DGIS POLICY SUPPORTING PAPER

Trends in watershed management in arid and semi-arid regions

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Patrick Moriarty, Charles Batchelor, Christine van Wijk

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Abbreviations and acronyms

ASA	Arid and Semi-Arid
DFID	UK Department for International Development
DGIS	Netherlands Department General for International Cooperation
ESA	External Support Agency
GTZ	German Gesellschaft für Technische Zusammenarbeit
FRIEND	Flow Regimes From International Experimental and Network Data
IHE	International Institute for Infrastructural, Hydraulic and Environmental Engineering
IRC	International Water and Sanitation Centre
IUCN	World Conservation Union
IWRM	Integrated Water Resource Management
KIT	Royal Tropical Insitute
MPA	Method for Participatory Assessment
NGO	Non Governmental Organisation
PRA	Participatory Rural Appraisal
SWAP	Sector Wide Approach
VWC	Village Watershed Committee
WATSAN	Water Supply and Sanitation
WSP	Water and Sanitation Programme

Terms of reference

For this Policy Support Paper on Watershed Management in Arid and Semi-Arid regions

Scope

The Ministry of Development Co-operation, in particular DGIS, has to advise Embassies on requests for funding and other proposals. The policy, strategy and decision-making base need to be supported by up to date information regarding recent developments and in methodologies and technologies in water supply and sanitation. This information includes updates on field experiences (positive and negative lessons learned) and the future potential for further introduction and application, and the possible threats of such technologies from different view points. Planning, funding, stakeholder participation, implementation, management and finance, and the contribution to poverty alleviation and the gender specific issues are to be included here. The present and potential role of institutions at different levels and their capacity related to watershed management are important issues for advisors and decision-makers.

Therefore, DGIS has requested IRC to make an updated overview of developments related to watershed management.

Main points covered in paper

- Current approaches to, and experiences from watershed management around the world
- The use of watershed management to improve access to and sustainability of water resources (this is an important point - as for example the “watershed” used in India has very little to do with water - it's mainly focussed on soil conservation and optimization of soil moisture
- 'Productive' uses of water, and the role of water in rural livelihoods, as an entry point to involving communities in watershed management
- The potential for productive uses of water within a watershed framework to sustainably reduce rural poverty, improve women's position etc.
- The development of appropriate institutional frameworks for applying a watershed approach at a community, intermediate, and national level
- Necessary tools, methodologies, and capacity building for the above
- Current international initiatives and developments in watershed management
- The role of watershed management in Dutch water policy

Watershed management is just one of a range of terms used to describe similar activities - catchment management, basin management, micro-watershed management, micro-catchment management etc. The paper will focus specifically on the interaction between watershed management, water availability, and rural livelihoods.

Executive Summary

- Watershed management covers a wide range of activities to do with land and water management. This paper focuses principally on the impacts of small scale watershed management on groundwater resources in arid and semi-arid areas. It draws mainly on experiences of watershed management from India, and to a lesser extent of catchment management from Southern Africa.
- In India watershed management is largely focussed on local level micro-watershed management for improved soil and water management. Where water resources are affected they are mainly groundwater. Much of the benefit gained is in the form of increased crop yields and the formation of self-help groups and other village-level institutions.
- In South Africa and Zimbabwe catchment management is largely focussed on river basin level initiatives to ensure that water is used in the most economical manner possible, and that allocation decisions are taken in a transparent and objective manner. However here there is little or no involvement of poor rural or urban communities, with most of the allocation issues being between large scale agricultural and industrial users.
- Watershed management has had a number of important successes, not least in raising agricultural production and reducing land degradation. It has also succeeded in increasing some ground and surface water resources. In addition, in India a decade of policies aimed at developing groundwater resources for small scale irrigated agriculture have led to impressive gains in yields for many farmers.
- There are, however, a number of concerns about current approaches to watershed management, in particular that:
  - Watershed management activities happen in isolation from each other: there are no mechanisms to allow for catchment (river basin) level water resource management.
  - Many of the benefits are unequally distributed. While watershed development has benefited many of the poorest through increased rainfed crop yields, and increased use of irrigation the results are often poorly distributed. In particular the landless poor have missed out on many of the potential gains.
  - Over abstraction of groundwater as a result of groundwater development policies. Rapidly falling groundwater levels are leading to the failure of village wells on which the poor and women rely.
  - Watershed management approaches may be over reliant on an idealised 'community'. The reality is one of conflicts between groups – landless and landlords, high and low caste, men and women.
- The WATSAN sector has a number of important roles to play in watershed management activities.
  - Watershed management can never provide unlimited extra water. The priority of watershed management efforts in areas where conflict exists over access to water resources must therefore be on demand and allocation management. Particularly on ensuring that this is equitable, gender sensitive, sustainable, and not harmful to the environment.
  - In areas where water resources are already under stress and the source of conflict, it should take the lead in ensuring the sustainable access of all people – but particularly women and the

poor – to a basic minimum to cover domestic and small scale productive needs. This is an activity that was clearly mandated in Vision 21.

- In areas where water resources are not yet fully developed the sector should work to broaden its approach to rural water supply and to address the productive uses of water within rural livelihoods. By taking this approach at an early stage of water resource development it will be possible to create demand for, and involvement in catchment level water resource management institutions. It will also allow better focus on the poor and women, and make water supply systems more relevant to their needs, and in the long term more sustainable .

- Dutch activities should focus on a number of key activities
- Integrating watershed management and WATSAN into water sector SWAPs.
- Advocating and supporting the inclusion of WATSAN activities and priorities within watershed (and water resource management) approaches.
- Advocating and supporting the broadening of the WATSAN sector to deal with productive uses of domestic water as part of a rural livelihoods based approach
- Advocating the need to address the rights of women and the poor within watershed and catchment approaches – particularly the right to an equitable share of water resources
- Helping governments and civil society to develop regulatory and managerial frameworks and the necessary capacity to implement them at all levels through: training, training of trainers, support to development of legislation, support for sharing of experience etc.
- Developing appropriate and factually based training materials and management tools. In this India's experiences can serve as a valuable source of lessons for spreading watershed management to other parts of the world

1 Introduction

In the ten years since the Dublin and Rio conferences catchment and watershed management initiatives have been seized on by a growing number of actors as a practical way to apply IWRM principles in the real world. However this widespread adoption of the watershed/catchment covers an equally wide range of activities stretching from high level trans-boundary river basin management to entirely localised community driven micro-watershed management. In many countries so called watershed approaches have increasingly lost any focus on 'water', becoming instead a holistic approach to natural resource management and rural development through improved land management and rainfed crop production.

