubhai Khetiyabhai Gamit). Similarly 'Kuvad' (*Cassia tora*) is considered as a green manure crop in the Sabarkantha district. Farmers broadcast its seeds before monsoon and about a month later, they incorporate into the soil as green manure (Rajesh B Parmar). Farmers in Valsad district use locally available seaweed for improving soil. It is dried, grinded and mixed with organic manure and is incorporated into the soil.

Inputs from animals are another mode of improving soil fertility. Penning is a wide spread practice in highlands and arid regions. The herders are paid in kind or cash, or provided refuge by the farmers to pen their sheep or goats in the fields. In some areas, farmers themselves pen their own sheep and goats in their fields (Samanbhai Dharambhai Dholakiya). Farmers in the coastal regions of Bhavnagar district apply salt and bones of sea fish around the coconut trees and they believe that it facilitates well-developed coconut trees and prevent fruit dropping (Jethabhai Karshanbhai Baraiya).

Manure is the most common mode of maintaining soil fertility. It is a common practice among farmers to use farmyard manure (FYM) every one or two years in their fields. It is believed that it improves the fertility, water holding capacity and also helps in maintaining the quality of the crop

product. Several innovations were made in the process of preparing manure sometimes using different materials. The farmers in the irrigated areas of semi-arid Mehsana district, Gujarat believe that FYM increases termites particularly in Wheat and Mustard crop. Hence they use a mixture of FYM and castor cakes or grow castor crop before the sowing mustard or wheat crop. According to them castor can control termite population in the soil, due to the presence of a toxic alkaloid Ricin (Jethabhai K Baraiya). Farmers in Surendranagar district of Gujarat apply the manure in a different way. They separate the well-decomposed dung of cattle from litter and mix with running water in the irrigation channel. Those with irrigation facility follow this practice for lucerne (*Medicago sativa*) crop. Farmers believe that the method helps in the uniform growth of crop (Lakshmanbhai Khimjibhai).

The purpose of these agronomic practices is to increase fertility. In Panchamahal district, farmers sow groundnut as an intercrop between the rows of sorghum to increase its yield. (Ambalal Prahaladbhai Patel). The fallen dried leaves of groundnut acts as manure apart from fixing nitrogen in the soil.

Indicators are an important feature of indigenous taxonomy to assess the fertility of soils all over the world. The indigenous knowledge related to it is as diverse as the ecological conditions. The observations include all those elements that interact with the soil directly or indirectly. Farmers in Mehsana believe that weeds like *Gutari* (*Setaria tomentosa*) grow better in light soil while '*Dabhdo*' (*Desmostachya bipinnata*) and *Dhaman* (*Cenchrus spp*) grow vigorously in fertile soil. They believe that the paddy yields more where *samo* (*Echinochloa colonum*) grows naturally. Several works have documented that color and taste are the general indicators of fertility (Chambers, 1983; Ettema, 1994). Ettema (1994) further notes that texture is first level of classification and is also more functional in nature.

3.2.4 Saline soil reclamation

Farmers in Gujarat treat the saline soils with castor shells (Arjunbhai Popatbhai Bharadiya) and cotton balls (Ambhavibhai Gokalbhai Dubariya). Farmers in humid regions of Uttar Pradesh apply *Perandaicissus ouandragularis* and *Elia azadirahta* to remove salinity (Balasubramanian, 1986). Farmers in Kutch, an arid region, grow *Prosopis juliflora* trees in the salt affected fields for about five to six years. Later, they cut the trees and pull out the roots. The field is cleared and is ploughed very deeply. Some farmers grow gram (*Cicer arietinum*) and okra (*Abelmoschus esculentus*) in the salt affected soil of Sabarkantha district (Mavaji Bhikaji Harijan).

Some farmers in coastal arid regions use physical means of reclamation. Farmers in Kutch (Gujarat) scrap off the saline crusts on top of the soil before monsoon (Mavaji Bhikaji Harijan). The first rains may perhaps leach out the salts from the soil layers below. In the same region, farmers steer the runoff into the fields and let the collected rainwater infiltrate and evaporate naturally so that during the process, the salts are leached away. Later, they loosen the soil by digging or ploughing and commence cultivation (Dahyabhai Ramsangbhai Rabari). In parts of Kheda district, which is a semi-arid region, farmers dig deep drainage channels around the salt affected fields to drain off the water from the fields (Ramabhai Keshabhai Jadav).

3.2.5 Moisture conservation or harvesting

Local innovations exploit the physiological interactions between the crops and the soil to use the available moisture optimally. The most common practice is mixed cropping. Tapping moisture at different levels of soil through a combination of long and shallow rooted crops is the basic principle of mixed cropping. This practice is wide spread in the arid and semi-arid regions and in the uplands particularly where the rainfed farming is practiced. Mixed cropping and a variation of it, strip cropping is practiced widely by the *Bhil Grasia* tribe in Gujarat (Sankaran, 1988).

In Northwest Bangladesh, farmers grow a banana plant between four betel nut trees. The suckers apparently conserve moisture during monsoon and release it to the roots of betel nuts during the dry winter season (Gupta, 1988). Gworgwor (1989) documents two traditional systems of mixed cropping in Northern Nigeria that optimize the utilization of moisture in the soil. *Gicci* system of mixed cropping is practiced to cope with the risk of late and erratic rains. Farmers sow cereals early in widely spaced rows and another crop later at right angles. The later crop may be cereal if the rains are poor or a cash crop if the rains are better. *Moskwa* is another cropping system where *moskwa* sorghum, a drought and cold tolerant variety is used during the dry season (September-December) on the black soil of the basin of lake Chad. When the waters recede (October), farmers transplant seedlings into holes 18 to 20 cm deep. Two to three handfuls of water are poured into the holes and are left uncovered. *Moskwa* sorghum has a short growth cycle and matures on the available residual moisture in the heavy deep soil.

Moisture conservation is also achieved by some multi-purpose microstructures. In the Dogn Plateau, farmers construct cone shaped earthen mounds while hoeing or weeding of millet or sorghum fields. Mounds are set along millet plants and vary in size with the height ranging between 35-60 cm. The mounds slow down the runoff and facilitate percolation. They also provide protection from storms and winds. They help cover weeds and function as mini compost heaps. They can also carry the next season's seedlings and their growth is encouraged by the nutritive elements present inside (Kassogne *et.al.,* 1990). Mounds and ridges are also constructed in the some parts of South-east Asia to keep the inter-crop plants like vegetables above the water table (Marten and Vityakan, 1986)

Farmers carry out some specific field operations for efficient moisture utilization. In *Khadin* farming, the land preparation includes alternate ploughing and planking several times so that the soil becomes more receptive to hold moisture for a longer period. In the semi-arid regions of Northern Thailand, farmers plough the land several times to make the soil muddy. Formation of hard pan prevents moisture loss. As a part of inter-culturing operations some farmers' practice tied ridging and harrowing to conserve moisture in maize crop (Gupta, 1988). Farmers in Matalon, Leyte plough land in strips of 4-10 m with the unploughed strips of 1-1.5m to prevent soil erosion (Tung and Alcober, 1991).

An interesting practice in the regions where frost occurs shows how farmers convert a disadvantage into an opportunity. In China, early in the morning, farmers drag a rope or a bamboo pole across the crop in order to harvest the dew or the frost. The harvested dew or frost supplies moisture to the roots (Shenghan, 1963). A similar practice is also reported from Bangladesh (Gupta, 1988). Agarwal and Narain (1997) give a detailed documentation of a 200-year-old bamboo drip irrigation system

practiced in Meghalaya. A network of bamboo pipes and channel sections involving about four to five stages of hierarchy is used for distribution of water in betel leaf or black pepper crops.

3.3 Concluding Remarks

The varieties of innovations discussed above for watershed management are based only on a few sources and limited reviews. An important lesson that can be drawn is that soil and water conservation for a farmer is much more than contour bunds and vegetative barriers. Farmers deal with the problem by exploiting all possible interactions between soil and water and other ecological parameters. What is more important is the need to draw a variety of scientific principles that underline the strategy of farmers. We are not very sure how many of such principles have been considered by the formal scientists while suggesting technological options for soil and water conservation. The first step towards incorporating local knowledge systems in watershed programmes is to recognize the necessity to understand the science underlying the local technologies. Formal science can contribute greatly by adding value to these innovations and making them far more efficient and acceptable.

There is a burgeoning literature on highlighting the importance of local knowledge systems (Verma and Singh, 1969; Biggs, 1981; Gupta, 1980; 1981-99; Honey Bee, 1990-99; Chambers and Pacey ,1987; Warren, 1989; Critchely *et.al.,* 1994; Ettema, 1994; Kerr and Sanghi, 1992; Banskota and Jodha, 1992; and Reddy, 1989) and the kind of undesirable consequences that can emerge if we do not build upon local knowledge systems. However, not many works focus on what could be the process or approach for building upon the local knowledge systems. The next section makes a modest attempt to develop a framework in this direction. We have looked at some successful cases giving due respect to the LKS to achieve sustainable outcomes.

4 Creating Space for Grassroots Knowledge Systems in Watershed Management

The Hanumantha Rao committee in its report submitted to the then Prime Minister, Shri P V Narsimha Rao, explicitly recommended to build upon people's own strategies for watershed management (MoRD, 1994). However there is very little work done on its implementation. Many training programmes being conducted by agencies like National Institute of Agricultural Extension Management & Institutions (MANAGE), Council for Advancement of People's Action & Rural Technology (CAPART), National Institute of Rural Development (NIRD), State Institute of Rural Development (SIRDs), etc., have paid limited attention to this problem, the only exception being the contribution of Dr N K Sanghi at MANAGE. Gupta, as a member of Hanumantha Rao committee tried to temper the enthusiasm for short cut methods of learning like Rapid Rural Appraisal/ Participatory Rural Appraisal (RRA/PRA) etc., but to limited effect. While national guidelines require that each state should build upon local knowledge, no serious attempt has been made by senior policy planners to monitor whether this was indeed being done. In this part, we review some experiences related to sustainability of the interventions vis-à-vis the local knowledge systems. The observations are not necessarily in the context of watershed management but discuss interventions in general.

Innovations and Interventions in Watershed Management

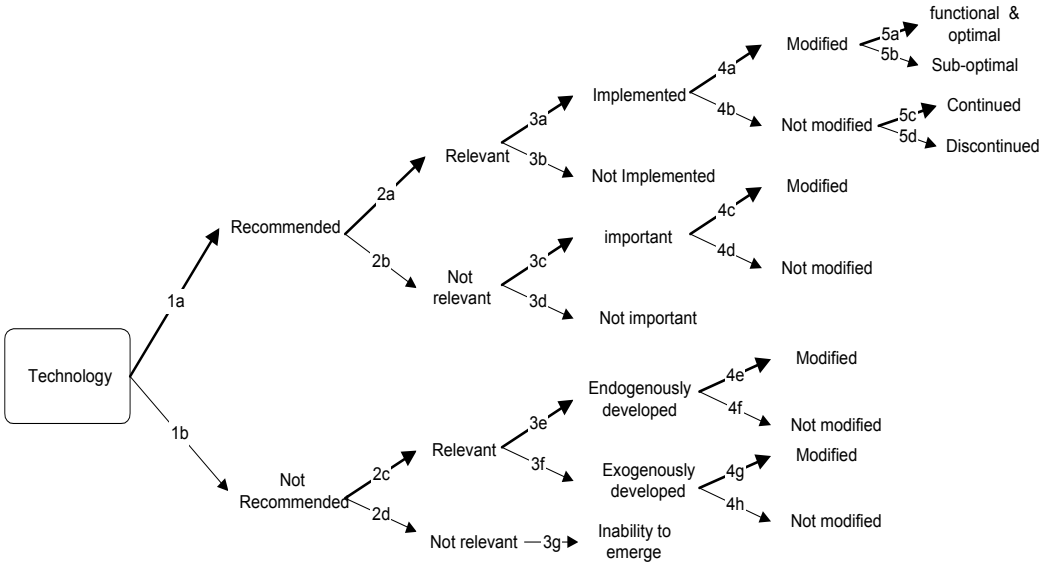
Innovations in watershed programmes may emerge because; the existing formal knowledge base fails to serve the location-specific technological and institutional need for resource management. Sometimes, the inadequacy of the recommended technology may spawn innovations. It is important that watershed managers realize the scope of the innovation so that the invisible becomes visible and worthy of study, emulating and adding value.

4.1 Domains for building upon local knowledge

4.1.1 Technological innovations

Farmers evolve a whole range of adaptive strategies and deal with specific variations in land and water use conditions as affected by various forces of erosion such as wind, water, animals etc. Using the framework in figure (a) we can deal with these strategies in such a way as to identify the nature and triggers of innovation in aided or unaided watersheds.

Figure 4.1



Farmers may use many traditional technologies such as field *bunds*, various kinds of water conservation practices, wind breaks etc., (1b) or may adapt recommended technologies (1a) such as crescent mounds, contour ploughing etc.

Many of the recommended technologies may be relevant (2a), implemented by farmers and PIAs with modifications (3a-4a) or without modifications (3a-4b). Some of the modifications may be quite innovative which are functional and optimal (5a), while other modifications may be sub-optimal (5b). One cannot assume that all modifications by the farmers are always functional and optimal. There are

examples where farmers' may have sub-optimized a technology due to avoidable or unavoidable constraints. These are the cases, which need to be studied so that comparison can take place with the structures in which modifications took place.

There are cases, most unwelcome of course, where irrelevant technologies have been recommended (1a-2b) and are implemented (3c) through the use of subsidies or some other incentives. Occasionally, farmers may modify these irrelevant but important technologies (4c) and generate innovative and useful solutions. But in most cases, these are monuments of official apathy and indifference to local needs. These can be used only to generate shame and introspection among younger project team members so that they would avoid the traditions of indifference and unwillingness to learn from mistakes.

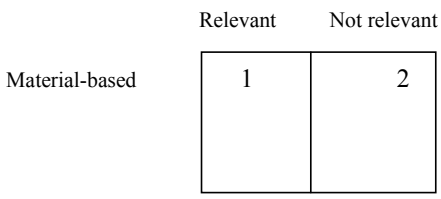
Most of the local technologies (structures and processes) of soil and water conservation may have been evolved by the farmers on their own (2c-3e) or may have been diffused through farmer-to-farmer networks (2c-3f). Each of these cases are insightful about the autonomous system of technology development at the farmers' level. Within these technologies, lots of modifications (4g) may take place to suit and exploit the local environmental conditions. We should also be careful not to underestimate the power of simultaneous inventions (Biggs, 1981,Richards, 1985) taking place all the time. In the recharging wells of Saurashtra, several innovations have evolved autonomously without any triggers from outside.

By definition, we do not expect irrelevant technologies (2d, 3g) to evolve since any such effort costs time and money. Why would farmers evolve something that does not serve any purpose? However, it is possible that some technologies were useful in the past and their current relevance may have gone down. Before a road came up, water might be passing through a particular passage and eroding some fields. After the road came up, such an eventuality did not exist and thus some structures might have become irrelevant.

