

## PART 2

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# REGIONAL REVIEW

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# CHAPTER 3

## SUCSESSES AND FAILURES IN WATERSHED MANAGEMENT IN THE ASIA-PACIFIC REGION (1982 TO 2002)

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### BACKGROUND

Before 1980, watershed management was practised in only a few countries in the Asia-Pacific region. Pakistan, India, China, and the Philippines have had substantial watershed management projects since the late 1950s. Nepal, Indonesia, Thailand and Malaysia began watershed management during the mid-1960s with small-scale pilot demonstrations.

Increased awareness of the importance of watershed management was triggered by Erick Eckholm's 1976 book, *Losing ground*. It reported the dangers of the massive degradation of the upland areas of the Himalayas. Eckholm's doomsday scenario drew the attention of the world to the problems of watersheds in the Himalayas and elsewhere. The subsequent call to launch a global initiative against the degradation of upland areas received large support.

During the 1980s, a series of global, regional and national meetings were held where planners and researchers worked out strategies for managing watersheds. Governments began to manage watersheds through donor-supported programmes with demonstration, training, education and research components. At that time watershed management received unprecedented attention from the international development agencies, bilateral donors and national governments, and became one of the leading development paradigms.

The 1990s saw an expansion in watershed management initiatives across the Asia-Pacific region. These programmes became popular in national and international investment portfolios, as they often performed better than the integrated rural development projects that aimed to deliver everything from new roads to improved health care, and than the forestry projects that focused on increasing forest productivity.

Many integrated rural development projects failed to deliver lasting benefits. They lacked focus, were too complex to manage, often failed to benefit the poor and had management costs that were too high. Funds were illegitimately diverted for urban development, and lack of management controls led to political conflicts between local and national governments. As a result, donors began to limit support to them. On the other hand, watershed management projects gained credibility because they are more pro-poor, environmentally friendly, simpler to manage and rural-focused. They give more attention to the basic needs of rural communities, such as livestock, forestry, small infrastructure and microfinance.

Conventional forestry projects were widely criticized for their environmental impact and for ignoring local people's needs. Donors' priorities shifted from production forestry to environmental forestry, including watershed management. However, nowadays watershed management is also being criticized. This paper analyses its successes and failures, and identifies the weaknesses that need addressing in future projects in order to attract more donor and government support.

## **SUCSESSES AND FAILURES**

A problem in evaluating the successes and failures of watershed management is the lack of baseline data. The paper by Tennyson in this volume documents the performance of watershed management programmes in the Asia-Pacific, using the baseline established in the report *Watershed management in Asia and the Pacific: Needs and opportunities for action* (FAO, 1986). The present paper complements Tennyson's paper by looking at the status of a few country-level projects. The analysis is based on project reports and the author's decade-long field observations in terms of the following fourteen issues – ranging from size of planning unit to sustainable funding – to reflect on successes and failures.

### **Planning unit: large versus small watersheds**

Watershed management initiatives implemented in smaller areas have usually worked better than those spread over larger areas. Similarly, projects involving fewer administrative units and functionaries have been easier to manage. The many types of inputs needed in watershed management make it easier to manage and coordinate projects in small watersheds that are governed by a single or few local government units, such as commune people's committees in Viet Nam, groups of gewogs in Bhutan and village tracts in Myanmar.

Integrated rural development projects and large watershed management projects have found it difficult to achieve success because of the complexity of coordinating the many local governance bodies and their diverse interests. In such projects, managers have to spend too much time bringing together the many project stakeholders. This was the case in Nepal's Resource Conservation and Utilization Project. This 1980s United States Agency for International Development (USAID)-funded project covered a very large area. The project concept looked good on paper, but managers had to invest too much time bringing together the numerous project stakeholders.

### **Project focus: forest versus multiple-resources productivity**

Watershed management is the process of guiding and organizing the use of the land and allied resources in a watershed to provide desired goods and services without harming soil and water resources. It recognizes the crucial importance of the interrelationships among land use, soil and water and between upland and downstream areas. Watershed projects implemented in the Asia-Pacific region have either focused on:

- the sustainable management of forests to improve forest productivity; or
- meeting communities' needs by working on forest management and protection, agricultural development (cropping and livestock) and small-scale hill irrigation, and by providing credit to farmers to buy agricultural inputs.

The first generation of watershed projects in the Asia-Pacific region focused on forest productivity. Because most watershed areas in the region are highly populated, many of these projects failed to win local support and achieved only limited success. The second-generation of projects were thus designed to improve the productivity of all types of watershed resources. These have received much more support from local communities and have been more successful.

### **Choice of project components: limited versus extensive**

The region's watershed projects have included a diverse combination of components. Earlier projects concentrated on improving forest productivity to achieve watershed management goals. They worked well where population densities were low, for example in the Kinda Dam Watershed Project (Phase 1), implemented during the 1980s in Myanmar. They were relatively straightforward to implement because only one agency – the forest department – was responsible for their implementation. These kinds of projects, however, failed in more densely populated mountainous areas. The Tarbela and Mangla Dam Watershed Project in the North West Frontier Province of Pakistan had only limited success because it focused only on planting trees on degraded slopes. It did not consider other activities related to meeting the basic needs of local people.