This document assesses the impacts of these activities with regard to the availability of 'blue'[1] water resources to poor urban and rural communities. The geographic focus of this document is arid and semi-arid regions and the main resource considered is groundwater which, with exceptions, is the primary resource used for WATSAN in these areas. Two contrasting approaches to watershed or catchment management are illustrated using the examples of South Africa and India. These examples help to illustrate how two very different approaches to watershed management both struggle to deal effectively with the question of ensuring equitable and sustainable access by the poor to drinking water. The paper then identifies the implications of these failures for future Netherlands assistance to watershed management projects.

The document does not deal with watershed management in Latin America. This reflects both the lack of access to Spanish language resources in the time available, and the focus on semi-arid areas and groundwater. While there is considerable expertise and experience of watershed approaches in Latin America, the focus on surface water, and the very different institutional and technological settings make it difficult to draw general conclusions appropriate to other regions. Nonetheless, Latin American experiences are important and insightful and deserve further attention.

[1] In the water 'rainbow', blue water refers to surface or groundwater resources – green water to soil moisture used by crops and other vegetation, white water to water vapour, and brown or grey water to different types of wastewater.

2 What is watershed management

Both watershed and catchment management approaches have grown hugely in popularity during the decade following the 1992 Earth summit.

"the appeal of [the] approach lies in a promise to satisfy Agenda 21's complex demands with a single coherent strategy of involving local stakeholders and communities at multiple scales and zones while addressing cross-ecosystem issues and interactions related to farming and natural resource conservation." - Rhoades (1998)

To most people from the water sector, watershed management is essentially to do with better water resources management. It draws inspiration from the first Dublin principle (see box) which refers to management 'across the whole of a catchment or groundwater aquifer' as being the most appropriate approach for a range of related land and water management issues.

> The first Dublin principle:
> Fresh water is a finite and vulnerable resource, essential **to sustain life, development and the environment**
> Since water sustains life, effective management of water resources demands a holistic approach, linking social and economic development with protection of natural ecosystems. Effective management links land and water uses across the whole of a *catchment area or ground water aquifer*.

However, watershed management as a paradigm is not, however, restricted to the water sector. To those from the agricultural and rural development sectors it tends to have much less of a focus on 'blue' water, and instead deals with optimising 'green water', often in combination with soil nutrients to improve crop yields. This adoption of the watershed concept by such a wide range of actors, while good in as much as it offers a chance to deal holistically with a range of resource issues, also carries the risk of potential confusion in application. This potential confusion comes from three main sources: terminology, scale, and activities.

- *Terminology* - In American (and Indian) English, a watershed refers to the geographic area contributing (through drainage) to some common point or feature – so the watershed for a river is the area contributing runoff to that river, similarly for a dam etc. In English (and much of anglophone Africa and Australia) the word for this geographical area is a 'catchment', while a watershed describes the feature dividing two catchments – typically high point or range of hills.

- *Scale* –The catchment referred to in the Dublin principle is a river basin – that is a large scale land and water management unit with areas measured in tens of thousands of square kilometres. The watersheds or micro-watersheds referred to in India, are typically of the order of a few hundred hectares. In different countries different terms are used to refer to these two extremes, and also to the intervening scales. Combining the problems of terminology and scale one finds references to: river basins, catchments, watersheds, sub-catchments, micro-catchments, and micro-watersheds. Generally (though not always) in developing countries 'watershed' refers to smaller units.

- *Activities* – The activities undertaken by watershed programmes cover a wide range of land and water management activities. They can be state or community driven and concentrate on land

or water resources or a mix of the two. They can aim to increase overall quantity and quality of water or to allocate more fairly what is already there – or again a mix of the two. In some countries watershed management has ceased to have any bearing on 'blue' water resources at all, so for example in Kenya it is aimed entirely at increased rural production through better soil nutrient and moisture management(Yeraswarq, 1992). In addition, there are a number of primarily ecology focussed initiatives being supported by organisations such as IUCN that will not be considered in this document.

Catchment or watershed management is not necessarily the same as Integrated Water Resource Management (IWRM), although at a large scale it is often a favoured approach to achieving IWRM. In many countries the large watershed or river basin is the logical unit at which to manage national or local water resources, however in some – particularly truly arid countries such as Egypt or Yemen, or countries where watershed boundaries do not make logical or useful units for demarcation – such as largely flat Bangladesh (or indeed the Netherlands), the approach is not suitable. In these cases IWRM initiatives continue to focus on accepted IWRM principals (such as the economic value of water, and management at the lowest appropriate level) but not within a watershed framework

The following two brief case studies illustrate the two extremes of watershed or catchment management. In India a small scale, community based, approach which focuses on increasing rural production, and in Southern Africa a large scale, river basin, and surface water focussed approach. For the rest of this document the terms watershed and catchment will be used to deal with the types of activities and concepts outlined in these two case studies: *watershed management* to refer to the rural development focussed package practised in India; and *catchment management* to refer to the river basin level water resource allocation structures found in Souther Africa.

2.1 'Watershed management' in India – a bottom up approach focussed on increased productivity and resource availability

Indian watershed management is heavily backed (through subsidy) by government as part of rural development strategy. Although there are great differences in the level of application between states it has been estimated that starting in the mid-1990s the Indian government has spent approximately $500million per year on watershed management projects (Turton and Farrington, 1998). Andhra Pradesh is one of the states where watershed approaches have been most extensively adopted.

A typical Indian watershed is some 500-1000 hectares. Watershed and village boundaries seldom if ever match exactly and there can be several villages[2] in a watershed or a village that spans several watersheds. Government implemented watershed management consists of a range of activities aimed at better management of the land within the watershed boundaries, and typically involve some mix of physical land management (ridging and bunding on the upper slopes); restriction (or banning) of grazing in forest and 'wasteland' areas; building of check-dams for increased groundwater availability; and de-sedimentation of 'tanks'[3]. The focus on water is entirely on increased local resource availability through improved land management and there is no effort to

[2] Indian villages are typically large and centralised with populations of the order of 5,000 people, but going as high as 20,000.
[3] Tanks are small artificial reservoirs which act as runoff capture and storage structures. Many tanks are hundreds of years old.

deal with local level water allocation issues. Neither is there any larger level catchment management framework within which the watershed initiatives are coordinated.

An exception to the failure to deal with allocation and equity issues is found in some NGO run projects, such as those of the Agha Khan Foundation and Outreach. These use PRA tools that lead to the exposure of competition for and conflicts over access to and use of natural resources including water. As a result equity issues and conflict management are addressed in these projects (see, e.g. Shah and Shah (1995)).