The innovation can be discontinued, (5d) after a while and replaced with something more appropriate. Much of the literature on extension has ignored the phenomenon of discontinuance of technologies adopted earlier and found irrelevant (Gupta, 1985b, 1987a; Bush and Lasey, 1987; Halter and Mason, 1984). Thus ostensibly, a relevant technology is transferred but then either at the same time, or later on, it ceases to be functional and is discontinued. Rather than interpreting it as a case of non-adoption, one ought to treat it as a progressive measure and deal with such farmers separately. Obviously such farmers could see the inappropriateness of a given technology faster and avoid losses.

Similarly, there are many domains where support from the formal system has been weak and this has triggered innovations. Most important of these are the technologies that do not involve transfer or exchange of material resources (cell 3 in figure 2).

Figure 4.2



Non-material based	3	4

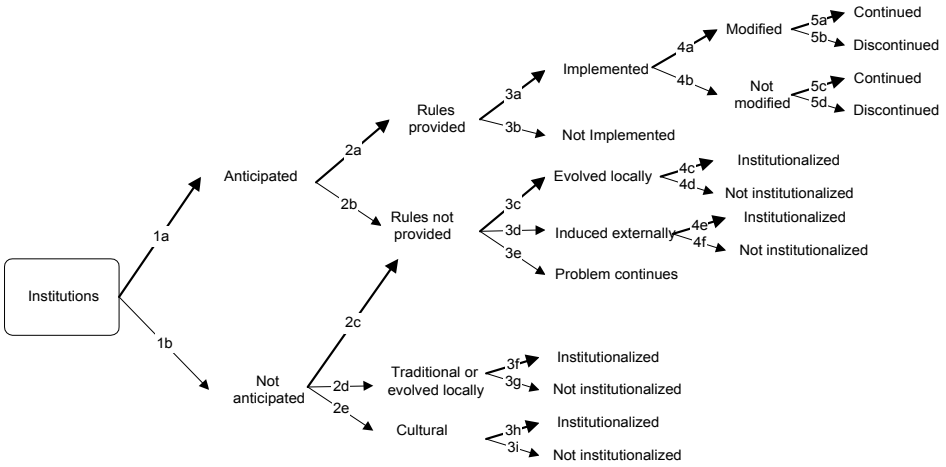
The proportion of non-monetary technologies has been found to be far less in extension literature (Nand and Kumar, 1980; Gupta, 1985a, 1987; Pastakia, 1996) than monetary technologies. Innovations in such domains are also least documented. Unlike structures, these are process-based innovations and are not easily visible. One has to spend far more time to observe these innovations.

4.1.2 Institutional innovations

When rules or processes evolve to arrive at collective decisions to manage a given resource, there remains a possibility of some individuals and subgroups coming out with new ways of solving a problem. Depending upon the group dynamics, attitudes of the PIA, norms of a programme or other socio-economic and cultural features, the innovations may or may not take place. And if they do take place, they may not be institutionalized. The innovations may sometimes be a response to technological constraints. By technological constraints, we also mean the rejection of the community to accept a technology completely due to cultural or other constraints.

Not all contingencies can be anticipated (1b). There may be institutions that are specific to the community and the region. These local institutions can be traditional or contemporary institutions (2d). Several of the local institutions draw upon the strong cultural ethic within the communities (2e). Depending on the changing life styles and shift of dependency on the local resources, the local institutions may break down (3g, 3i). Some of them may be still strong (3f, 3h). Cultural values and beliefs can be potential starting points for mobilizing people for collective action.

Figure 4.3



Anticipated institutions can be provided with definite rules in very few cases (2a). In most cases, the rules cannot be provided (2b) given the varying local socio-economic conditions and cultural attitudes. The same factors influence the necessity to modify the rules while implementing (3a-4a). When the rules are not modified (3a-4b) or the modifications do not reflect the local values and aspirations, there is a danger that the institutions may be discontinued (5b, 5d) over time. We discussed earlier about the concept of interlocking of rules for building sustainable institutions. When the rules blend with the local aspirations and draw support from other institutions, the institution may sustain (5a, 5c) over time.

`Institutions anticipated but the rules are not provided' are those that require sincere efforts from the PIAs (2b-3d). It is possible that the proposed institutions may blend with the local institutions and draw upon them (2b-3c). Evolution of rules that can institutionalize the intervention ought to reflect the needs and priorities of the participants (4c, 4e). Lack of sufficient level of participation of people in the rule making process may destabilize the institution over time (4d, 4f).

The frameworks presented above are in addition to the 3-P framework presented earlier to identify local innovations in general based on the heuristics of farmers while solving the problems. These frameworks are specific to watershed context and may be helpful in possible domains for building upon local knowledge systems.

4.2 Framework for building upon local knowledge systems

There can be several ways of building upon local knowledge systems. We will discuss some empirical experiences of the cases that attempted to draw upon local creativity and draw lessons from it. A general framework for building upon local creativity may be developed by revisiting the 4-A framework used by Gupta (1992) for understanding the choice of technology.

4.2.1 Eco-institutional (4-A) framework for choice of technology

Human choices in a given eco-sociological configuration are circumscribed by the historical evolution of institutional structures. Institutions provide a framework of rules, sanctions, and meanings that are commonly understood by people in a given region. Institutions provide assurance to individuals and groups about the uncertainties faced over space and time. Assurances help in generating cooperative behavior when we deal with common properties (Sen, 1967; Runge, 1986; Gupta, 1985b) and make behavior of others more predictable. In the case of private resources, assurances may stimulate demand for better access or technical skills or both. Even if we have an institution that provides assurance, if we do not have access to resources or we do not have skills or abilities to use the resource, the investments from people will not follow.

All the three vectors of choice, access, assurance, and abilities, must be synchronized to match with the attitudes of people towards change or maintenance of a resource use system. Thus, within a specific spatial, sectoral and seasonal configuration, portfolios may vary within a given range because of changes in access, assurances, and abilities.

The access to natural resources, assurances from the institutions, ability in terms of skills and technology to convert access into investment, and attitudes in terms of culture and dependency on the resource, collectively influence the household portfolios (Gupta, 1990). Thus, if we want to introduce technologies that presuppose the existence of certain skills, access modes, or institutional structures, but some or all of these vectors are missing, we cannot fault people for not using the given opportunity. If we know the complexity of access and the abilities of the people in a given system, we should be able to anticipate what kind of assurances will generate or respond to the given attitudes. Attitudes here are the outcome of historical experiences and current dependency on the resource that influence the inputs into the choice. These also shape the way a community looks at the opportunities. In that sense attitudes are both endogenous as well as exogenous variables.

4.2.2 Framework for drawing upon local creativity in a watershed management

An appropriate blending of 4-A framework with the framework for delineating the domains of local creativity in watershed management may yield possible directions for building on local knowledge systems in watershed management. It also helps to understand various dimensions of choice of technology, which need to be considered to introduce an exogenously evolved technology or institutional design.

All the four ‘A’s i.e. access, assurance, abilities and attitudes, must be satisfied in a system for it to be sustainable. The advantage of the framework is if we know any two dimensions we can speculate about the third. And if we know three, we can speculate on the fourth. Let us take the case of a technology for plant protection. It is useful for me to use biological pest control, if I have some assurance about others behavior. But if I did not, I might spend more on chemical pesticides, and increase the cost of plant protection of others as well. Further it is not enough to have access to technology and skills or ability to use it, if assurances are not available. Likewise, the culture of collective survival vis-à-vis individual survival would also influence the sustainability of technology as well as institutional arrangement.

For instance, pastoralists need access to grazing land, water, place for night shelter, food and other necessities like veterinary medicine during migration. Need for assurance about security of livestock

and self in the unknown or less known regions generates institutions for collective survival. Aggrawal (1991) illustrates how in some of the migrating *dangs* (group of shepherds) a sort of relay race is performed for night watchman duty. Every person has to guard the herd in the night by moving around the herds, settled in concentric rings with women at the center and the animals and the men around them. He takes a small stick to be handed over to the appointed person at fixed time in the night to change their turn. If a person sleeps over, it is easy to find out the culprit.

Likewise, other mechanisms have been developed. People in the Andhra Pradesh villages receiving herdsman from Rajasthan have an informal arrangement for deciding whose fields should be penned this year by whose herd. An assembly of village elders negotiates with the scout party of the pastoralists about which herd will stay in whose field. The obligations of payment to a village common fund, herdsman or the farmers are also spelt out (Wade, 1980). Friendly relations between the visiting herdsman and the local settled populations cannot always be taken for granted. There have been many cases of violence against pastoralists for grazing in the forests or sanctuaries, private fallows, roadside fallows, at inter-state borders etc. There is a Supreme Court Judgement permitting unrestricted right of pastoralists to move from one state to another. However, weakening of assurances from state or host village communities obviously increases grazing pressure on more marginal uninhabited lands leading to ecological crisis.

The improvement in access or assurances only will not help if the skills of the pastoralists to use available opportunities do not simultaneously improve. Most pastoralists can inject medicines or vaccinate their animals themselves. But there remains a vast range of traditional medicine systems or knowledge about combination of stress fodder and feeds during drought, which remains to be properly analyzed, screened and diffused.

Figure 4.4

Dimensions to build upon local knowledge			Traditional	Traditional Modified	Contemporary
Access	Resources	Time			
		Space			
		Sector			
	Technologies				
	Institutions				
	Cultural resources	Gender			
Assurance	Horizontal	Cultural			
		Technological			
		Institutional			
	Vertical	Cultural			
		Technological			
		Institutional			
Abilities	Resource interpretation		Indicators		

	Resource use		Testing, Improved methods of extraction		
Attitudes	Resource	Dependency			
	Technology				
	Institution				
	Culture				
	Gender				

The local knowledge systems may be (I) traditional or (ii) traditional, but may be modified recently (iii) contemporary, knowledge acquired recently. We will discuss some empirical cases where attempts have been made to build upon the local knowledge systems and try to understand the variety of strategies that may be adapted to generate sustainable interventions.

4.3 Spawning Success: Lessons to Learn from LKS

4.3.1 Sustainability of interventions for sustainable use

The formal research institutions have done not much work on the indicators of sustainable resource extraction. A wealth of knowledge exists with the communities in the area of ecological indicators (Gupta, 1994a), which cannot be disregarded while making interventions that involves extraction of the local flora. The contribution 6.1 in the compilation of the innovations part B, documents the women's knowledge about the grasses and fodder that they collect from the wild. There is a specific way of extracting fodder from different fodder plants and grasses. It also changes over time and space. It can be very useful to draw upon such insights while making interventions that involve extraction of any resource.

A watershed project in the 'Doon Valley Watershed Project' has an interesting experience to share in this regard. The project was implemented in the Kotla village of Dehradun district. As a part of project implementation, the PIA had proposed to revitalize the severely degraded pasturelands in the village. The PIA cleared the pasture lands severely infested by the *Lantana* weed and planted *ginni* grass. Next season, PIA suggested to the villagers to harvest the grass at a stage when it is supposed to contain high nutrient content. Villagers refused to do so. They explained that along with the *ginni* grass, a local grass called *golda* also grew and harvesting grass at that stage would prevent the *golda* grass from growing. *Golda* is most preferred in the area and is believed to be more nutritious.

In the central hills of Nepal, the propagation of *Ficus nermolis* (a tree fodder species) became difficult because the animals graze on the young plants. The communities suggested and used *Neolitsea umbrosa*, a small bushy tree as a nurse plant for the *Ficus nermolis*, which is ignored by grazing animals. It has been reported that *Ficus nermolis* grew more quickly in company with *Neolitsea umbrosa.*

4.3.2 Local resource based opportunities for conservation

4.3.2.1 Neglecting local resource base and traditional practices while creating opportunities can lead to undesirable consequences on the resource base itself. *Leesa* is a resin extracted from *chid* (pine) trees in the Sub-Himalayan parts. The resin has inflammable properties and is traditionally extracted to use for domestic purposes. It is also sold in the markets and is a means of generating income. The opportunities created through several recent development interventions do not build upon this practice. People no longer prefer to collect the resin because of the tedious process involved. And it is believed that the resin that was not extracted could be one of the reasons for the frequent forest fires. A casually thrown matchstick can cause forest fires. An improved and easier method for extracting resin would perhaps have been an appropriate intervention in this regard.

However, there is an entirely different hypothesis for the cause of forest fires. Burning the crop-residue after harvesting is a traditional practice among hill-farmers. While harvesting, farmers cut the stems halfway and leave it as such so that these can be burnt when the base dries up. Farmers narrate following reasons for doing so; (I) Burning is possibly the fastest way to clear the field, (II) It kills the insects and also burn the seeds of any weeds (III) The ash increases the fertility of the soil.

There are some associated practices to avoid the spread of fire the beyond the field. Wheat is harvested when summer approaches. At this time, the old people and children move to higher altitudes and help monitor the spread of fire while the young and able bodied set the field on fire (Personal communication with Lepcha, 1998).

However, the forest department, the PIA for implementing watershed projects in the region discourages the practice of burning in the fields to prevent forest fires. It proposes to cut right at the base while harvesting crop so that the residue can be used as fodder in the lean seasons.

Mr Lepcha, formerly associated with the 'Doon Valley Watershed Project', has some interesting insights on the forest fires. 'Money Order Economies' is a term frequently used for the household economies that receive income from outside the village. In most mountain regions, the trend is that one or two resourceful persons in a family leave the village in search of jobs in the urban centers. They regularly send money orders from outside to their dependants. With the incomes assured, many families leave cultivation and stay idle. The increased liquor consumption in these regions has also been attributed to the 'money order economy'. Obviously, it has even encouraged people to refuse to comply with the institutional norms for managing local resources. There are several instances where the local institutions broke down because of shift in dependency on the local resource base.

Lepcha plotted the occurrence of forest fires and presence of money order economy on a map in a specific region and found that these match with each other. He believes that as the dependency of people over the forest shifted, they are no longer encouraged to protect and manage the forests.

4.3.2.2 Local skills: A Resource?

Etikoppaka village of Andhra Pradesh is known for skilled artisan groups that make wooden toys and artifacts. Few years back, a number of artisan families were on the verge of migrating to the urban centres because of the low returns from the local markets. C.V. Raju, a young man, realized the

precious skills that they had, and tried to prevent their migration. He improvised traditional methods of making tree-based colors to get wide-ranging colors options and generated market demand for them as eco-friendly products. He initiated a cooperative of the artisans and linked them with larger markets.

The cooperative, 'Padmavati Associates', is now probably one of its kind producing wooden toys and artifacts made with tree-based colors. The group receives regular orders from national and international buyers. The case reveals several lessons for institution-building also (Chokkakula and Raju, 1997).

Skills may be a resource too, based on which we may generate sustainable livelihoods. In case the artisan-families were allowed to migrate, they would have had no choice but to work as unskilled laborers in the urban centers. Such are the conditions which lead to 'money-order economies'.