In highly populated watersheds such as Phewa Tal and Kulekhani watersheds in central Nepal, people-centred integrated watershed management has been much more successful. These projects have focused on resource management and have components to promote field crops, home gardens, animal husbandry and veterinary care, irrigation renovation, water management, forest management, and savings and credit. The third type of projects, such as Nepal's Resource Conservation and Utilization Project (RCUP), included a wider range of activities such as formal research and education, water supply, environmental education in schools, and sometimes health and nutrition education. These have been more similar to integrated rural development projects and have often been unsuccessful because of a failure to coordinate the many project components and stakeholders.

### **Approaches to watershed management: flexibility versus prototype replication**

FAO has classified the Asia-Pacific region's watersheds into seven types according to their biophysical setting and socio-economic situation (FAO, 1986). The same report documents the causes of watershed degradation. It says that they are largely situation-specific; meaning that there cannot be a single approach to watershed management. Several watershed management projects have failed because they have tried to transfer a successful approach in one country to another country where conditions are different. For example, the Government of Bhutan was looking for alternatives to shifting cultivation to protect its watersheds. Farmers were encouraged to stop shifting cultivation and practise sedentary agriculture. In the early 1980s, a number of farmers were encouraged to make this move by being given new land in low-lying

areas. But most could not adjust to the new setting, and moved back to their previous villages and practices. A study suggested that it would have been better to have altered the shifting cultivation practices to minimize their harmful effects on the environment (FAO, 1995).

The experience of forestry-focused projects has shown that just planting trees often does not rehabilitate degraded watersheds. Projects have been most successful where they have introduced management practices that encourage sound land use (Brooks *et al.*, 1992). Projects that have created alternative income opportunities for resident populations have been able to improve the hydrology of watersheds by reducing local people's dependence on forest products and by encouraging the natural regeneration of forests on bare hillsides. In densely populated watersheds, projects focusing on improving food security, alongside soil conservation measures, have worked better than single-pronged forestry-focused projects. Three generations of United Nations Development Programme (UNDP)-funded participatory watershed management projects designed to protect critical watersheds, including the famous Inle Lake watershed in Myanmar, and two generations of similar projects in Hoanh Bo District Quang Ninh Province in Viet Nam have been successful as they have taken this approach. Farmers are more concerned about food security than environmental conservation, and it is therefore crucial that watershed management tends to this need.

### **Centrally planned versus participatory projects**

Many types of participatory watershed management and project implementation were tried during the 1990s. These projects have worked better than the 1980s top-down, centrally planned ones. However, the benefits brought by projects that relied overly on external expertise have often disappeared once project support has ended. RCUP's field component relied heavily on external technical inputs and collapsed after these were withdrawn, whereas the capacity building component, including in-service training and support to formal training in natural resource management, created a sustainable impact with a large pool of watershed management experts. Projects that have focused on building local capacity to institutionalize participatory methods and approaches have performed much better. The Watershed Management in Three Critical Areas Project in Myanmar and the Participatory Watershed Management Project in Hoang Bo District in Viet Nam created significant impacts in a short time as they were designed and implemented in close cooperation with project beneficiaries, using participatory management tools.

### **Project design: process versus product**

Some projects have failed because they were poorly designed. Projects designed in a hurry with heavy external technical assistance inputs have often not given enough attention to studying stakeholders' needs and the particular characteristics of a watershed. Local land users' needs cannot be fully understood in a short time. Such projects have encountered serious difficulties. A major USAID-supported project in Nepal, which ran from the late 1970s to the early 1980s, was designed by a team of international and national experts without involving local beneficiaries. This project was not well received by beneficiaries.

Some projects have had contradictory objectives. For example, a project's first objective may be to promote the improved and faster delivery of goods and services to local people. However, the second and third objectives may call for building up the capacity of community-based extension networks and institutionalizing participatory processes. The problem is that the first objective cannot be met without laying the foundations of the second and third objectives. In this regard, the objectives of Participatory Watershed Management in Hoanh Bo District, Quang Ninh Province, Viet Nam were revised halfway through the project to give it a more realistic goal (FAO, 2002).

#### **Project duration: short versus long duration**

Most watershed management support in the Asia-Pacific region has taken the shape of three to four year-long donor-funded projects. Most of these projects have focused on involving people in planning and implementation, something that cannot be achieved in a limited period. As a result, many projects have had a limited success owing to the clash between the limited time and the need to involve local people fully. Real people's participation takes time and involves painstaking building of capacity at the grassroots level and consolidation of field activities to ensure real sustainability.

#### **Project organization: umbrella agencies versus interagency**

Most recent watershed projects have taken an integrated approach by working on developing cropping and livestock husbandry, forestry, water management and microcredit. These projects have been implemented either under one umbrella agency or through a number of agencies working together. The implementation of Participatory Watershed Management in Hoanh Bo District, Quang Ninh Province, Viet Nam was easy, and impacts were immediate because it was organized at the district level under a single command. The management of RCUP, Nepal was located at the central level with more than seven government agencies responsible for implementing the project in three districts. Field-level coordination was a big problem, and it took a long time to produce results.