In general watershed projects aim to arrive at 'win-win' solutions – in which for example water retention through construction of bunds leads both to increased rainfed crop yields, and greater groundwater recharge. The key underlying assumption is that good land management will lead to increased availability of water resources for productive and domestic use. In addition to the physical work of land management, village watershed committees (VWC) are formed to undertake the planning and implementation of the work, which is carried out by community members.

In parallel with its policy of watershed management, India has seen a huge increase in small holder irrigation which has in many cases led to greatly improved rural livelihoods. This has been aided in many cases by subsidies to the costs of developing groundwater (through the provision of loans for borehole drilling and purchase of submersible electric pumps) and provision of free (or nominally priced) electricity to farmers.

Other countries that adopt similar bottom up, rural development focussed approaches to watershed management include Pakistan, Kenya, and several other Asian and East African countries.

2.2 Catchment management in Southern Africa – large scale, top down, allocation based

Rural water resource development in Southern African takes place within a 'catchment management' framework. Supported by its new water law, this model is focussed at the river basin level, and is mainly aimed at the sustainability and optimisation of blue water resources. In general, groundwater is not considered as providing an important source – apart from for rural domestic water supply – and the use of water by small scale rural users is seen as being 'insignificant'.

The law allows for estimation and protection of a 'catchment reserve' to cover minimum environmental and WATSAN needs. Water in excess of the reserve is then allocated on an economic basis through a system of water rights. Different land and water users are rewarded or penalised according to whether they 'use' or 'contribute' water to total catchment resources.

Zimbabwe's new water law which has been supported by the Netherlands, is based on a similar model to that of South Africa. The country is divided into seven basin scale catchments, each of which will be governed by a catchment council drawn from, and elected by the water users of the area. Within each catchment are a number of sub-catchments, each of which also has a representative catchment council. The whole is overseen and coordinated by the Zimbabwe National Water Authority (ZINWA). (Husselman, 2001)

In theory, in both South Africa and Zimbabwe, all water resource development should take place under a system of licensing that is made on the basis of resource allocation decisions at a catchment level. The decisions should be taken by democratic or quasi democratic 'stakeholder' groups, such as sub-catchment councils. However, the reality, at least for the moment is that capacity is largely lacking to either monitor or make informed allocation decisions, and that 'management' largely consists of the allocation of abstraction licences to large scale commercial and industrial users of surface water. For a mix of political and practical reasons, water development and use in non-commercial rural areas is largely ignored, in terms both of making allocations, and of estimating the impact of water use on overall resource availability. The assumption is that (domestic) water use in these areas is 'negligible' in terms of the overall water balance, an assumption that experience in India strongly refutes.

The catchment management model used in Southern Africa is the classic model of rational decision making about water resource allocation issues that lies at the heart of the Dublin issues. It is recognisable in many developed countries, for example France, the USA, and Australia, and is the model to which new water laws in many developing countries aspire. While the Indian watershed model focuses largely on the local level and has no larger allocation decision making framework, the catchment model of Southern Africa makes assumptions about ability to monitor and make decisions that have in reality been little tested.

3 Major actors in watershed management

"Enthusiasm for participatory watershed management is so high that virtually all major development organisations are promoting the approach in hundreds of communities found throughout North and South America, Asia, Africa, Europe and Australia." – Rhoades (1998)

Watershed management internationally is being strongly supported by DFID, GTZ, DGIS and the Nordic countries, in addition to a number of multilaterals. Both DFID and GTZ have undertaken major watershed programmes in India, while DFID, DGIS and GTZ have been instrumental in developing new water laws and policies in Southern and Eastern Africa.

India is probably the worlds largest advocate of watershed management; however, the approach is also being widely implemented by governments and NGOs around the world. A recent review of experience (Hinchcliffe et al, 1999) identifies examples in Africa, Asia, and Latin America.

In Australia, and the USA both large scale state led, and small scale community based watershed management projects are popular and fast increasing in number. In Australia the Murray Darling river basin is one of the most celebrated and oldest examples of government instigated catchment management while informal 'landcare' groups are springing up across the country.

3.1 Dutch policy and activities in watershed management

Dutch aid in the water sector is targeted on seven countries: Egypt, Mozambique, Tanzania, South Africa, Bangladesh, India, and Yemen, all of which see water resource issues as a priority. Watershed based approaches of one or both types described above are likely to be of importance in Mozambique, Tanzania, South Africa, and India, while for the reasons discussed earlier they are unlikely to figure largely in Yemen, Egypt, or Bangladesh. Most ongoing Dutch activity in the catchment/watershed management areas is in the form of support for sustainable wetland management, or large scale catchment management initiatives such as those supported in Zimbabwe.

The NEDA publication 'Water for the future' (NEDA, 1998a) sets out Dutch policy on water sector projects and integrated water resource management. While it does not deal specifically with the issue of watershed or catchment management, it provides a framework for the analysis of proposed programmes and projects that is fully applicable to watershed (and WATSAN) activities.

The WATSAN sector has traditionally been strongly supported by the Netherlands, but has seldom in the past been explicitly linked to either catchment or water resource management programmes. However, both IWRM (NEDA, 1998a) and WATSAN (NEDA, 1998b) strategies emphasise the need for a more integrated approach in the future. The issue of how and why WATSAN should be dealt with in watershed approaches is dealt with in more detail in sections five and six.

4 Successes and causes for concern in watershed management

This section looks at on some of the main successes and causes for concern surrounding the implementation of small scale, community focused watershed management. While watershed management as practised in India lacks the larger scale framework deal effectively with basin level conflict and allocation issues, it does have the merit of taking the level of the community as a starting point. Such approaches would therefore seem to have more potential as an entry point for WATSAN issues that the higher level catchment management approaches described earlier.

Batchelor et al. (2000) identify the following positive and negative aspects to Indian watershed management:

On the positive side:

- Increases in net agricultural production on arable and non-arable lands;
- Development of village-level institutions;
- Substantial improvements in the livelihoods of some social groupings;
- Implementation of an approach that has widespread political and public support.

The less positive aspects of the programme in dryland areas include:

- Certain groups capture water resources often at the expense of the poor;
- New village-level institutions are usually outside government and, consequently, they often have minimal political or legislative support for any actions or decisions that they might take;
- Protecting drinking water supplies is not seen as an integral part of watershed development;
- Emphasis is on development of water resources (i.e. on increasing water supplies by constructing check dams, rehabilitating tanks etc.) and not on management of water resources (i.e. on managing demand and on maximising the social and economic value of water).
- As planning takes place at the village-level, a whole range of wider issues are ignored (e.g. upstream-downstream equity, inter-village equity, flood protection, drought preparedness, pollution of water courses, biodiversity and protection of rare habitats etc.)
- Watershed development publicity or propaganda (e.g. wall paintings, street plays etc.) is often misleading in that suggests that there are quick fixes to water-related problems in semi-arid areas.