4.3.3 Improvisation of structures: Let Locals Lead

In marginal environments, there cannot be alternatives to the traditional structures particularly for soil and water conservation. The scope for innovations with regards to the basic principles underlying the structures found locally is limited. The innovations can at the most be in the form and material that may improve the efficiency and reduce the cost involved. The best strategy offered by the experiences is to let people lead the implementation and restrict PIA's role to providing material and technical inputs to use the material.

4.3.3.1 Innovations in *guhl* reconstruction

Watershed projects in the mountain regions necessarily include renovation of *guhl*s. *Guhl*s are irrigation channels in the mountain regions that carry water from sources like *Bawdi* and *naula* to distribute water to the fields. Construction of new *guhl*s involves several stages, identification of source, surveying the area, alignment and finally construction. Reconstruction of *guhl*s involves converting the stone and soil made *kuccha guhls* into cement made concrete pucca *guhl*s. Vander Velde (1990) recounts the experiences of projects that involved constructing new *guhl*s in the Himalayan mountain regions of Pakistan. Traditionally, people use water as a level to determine slope and alignment of *guhl*s. Elders in the village are consulted to find out about past avalanches and mudflow paths. While constructing new *guhl*s, PWD ignored this knowledge and as a result, out of the 20 schemes implemented at a cost of 1.85 million rupees, only one is working properly.

Converting *guhl*s to concrete structures reduces flexibility for distribution and increases velocitiy. Generally, PIA makes necessary design changes to reduce the velocity of water and to keep the structure strong enough. However, the designs lack the flexibility and do not synchronize with the existing institutional arrangements. Lack of inputs in this regard may result in damage to the structures due to frequent breaching of the channels. In this particular watershed, the PIA provided the designs and materials for construction. People were in charge of construction.

Innovations in *guhl* reconstruction

Weirs at diversions to regulate flow into water-harvesting tanks

*Guhl*s feed water to fields as well as water harvesting tanks or farm ponds. The tanks are modified versions of what are locally called *hoj* or *khal* in different parts of UP and Northeast India. These are temporary storage structures of water for domestic as well as irrigation purposes. In the *kuccha guhl*s, the *guhl* is temporarily breached to divert water into the tank. Once the tank is full, the breach is closed again.

In the Neher village of Dehradun district, while constructing concrete made *guhl*s, villagers constructed a small weir (a projection elevated above the bed of the *guhl*). The water overflows into the diversion only when the water level in the *guhl* rises above the level of the weir. Effectively, the modification allows only sufficient amount of water into the tank to fill the tank, without which the tank may overflow if the diversion is not closed properly and in time.

Guhls can also be pathways!

In the Bhavani village of Tehri Garhwal district, people wanted broader walls on the channels of the *guhl*s so that the width is sufficient for them to walk through the fields. Traditionally *guhl*s are aligned along the boundaries of the fields. Usually farmers do not like to have separate boundary *bunds* because, it would be wastage of valuable land. According to the PIA's design of *pucca guhl*s, the width of the wall is about 10 to 12 cm. However, farmers preferred at least one side of the wall to be more than 20 cm width so that they could walk over the *guhl*s.

4.3.3.2 Cost-effective construction of Contour *bunds*

'Shri Kundla Gram Vikas Mandal' is an NGO working in the Savarkundla district of Gujarat. A major soil and water conservation programme implemented by them involved constructing contour *bunds*. When they were constructing the *bunds* according to the dimensions derived by the standard formula, the farmers suggested that at some places the *bunds* need not be larger than the recommended ones. Depending on the land use, the dimensions can be reduced and accordingly the cost can be reduced (Personal communication, Mehta 1998).

4.3.4 Invisible innovations

Local innovations need not necessarily be traditional and well diffused. Innovations can evolve in response to a specific constraint from an individual or a group. The innovative strategies of Shaligram to create fertile soil (refer 1.3) can easily be replicated in other cases also. In this case, the innovation is by an individual. There are several other examples of individual innovations for various problems (refer 2.9, 2.10, 3.1, 3.6, 3.8 etc). Constructing a retaining tank (refer 2.7) to increase pressure heads so that the water reaches the last field is an interesting example of collective innovation for a common problem. Though the tank has not been constructed under any watershed project, it is important to note that the villagers have diverted the funds from a drinking water scheme. Rest of the inputs was borne by the villagers collectively and voluntarily. An important

question is, why cannot such initiatives take place in watershed management projects too. We will discuss these aspects further when we discuss the case of Premjibhai's 'cement scheme'.

The case of retaining a tank raises some important questions.

(i) There cannot be any better solution than that generated by people under the given constraint. Would any watershed project approve suggestion for such structures by people?
(ii) Could such prioritization for tanks be allowed?
(iii) Even if the structures were allowed to be constructed, would it be possible to elicit such strong collective institutions, as they exist in this case for managing the structure?

4.3.5 Blending with traditional and existing institutions for sustainability

Institution building requires careful understanding of local socio-cultural and institutional networks. The proposed institutions need to blend properly with the local institutions so that they draw support and sustenance from them. Earlier, we discussed this aspect as 'interlocking of institutions for sustainability'. The process of institution building itself is the most crucial aspect of blending with local institutions.

In the 'Doon Valley Watershed Project', a watershed committee called GAREMA (Gaun Resource Management Institution) is facilitated to manage funds for post-project management of interventions. In most of their watershed projects of earlier phase, it so happened that the GAREMA*s* usually clashed with the existing traditional institutions. In this region, there is a strong tradition of *guhl* management institutions (Refer 8.1, 8.2 and 8.3). The GAREMA*s* functioned well as long as the PIA was in the picture and once it withdrew, the conflicts arosed. Such conflicts lead to total breakdown of collective bonding among the communities in some areas but in other areas, the collective institutions have become stronger.

The experience in the Halduwala village of Dehradun district is a typical example. The PIA withdrew from the Halduwala village last year after a project implementation period of three years. The village had its own traditional institutions for managing *guhl*s and distribution of water before the arrival of the PIA. The PIA not only renovated the existing *guhls* but also extended it and constructed a new one, thus creating new cultivable lands. The project created a GAREMA and the association was left with sufficient funds. When we visited the village this year, the condition was pathetic. The *guhl* had been damaged by landslides and was lying defunct without repairs though there are sufficient funds with the GAREMA. Much worse was that the newly created cultivable lands have also been abandoned, as there was no supply of water. Even then neither traditional institutions nor the GAREMA took charge of the situation. The obvious reason was when GAREMA was created, efforts were not made to understand the existing institutional arrangements and the GAREMA had challenged the authority of the traditional institution. The GAREMA became a parallel institution with similar responsibilities to that of the traditional institutions.

In contrast to this situation, there is another case in the Neher village where the newly created institutions blended well with the traditional institutions and drew support from them.

GAREMAs and Guhl management institutions.

In the Neher village, the PIA spent sufficient time to explain the purpose of the project and made clear that the PIA would withdraw after project completion and the villagers would have to manage the assets on their own. Office-bearers of the existing institutions for managing *guhl*s and the villagers were consulted and a separate committee was formed to look after the management of *guhl*s. In addition to that GAREMA was set up to look after the funds.

The *guhl* management committee hired the same *guhlwala* who used to look after the *guhl*s earlier also to take care of the repair and maintenance of the *guhl*s. The committee also decides on the order in which the water has to be distributed among the farmers based on the location of the farm, the requirement and the farmer's position in the previous order, etc. The farmers are allotted water for specific number of hours and a rotational system is followed. The *guhlwala* ensures that the order is followed. Any violations are dealt with by refusing water to the farmer.

Earlier, the villagers used to repair the *guhl*s collectively every year by contributing voluntary labor. Since the *guhl*s have become *pucca,* there are not much repairs and *guhlwala* gets the *guhl*s repaired periodically using hired labor. The committee approves the costs and if necessary, GAREMA provides the necessary funds. The GAREMA's funds are also regularly recuperated by a cess that was agreed upon by the villagers, *guhl* management committee and the GAREMA. The cess is collected for providing water on the basis of land holding.

The *guhlwala* is generally a person who is the poorest among the villagers with very little or no land holding. After every six months, farmers contribute up to five to ten kilos of their harvest to the *guhl*wala. In addition to this, the *guhl*wala is paid Rs 250 per month as a salary from the revolving fund. *Guhl*wala also takes care of the common bull and receives part of the earnings on it. Any surplus funds from *guhl*s are transferred to the GAREMA's funds at the end of the year.

4.3.6 Unanticipated Institutions

Unanticipated but successful institutions invariably draw upon abilities, values or attitudes associated with local traditions and culture. Building on a value or norm commonly respected or a need commonly felt can generate collective action. These provide assurances to individual participants. Appropriate inputs and outside help to build stronger and sustainable institutions. Some examples below provide further understanding on the issue.

4.3.6.1 Cultural values as starting point

Local cultural values can be a potential starting point for mobilizing masses for collective action. It can bring tremendous momentum into the project. In a watershed project in the Rishikesh division of the 'Doon Valley Watershed Project', the Project in-charge, Ms Jyotsna Sitling attempted to exploit the local cultural values to mobilize a massive plantation programme. Pouring a handful of soil into a stretched towel is a symbolic gesture of a promise to the recipient of the soil. Such a promise cannot

be broken and is considered a sin if broken. Jyotsna and her team obtained promises from everybody that they would participate in the tree plantation programme. On the given day, there was a huge turnout of the villagers to participate in the plantation programme. Many elders recollected similar traditional rituals, which they used to draw upon while organizing such programmes of collective interest. The programme was a big success and the PIA could generate active cooperation from the villagers in their subsequent activities also.

4.3.6.2 Culture values provide assurance

A similar case from Andhra Pradesh further highlights the importance of the cultural values in building sustainable institutions. The tribal belt in the East and West Godavari districts has a strong traditional forest management institution called *Noorinti Adavi* (forest of hundred households). Certain forest patches in and around a village are demarcated as a *noorinti adavi* and that implies that the forest in these patches is a common property. People have genuine respect towards the institution and sometimes associate it with some religious rituals too. People collectively contribute for maintenance of the forest and distribute the income from the forest among themselves. However, the colonial rule and some subsequent reforms like allocating permanent ownership of lands destroyed the institution in most parts. The recent Joint Forest Management (JFM) projects, with their conventional approach of farming *Vana Samrakshana Samitis* (Forest protection Committees) and making people own and manage the forests miserably failed. An NGO in the region, SHAKTI attempted to build upon the cultural associated values with *Noorinti Adavi* by calling the forests as *Noortinti Adavi* and achieved tremendous success. Though other factors like the approach of the NGO and the process of building rapport may have helped the process, but the concept of *Noorinti Adavi* has assured the people that it is a common property owned by them.

The venture capital institutions like CAREMA (Clustered-village Resource Management Association) (Refer 12.1) are unique ideas on the lines of the concept of agro-industrial watershed suggested by Bali (1980). Particularly, more than one village level institution, like GAREMAs coming together to put in equity investments to a kind of venture capital or promotion fund is a revolutionary idea that has never been conceived earlier.

These institutions discussed were not anticipated while planning for the watershed project. But they were triggered off by the opportunities generated at the local level and have since been nurtured.

4.3.7 Case study of Premjibhai's 'Cement Scheme'

Premjibhai is a maverick-crusader for tree plantation and protection of trees in the Saurashtra region of Gujarat (Refer 5.2). Given his reputation and his concern for the environment, he was encouraged to take up watershed projects through Drought Prone Area Programme (DPAP) programmes.

Watershed programmes in Sauarashtra focus on water conservation and harvesting as the region suffers from the problems of groundwater depletion and salinity ingress. Major activity is constructing check dams and revitalizing other water harvesting structures like tanks. With an

experience of over two years of implementing these programmes, Premjibhai was not satisfied with the efficiency and effectiveness of the programmes. He felt that the estimated costs were too high. Also, that the process of implementation does not contribute in anyway towards the people becoming self-reliant or for strengthening collective institutions. Contrary to it, it contributes to the increasing dependency syndrome. Saurashtra being an arid region, the major component of watershed programme is to construct check dams for rainwater harvesting.

The estimated cost of construction for check dams according to the DPAP scheme is Rs 2200 per 1000 cft. But Premjibhai's expenses comes to about Rs 1300 per 1000 cft. And, though farmers do participate in the decision-making and construction process, there seems to be lot of indifference to the process as the farmers assume that there are abundant funds and it is anyway the Government's (PIA's) job to construct the dams.

The process recommended is the following. The construction costs are estimated at the rate of Rs 2200 per cft after deciding the location and the amount of construction needed. Farmers are asked to contribute about ten percent of the estimated cost as the maintenance fund in the post-construction period. During the construction, farmers are hired on daily wages.

Effectively, farmers do not pay any costs at all and in some cases, they make money. In other words, there is no incentive with the farmers to maintain the structures

Although PIAs satisfy themselves that the farmers have participated in the process, in the end, the beneficiaries do not actually own the structures, as is assumed. When we asked the beneficiaries in the watershed project in the Sanala village, whether they would contribute towards repair and maintenance of the check dam check in case of any failure of the dam in the later stages, they were not willing to commit to it. They were under the impression that once they commit to it, they may not get the aid from the Government to maintain the structure, knowing fully well the benefits that may accrue from the dam.

4.3.7.1 Cement Scheme

Some farmers from villages adjacent to those in which watershed projects were taken up used to meet Premjibhai with a request to initiate such projects in their villages too. Premjibhai used to explain to them it was not possible but used to encourage them that they could collectively build check dams on their own.

One of the enthusiastic farmers, Babubhai Chanabhai Parmar from Bhayavadar village, developed an innovative way of farm-recharge (Refer 2.10). Over a certain period of time, Babubhai and Premjibhai worked out an arrangement, where Babubhai would construct a check dam on his own and Premjibhai would bear the cost of cement. It worked and this encouraged many more farmers to construct check dams with this arrangement. Premjibhai was too keen to bear the expenses of cement. Over time, instead of individual farmers, groups of farmers began to come to Premjibhai seeking support for constructing check dams collectively.

Premjibhai was quite happy with the kind of change taking place among farmers. He was convinced that once the farmers realize the benefits, they would take initiative on their own to take up any activity. He was also sure that large subsidies are not always necessary.

Encouraged, Premjibhai placed an advertisement in the local daily, inviting individuals/ group of farmers to get in touch with him in case they are interested in constructing check dams and offering to bear the cost of cement. He called it the 'cement scheme' and there was a very good response from farmers. Now the work is in progress or in the stage of completion on about 75 checks dams in more than 25 villages of Rajkot and Jamnagar districts. Majority of them are through collective action by groups of farmers.

Premjibhai spends his own money for the 'cement scheme'. Deducting the cost of the labor as the farmer contributes it, the cost of cement comes to about one-third of the total construction cost. Many times while paying, Premjibhai explains to the farmers that he does not receive any aid for this scheme. Mostly farmers bear at least half of the cement costs too. Sometimes Premjibhai would say that he used funds from Gokul Gosadan[2]. Farmers would never accept funds from Gokul Gosadan.