The last points clearly highlight the negative impact of not having a higher (catchment or other) level management framework within which to coordinate the efforts at a watershed level. Some of these points find resonance with the eight ‘landmines’ affecting the watershed approach identified by Rhoades in 1998 (see box). Some of the most important issues are looked at in more detail in the following paragraphs.

Landmine 1: Scale confusion and scale wars
Physical and human processes take place in different ways at different scales. Physical boundaries seldom coincide with human ones, and the effort to force them to can lead to failure
Landmine 2: The participatory methodology fetish
Participatory methods can be used naively and superficially. Lack of sufficient attention to stratification and differentiation within 'communities' can lead to exclusion while maintaining a veneer of inclusion and participation.
Landmine 3: Social underdesign of projects
Projects continue to be dominated by physical scientists and engineers, despite the most pressing problems being social and institutional.
Landmine 4: Re-invent the wheel syndrome
There is a lack of serious effort to document and then use other people's experience. There is a lack of high quality external documentation assessing success and failure, and drawing lessons. Most evaluations are being carried out by projects themselves.
Landmine 5: Great expectations
Projects promise all things to all people. They search for elusive win-win scenarios, while ignoring the multiplicity of stakeholders often with completely conflicting agendas.
Landmine 6: Tragedy of the participatory commons
An attempt to involve all stakeholders often leads to 'turf wars' and the no-one in command syndrome
Landmine 7: Duplicating management structures
Projects often create structures where non seen to exist – ignoring local institutions and norms, and frequently fostering conflict
Landmine 8: Stakeholder complexity and competition
Failure to take conflicting points of view into account.

Box 1 Eight landmines for watershed management

4.1 Water resources are increased – but not indefinitely

Properly executed watershed management can and does lead to increased availability of water resources. Retaining water that would otherwise become runoff improves soil moisture availability for crops and other plants, it can recharge groundwater aquifers, and in some cases lead to increased dry season stream flows. In addition, management approaches that reduce the speed of runoff (through either physical structures (bunds, check-dams etc.) or enhanced vegetation) can significantly improve water quality, most obviously by reducing sediment loads, but also by subjecting surface waters to the filtering effects of the soil.

However, water resources cannot be increased indefinitely. By definition arid and semi-arid climates are dominated by the effect of evapotranspiration[4] which will always exceed annual rainfall. Studies in India have suggested that as little as 2% of rainfall in some watersheds becomes runoff (Batchelor et al, 2000). While a greater amount is available as groundwater recharge (up to 20% - Moriarty, 2000), however as many arid and semi-arid (ASA) countries are underlain by shallow hard-rock aquifers where storage is limited and competed for by deep rooted vegetation. Nonetheless, groundwater is the main resource available to rural communities in ASA countries.

In addition to absolute availability of groundwater, temporal availability an important issue. Groundwater levels typically reflect cumulative rainfall over a number of years (depending on a variety of parameters). Studies have shown that in many areas rainfall patterns are cyclical, with

[4] Evapotranspiration is a term that combines the direct evaporation of water from soil and open water and plant interception, with the evaporation of moisture transpired by plants.

extended periods of above and below average rainfall being the norm and groundwater levels reflect this pattern while smoothing out the effects of year on year variability. Groundwater can therefore act as an important buffer for the dry periods, when other sources such as surface reservoirs dry up and as such play an important role in drought preparedness and mitigation strategies (Moriarty and Lovell, 1999.

Perhaps the most important lesson from the Indian experience is that that greater water availability from watershed activities is quickly nullified by increased use of water for irrigation and other purposes. The implication is that watershed management alone cannot satisfy increasing needs, and that at some point allocation and demand management must be dealt with as well.

4.2 Increased availability is not evenly spread

While succesfull capture of rainfall in one part of the watershed can lead to improved local availability this can lead to problems further 'downstream'. There is a growing body of evidence in India to suggest that a mix of succesful water harvesting and subsequent overexploitation of groundwater for irrigation in upper catchments is leading to the failure of tanks and town supplies downstream (Butterworth and Soussan, 2001).

Even at the scale of the scale of the small watershed itself, there are problems linked to capture by landholders in the valley bottom of improved water resources created by investments in good land management on the hill slopes (Kerr, 2000).

4.3 Succesfull watershed management can increase agricultural production – but not for everybody

Perhaps the greatest impact of watershed management programmes is in terms of agricultural production. Improved soil moisture management can have dramatic effects on rainfed crop production which, coupled with enhanced groundwater availability has led to some dramatic increases in total production in India and elsewhere. Watershed management can claim direct responsibility for improved rainfed crop production, and in addition where conditions are right – high demand and high values for irrigated crops – also increased irrigated agriculture.

However, benefits are again not necessarily spread evenly. In India watershed management and groundwater development have made many people better off. Many of these are among the poorest farmers – it can be argued that an entirely new 'strata' of small scale irrigators has been created. However, landless people in particular are often left out of the benefits. Access to previously 'common' land can be restricted, and greater groundwater availability may only be accessed by those with the wherewithal to continually deepen their wells to chase the falling groundwater table.

4.4 Succesfull watershed management can maintain agricultural land and improve wasteland and commons

An important component of most Indian watershed management projects is the fencing (often "social" rather than physical, with fines imposed on anybody that doesn't abide by the rules) of forest and wasteland, linked with controlled or completely stopped grazing and use of forest products. This can lead to rapid regeneration of the wasteland, which in turn reduces erosion. In

addition there is some evidence that reduced access to range land for grazing leads to an intensification and eventual increase in animal production.

However, reduced access to forests can also impact negatively on the poor. Women must go further to find firewood and other forest products, and access to grazing for those without the necessary inputs to undertake intensive livestock raising is reduced. Conflicts related to these negative impacts can themselves lead to reduced effectiveness of the recovery. Physical fences are broken, or social ones ignored.

4.5 Multiple stakeholders lead to friction and competition

"This reality runs counter to a participatory rhetoric which envisions good-willed people sitting down around mythical 'conservation or debate tables' to resolve their differences. Resolving such differences will involve more than just dialogue." – Rhoades (1998)

Watersheds are inhabited by a range of different people, undertaking different activities, and with widely different agendas. In India the most visible problems occur at the watershed level, between members of different castes, men and women, and between land-holders and the landless. In South Africa and Zimbabwe the visible problems are at the catchment level where conflict occurs between different major land uses: forestry, irrigated agriculture, industry and towns.