Comment [PAG1]:

In the end, the farmers on their own initiated collective action and constructed the check dams effectively. The offer to bear the cost of cement acted as a trigger to the institutions to manage and repair the structures in future. Thus, this process helps to revitalize the ethic of self-help and collective bonding among people.

The structures constructed through the cement scheme have some very striking differences in the design and construction of check dams compared to the dams constructed through watershed projects.

An illustrative example is the check dam constructed in Navagam village through a cooperative effort between 11 farmers under the cement scheme. Just about a distance of a kilometer, there is another check dam constructed under EAS (Employment Assurance Scheme). The table below gives a comparison.

Table: 3 Comparison between check dams constructed under EAS and Premjibhai's Cement Scheme

	Constructed through EAS scheme	**Premjibhai's Cement Scheme**
1	Total expenses were about two lakhs	Total expenses Rs 12,000
2	Costs totally born by the government, ten percent of the costs were collected from the beneficiaries and kept as maintenance fund	Large portion of construction material was mobilized from the beneficiaries and about 50 percent of the cement cost was provided by Premjibhai
3	Beneficiaries were paid daily wages while working on the check dam.	Beneficiaries contributed the labor free
4	Other than beneficiaries were employed on	None other than beneficiaries

[2] *Goseva* is a strong traditional institution for caring of cows in the villages of Saurashtra. Contributing to this institution is considered sacred act and taking funds from the institution, a sin. Premjibhai is the Vice-President of a regional level institution called Gokul Gosadan in Upleta, set up by like-minded people like him during the drought 1970s in Saurashtra to take care of the old and worn out cows and cattle.

	daily wages	
5	Location was not decided to minimize the cost and increase stability. The dam was constructed at a wider part of the stream and thus the length of the dam is very long.	The length of the dam was minimal possible as the location was chosen at a place where there were rocks in the streams and the dam was made with just by plugging the gaps.
6	Straight dam. Large dams may follow regular shapes like straight or arch shaped, but check dams need not necessarily do so as the stresses are low.	The dam was of irregular shape as it was basically plugging the gaps.
7	Artificially constructed embankments.	Natural rocky embankments and narrow gorge.
8	Temporary constructions were made by the users of the dam to raise the level, which implies, users did not have sufficient say while deciding the height of the dam.	There were nobody involved in the construction of the dam other than the beneficiaries and probably the mason
9	No more features	Buttresses were constructed on the d/s at places where the dam height was high to take the stress; No need of apron as there was rocky bed
10	Well-packaged	Packaging limited to prevent seepage

4.4 Discussion and lessons

The case 4.3.1 is an interesting example highlighting the local abilities for making resource use systems sustainable. It is a case of technology not recommended but important nevertheless (1b-2c-3e). The idea is to build upon the local abilities of resource interpretation and use (figure 4.4) for sustaining the supply of resource, *golda*. It also highlights the need for better access to technology, to clear the *Lantana* weeds and plant *ginn*i grass to renew the pastureland. An interesting fusion of local knowledge and formal technology to develop sustainable resource use systems. There could of course be appropriate institutional arrangements for providing access to grass and fodder (9.1, 10.1**).**

The observations in 4.3.2 about forest fires indicate that the blending of interventions with local knowledge systems extends beyond technological and institutional considerations (1b-2c-3e-4f in figure 4.1). We need to consider the changing attitudes (figure 4.4), viz., lifestyles, values and perceptions towards the resources and institutions. It is also important to note that the resources may not be conserved unless we create opportunities based on the resources and by adding value to the traditional practices if necessary. The opportunities need to be created based on the local skills in order to conserve precious skills and avoid 'money order economies'. The strategies should provide proper market linkages to generate demand for the resource-based products.

The innovations in 4.3.3 may be categorized as 'technologies recommended, but modified' (1a-2a-3a-4a-5a) in the framework in fig 4.1. When people are provided access with better technology in

terms of material and designs and allowed to take the lead for implementation, their needs and interests can be best met. Thus, the structures can be long lasting and also cost-effective.

The case of retaining tanks and other contemporary innovations (4.3.4) by individuals and groups are those technologies not recommended but relevant (1b-2c-3e in fig 4.1). It is interesting to note that the Sorna village was one of those villages where a watershed project had already been completed. Somehow the project missed this innovation so strikingly seen just at the entrance of the village. Obviously, there could not be any better solution given the constraints that the villagers had. Building such retaining tanks to increase the pressure heads was never tried earlier by any PIA even when they faced constraints similar to those in Sorna village. Watershed projects may need to include the components for identifying such invisible innovations and provide access to such solutions to people facing similar problems. In other words, there is a need to build knowledge networks among people so that they learn from each other.

Blending with traditional institutions (4.3.5) is an important prerequisite for any institutional arrangement to succeed and sustain. The contrasting experiences from Halduwala and Neher show how attitudes (fig 4.4) of existing institutional set-up towards the new institutions can influence their sustainability. The attitudes are important and define the blending process. The process should primarily involve development of mutual dependency between the traditional institutions and new institutions. The experience in Neher was successful because the setting up of GAREMA involved active participation of the existing informal institutions and drew support from them.

Attitudes (fig 4.4) that arise from cultural rituals and symbols are very powerful and can be built upon to mobilize collective action (4.3.6.1). Cultural values also communicate assurances much more effectively (4.3.6.2). The venture institutions like CAREMA draws upon people's attitudes and pools in their entrepreneurial abilities. Building such institutions need access to innovative ideas or information or value added traditional technology and institutions to network for organizing business ventures.

Premjibhai's experiences with the 'Cement Scheme' breaks several myths about subsidies and other such instruments of interventions. It seeks an activist mode of approach for development and revitalizes the inherent ethic of self-help among the communities and helps rebuild their self-esteem. The qualitative investment of efforts through such support compensates and reduces material investments involved. Subsidies are not always necessary for people to adapt a technology. If a farmer is convinced of the technology and is provided access to necessary information, all that is needed is encouragement from the PIA to act on their own. It may also be derived that people will own assets only when they invest sufficiently in building those assets. It is also interesting to note that innovators and 'self-starters' like Babubhai can be potential starting points for diffusing an idea.

A revised framework with possible strategies for building upon various dimensions is shown in the **fig 4.5.** The gaps may be filled with lessons from other appropriate examples.

Dimensions to build upon local knowledge			Traditional	Traditional Modified	Contemporary
	Resources	Time			
		Space			

Access		Sector			
	Technologies		(I) Value addition to improve efficiency (ii) Access to new material and information		(I) Knowledge networks (ii)Value added technology (iii) Innovative ideas and associated skills (iv) Access to information and skills
	Institutions				
	Cultural resources	Rituals			
		Gender			
Assurance	Horizontal	Cultural	Generate collective action		
		Technological			
		Institutional			
	Vertical	Cultural	Generate collective action		
		Technological			
		Institutional			
Abilities/ Skills	Resource interpretation		(I) Use Indicators		(I) Innovators/ self-starters as change agents
	Resource use		(I) Improved methods of extraction (ii) Generate market demand		
Attitudes	Resource	Dependency	(I) Build opportunities on local resource base		
	Technology		(I) Improve efficacy		
	Institution	Process of institution building	(I) Interlocking and draw support		(I) Entrepreneurial attitudes (ii) Revitalize ethics of self-help and cooperation
	Culture		(I) Build upon to mobilize collective action	(I) Provide assurances	(I) Build on culture of cooperation
	Gender				

5 Rethinking Policy Options[3]

We argue here for certain basic re-thinking in the policy options for viable watershed management by combining local knowledge with the formal science through rejuvenated or revitalized traditional institutions. Natural scientists have committed a fundamental error when they assumed that major challenge in watershed management was transfer of technology instead of development of technology on people's lands and in their neighborhoods.

5.1 Policy Environment: Where have we gone wrong?

The policy environment for management of land-use in India has been quite muddled. Part of the reason is lack of accountability among senior level public administrators, policy planners and various constituents of the existing institutions who decided not to complain even when institutions strayed away from their goals. When Gupta attended a meeting of a Committee of Secretaries of Government of India some years ago to discuss the state of affairs of Land Use Policies in India, the government report implied that every thing was satisfactory. He raised a question as to how many times the State Land Use Boards (SLUB) chaired by the respective Chief Ministers had met in the previous five years. In most states, the SLUB had not met even once. The situation of the National Land Use and Watershed Council was no different. In fact Gupta had resigned from the membership of the National Land Use Board when it did not meet even once during the three years that he was a member. Such is the policy concern and attention paid at different levels to land use problems.

The Hanumantha Rao Committee Report on Drought (MoRD, 1994) recognized that the Drought Prone Area Programme (DPAP) and Desert Development Programme (DDP) despite having been in operation for almost two decades has had a minimal impact. The beneficiaries of water harvesting structures and other common assets created through watershed programs have not assumed responsibility for maintenance after the PIAs withdrew even when the benefits were substantial. The people's participation "was conspicuous by its absence either in the preparation of plans or in their implementation" except in rare cases where results were much better. Contrary to the expected benefits, it seems the interventions have done more damage in many cases.

5.2 What could have been avoided?

5.2.1 Segmented approach

The conventional interventions including those through watershed management programmes (WMPs) preferred segmented approach without understanding the externality effects. As several researchers observed, the household economies in marginal environments are inter-connected and any intervention aimed at solving the constraints in one sector is bound to have effects on other

[3] This part of the monograph primarily draws upon an earlier paper, Anil K. Gupta, "Rethinking Policy Options for Watershed Management by Local Communities: Combining Equity Efficiency and Ecological-Economic Viability", IIMA Working Paper No.1341, November 1996, presented at 8th International Soil Conservation Organization Conference, New Delhi, November, 1994.

sectors (Gupta, 1981; 1983; Jodha, 1992). However, these effects may be positive or negative. Bajracharya (1992) looked at it from a different perspective of 'inter-sectoral complementarities and cautioned that the intervention in one sector cannot be presumed to directly lead to improvement in another sector. It should consider supporting activities in other sectors also to ensure expected improvements. The hydro-electricity projects in hill regions of India and Nepal were a failure because the electricity may be a necessary condition for industrialization but not a sufficient condition (Banskota *et.al.,* 1992). The inter-sectoral links could be as remote and inconceivable as Zimmerer reported (1992); that seasonal shortage in labor availability caused the loss of native germplasm in the Andean Highlands. Due to various seasons such as (i) unfavorable terms of trade in the highland agriculture (ii) temporary migration of labor to low lands for higher wage rates (iii) stagnant or shrinking land base and the reduced supply of labor forcing many peasant farmers to forego production of slow-maturing varieties.

Hanumantha Rao Committee Report (1995) was thus an important milestone. It emphasized the need to carry out the area development programmes on watershed basis with a holistic and integrated approach. Albeit there are some important concerns that it failed to respond. We discussed these issues elsewhere (Gupta, 1994a and see the annex).

5.2.2 Building upon LKS: By default or by choice?

In the arid parts of Rajasthan, particularly in the regions with 150 mm to 300 mm average annual rainfall, where *khadin* farming is practiced, there were hardly any other alternatives we could experiment with. For the past several years, the only effective intervention made by the Departments of Soil and Water Conservation is to make the *khadins pucca* and strengthen the *bunds*. A major contribution made by Central Arid Zone Research Institute (CAZRI) for water conservation is to improve the traditional structures like *kundi, tanka* etc. Similarly in the case of high mountains, major the proportion of funds were spent on revitalizing the *guhl*s by making the *guhl*s *pucca* structures. It is a different matter that in both the cases, the need to strengthen the institutional aspects simultaneously has been entirely ignored.

These lessons were not learnt by choice but by default. It is evident from growing number of failures of various schemes by deliberately ignoring the local knowledge systems. Banni area is a saline desert in the Northwestern part of Gujarat. Billions of rupees have been spent in the last couple of decades to supply drinking water through pipes from the nearest town, Bhuj, which is about 80 km away. These systems failed due to lack of appropriate supporting mechanisms in case of leakage of pipes and people have been forced to turn to *Virdas*, the traditional structures for drinking water. *Virdas* have never been considered to for developing a research programme for generating an everlasting solution.

5.2.3 Mindset

Building upon Local Knowledge Systems (LKS) while planning interventions has never been easy. While the root of the problem lies with the mindset, it extends further with the ease with which we try to simplify these technologies.

The seemingly simple indigenous resource use systems are actually evolved from and embedded in the local socio-cultural context and many times this context provides inherent support for the systems to work. Recalling again what Sengupta (1985) observed while studying the *ahar-pyne* systems in Bihar, that though the systems looked simple, understanding the institutional arrangements and the actual reasons that facilitated collective action was an exhausting study .

Several recent works further highlight this attitude particularly while comparing the indigenous soil classification and western soil classification. Williams and Ortiz-Solorio (1981 in Ettema 1994) observe that the apparent simplicity of indigenous classifications undoubtedly relates to lack of systematic investigations.

Some systematic investigations found that the indigenous classifications are more functional in nature and the first level of classification includes physical dimensions of soil such as color, texture and taste (Kervan *et.al.,* 1995, 1995; Warren and Rajasekaran, 1995; Ettema, 1994; Warren, 1986; http://www.physics.iastate.edu/cikard/iked3.html). Indigenous classifications also use perceptual dimensions that are not readily recognizable such as soil workability, suitability classes for certain types of crops (Ettema, 1994). Dvorak (1988) collected soil samples from different semi-arid tropical villages of India and did a systematic analysis to compare the decision-making based on indigenous and formal classifications. It was found that the results generally supported the farmers' way of thinking about the soils. In one village, the indigenous system performed better than the formal classification based recommendations.

The soil classification systems cannot be uniform for the highly heterogeneous conditions of dry regions and mountain regions. There is an obvious need to redefine the soil classification systems in these regions. It cannot be done without blending indigenous soil taxonomies with that of formal science. Inter-state soil conservation board set up in 1961classfified the land into eight capability classes, I-VIII, and designated their specific uses without reducing the land's productivity. According to this classification, in the entire Himalayan regions, there are no class I and II lands and the entire land would confirm to class V-VIII types, which are classified as not suitable for cultivation and must be spared for permanent vegetation like orchards, forest pastures etc. All these lands with slopes 30 to 100 percent, where the cultivation is not permissible are actually being cultivated for long by making terraces. In fact in the last 100 years, the land under cultivation has increased by 50 to 65 percent in many Himalayan Regions. It is argued that that the land use specification based on capability poses severe difficulties and suggests. For example, in class IV lands, which are at present being used for marginal production of cereals. A mixed land use for orchards and cereals was found as most suitable (Gupta, 1992)

5.2.4 Crisis of confidence

Failure of the benefits in reaching the actual intended has created a sort of 'crisis of confidence' between people and the state (Bajracharya, 1992). This has further bolstered with the responsibility

of implementing watersheds having been given to the line departments in most cases. It is too much to expect from the staff of the line departments entangled with bureaucracy to suddenly shift to activist mode that is necessary for participatory watershed development. The inherent inflexibility in the system (Thapliyal, Lepcha, Kumar, Chandra, Virgo and Sharma, 1992) prevents from responding to any local initiatives. To certain extent the personnel are also not equipped to carry out various functions in watershed management (Vaidyanathan, 1991). Hanumantha Rao Committee (www.rural.nic.in/book00-01/ch-22.pdf) strongly sought to encourage voluntary agencies to take up the WMPs. Experience in WMPs where the voluntary organizations (VO) participated, shows considerable success. It has been found that the VOs establish a better rapport with the farmers and facilitated continuous feedback from them. The farmer's felt much more convinced while adapting to recommended technologies with the VOs involvement. It also helped to monitor the implementation by Government Organizations' (GOs) in some cases (Shah, 1995). Shah (1995) further recommends the following policies for the VOs involvement.

(a) VOs should be involved in all the three major stages of the project, planning, execution and follow-up management.
(b) Sequencing of activities between GOs and VOs with proper coordination is important. For example, VOs may play a better role in entry phase that will be crucial for better implementation by the GO later.
(c) Instead of strictly adhering to the project provisions, NGOs should be able to mobilize voluntary contributions from the people and organize them for collective action.
(d) Gradually, the GO's role should be changed to that of facilitator and the VOs' role to that of implementers.

However, the transition of the role of government organization into a facilitator does not seem to be acceptable, at least at the lower level. There is a constant friction between the GOs and the VOs on the kind of initiatives that can be taken up and the process of implementation, leading to delays in implementation. This may be due to absence of a parallel monitoring mechanism to ensure that the delays are avoided and resolve the conflicts.

In fact, the root of the problem is that the GOs are not accustomed yet to the idea of participatory watershed management. In addition to training for the watershed management staff of the VOs, there is a necessity of reorientation programmes for the staff of the GOs.

5.2.5 Perverse incentives

Incentives in the form of subsidies and other short-term measures to encourage farmers adapt new technologies are being increasingly recognised as perverse incentives. They do more harm than good (Kerr, Sanghi and Sriramappa, 1996; Feder and Slade, 1985). They cause what is called the 'dependency syndrome' (Thapliyal, Lepcha, Kumar, Chandra, Virgo and Sharma, 1992) among the people, leading to conflicts, which sometimes hamper traditional institutions.

In Halduwala village of 'Doon Valley Watershed Programme', the Project Implementing Agencies (PIA) supported farmers to construct their own *pucca* water storage tanks. These tanks are to store the water temporarily so that the farmers can use it for irrigation purposes. Farmers were expected to

deposit about 10 percent of the cost with a common fund to maintain common assets after the project. The PIA withdrew about a year back. A forester posted there looks after any complaints from the villagers. He was accompanying us during a recent visit. When we visited the village this year, a farmer, Jabbar Singh met us on the way. Jabbar Singh was very happy that the project provided harvesting tanks and told us that he could harvest high yields of onions in the previous three seasons because of it. In the end, he began complaining that the tank was leaking and wanted it to be repaired by the project. To our astonishment, despite high returns, he was not willing to invest in it even though it was a private asset. The attitude of people in the much-acclaimed Fakot Watershed Project towards private as well as common assets is nothing better.

Premjibhai's cement scheme is thus an eye-opener in this direction. Unless we find ways to phase out subsidies, we cannot dream of a self-reliant society.

5.2.6 Conserving resources or skills?

Most poverty alleviation programmes tend to increase the dependency of the community on the outsiders and end up importing workers, decision makers and capital resources from the developed regions and exporting local skilled people as unskilled laborers to the developed regions (Banskota and Jodha, 1992a, 1992b). This creates a 'money order economy', which in turn leads to local resource degradation. There is a danger of similar consequence for watershed projects if we do not conserve local skills along with the resources through appropriate value addition and marketing strategies.

In Andhra Pradesh, C. V. Raju successfully stemmed the erosion of skills of artisan groups in his village by adding value to the traditional technology and generating market demand.

Even though the concept of agro-industrial watershed was suggested way back in the 1980s (Bali, 1980), not many watershed projects could emulate this idea. The idea is that changes in the income or the productivity are likely to be of very small order (10 to 15 percent on average) in the early years even if everything was done ideally. On the other hand, if the produce of the watershed whether fruits, vegetables, crops like pulses or oil seeds, is processed into intermediate or final consumer product, the increase in the income can be very high. Further, the catchment area for processing plants need not be coterminous with the boundaries of catchment of watershed. The fluctuations in the market place can also be reduced through value addition at the local level. At the same time, the need for systematic market research, linkages and other support measures remains.

Absence of explicit policy guidelines is one of the major reasons for not attempting this concept in watershed projects. When some VOs took initiatives in this direction, they were discouraged and their attempts were thwarted by the GOs on the pretext that the policy guidelines did not permit the same.

5.2.7 Other key weaknesses of the existing watershed development approaches are:

a) Lack of attention to the interaction between property right regimes, degree of degradation, nature of investment required and the time frame for developmental options.

b) In an action research study on linking banking and technology on watershed basis in two districts of Karnataka, it was learnt that bankers were seldom involved in the design and planning stage of watershed projects. There were expected to support crop development once the watershed project had been developed. Large number of bankers in fact had never visited a developed watershed project.

c) In a joint watershed project designed and implemented by International Center for Research In Semi Arid Tropics (ICRISAT), Central Research Institute for Dryland Agriculture (CRIDA), Indian Farmers' Fertilizers Co-operative Limited (IFFCO), State Bank of India (SBI), State Department of Agriculture and other local authorities, it was discovered that

   (i) most people did not have updated land records,
   (ii) most people had some or the other outstanding loans (generally overdue) against them either from state government or from banks,
   (iii) the scientists invested more in the village where people were apparently more courteous but less careful in use of inputs and repayment of loans whereas the bankers found the more backward village with more assertive people to be more careful in repayment of loans,
   (iv) the retail center for providing fertilizers had to be closed down because it could sell hardly 30 tons per year whereas it required sale of at least 300 tons per year to recover its recurring cost,
   (v) the technological trials were primarily driven by scientists and subsidies in the beginning though later people were encouraged to bear the cost (Gupta, *et al.,* 1989).

   The need for upgrading land records, generation of local saving and credit groups for dealing with small investments and the development of viable input distribution systems are areas, which remain relevant for any future project.

d) In all the districts in India, there is a District Level Coordination Committee (DLCC) to coordinate the activities of bankers and district level officials. There are four standing committees dealing with agriculture, industry, trade and services. In no district, is there a standing committee on science and technology with a result that most developmental projects do not draw upon the latest scientific insights available with the concerned institutions located in and around a district. In watershed projects this weakness becomes even more apparent.

e) None of the watershed projects have been used as an on-farm research site with experiments designed and implemented jointly by scientists and farmers for developing location specific technology. In a few places, there are trials of new varieties. But, very seldom are advanced lines of different crops taken up for experimentation in these watersheds. Similarly, no effort has been made to interrelate the design of different structures as modified by the farmers after using it for some time in different agro-climatic conditions within a region. The result is that

the science of fitting structural designs with the specific microenvironment is far more speculative than scientific.

f) From the point of view of invoking co-operation of different segments of a village, one has to use a pluralistic approach to technological change. In many watershed projects, excessive emphasis only on land in micro watersheds alienate other communities who do not have any land or have only marginal land in a watershed. Therefore, those technologies which may perform if not optimally at least better than the existing technologies in non-watershed area may be made accessible to other farmers as well. Similarly, those farmers who have only limited land in a watershed may have lesser incentives to cooperate than those who have more lands. To overcome this problem, development of common funds for common facilities particularly in the form of farm implements may have some advantage.

   Going beyond the land-based activities is necessary to achieve the goal of equity in watershed projects. Other than daily wages as long as the project remains, there are no direct benefits for the landless (Adolph, 1997). Similarly, given the importance of the women's role in managing household economy in the high risk-environments, it is important that the interventions should generate income-generating opportunities for women. As noted by Adolph (1997), since women do not hold any rights over land, it will be useful if the opportunities are based on non-land based resources such as Non Timber Forest Products (NTFPs).

   Absence of explicit policy guidelines is one of the major reasons for not attempting these ideas in watershed projects. When some VOs took initiatives in this direction, they were discouraged and their attempts were thwarted by the GOs. For instance, SEWA (Self-Employed Women's Association) wanted to initiate craft-based training and income-generating programmes. But the DRDA did not approve on the pretext that the policy guidelines did not allow such activities.

g) The participation can be monitored in terms of the shift that comes about in the design of watershed project in the light of learning made at the end of people as well as the professionals through their interactions. If the design does not undergo any basic change, then either people have no comparative advantage in knowledge or the system is too rigid or inflexible (Gupta and Mathur, 1983). Participation in people's plans would imply the ability of development officials to acknowledge inadequacy of their understanding. The blue print approach gives tremendous power and authority to the officials and thereby sometimes mutes the articulation of the people.

h) Institution building for watershed management is one of the most neglected aspects of the watershed projects. The very concept of 'handing over' of the project to the people implies that ownership has changed. However, if officials were to participate in people's plans, the question of handing over wouldn't arise. The institution building process involves generation of self-renewing capability in the organization and also ability to align missions and goals with the emerging changes in the environment without losing basic ethics and spirit. One cannot invent institutions without building upon long traditions of conservation, which have indeed become weak in most places though not everywhere. The leadership if based on performance and competence is likely to generate a different kind of dynamics than a

leadership based on clout and political influence. Many a time scientists do not realize the impact such decisions can have on the project. The self-renewing mechanisms require the building of learning capacities in the organization. Therefore, if per unit cost of different structures goes down over time, then efficiency increases through innovations. Unfortunately in a governmental system, the cost must escalate because there is no incentive for learning or innovation. In people's organizations also, similar weaknesses can exist if attention is not paid to these aspects.

i) There is a general neglect of local knowledge about indigenous soil taxonomy, biodiversity, soil and water conservation structures and traditions and experimental ethic of the local communities. There are only a few examples where watershed projects have required significant compromise in the prescriptive model compared to farmers' suggestions. For instance, in a particular watershed project, the drainage lines were drawn along the field *bunds* instead of contour lines without any significant difference in the efficiency (Sanghi, 1991). Similarly, in another project, the *gullies* were used for digging wells and creating farm ponds instead of plugging them through conventional treatments (Subramaniam, 1989). It is possible that local knowledge may have its limits (Gupta, 1993; 1991b). However, using it as a building block helps in generating mutual respect and overcoming the fear of unknown.

5.3 Property Rights, Portfolio and Design of Participative Institutions

The property rights may be precise or ambiguous, customary or legal and single layer or multiple layer, seasonal or permanent, product or use specific or indifferent in nature. For instance, in a common property catchment area, several people may have rights depending upon their nature of residence in a village, or ownership of private residential or cultivable land in that village or on their contract with the village council or individual owner having a right in the common property. Not everybody's right may be precisely defined. If a group of shepherds have been passing through a particular way for decades or centuries, the rights of passage and halting may become customary. Sometimes a private resource such as well becomes a common property for drinking water purposes in a drought year. Nobody can refuse water for drinking purposes. Once the market for drinking water emerges, this right may undergo a shift. The right of access may still remain but not without a price. Private agricultural lands after the crop is harvested may become accessible to all or turned into a common property grazing land. The nature of boundary as well as the system of allocation would indicate the kind of property rights that may exist. Within a forest, the boundaries for collecting different kinds of products may vary over time. The boundaries may be fuzzy and may contract or expand in different years. For example, in Senegal, it was noted that the boundary of area from where gum arabica was collected varied over the years depending upon the millet prices and thus the ability to hire the labor for the purpose.

5.3.1 Organizing 'Inequity': The key to Sustainability

The implication of varying property right rules for developing management institutions for watershed are very complex and yet very important:

a) Assume that there are three groups in a village A, B and C having varying dependence on the common lands for their survival. The ratio of dry matter obtained from commons, public or open access resources (road sides or revenue lands, canal bunds, etc.) or private property may vary in the portfolio of three groups. Assume that group 'A' has only ten per cent dependence on private property as against group 'C' which may have 90 per cent dependence on private resource. The herd composition may reflect the variance in dependence on resources governed by different property right regimes. In general, higher the risk and lesser the assurance of dry matter from private sources, greater is the probability of a herd having a larger number of smaller ruminants of low quality but high adaptability to poor and variable nutrition.

b) The time that each group would spend on common land would vary, the quantity of dry matter they draw also varies and their respective stake in conserving the common property may also vary depending upon whether access to other kind of resources is tied to their contribution to the common property resource. For instance, imagine a watershed project in which the commons form three-fourth of the catchment area, and therefore require everybody's cooperation in terms of closure. Group 'A' being most dependent on commons has most to lose by not grazing its animals on the commons. On the other hand, the group 'C' has least to lose. At the same time since group 'B' and 'C' have much more land holding, any improvement in catchment in terms of water conservation and recharge is likely to improve the recuperation rate or water level in their private wells. Even otherwise, catchment treatment may reduce the velocity of run-off and thereby help in conserving their private lands. Under such circumstances how should costs and benefits of developing catchment be distributed among different beneficiaries? For instance, if orchards are planted on the commons, should the income from the fruits be distributed equally among all the beneficiaries, or unequally so that larger share goes to those who supplied the most restraint (if one unit of animal not grazed on commons is equal to one unit of restraint, then units of restraint are proportional to number of animals conventionally grazed on the commons). Part of the income from private wells in which the gains of the water table accrues because of collective contribution of the community which supplied restraint, should go to a common fund for maintaining various structures after the project support is over. These funds can also be used for augmenting various common facilities and generating entrepreneurial opportunities.

The distributional matrix thus one can argue has a close bearing on the use matrix and vice versa. Both together provide necessary conditions but not sufficient conditions for sustainability.

Portfolio approach thus implies that equity should not be aimed at enterprise level or at a segment level. One cannot have equity in distribution of each benefit and yet aim at a sustainable outcome. It is obvious that land based investment is likely to help the landed people much more, at least in the short term. At the same time without cooperation, involvement and commitment of landless or marginal farmers' having livestock in greater numbers, one can not expect a durable solution to the problem of soil and water conservation. Thus one should not one aim at generating an 'iniquitous' situation by providing greater access and share to such livestock dependent communities in the biomass produced in the common as well government lands. The NGO or any other support agency

may also help trigger experiments with regard to decentralized fodder banks at least in each watershed so that stakes of landless livestock owning communities in the conservation of soil and water can be institutionalized. The common water points particularly for drinking water purpose (human as well as for animals) have to be an inalienable feature of watershed projects. It is a pity that National Drinking Water Mission does not seem to coordinate well with the watershed wing of Department of Rural Development as well as Ministry of Agriculture to ensure this.

The credit, input and marketing support for Non-farm employment activities once integrated in watershed projects can also be used to offset some of the inequities linked with land based investments.

The equity, Gupta (1985a) has argued, has to be achieved at portfolio level and not at enterprise level because the latter is neither feasible nor viable and sustainable. The portfolio will include land and non-land based investments, farm and non-farm activities, and short term and long term transfers of benefits. Thus equity may also have to be achieved over time.