This does not mean that India does not suffer from catchment level problems, nor that in Southern Africa there is no local level conflict over resources. However, in both cases the framework provided by different (and incomplete) approaches to land and water management either ignore or conceal the true extent of existing and potential conflict.

4.6 Succesfull watershed management can improve rural livelihoods – but whose livelihoods?

"In India, watershed development has consistently boosted agricultural production; facilitated the development of village-level institutions and substantially improved the livelihoods of some groups." – DFID 2001

On balance the experience from India seems to point to watershed management projects having a net positive effect on livelihoods, although there is little 'hard' evidence to weigh the costs of implementation against the benefits gained. What this aggregated evidence does not show is the division between relative winners and losers, and particularly the problem of the capture of many of the benefits by local elites. For example, the dramatic improvements in agricultural yields from rainfed farming are captured mainly by those who own land while the landless are penalised by being excluded from the 'common' land where they previously grazed animals and collected forest products.

At the local level, perhaps the biggest 'losers' from watershed development are those members of a community who benefit least from increased crop production and suffer most from reduced access to domestic water: the poor, and particularly poor women. While over-irrigation is not an aim of watershed projects, failure to deal with the issue of demand management and equitable allocation

means that the resources injected into villages by watershed schemes will almost inevitably result in greatly increased irrigation.

At the larger catchment level, competition over water resources remains largely invisible due to the absence of basin level organisation or monitoring. However here too rapid increases in irrigation are increasingly seen as having a negative effect on shared resources 'downstream', either tanks which no longer fill, or rivers that fail during the dry season leaving towns and industry without water.

5 Why the WATSAN sector has a role in watershed management

This section deals with the issue of watershed management particularly as it affects the WATSAN sector. It sets out the reasons for which becoming involved in watershed management is an important issue for the sector, and in the following section it identifies the main areas in which involvement will be necessary.

Watershed management as it is currently being developed is focussed largely on rural productivity and environmental preservation. It concentrates on improving rainfed and irrigated crop yields, and on minimising erosions and land degradation. What it does not deal with nearly as effectively is: access to drinking water; non 'agricultural' uses of water (including small scale vegetable gardening and livestock watering); or catchment level allocation issues.

The first of these issues is clearly of concern to the WATSAN sector. The second is currently not an issue for the sector, but this paper argues that with the increasing use of 'livelihood' approaches particularly in rural areas, it will soon become one. Finally, the third is also an issue in that the over use of water in upstream areas leads directly to the failure of supplies in urban areas, and to the urban poor in particular.

Currently the WATSAN sector continues to see its responsibility largely in terms of service provision. The assumption being that the resource can be taken for granted. However, it is clear that as pressure on resources for all uses increases there will be an ever greater need to effectively 'ring-fence' or protect those necessary for domestic uses. In addition, as the WATSAN sector broadens its perspectives to include activities such as source protection (advocated by the WSP in India) and small scale productive uses (which NGOs such as WaterAid now deal with explicitly) the area of overlap between WATSAN and watershed activities, and hence the possibility for collaboration will become more important.

Some of these issues are taken up in more detail in the following sections.

5.1 Water shortage is affecting access to and sustainability of drinking water supplies

"In many hard rock areas, the water table is now too low for the shallow aquifer to re-establish in all but the wettest years. As a consequence shallow or open wells are almost permanently dry and farmers living in areas where neighbours have drilled deep borewells have found that their shallow wells have become unreliable or rendered defunct" – DFID 2001

In many parts of the world conflict between water users is a daily reality. In India, a decade of rapid rural development has led to widespread domestic water shortage due to intense groundwater use. This shortage has disproportionately affected the rural poor. While under the national water law or 1987 water for domestic use should be given first priority, and exploitation of groundwater is supposed to be controlled (Nigam, 1998), the reality is that groundwater development is largely a free for all with little or no effective planning.

In many of the arid regions of India, the success of policies to improve rural livelihoods by supporting the development of small holder irrigation using groundwater is having a serious negative impact on village domestic water supplies. While initiatives such as rainwater harvesting can replace some of the missing water, the reduction of the groundwater 'buffer' that traditionally ensures at least some access to drinking water in time of drought is a critical issue. As a result drinking water supplies are increasingly having to be piped or tankered over great distances at high costs. Those most affected are the poor. They rely on shallow groundwater wells for both domestic and productive use and have no access to the deeper irrigation wells, which better-off households also use for domestic purposes.

Vision 21, which is supported by Dutch policy (Saade et al, 2001), expressly identifies the need for the WATSAN sector to play an active role in IWRM and to ensure that access by the poor and women to an equitable share of water resources for both domestic and small scale productive uses is safeguarded. Dutch policy also places water for domestic and livelihoods uses as two core areas for support within IWRM policies (NEDA, 1998). In rural areas watershed management offer the ideal arena in which to start integrating these two aspects of water development with other rural development activities.

5.2 Poor catchment management can effect quality – particularly of surface sources

The issue of water quality is seldom dealt with in Indian watershed management projects, although there is an increasing body of evidence that groundwater problems such as excess fluoride and iron can be exacerbated by groundwater mining. The quality issue of most concern in India – and indeed throughout the ASA countries is that of sedimentation. Much work on watershed management is focussed squarely on reduction of sediment loads, at both the small watershed scale (where small dam siltation is a problem) and at the scale of larger river basins.

Water quality is of course a far more important issue in more humid zones where surface runoff is a major drinking water source. In Latin America where the catchment is seen as the first barrier in water treatment (IRC, 1997) work has focussed on the effects of contamination of surface waters by for instance human habitation or animals living in the catchments, and the effects these have on the level of remedial treatment necessary (Quiroga et al, 1997; Visscher et al, 1996).

5.3 A broader approach to domestic water supply is needed to reach the poor

The WATSAN sector is traditionally focussed on the rights of the poor to access domestic water. The failure of village water supplies due to over-abstraction of groundwater for irrigation clearly calls for some form of intervention to better manage and allocate the resource (Nigam, 1998). However the issue is more complicated than this. The complex distribution of land and other resources in India, and the central role of water as a productive resource in all dryland areas means that the issue cannot be limited to simple ring-fencing of domestic water supplies. The whole issue of who has access to water for productive purposes is also crucial to poverty reduction and the empowerment of women.

As long as the WATSAN sector restricts itself to a purely domestic ('drinking') water focus it will effectively collude in the injustice associated with current watershed management approaches, that see the relatively better off landholders benefiting disproportionately from increased access to water.