The accounting of various services (ecological, economic and social) provided by a watershed project will help generate the mental preparedness among the communities for adopting portfolio approach to partnership and equity in watershed projects. This will also help in conceptualizing the issue of subsidy properly. It may not be out of context to mention here the provision of Non-Actionable Subsidies under General Agreement on Trade And Tariffs (GATT). Under this, the areas which have per capita household income or Gross Domestic Product (GDP) per capita not above 85 percent of the territory or region and unemployment rate at least 110 per cent of the region are eligible for subsidies which can not be questioned or objected under GATT. Most of the disadvantaged dry regions would be eligible for this support for farm and non-farm purposes.

5.3.2 Information

The subsidies in watershed projects have to be seen not just in terms of physical structures but also in terms of creating appropriate infrastructure for information, technologies, on farm research and value addition and marketing of the outputs besides a reasonable household portfolio insurance system.

To illustrate how information can help, an example of the marketing of silk cocoons and mango seedlings from Karnataka is given. In the case of silk rearing, it was noted that farmers from Shimoga and Chitradurga had to send their produce to far off markets. In the absence of proper information about various markets, the small farmers had to often sell their produce to intermediaries at a discount price. If the watershed project in collaboration with National Informatics Center project could provide access to information about various markets to farmers, the incentives for mulberry plantations as well as for other investments may increase. Similarly, the project authorities discovered that mango seedlings were in great demand by farmers for plantation in the catchment areas. The collection and dispersal of information about this led to emergence of a buoyant enterprise of raising mango seedlings in low cost makeshift greenhouses.

There are many other examples. Agave was planted in various watershed projects but often without linking its cultivation with processing. Even where processing has been done, it is only of fiber where as the Indian Institute of Science scientists had identified more than six products from agave

including tannins and waxes besides fiber. Information about such possibilities has to be pooled and made accessible to various watershed projects. Otherwise investment options will remain sub-optimal and thus returns from investment inadequate. The structures created with great care may be wasted.

The information about various technological choices about farm implements, agro-forestry options, indigenous technological and institutional innovations such as the ones documented by Honey Bee Network and SRISTI (Society for Research and Initiatives for Sustainable Technologies and Institutions), markets etc., can make considerable difference to the incentives that different watershed teams may have for building sustainable institutions.

5.3.3 Institutions

The institutions provide the self-regulating character to any human endeavor. We distinguish between institutional behavior and organizational behavior by looking at the extent to which regulation is internal or external. When human beings act in a particular manner because of their internal values and beliefs or rules, which have been internalized, the behavior is institutional in nature. As against this, when a person performs the way he/she does only because somebody is supervising, the behavior is organizational.

In real life we follow internal rules in some matters and require external rules in other matters. In a watershed project, coordination among various stakeholders cannot be achieved only through external supervision. There has to be internalization of the values and ethical concern for renewability of resources (Gupta, 1994c; 1995a; 1995b). The economic benefits are necessary but not sufficient inducement for triggering chain reaction of watershed projects.

When we look at some of the old but still functional soil and water conservation institutes such as *Virda* in Kutch or *Khadins* in Jaisalmer, we notice a combination of technological and institutional innovations. Some of the key lessons that can be inferred from the study of traditional institutions are:

a) The rules are not constant though process may be more durable. In other words, when violation of a particular rule takes place, the sanctions need not be necessarily specified in advance. What may be known is that there would be sanctions. But precise sanctions may follow after considerable deliberations on the merit of each case. Thus, subjectivity and objectivity are blended through an open and participative process.

b) These institutions often are multifunctional. While modern institutions are segmented, sectoral and less flexible, the traditional institutions may deal with more than one resource or region, may be multi-sectoral in nature and may be quite flexible.

c) These institutions have a variety of leadership models ranging from hereditary to entirely on the basis of excellence in a particular skill.

d) The tasks distribution is based much more on competence rather than status. For instance, for aligning a water stream in a hill area, people may rely on a shepherd's knowledge of terrain rather than on a mason's knowledge of structures (though both knowledge systems are important).

e) The compliance to a common order is achieved often through blending of secular goals with sacred symbols. In most situations, where natural resources have been used in a sustainable manner for hundreds of years, the sacred symbols and institutions seem to have played a significant role.

f) The concern for other sentient beings such as wild life, birds, other animals is expressed through various customs and rituals.

g) The diversity of eco-system and biological resources within it is maintained in some pockets more than others but is seldom eroded in any traditional institution, and

h) The rules regarding boundary (who is in, who is out), resource allocation (who guides, what, where and when) and conflict resolution (who compensates whom, when, how much and why) are evolved through experimentation over a long period of time.

Institutional performance in watershed projects is of crucial significance and requires lessons from traditional institutions, technologies and also cultural repertoire.

The incentives, information and institutions as seen above interact to produce a portfolio level equity over a longer period of time to generate sustainable outcomes. The theory predicts that balancing of books of accounts among different actors can seldom be achieved in short term or in single market. Multi-market, multi-level solution (Gupta, 1985a in Ostrom, Feeny and Pischt, 1990, Ostrom, 1993) coupled with a variety of decision criteria may help in generating optimal institutional arrangements in different cases. In watersheds, which have predominantly private lands in the catchment, the coordination may be required much more in resolving second-generation problems rather than first generation challenges. For instance, a diversion channel may start eroding or cutting into a field of a poor farmer because of the pressure of the water and this problem though affecting an individual may require collective solution because the benefits from the diversion channel are collective in nature.

Similarly, when technologies are introduced for seed production, cultivation of plants with medicinal, herbicidal or pesticidal properties or some other commercial use, production may be pursued individually, the quality control and marketing with or without value addition may have to be pursued collectively. At the same time, it is also possible that a trader or a farmer entrepreneur instead of a collective institution may better perform some of the value adding or marketing functions. The scientists and local communities will have to appreciate the viability of the whole range of institutional arrangements rather than making a pre-determined choice.

5.4 Implications for Participative Portfolio Management in Watersheds

It has been argued elsewhere (Gupta, 1991a) that farmers use a playful portfolio approach to risk adjustment. There is a combination of serious institutional effort and playfulness in resolving various

problems. The role of fun and light heartedness is not often realized in building social institutions. Any student of social change would be able to recall many examples where people transform the meanings of acronyms used for designated different development programmes. Through metaphors and acronyms, the people communicate their actual feelings about programme and their contents. The watershed teams can benefit a great deal by building upon a rich reserve of local legends, fables, myths and humor. When we were deciding the precise villages in which to take up more detailed investigations in an action research project in Karnataka, the first question we asked in every village we visited was information about the initiatives or activities that people in the village had taken up on their own collectively without outsiders' help. It was very interesting that in different villages different kinds of initiatives had been taken in the past. In one village, people had used the discount money of a local chit fund (rotating saving and credit association) to buy mats for a primary school, public address system for a temple in another village and building a small place of worship in still another village. These collective actions were useful to recall because then the concept of watershed and inherent coordination did not have to be told from outside. Also the outsiders could demystify their contribution in the matter.

The key policy lessons that may help in participative design and management of watershed are summarized below:

1. Watershed projects, as K.M. Munshi said in 1952, are a means of land transformation. As he suggested, the hydrological cycle, the nutrient cycle and the village institutions had to be linked together in an organic manner. The principle of land transformation is so vital and yet so feeble in its actual operation that people have often a very low image of state induced interventions. The vitality of land transformation, Munshi had suggested could be maintained by organizing a land army of unemployed youth, disciplined and dedicated to bring about change in a time bound manner. Unfortunately, the experiments on the concept of a land army were never seriously taken up for long enough period (a beginning was indeed made in Karnataka in the late 70s). The policy implication therefore is to convert watershed programme into a social movement blending it with different cultural and institutional crosscurrents so that it has a widespread appeal.

2. Social movements begin in the heart and not just in the mind. Therefore, the consciousness about watershed approach and sustainable natural resource management will have to be raised in the minds of young students at an early age. This will help build commitment among future leaders.

3. The incentives for cooperation sometime may emanate from the access to indicators of social and ecological change. These indicators can also help in monitoring the extent of ecological recovery and, therefore, the success of various investments. Instead of monitoring inputs, output indicators whether in terms of grass or shrubs, insects or birds or changes in the soil microbial properties measured through quality of humus or other means etc., may help in keeping track of investments in watershed projects. Different kinds of indicators would require different kinds of benchmark. The land-use maps depicting biological diversity and indigenous soil taxonomies may help monitor the changes effectively. Identification of these indicators could be through organization of biodiversity contests as attempted by SRISTI and

Honey Bee network in different parts of the country or through surveys of innovations through extension workers, farmer innovators or students in summer vacations.

4. Participation in people's plans requires respecting their knowledge and experimental ethic. There are very few examples illustrating documentation of indigenous innovations and on-farm and on-station research on the validation of or value addition in the same. The scientists as well as the administrators at the top level have to unlearn various presuppositions in this regard.

   Transformation in thinking of just the top-level administrators towards participative watershed management is not sufficient. It needs to trickle-down sufficiently so that the lower level functionaries also internalize the change in their role as facilitators. A separate body may be setup to monitor and smoothen the interaction between the facilitators, the GOs and the implementers, the VOs.

   However, in any meeting on the subject, one often hears only a few VO led examples of watershed developments. No reference is made to large tracks of well-conserved resources in dry regions as well as in hill areas by people on their own. The result is that projects are located around the NGOs instead of encouraging evolution of people's institutions where they have already performed well. Excessive emphasis on VOs may provide false satisfaction about the issue of people's participation. There is no escape from involvement of decentralized institutions of public governance such as panchayati raj institutions in India. This means that political parties and their various organs have to be involved in understanding and articulating the agenda for land transformations through their cadres. The scientists will have to interface with the leaders of various parties so that camps can be organized to help them take lead in this regard, obviously in a non-partisan manner. Perhaps the Parliamentary institutions can be involved in interfacing the interaction between scientists, NGOs, people's institutions and political leaders.

5. The portfolio approach to participative watershed development implies attention to inter-sectoral linkages, which manifest in the form of interactions among enterprises and social classes over time and space. The portfolio approach has an advantage that not each enterprise in a portfolio has to be viable. For instance, the direct benefit from summer ploughing and other such operations may be limited but indirect advantage through in-situ conservation of moisture as well as harvesting of residues during summer may be much more. These benefits may not accrue always to those who bear the cost. Thus, just as households cross subsidize different enterprises, watershed groups may have to cross subsidize different social segments relying upon lands or other resources governed by different property rights regimes. The equity may be achieved at the portfolio level rather than at the enterprise level. The ecological economic accounting of watershed projects can help in conceptualizing the contribution of subsidies appropriately. Since it is unlikely that state would have resources to invest in large areas in near future, specific contractual arrangements between value adding firms in private and public sector and groups of farmers may have to be negotiated. To avoid exploitation of poor farmers, federation of watershed teams for their fairness and ecological friendliness should monitor these contracts.

6. The watershed programmes cannot grow if they continue to deal with only soil and water conservation leaving technology development for land-use choices in farm and non-farm sector entirely to market forces. In each watershed clusters, some on-farm research experiments should be designed by the people and monitored and interpreted jointly by local communities and outsiders. Depending upon the results, further action plan should be drawn. It is a pity that none of the coordinated commodity programmes in crop, livestock or farm implement sector, watersheds are used as on-farm research site. The crop improvement programmes in dry regions could gain a considerable head-start if watershed teams are invited to the university farms and asked to make selections of advanced lines suitable for their region. The biodiversity may so be increased and at the same time the pace of technological change can be enhanced.

7. There is worldwide concern for declining biodiversity in most regions particularly the ecologically fragile regions. The biodiversity prospecting or accessing for developing drugs, herbal pesticides, weedicides, anti-oxidant compounds, vegetative dyes, etc., is becoming an extremely promising field of global negotiations and collaborations. The moisture conserved in many watershed projects becomes so precious after making huge investments that growing food crops may not help in cost recovery. Therefore, by strengthening the public distribution system for food, the pressure for cultivation of local food surplus can be reduced. Instead processable commodities such as medicinal plants, oilseeds, pulses, vegetables, flowers, etc., may be encouraged wherever feasible to give economic incentives for watershed programmes to diffuse. Given the low population density, the cost of logistics is indeed very high in dry regions. Various incentives similar to freight equalization will have to be developed to encourage markets to move closer to clients in watersheds.

8. Seed production has been recognized as one of the very important land-use option because of the possibilities of maintaining good isolation and also lesser diseases and pests for certain crops. A memorandum of understanding would need to be established between federations of watershed teams and seed producing institutions in public and private sector with proper arrangements of quality control and buy back.

9. The value addition in agro-forestry products, livestock or other activities taken up in the watersheds is a necessary condition for improving returns to watershed technology. To ensure this, the collaboration between agricultural and industrial research organizations is very important.

10. There is a need for long term research programmes to be started in different agro climatic zones linking crop, livestock, trees and tools as discussed in the multi-tier workshop on management of research in rain fed regions organized jointly by us with ICAR. These workshops had provided valuable insights about the areas of weakness in inter-disciplinary research and ways of strengthening them. It was noted for instance that there was very little emphasis in post-graduate research to identify the scope of such linkages and measuring their effectiveness (Gupta *et.al.,* 1990). If young scientists do not get exposed to these ideas, it is unlikely that when they assume leadership, they will be able to commit themselves to these ideas. The unfortunate imbalance between resources for extension vis-à-vis on-farm research

needs to be corrected if theories applicable to variety of agro-climatic conditions have to be developed.

11. The macro economic policy has an important bearing on the incentives or disincentives for households to use resource-conserving portfolios. There is a need for top level monitoring of macro economic policies to draw their implications for the micro level land-use choices. This will require use of various technologies including remote sensing, market intelligence information databases and simulation models. We do not have a strong research base in this direction.

    In this part, we have covered whole range of issues involved in linking equity, efficiency and ecological economic dimensions of sustainability. We have also argued that building upon local creativity and innovations can combine the goals of conserving diversity and improving economic opportunities for poor people. It is possible that many of the local innovations may have become dysfunctional or sub optimal because of various reasons. Bridges between formal science and informal knowledge will have to be built to generate sustainable options.

The WMPs provide arena for confluence of several technological and social change programmes. If watersheds can be conceptualized as crucibles of creativity, then various research programmes should aim at locating their experiments in these watershed projects. The bankers have to be involved in the design stage itself so that their commitment to the philosophy can be achieved.

The participative design of institutions cannot be crafted in isolation of traditional institutions and local knowledge system even if these have become weak in many areas. It is true that many of the traditional institutions were not very fair or democratic. But one has to blend the strengths of the traditional systems with modern approaches. While there are many traditional resource management institutions, which have worked in a sustainable manner for hundreds of years, there are not many examples of modern institutions, which have worked with similar efficiency over such a long period of time in the field of natural resource management. Therefore, blending the rules that regulate human behavior from within with the rules that are enforced from outside may help in generating viable and sustainable institutions for watershed management.

SUMMING UP

Managing watersheds is more than managing technological change. This is the first lesson that needs to be underlined for improving the design and implementation of watersheds in fragile regions. Some of the technological inadequacies can be compensated by institutional arrangements and innovations and vice versa. But there will remain a need for constant upgradation of technological as well as institutional repertoire. This is the purpose of Knowledge Network for Sustainable Technologies and Institutions being set up by Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI) in collaboration with IIM-A, GIAN, and other members of Honey Bee Network.

The inventory of innovations presented in this monograph is just an illustrative list of how creative the farmers are. We have more than eight thousand innovations in Honey Bee database of which less than one percent has been presented here. We are very keen to expand the Honey Bee network so as to enhance people to people linkages for learning in the South-Asian and other regions of the world. The idea is to generate local language nodes in different parts of the world so that scouting, experimentation, and dissemination of innovations can take place to reduce cost and enhance sustainability of soil and water conservation and overall watershed management.

The institution building is the crux in watershed projects. Unless local communities own the idea of regenerating local resources by blending formal and informal science, local and external knowledge and, material and non-material incentives for conservation, there is not much hope for this cause.

The challenge is to create Knowledge Network possibly with real time connectivity around sustainable watershed management so that lateral learning among communities, facilitators and policy makers can take place effectively. Traditional knowledge of one place can trigger a contemporary innovation in another place. If this study helps unfold this potential, Honey Bee network would have made a small contribution to the cause of augmenting grassroots innovations for sustainable natural resource management.

References

Abedin, E. and Haque, F. Md. 1987. Learning from Farmer Innovations and Innovator Workshops: Experiences from Bangladesh. IDS Workshop. Institute of Development Studies, Univ. Of Sussex. July 27-31,1987.

Adolph, B. 1997. Scaling up Participatory Approaches to Watershed Management: Challenges and Opportunities, Germany, University of Hohenheim.

Agarwal, A. and Narain, S. 1989. "Fighting the Big Thirst", The Illustrated Weekly of India, (July 9), p.28-31.

Agarwal, A. and Narain, S. (eds.). 1997. Dying Wisdom: Rise, Fall and Potential of India's Traditional Water Harvesting Systems, State of India's Environment: A Citizens' Report, Centre for Science and Environment, New Delhi.

Andrew, J. C. 1987. Making the Transition To Low Input Agriculture: A Farmer's Perspective; Agricultural Chemicals. Vol-2,no-1. 17-18, March 1987.

Anonymous. 1995. Strategy for sustainable plant protection, assessment of pesticidal residues, organic certification and microbial diversity: Towards a scientific network. Minutes of the meeting held at IIM-Ahmedabad, February 4, 1995.

Ashby, J. A.; Gracia, T.;Guerrero, M. d. P.;Quiros, C. A.;Roa, J. I., and Beltran, J. A. 1995. "Institutionalising Farmer Participation in Adaptive Technology Testing With the `CIAL'". Agricultural Research and Extension Network. London. Overseas Development Institute .

Ashby, J., Quiros, C. A. and Rivera, Y. M. 1987. Farmer participation in on-farm varietal trials. Agricultural administration (Research and extension network). Discussion paper no. 22. London : Overseas Development Institute.

Atte, D. O. 1992. Indigenous knowledge and local level development: The participatory research approach. Paper presented at the International Symposium on Indigenous Knowledge and Sustainable Development, held at IIRR, Silang, Cavite, Philippines, 20-26 September,1992.

Bajracharya, D. 1992. Institutional Imperatives for sustainable Resource Management in the Mountain Agriculture,Vol I. Editors N. S.Jodha, M. Banaskota, and Tej Pratap. 204-234. New Delhi: Oxford & IBH.

Banskota, M. and Jodha, N. S. 1992. "Public Investments, Subsidies, And Sustainable Agricultural Development: Some Perspectives". LF. 1-19. International Symposium On Strategies for sustainable mountain Agriculture September 10-14, 1990.

Banaskota, M. and Jodha, N.S. 1992. Investment, Subsidies, and Resource Transfer Dynamics: Issues for Sustainable Mountain Agriculture. In Sustainable Mountain Agriculture, Vol I. Editors N. S.Jodha, M. Banaskota, and Tej Pratap. 185-203. New Delhi: Oxford & IBH.

Bayer-Waters, A. and Farrington, J. 1990. "Supporting Farmers' Research and Communication: The Role of Grass- Roots Agricultural Advisors,". 10th Annual Symposium of the Asssociation for FSR/E, Michigan State University, Michigen. 14 Sept., 1990, 1-18.

Biggs, S.D. 1981. Agricultural research: a review of social science analysis. Discussion paper no. 115, SDS. VIC: University of Anglia.

Bose, S. K. and Osman, G. 1998. A Compilation of Indigenous Technology Knowledge for Upland Watershed Management In Bangladesh, Bangladesh. Participatory Watershed Management Training in Asia (PWMTA) Programme; 1-49

Bush, L. & W.B. Lasey. 1987. Sorghum research and human values. Agricultural administration (Research and extension network). Discussion paper no. 15. London: Overseas Development Institute.

Chambers, R.; Pacey, A. and Thrupp, L.A. (eds). 1989. Farmers first: Farmer innovation and agricultural research. London: Intermediate Technology Publication Group.

Chambers, R. 1983. Rural development: Putting the last first. Burnt Mill, Hallow, Essex: Longman, Scientific and Technical.

Chokkakula, S. 1997. "The Man Who Planted Trees and Never Looked Back". Honey Bee: 7(3): 3-5.

Chokkakula, S. & Patel, S. R. 1994. Virda. In: Ingenious Method of Rain Water Harvesting, Honey Bee Vol5(3):7.

Chokkakula, S. and Raju, C. V. 1997. Dyes and dexterity: Revival of dying skills in Honey Bee, 8(3): 3, 1997

Critchely, W.; Reij, C. and Wilcocks, T. 1994. Indigenous Soil and Water Conservation: A Review of the State of Knowledge and Prospects for Building on Traditions Land Degradation and Rehabilitation, Vol 5, pp 293-314.

Deshpande, R. S. and Nikumbh, S. R. 1993. "Treatment of Uncultivated Land under Watershed Development Approach: Institutional and Economic Aspects", Artha Vijnana, 35(1):1-21.

Dijk V. J. A. 1993: Opportunities for Expanding Water Harvesting in Sub-Saharan Africa: The Case of the Teras of Kassala. IIED, 1-19.

Dvorak, K. A. 1988. Indigenous Soil Classification in Semi-Arid Tropical India; 1-38.

Ettema, C. H. 1994. Indigenous Soil Classification. University of Georgia, Athens,Georgia' web site.

Farnsworth, N. R. 1988. Screening plants for new medicines. In: Biodiversity, ed. E.O. Wilson and Francis Peters. Washington D.C.: National Academy Press.

Feder, G. and Slade, R. 1984. A Comparative Analysis of Some Visit System of Agricultural Extension in India. World Bank,Washington D.C. Aug 1984.

Ferroukhi, L. & Suthar, J. H. 1994. Rainwater harvesting in the Banni Grassland, Honey Bee Vol.5(2):5-7.

Ferroukhi, L. 1995. Rainwater harvesting and groundwater recharge techniques: A case study of the Moti Rayan project in the salt affected crystal area of southern Kachchh District, Gujarat State, India; Sweden (Uppsala), Swedish University of Agriculture Science (International Rural Development Centre)

Gelles, P. H. 1991. The Political Ecology of Irrigation in an Andean Peasant Community, To appear in Indigenous Irrigation, 1991, 1-37.

Gupta, A. K. 1980. "Management Issues in Watershed Development in Arid Regions". Mimeo.

------. 1980. Communicating with farmers - Cases in agricultural communication and institutional support measures. New Delhi: IIPA. 92 pages.------. 1993. Note prepared for the National Technical Committee on Drought.

------. 1981. Viable projects for unviable farmers - An action research enquiry into the structure and processes of rural poverty in arid regions. Symposium on Rural Development in South Asia, IUAES Inter Congress, Amsterdam, 1981.

------. 1988. On the concept of knowledge: The conundrum of criticism, control and commitment in peasant science. Key note paper presented at a conference on Farmer Participatory Research at Leusden ILIEA, April 11-12, 1988.

------. 1983. Impoverishment in drought prone regions: A view from within: (Joint field study SDC/NABARD/IIM-A) CMA, IIM, Ahmedabad, 1983, p.573.

------. 1985a. Indigeneous agricultural revolutions: Ecology and food production in West Africa. Boulder Co./ London: Allen and Unwin.

------. 1985b. Managing common property resources: Some issues in institutional design. Paper presented in NAS Conference on CPR, Annapolis, April 21-26, 1985.

------. 1987a. Indigenous/Local knowledge system: Complexity, simultaneity, universality and common property: A reflective summary. Group Report presented at International Conference on Farmer Participatory Research organized by IDS, Sussex. 26-31, July 1987.

------. 1987b. Organising the poor client responsive research system: Can the tail wag the dog? Paper presented in a Workshop on Farmers and Agricultural Research: Complementary Methods, Institute of Development Studies at the University of Sussex, U.K., 26-31 July 1987 and at International Advisory Committee of meeting of ISNAR on on-farm Client-oriented Research at The Hague, October 1987.

------. 1987c. Reorienting on-farm research at BARI (Bangladesh 1985-86): Lessons discovered, learned and not learned. ISNAR, The Hague. Netherlands. Sept 1-5, 1987.

------. 1987d. Role of women in risk adjustment in drought-prone regions with special reference to credit problems. IIM working paper no. 704. Ahmedabad: IIM

------. 1987e. Scientific perception of farmers' innovations in dry regions: Barriers to the scientific curiosity. September 1987, IIM working Paper No.699, presented at International Conference on Farmer Participatory Research at IDS, Sussex, July,1987.
------. 1989a. Maps drawn by farmers and extensionists. In: Farmer First, Robert Chambers, Arnold Pacey and Lori Ann Thrupp (eds.). pp. 86-92. London : TDG.
------. 1989b. Scientists' view of farmers' practices in India: Barriers interaction. Abridged version. Rural Finance 3 (1): 22-24.
------. 1989c. Managing ecological diversity, simultaneity, complexity and change: An ecological perspective. W.P. no. 825. IIM Ahmedabad. p. 115, Third survey on Public Administration. New Delhi: Indian Council of Social Science Research.
------. 1989d. Participatory technology development in sustainable agriculture. ILEIA. Methods of making Inventory of Existing Technology and Indigenous Knowledge. Report of Working Group on Inventory of Existing Technologies and Indigenous Knowledge, pp.21-22.
------. 1989e. The design of resource-delivery systems: A socio-ecological perspective, Int. Studies of Management and Organization, Vol-18, no-4.pp 64-82, 1989.
------. 1990. Survival under stress: Socio-ecological perspective on farmers' innovation and risk adjustments. Capitalism, Nature and Socialism. May 1990: 79-96. Also as W.P. No. 738, 1988, International Congress on Plant Physiology, New Delhi, 1988.
------.1991a. Household survival through commons : Performance in an uncertain world, Paper presented at International Conference on Sustainability Through Commons, Duke University, September, 1990 and revised version presented at International Conference of Society of Advancements in Socio-Economics, Stockholm, June 16-19, 1991.
------. 1991b. Why does poverty persist in regions of high biodiversity? A case for indigenous property right system. Paper invited for the International Conference on Property Rights and Genetic Resources sponsored by IUCN, UNEP and ACTS at Kenya, June 10-16, 1991.
------. 1991c. Building upon peoples' ecological knowledge: Framework for studying culturally embedded CPR institutions. Presented at the Second Annual Conference of the International Association for the Study of Common Property, Winnipeg, Manitoba, 26 - 29 September, 1991. IIMA Working Paper No.1004.
------. 1992. Saga of a star fish: How do we participate in the people's design of institutions for natural resource management. Paper wriiten for a workshop of APDC, Kualalumpur, at Bangkok, Nov 19-20, 1992.
------. 1993. Honey Bee has stung, "Forests, People, Tree Newsletter" No.18, pp.8-16.
------. 1994b. Development and diffusion of technology: Recasting extension science for drylands. In Dryland Farming in India: Constraints and Challenges, ed. J.L. Raina, Jaipur, 1994. An earlier version was presented at the International Conference, 'Making the Link', ISNAR, The Hague, November 1989.
------. 1994c. Ethical issues in prospecting biodiversity. IIMA Working Paper No.1205. August 1994. Ahmedabad: Indian Institute of Management.
------. 1995b. Dilemma in conservation of biodiversity: Ethical, equity and moral issues, a review. Prepared for a workshop of Pew Conservation Scholars on Developing Ethical Guidelines for Accessing Biodiversity, Arizona, October, 1994. Also published as "Ethical Dilemmas in Conservation of Biodiversity: Towards Developing Globally Acceptable Ethical Guidelines" in Eubios, Journal of Asian and International Bioethics 5 (Japan), March 1995, pp.40-46.
------. 1995c. Knowledge centre: Building upon what people know. Presented at IFAD's International Conference on Hunger & Poverty in Brussels during November 16-23, 1995.
------. 1995d. Sustainable institutions for natural resource management: How do we participate in people's plans? Syed Abdus Samad, Tatsuya Watanabe & Seung-Jin Kim (eds.) Published by APDC in: People's Initiatives for Sustainable Development: Lessons of Experience, Chapter 15, pp.341-373.
------. 1996. The Honey Bee Network collects indigenous knowledge for crops, creativity and compensation. Forthcoming in Biodiversity, November, 1996.
Gupta, A. K. and Mathur, K. 1984. Action Research for Micro, Level Planning: A Self Appraisal