5.4 Gender inequalities are often exacerbated

Watershed management projects affect women and gender relations in different socio-economic strata differently. Women in better-off households may reduce their *domestic* workload from a better access to water, but see their net workload increased from a greater amount of physical work in *economic* water and land use, often of a repetitive nature (e.g., weeding, animal watering, milking) and of a low status. The increased work will actually worsen their position, unless it leads to improvements in gender relations, such as a greater appreciation of their economic roles and a share in the increased produce and/or decision-making on the uses of the generated income.

6 How to get involved – what are the priorities

Based on the previous section, two main areas for WATSAN sector involvement in watershed activities are suggested. The first of these is in the issue of allocation or water rights. Typically ignored in watershed management approaches this is most crucial in countries such as India where over use and conflict is an everyday reality. The second, is in the area of productive uses of water at the household level, particularly as it affects the livelihoods of women and the poor. This second issue will call for the WATSAN sector itself to re-evaluate what it understands by 'domestic' water supply.

6.1 Focussing on allocation

In India, the focus to date in WATSAN has been almost entirely on the supply-side of the equation (i.e. on augmenting supplies by constructing new or deeper borewells, on piping in water from some distance, on rainfall harvesting within urban areas etc) and increased agricultural use. However, this paper has shown that whilst it is true that measures can be taken within a watershed development programme to increase the amount of water available, that increase is finite; once the measures have been implemented, very little can be done that is economically feasible to capture more.

Moreover, once modes of agriculture and lifestyles have changed, pressures on and conflicts over the finite amount of available water increases, rather than diminishes. As a result, the focus for preserving domestic resources needs to turn increasingly to managing demand and assuring equitable distribution of what resources there are (within practicable limits). Demand management has already been identified as a priority for Dutch WATSAN policy (NEDA, 1998), however this has been seen exclusively in the light of making an existing WATSAN resource stretch further. Within a watershed framework it will be necessary to deal with demand management and allocation of all water using activities.

Recent work in India has suggested several ways in which water could be physically managed to ensure access to a basic minimum.

Economic measures	• Tax measures (e.g. taxes on sugar production) • Increased electricity charges (i.e. reduced subsidies) for pumping water • Infrastructure (e.g. GO-sponsored marketing, storage and transport) • Water charges (e.g. water metering) • Charges for abstraction licences • Paying farmers not to pump groundwater in certain areas
Legal measures	• Implementation of groundwater law (e.g. zoning, abstraction licences, well depth restrictions, restrictions on duration of pumping, tradeable water rights etc.) • Implementation of regional resource management and planning frameworks
Institutional	• Re-establishment of traditional water-related institutions

measures	• Village-level groundwater-level monitoring and decision-making • Linking watershed development committees to the PRI system
Social measures	• Training and awareness raising • Community and social pressure

The WATSAN sector should encourage an approach that uses a combination of the above approaches to address the issue of allocation, and particularly of equitable allocation. Poor people and particularly women need help in ensuring that they are included in decision making fora.

Watershed management committees need encouragement, training and the necessary tools to widen their remit to include allocation decisions. Approaches that empower communities and local level support agencies such as NGOs, and that give them real power in water resource decision making should be encouraged, particularly to minimise the opportunities for rent seeking and corruption.

While outside the scope of a paper focussed on small scale watershed management, it is clear that without the development of higher (catchment) level management frameworks any success in addressing community level issues through watershed management activities will be strictly local in impact. It is essential that watershed managers are helped to develop a picture of their place in the larger water resource picture, and that capacity exists to ensure that positive developments at the local scale do not lead to negative impacts, particularly failure of domestic water sources, downstream.

6.2 A livelihoods based approach will lead to greater sustainability

Traditionally, rural WATSAN has focussed largely on drinking water. However, the combined challenges of maximising the impact of improved water supply people's livelihoods, cost recovery and succesfull implementation of demand responsive approaches is forcing a wider vision of the role of 'domestic' water in rural peoples livelihoods (Nicol 2000). The sector needs to broaden its own focus to include productive uses of water within a livelihoods based approach. Rather than being a supplier of 'drinking water' it should start from a basis of understanding the role that water plays in peoples lives and then seek to supply adequate water to meet these. This may often involve a need to seek alternative sources, and to deal with issues such as wastewater reuse, water harvesting, and multiple supplies.

This focus on the productive uses of domestic water has important implications for watershed management, as it implies the need to safeguard a larger share for domestic use than drinking water norms might imply. Once again, the WATSAN sector has an important role to play in watershed projects in encouraging and enabling the development of water resources for a whole range of non-irrigation productive activities.

Combining productive and domestic uses of water through productive water points – communally managed water points that give water for productive but also domestic supplies is one way to solve a number of problems related to cost recovery and system maintenance in water supply projects. There is an increasing body of work relating to their introduction as part of rural water supply

schemes in Africa (Lovell, 2000; Nicol 2000), and there are also interesting cases of their use in India some of which are briefly described in the box below.

- A comparative study of villages in Banskhanta, a dry part of Northern Gujurat, showed that the addition to the domestic water supply (provided by a DGIS project) of a women's micro-enterprise project brought extra household income, improved management of the supply, and better gender relations.

  When the water supply broke down the women entrepreneurs (and their families) lost an average of Rs. 50 per month in earnings. In addition, in summer (when they had to fetch water from farther away) they lost a total of 7 hours per month, time which they would otherwise spend on childcare, household activities, social and personal activities, and sleep.

  When water collection was highly time consuming (in summer), or when the water supply broke down, husbands and sons in the households of women entrepreneurs were prepared to give more time to help that those in villages where there was no income generating project connected to the water supply IRC/SEWA/FPI/HabiCom, forthcoming)

- MYRADA (a large NGO) has been trying different types of community irrigation using community 'gardens' in areas away from the village.
  - In one case a mixed group of landless SHG members have taken up 2 ha of land under a renewable lease arrangement. These members have taken a loan to construct a borewell and install a pump.
  - In other cases, loans are being provided to groups of farmers with adjacent landholdings so that they can pay for installation of borewells and pumps for communal use. One condition is that there should be no paddy or sugar cane cultivation and fodder should be grown on bunds;
  - In a third case land belonging to one person is being split between four people one of whom is the original landowner. The other three are landless and taking the land under a lease basis. The landowner is not taking rent, however, he is benefiting from the borewell and pump that has been installed by the "landless" scheme members using a loan.

6.3 Developing monitoring and decision making abilities at all levels

Undertaking this wider role in watershed management activities calls for efforts under a number of headings, one of the most important of which is developing the ability to manager the resource at a watershed and higher level.

The key to managing any resource is the ability to monitor its status and then make management decisions which are enforceable. Recent work in India has shown that much of the necessary baseline information for monitoring water resources at intermediate levels exists already, and that using new technologies such as geographical information systems it is possible for intermediate level managers to use this information as the basis for management strategies (Batchelor et al, 2000).

In addition, evidence from the water and sanitation sector has shown that communities can themselves be involved in monitoring, and that where this is done using the appropriate tools the results can be of use both to the communities but also to those at higher levels. The Method for Participatory Assessment (MPA) developed by IRC and the WSP is one such tool (Dayal et al, 2000), and it is currently being adapted for use in watershed management programmes in Karnataka.

Much monitoring and reporting is gender and poverty blind. Monitoring systems should be made gender and poverty-specific in their process ("Who monitors and how are burdens and benefits of

monitoring divided between rich and poor, women and men?"), their indicators and analysis and recording/reporting.

Linked to monitoring ability and its gender and poverty perspectives is decision making ability. Natural resource management calls for the ability to weigh numerous competing claims and factors, and to make allocation and management decisions based upon these. Initiatives such as the Dutch supported India National Hydrology Programme and UNESCO's Southern Africa FRIEND are developing some of the necessary background data, but seldom in a format that is appropriate for use at a catchment or watershed level. Dutch IWRM policy identifies the need to support the development of '*national and regional capacities [for]… generating the information and analyses to support IWRM'* as a core area for support (NEDA, 1998).

6.4 Developing institutional capacity and legal frameworks

In addition to developing the ability to assess and make management decisions, there is a need for clear and enforceable regulatory frameworks supported by government policy, and the institutional capacity to manage them. The development of institutional capacity at all levels has been highlighted as an IWRM priority in Dutch policy (Diphoorn, 1998) particularly the development of capacity at the community level to take and active and meaningful role in water resource management.

South Africa and Zimbabwe both have new water laws that provide the framework for a catchment approach, but there are many doubts surrounding the practicalities of enforcing it – not least that there is widespread disagreement about how to measure water use. In India water abstraction and use are not currently governed by an effective regulatory system, and 'free water' (and free electricity to pump water) is a widely seen as a political imperative. At the intermediate level of local government, there is doubt as to whether even in the case that an appropriate framework existed there would be the ability (or desire, given high levels of corruption) to enforce it. Development and implementation of effective groundwater legislation and regulations has been identified as crucial to sustainability (Nigar et al, 1998; Batchelor et al, 2000).

Developing the necessary frameworks to monitor and manage water use, and to ensure that the necessary capacity to effectively implement them exists is therefore a priority, in particular Nigam et al (1998) identify the need to include communities in the management of their own fresh water as a key issue in ensuring sustainability and equity. In addition, there is a clear need to develop models that are sufficiently robust to work even in situations where capacity is low and corruption a problem.

7 Priority areas for Dutch support

"When confronted with multiple local stakeholders with the sanctioned right to press for their needs, grassroots workers need not only a 'paradigm shift' but good science, appropriate methods, organisational skills, workable technologies, sufficient money, and donor patience" Rhoades

A number of donors, including the Dutch, are currently redefining their roles within development. They are encouraging governments to take the driving seat in terms of developing policies and identifying priorities. Dutch policy is committed to the use of Sector Wide Approaches (SWAP) in which most aid should be direct budgetary support to governments for allocation within a sectoral spending framework (Moriarty, 2001). The suggestions for actions set out in this section are all fully compatible with SWAP. They focus on the development of stakeholder capacity, on the piloting of innovative approaches, on the development and sharing of appropriate knowledge and adequate information, and on the facilitation of national activities rather than imposition of parallel processes.

Limiting SWAP to water 'sub-sectors' would represent a significant 'missed opportunity'. While the final direction of SWAP must be decided by national government, the Netherlands should strongly support the integration of drinking water and other sub-sectors within unified 'water sector' SWAPs. Within these, and where appropriate, watershed management approaches should be advocated and supported.

As an internationally recognised centre of excellence in the field of water management the Netherlands is in a strong position to give guidance and support in the development of water sector SWAPs. The activities and expertise of organisations such as Wageningen Agricultural University, IHE, KIT, and IRC are recognised world wide. However, to date there has been insufficient collaboration between the agricultural and natural resource focussed organisations on the one hand and WATSAN ones on the other. In addition, links between the research and implementation communities also need to be strengthened, particularly on the side of dissemination of research findings. There is therefore real and pressing need to collect, quality control, and distribute the lessons learned from the huge range of experience, particularly from India, and to turn this into useful products for people and organisations both in India and other parts of the world. Encouraging the development within the Netherlands of thematic networks capable of giving support and guidance in the development of truly watershed management should be given high priority.

Drawing on the findings of the previous two sections, it is clear that there are a number of activities in which donors (and the Dutch in particular) can profitably take part in watershed management activities including:

- helping to develop regulatory and managerial frameworks at all levels, and supporting the development of the necessary capacity to implement them through: training, training of trainers, support to development of legislation, support for sharing of experience etc.
- supporting the development of appropriate and factually based training materials and management tools

- advocating the broadening of the focus of rural water supply to deal with productive uses of water as part of livelihoods based approaches, and piloting such approaches where appropriate
- advocating and piloting demand management approaches that lead to more equitable and productive uses of water
- advocating the need to address the rights of women and the poor within watershed and catchment approaches – particularly the right to an equitable share of water resources for domestic and productive use

As a general rule, in areas such as Southern Africa where water resource availability for rural people is not yet a critical issue the broad focus should remain on developing sustainable and appropriate supplies, but with broadening of scope to take account of all the non-drinking water livelihood roles of water. However, in areas where mixed use is already causing shortage, the starting point should be the safeguarding of domestic water supplies, and the equitable distribution of what remains for productive purposes between socio-economic groups and between women and men within these groups.

7.1 Identifying appropriate institutional frameworks and capacity requirements at all levels

In many countries there is a critical lack of capacity at all levels from (national to community) to implement proper water resource management and, by extension, watershed management. At the same time, in countries such as India where technical capacity exists it is often stifled by problems of corruption, lack of motivation, political interference and so on. While at the *national level*, there are more and more examples of countries with good legislation, there remain huge gaps between this and their ability to effectively implement water resource management (Visscher et al, 1999).

National, regional, and local Hydrological networks and the information needed to make informed management decisions are almost non-existent. Where water laws are enforced at the basin level they tend to be captured by local power elites. To date, there are no examples of credible schemes to involve the rural poor and women in basin level decision making.

At *intermediate levels* – government, ESAs, and private sector – management capacity is patchy, and even where present is hampered by a lack of appropriate regulatory frameworks and implements. In many cases people lack the basic knowledge of hydrology necessary to make informed decisions. Mechanisms for monitoring both the resource and its use are lacking. Support for communities in terms of facilitation and monitoring are inadequate.