International Review of Administrative Sciences Vol. L(1) 60-68.
Gupta, A. K. and Prakash, A. 1993. On Internalization of Externalities. IIMA W. P. No. 1126, August 1993.
Gupta, A. K., Patel, N. T. & Shah, R. N. 1990. Review of post-graduate research in agriculture (1973-1984): Are we building appropriate skills for tomorrow? W.P. No-843, p.13. Ahmedabad: IIM.
Gupta, A. K. and Ura, K. 1992. "Indigenous Farming Technologies And Environment: Experiences In Bhutan". Published in Sustainable Mountain Agriculture, entitled "Indigenous Farming Technologies and Environment: Experiences in Bhutan" (Eds. N.S.Jodha, M.Banskota and Tej Partap), Oxford & IBH Publishing Co Pvt.Ltd., New Delhi. pp. 540 - 568., 1992.
Gworgwor, N. A. 1989. Traditional Water Harvesting Techniques as Bases for Ecological Improvements of Agricultural Techniques in Northern: Nigeria. Dept. Of Science, University Of Maidugiri Borno State, Nigeria. P 12, Jan 2-5,1989.
Hill, S. B. and Ramsay, J. 1977. The Macdonald Journal, June, 1977.
Horn, J. S. 1969. Away with all pests: An English surgeon in People's China 1954-1969. New York: Monthly Review Press.
Husain, T. 1992. The Agakhan Support Programme: An Approach to Village Management Systems in Northern Pakistan. In Sustainable Mountain Agriculture, Vol 12. Editors N. S.Jodha, M. Banaskota, and Tej Pratap 671-684. New Delhi: Oxford & IBH.
Ives, J. D. and Messerli, B. 1989. The Himalayan Dilemma Reconciling Development and Conservation, United Nations University Press, Great Britain **324 p.**
Jodha, N. S. 1992. The Regions And Global Warming : Impacts and Response Strategies, New York, Oxford University Press, 203-218
Jodha, N. S.; Banskota, M. and Partap, T. (ed). 1992. "Sustainable Mountain Agriculture: Perspectives and Issues (volume 1)". Kathmandu. International Centre for Integrated Mountain Development. Document:p.1-389.
Kolarkar A. S. 1989. "An Innnovative Traditional Old Method of Agriculture in Jaisalmer - Thar Desert Region,". Paper Submitted for Workshop on "Traditional Technologies in Indian Agriculture. 6-8 Mar., 1989, 9.
Kassogne, A.; Dolo, J. and Ponsioen, T. 1990. Traditional Soil and Water Conservation on the Dogon Plateau, Mali, IIED, Issues paper No 27. IIED London.
Kerr, J. and Sanghi, N. K. 1992. "Indigenous Soil and Water Conservation in India's Semi-Arid Tropics". London. International Institute for Environment and Development (IIED).
Kerr, J. M.; Sanghi, N. K. and Srimappa, G, 1996: Subsidies in Watershed Development Projects in India: Distortions and Opportunities; International Institute for Environment And Development; Gatekeeper Series No.61, 1-21
Kervan, C.; Hilde, D. and Ragahild, R. 1995. Indigenous Soil Classification Systems in Northern Zambia PP 82-87. In the cultural Dimension of Development: Indigenous Knowledge System London: International Technology Publication.
Kolarkar, A. S. 1989. An Innovative Traditional Old Method of Agriculture in Jaisalmer - Thar Desert Region, Paper Submitted for Workshop on "Traditional Technologies in Indian Agriculture, 6-8 Mar., 1989, 9.
Marten, G. G. and Vityakon, P. 1986. In GG Martine ed. Traditional Agricultural in Southeast Asia: Watershed Press, Boulder, Colodado, pp 199-225.
Nand, H. & Kumar, D. 1980. Folk beliefs associated with dry farming, Indian Journal of Extension Education. Vol 16 (3&4), pp. 36-42.
Ostrom, V.; Fenny, D and Picht, H. 1990. Institutional analysis and Development: Rethinking the Terms of Choice, in Rethinking Institutional Analysis and Development, V.Ostrom, David Feeny and Hartmut Picht (eds.), International centre for economic Growth, USA.
Ostrom, E. 1992. Crafting Institutions for Self-Governing Irrigation Systems. California: Institute for Contemporary Studies.
Ostrom, V. 1993. "Great Experiments and the Welfare State: Basic Paradigmatic Challenges". Indiana. Workshop in Political Theory & Policy Analysis.

Pangare, G. 1992. Traditional Water Harvesting on Way Out: Economic and Political Weekly; 7-14

Pastakia, A. R. 1995. Grassroots innovations for sustainable development: The case of agricultural pest-management. Unpublished Fellow Programme in Management dissertation. Indian Institute of Management, Ahmedabad.

Prakash, A. and Gupta, A. K. 1997. “Ecologically Sustainable Institutions” in Fraser Smith (Ed), “Environmental Sustainability: Practical Global Implications”. Florida: St Lucie Press. Pp 47-65.

Ramakrishnan, P. S. 1992. "Ecology, Environment and Sustainable Rural Development in India". in Roy, Kartik C. *Economic Development: A Case Study of India.* Delhi. Oxford University Press. 42-67.

Randhawa, R. M. 1985. "Forestry Planning and Development Project". 10-16. This Project was started to launch a large scale tree plant programme on private farm lands in accordance with the needs of the farmers to promote farm forestry.

Rhoades R. 1988. "Traditional Potato Storage in Peru: Farmer's Knowledge and Practices,". Potato in Food Systems Research Series, International Potato Centre. 4, 1988, 1-59.

Runge, F. 1986. Common Property and Collective Action in Economic Development, World Development 14 (5) pp 623

Reddy S. S. T. 1989. Water Management in Areas Irrigated by Tanks, Workshop on Traditional Technologies in Agriculture, NISTADS, New Delhi, 6-9 Mar., 1989, 1-47.

Reij, C. 1991. Indigenous Soil and Water Conservation in Africa IIED Gate Keeper Series No 27, IIED London.

Richards, P. 1986. Coping with Hunger: Hazard and Experience in an African Rice Farming System, Allen and Unwin London

Richards, J. F. 1987. 'Environmental changes in Dehra Dun valley, India: 18801980', Mountain Research and Development 7(3): 299-304.

Sanghi, N. K. & Rao, V. T. 1982. Analysis of constraints in transfer of dryland technology : An operational research experience. Report of All India Co-ordinated Research Project for dryland agriculture, Hyderabad.

Sanghi, N. K. 1987. Participation of farmers as co-research workers:Some case studies in dryland agriculture. Paper presented at International conference on " Farmers and agricultural research : complementary methods " held at IDS at the University of Sussex, Brighton. July 1987.

Sankaran V. 1988. Indigenous Innovations in a Semi- Arid Region. A Case Study of Bhil Garasia Tribes of Western India. Presented at 7th World Congress Of Rural Sociology, Bologna, Italy. P 8.

Sen, A. 1981. "Description As Choice.". Oxford Economic Paper. Pp 353-369, 1981.

Sengupta, N. 1985. “Traditional Vs Modern”, Economic and Political Weekly, XX (45,46 and 47): 1919-38.

Shah, A. 1995. "AGO-GO Interactions in Watershed Development: Experiences from Gujarat (India)". London. Odi (Overseas Development Institute) Agricultural Research and Extension Network. 1-18. Network Paper 56.

Sheng Gan Shih. 1963. An Agriculturist Book of China Written by Fan Sheng-chih In the First Century B.C. China, Science Press,Peking,China.

Sinha, R.; Pastakia, A. R.; Bjerregaard, T. and Srinivas, C. 1996. Augmenting survival: An evolving database on indigenous CPR institutions for managing natural resources. Presented in National seminar on Common Property Land Resource Management organized by IGIDR, Mumbai, India, 9 November1996.

Thapliyal, K.C. ; S Lepcha,. T. S.; Kumar, P.; Chandra, B.; Virgo, K. J. and P.N Sharma. 1992. Participatory Watershed Management in the Lesser Himalayas: Experiences of the Doon Valley Project. Deharadun: Watershed Management Directorate, Govt of Uttar Pradesh. Mimeo.

Tung, L. and Alcobar, D. L. 1991. Natural Grass Strips Preferred ILEIA No 1&2 27-28.

Vaidyanathan, A. 1991. Integrated Watershed Management: Some Major Issues. New Delhi. Foundation Day Lecture: Society for Promotion of Wastelands Development.

Vangani,N. S.; Sharma, K. D. and Chatterji, P. C. 1998: TANKA-A Reliable System of Rainwater Harvesting in the Indian Desert, Jodhpur, Central Arid Zone Research Institute.

Vasquez G. R. 1996. Puka suytu versus *Solanum tuberosum*: How scientific are the scientific names?. Honey Bee 7 (1).

Vander Velde, E. J. 1990. Irrigation management in Pakistan's mountain environments. (MFS [Mountain Farming Systems] discussion paper, 20). Kathmandu: International Centre for Integrated Mountain Development. 1990. 20p.

Verma, M. R. & Singh, Y. P. 1969. A Plea for Studies in Traditional Animal Husbandry Farmer, Vol XLIII(2): 93-98.

Wade, R. 1988. Village Republics: Economic Conditions for Collective Action in South India. Cambridge, Cambridge University Press, P. 238

Warren, D. M. and Rajasekaran, B. 1995. Using Indigenous Knowledge for Sustainable Dryland Management Development Studies, ed. Chichester: John Wiley and Sons on Behalf of the United Nations Environment Project.

Warren D.M. 1986. "Linking Scientific and Indigenous Agricultural Systems,". The Transformation of International Agricultural Research and Development: Lin Compton, Westview Press.

Warren, D.M. 1988. Linking scientific and indigenous agricultural systems in the transformation of international agricultural research and development: Some US perspectives. J. Lin Compton (ed.). Boulder: Westview Press.

Willcocks, W. 1930. Lectures on the Ancient System of Irrigation in Bengal and its Application to Modern Problems, Calcutta University Readership Lectures, University of Calcutta.

Williams and Ortiz-Solorio. 1981. The apparent simplicity of indigenous classifications undoubtedly relates to the lack of systematic investigation in ethnopedology.

Zimmerer, K. 1992: Land-use Modification and Labour Shortage Impacts on the Loss of Native Crop Diversity in the Andean Highlands. In Sustainable Mountain Agriculture, Vol2. . Editors N. S.Jodha, M. Banaskota, and Tej Pratap.413-422. New Delhi: Oxford & IBH.

http://www.physics.iastate.edu/cikard/iked3.html

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Annexe: A Critique of Watershed Management Policies

The National Technical Committee on Drought[4] reviewed various arrangements with regard to drought proofing and decided to focus major attention on the watershed approach to resource conservation. The committee recognized that drought prone area programme and desert development programme, inspite having been in operation for almost two decades have not created a substantial impact. The beneficiaries of various water harvesting structures had not assumed responsibility for maintenance after the works were completed even when the benefits were substantial. The people's participation "was conspicuous by its absence either in the preparation of plans or in their implementation" except in rare cases where results were much better. The report further accepted the need for greater attention to people's own strategies and indigenous technologies and knowledge about local biodiversity in various plans for mitigating drought. The need for value addition in local resources relying on indigenous innovation as well as external technologies was also recognized. The treatment plans for watershed, the report suggested should include all kinds of lands governed by different ownership arrangements. It was recommended that watershed development teams would be constituted for the purpose comprising at least five women members out of total ten members. All adult members of a watershed area will constitute the general body. The representation of Scheduled Caste and Scheduled Tribes would be in proportion to their population. At least two of the local level development officers will assist the team besides an educated village youth selected by the team to carry out its instructions. The micro-watershed with about 500 hectare was supposed to be taken up in the first year. The functionaries were to be given a multi-disciplinary training for first three months. The drought relief work was supposed to be integrated with area development programmes to conserve soil moisture and generate other employment opportunities. The voluntary organizations were also to be involved wherever they were available. The state level committees for promotion of voluntary action for Drought Prone Areas Program (DPAP) and Desert Development Program (DDP) were to be constituted. Similarly, district level committees and block level committees were recommended. The state governments were to hand over various assets created under the programme to the community for eventual maintenance. The subsidy on programme works was recommended for everyone regardless of size of land holding. In all about Rs.1, 500 crores every year was expected to flow towards watershed based development of dry regions. This allocation is a substantial increase from about Rs.2, 000 crores allocated over last twenty years.

It was recognized during the deliberations of the Committee that efforts to improve coordination at grass roots level would be futile unless coordination at the top level was improved. This is a serious problem in most other countries in the region as well.

Even though the concept of agro-industrial watershed was developed way back in 1980s by senior leaders in the discipline, (Bali, 1980), the Committee could not integrate this as a major instrument of

[4] Anil K Gupta was a member of the National Technical Committee on Drought. The committee was headed by Prof. C.H. Hanumantha Rao and comprised representatives of central and state ministries, planning commission, and two non-officials. It gave its report to the Prime Minister in June 1995. The implementation of the report led to very major escalation in the allocation of central budget for watershed management in the country. The report also acknowledged the need for incorporating indigenous knowledge in the design and implementation of watershed though not to that extent as was necessary. The critique of the report is available in the original paper (Gupta, 1996).

policy change. The idea is that changes in the income or the productivity are likely to be of very small order (10 to 15 percent on average) in the early years even if everything was done ideally. On the other hand, if the produce of the watershed whether fruits, vegetables, crops like pulses or oil seeds, is processed into intermediate or final consumer product, the increase in the income can be many times more. Further, the catchment area for processing plants need not be co-terminus with the boundaries of catchment of watershed. The fluctuations in the market place can also be reduced through value addition at local level. At the same time, the need for systematic market research, linkages and other support measures remains.

The need for macro policy reforms to provide market incentives for generating sustainable portfolios at the household level was also not emphasized by the Committee. It was, for instance, not realized that if import of wool or rags depresses the real prices of wool, then shepherds would have no incentive to improve productivity of their herd through quality improvement. Also if their access to improve pastures and their share in the value addition in leather does not increase, they can hardly be blamed for increasing their herd size of small ruminants of low quality. If environmental degradation is enhanced in the process, the reason is obvious. Therefore, an important weakness of the Committee Report was to ignore the linkage between macro economic policy and micro level decision making incentives or disincentives for households to modify their portfolios.

National Commission on Development of Backward Areas (NCDBA) in 1981 had committed similar mistakes when the technologies developed by ICRISAT were considered indicative of the direction for future development in dry regions. As the experience has shown, the expectations were misplaced. Further, while looking at the organizational models for developing these regions, the examples were drawn from well-developed irrigated regions. This was another assumption proved inadequate. The emphasis on watershed approach has been expressed in most policy statements around the world. The entry point may be trees, grasses, soil conservation, water conservation etc.

ABBREVATIONS

CAPART	:	Council for Advancement of People's Action & Rural Technology
CAREMA	:	Clustered-village Resource Management Association
CAZRI	:	Central Arid Zone Research Institute
CRIDA	:	Central Research Institute for Dryland Agriculture
DDP	:	Desert Development Programme
DLCC	:	District Level Coordination Committee
DPAP	:	Drought Prone Area Programme
DRDA	:	District Rural Development Agency
EAS	:	Employment Assurance Scheme
GAREMA	:	Gaun Resource Management Institution
GATT	:	General Agreement on Trade And Tariffs
GDP	:	Gross Domestic Product
GIAN	:	Grassroots Innovations and Augmentation Network
GOs	:	Government Organizations'
ICRISAT	:	International Center for Research In Semi Arid Tropics
IFFCO	:	Indian Farmers' Fertilizers Co-operative Limited
IIM-A	:	Indian Institute of Management, Ahmedabad
JFM	:	Joint Forest Management
LKS	:	Local Knowledge Systems
MANAGE	:	National Institute of Agricultural Extension Management & Institutions
NGO	:	Non Governmental Organisation
NIRD	:	National Institute of Rural Development
NTFPs	:	Non Timber Forest Products
PIAs	:	Project Implementing Agencies
PWD	:	Public Works Department
RRA/PRA	:	Rapid Rural Appraisal/ Participatory Rural Appraisal
SBI	:	State Bank of India
SEWA	:	Self-Employed Women's Association
SIRDs	:	State Institute of Rural Development
SLUB	:	State Land Use Boards
SRISTI	:	Society for Research and Initiatives for Sustainable Technologies
VO	:	Voluntary Organizations
WMPs	:	Watershed Management Programmes