At the *community* level, with a few important exceptions, traditional structures are often largely unsuited to managing water resources at current levels of intensity of use. It is only recently that the issue has switched from insufficient supply to a need to manage demand. Communities need help in monitoring, assessing, and making decisions about how to use their water resource. They need basic tools with which to understand the issues facing them. They also need outside help to facilitate inevitable conflicts over resource use. Equity issues need to be integrated in monitoring, assessing and decision making approaches and in the development of tools.

A complication to the need to develop institutional capacity is the issue of corruption. While not widely reported there is much anecdotal evidence that in India where corruption is endemic, the high levels of subsidy attached to watershed approaches are often leading to inappropriate developments based mainly on the desire for kickbacks. Developing frameworks that can somehow reduce the incidence of corruption and rent seeking – for example by strengthening the hand of communities and NGOs – is a matter of priority.

Areas of priority include

- Supporting governments, NGOs and CBOs in developing and piloting of new approaches that bring together community and local government monitoring, management, and allocation of water resources in coherent frameworks that acknowledge differences of use and interests within communities and households;
- Supporting and piloting the development of appropriate monitoring tools for use by the different stakeholder groups in communities and intermediate level managers;
- Supporting research into scale related issues, in particular how to ensure that local level watershed activities are included in and regulated as part of wider IWRM frameworks
- Supporting and piloting the development of management frameworks that minimise the negative effects of corruption and the capture of benefits by the powerful and inequitable division of benefits between the sexes.

7.2 Quality controlled, tested, and appropriately targeted information is essential for practitioners at all levels

As Rhoades (1998) has pointed out there is a serious lack of quality information available in the watershed management field. Decisions continue to be made on the basis of outdated 'myths' – see appendix 1. Much watershed development happens in an unsystematic manner, and 'evaluations' of effectiveness are too often written by project personnel. There is a need for high quality factually based, information targeted at the different users at different levels and at different groups within the levels. Developing such information and giving all interest groups access to it is one area where donors can play an important role.

In particular priority should be given to

- Support for the collection, evaluation, and distribution of lessons and 'best practice' from around the world and incorporation of this information into Dutch supported activities. A hard headed evaluation of the strengths and weaknesses of Indian experience in watershed management could serve as a valuable resource
- Support for the development of updated manuals and other tools for watershed management that encourage effective land and water management but do not raise unrealistic expectations
- Support for the development of tools that support the participation for groups that under the current practices are often excluded, particularly women and the poor

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Appendix 1 – Myths about water

Below are some of the more common misconceptions about groundwater, runoff and crop water use as reported by the Karnataka watershed development project (KAWAD, 2001). Subscription to myths such as these can lead to poor decision-making and wastage of human and financial resources.

MYTHS ABOUT WATER

1 – Aquifers are underground lakes

The observation that water tables have risen in wells that are immediately adjacent to check dams is often recounted as an indicator of success of watershed development programmes. Unfortunately, many such reports fail to recognise the fact that, in semi-arid areas that are underlain by hardrock aquifers, structures such as check dams, even in the absence of increased groundwater extraction, rarely lead to regional rises in groundwater water levels. The reality is that check dams and other such water-harvesting structures usually have only localised impacts on the water table and aquifers rarely behave like underground lakes (i.e. that localised recharge in one place leads to an immediate rise in groundwater levels at another place many hundreds of metres away). Aquifers are geological formations that contain groundwater. In simple terms, groundwater is water that accumulates underground and is stored in the pore spaces that exist in sediments or weathered materials and/or in the fractures in rocks such as granites or basalts. Groundwater is in continuous slow motion in the direction of potential gradients that are created by gravity and capillary forces. In areas of permeable subsoil, excess rainwater travels through the soil and the unsaturated layer below. When it reaches the water- table and joins the aquifer, it begins a slow underground journey, typically at rates ranging from a few millimetres to a few metres per day. Eventually it finds outlets, such as riverbeds, wetland seepages, natural springs etc. Drawing groundwater from wells can have a big impact on groundwater regimes and availability. Cones of depression in the water table are created around wells and these influence potential gradients and, hence, the speed and direction of water movement.

2– Runoff in semi-arid areas is 30-40 per cent of annual rainfall

Although localised runoff, and runoff from individual storms can be high, annual runoff in semi-arid areas – at scales larger than the micro-watershed – tends to be much lower than 30-40 per cent. In large areas of semi-arid India, mean annual runoff is lower than 5 per cent of annual rainfall. Groundwater extraction, soil water conservation and construction of water harvesting structures have all contributed to a further reduction in mean annual runoff. This fact explains why, in the areas surveyed by the KAWAD Water Resources Audit, inflows to tanks are significantly reduced and why rivers that were once perennial are now seasonal.

3 – Planting trees increases local rainfall and runoff

The worldwide evidence that high hills and mountains usually have more rainfall and more natural forests than do the adjacent lowlands has historically led to confusion of cause and effect (Pereira 1989). The reality is that forests exert a small, almost insignificant, influence on local rainfall (Calder, 1999) Notwithstanding a small number of exceptions, catchment experiments generally

indicate reduced runoff from forested areas as compared with those under shorter vegetation (Calder, 1999).

4 – Rainfall has decreased in recent years

Studies of long-term rainfall records have, to date, shown no systematic annual rainfall in semi arid areas of India, despite widespread reporting to the contrary.

5 – Water use of crops depends mainly on crop type

A common misconception is that the daily water use of crops is directly related to the crop type and that the evaporation rates from certain crops are many times higher from some crops as compared to others. The reality is that, assuming that a crop is well supplied with water, the evaporation process is driven primarily the meteorological conditions (e.g. radiation, wind speed, dryness of the air).

6 - aquifers once depleted stay depleted

A pessimistic view of aquifer depletion is that this is an irreversible process. The reality is that, in most cases, aquifers can be re-established or replenished as long as the balance between recharge and extraction is swung towards recharge. This can occur as a result of higher than average rainfall or a reduction in groundwater extraction. There is nothing inherently wrong in extracting groundwater. So long as supplies of drinking water, water for domestic use and wildlife are not endangered, extraction of groundwater for agriculture and other livelihood uses is sensible. Moreover, there is some evidence to suggest that optimum use of groundwater resources is good for the long-term ‚productivity™ of aquifers. For example, in certain areas of the watersheds surveyed, it appears that increased extraction of groundwater has actually led to an increase in annual recharge. This is because groundwater extraction of has a direct influence on the potential storage volume of the aquifer , particularly at the beginning of the rainy season.