In the former case, staff from different disciplines work under a single project management. In the latter case, different agencies are assigned responsibilities in their subject areas with a steering committee coordinating implementation. These two models have advantages and disadvantages. The first one has been successful where project goods and services have to be delivered in a short time to have a rapid impact on local people's livelihoods. However, these benefits are often not sustained. The second model is more appropriate where a project aims to build local capacity and institutionalize watershed management principles. The drawback of this approach is that local people often have to wait a long time to see improvements in the meeting of their basic needs.

#### **Project location: national versus decentralized**

Watershed projects work with different levels of partners. Delivery-oriented projects tend to work well where NGOs carry them out. Projects focused on institutional and organizational

reforms, resource inventories, strategic planning and human resources development work best when implemented in partnership with national-level institutions. Myanmar's Three Critical Watersheds project produced significant impacts as it was a direct-delivery project grafted on to the local institutional set-up. However, its sustainability after the project was questionable as it excluded the government's regular extension network. Bhutan's Integrated Forest Management project was grafted on to the forest department and focused on building up the capacity of government staff and local communities. As a result, the government continued to plan and implement integrated resource management projects after UNDP-FAO project inputs were withdrawn.

The delivery of technical assistance has worked best in these kinds of projects. Projects with combined objectives have been most cost-effective when they have worked in partnership with intermediate regional government agencies. A main reason for this is that technical assistance and other management costs are greatly reduced if larger projects work at provincial levels for capacity building and monitoring and evaluation, and at the district level for delivering goods and services.

#### **Conflicts: national policies versus project priorities**

Watershed management is a new concept in many Asia-Pacific countries. Only in India, China and Thailand are there adequate legal and institutional infrastructures and trained personnel. Watershed management projects demand horizontal coordination for interdisciplinary action, vertical linkages for technology transfer, and the decentralization of authority for fast decision-making. However, many Asia-Pacific countries are characterized by centralized decision-making and a failure to connect policies and procedures horizontally among different government agencies and vertically within the same agency. Lower-level officials and technicians are often not sufficiently motivated to take timely decisions. This means that project implementation often suffers from conflicts between national policies, programmes and procedures and local needs.

#### **Technical capabilities: biophysical diagnostic expertise versus participatory skills**

Watershed management is a multidisciplinary subject. Projects have worked best in countries with good technical biophysical diagnostic and socio-economic expertise. India, China, Indonesia, Pakistan, Thailand, Malaysia, Sri Lanka and Nepal have many trained personnel. Their performance in implementing watershed management projects has been better than that of countries such as Afghanistan, Myanmar, Viet Nam, the Lao People's Democratic Republic, Cambodia, Bangladesh and Bhutan, which lack trained personnel. In countries that depend on donor funding, existing capabilities to carry out biophysical analysis are deteriorating as donors shy away from funding projects that need heavy investments in equipment, supplies and technical assistance. As a result, poorer countries have to rely more on participatory problem analysis. However, issues such as causes and effects of watershed degradation, upstream-downstream linkages and interrelationships between types of vegetation and watershed hydrology cannot be fully understood from participatory information gathering alone.

### **Conflicts: regular institutions versus projects**

Most watershed management in the Asia-Pacific region has taken a project approach. Projects tend to establish parallel organizations for the faster delivery of goods and services, extension, training of farmers and other activities. One big problem is that project extension teams encroach on the jurisdiction of government institutions. This often leads to conflicts, and hinders project delivery.

### **Research**

Many watershed management projects have suffered owing to the lack of research infrastructure. Watersheds are systems that house a complex web of interactions between human and biophysical factors. Many preventive and curative watershed rehabilitation measures have not been based on the findings of systematic research. For example, experience has shown that planting trees is not always good for watersheds. One study in Fiji showed that water flows were reduced by up to 60 percent in grassland areas six years after they had been planted with pine trees (Brooks *et al.*, 1992). In developed countries such as the United States, best practice guidelines have been introduced for managing watersheds. However, implementing these needs a good understanding of a country's specific biophysical setting and institutional linkages, for which research and education is very important.

### **Sustainable funding: programme versus project approach**

Most watershed projects in the region have been funded from donor assistance. This has led to watershed management being project-oriented and focused on limited project periods, a diverse approach, temporary institutional arrangements and lack of continuity and follow-up. The third phase of the Participatory Watershed Management in Hoanh Bo District, Quang Ninh Province, Viet Nam had to be wrapped up prematurely as FAO and the Government of Belgium decided against extending the project. Several other projects have been prematurely ended owing to donors' erratic funding policies. Only countries such as India, Thailand and China have funded large projects themselves. Watershed management initiatives in Nepal have survived by convincing other donors to take over after the original donor has ended its commitment.

## **CONCLUSIONS**

The main difficulties for watershed management are caused by its interdisciplinary approach where different technical agencies have to work together. In many Asia-Pacific countries, these agencies are poorly equipped and lack trained workforce. Coordination is often lacking for planning, implementing, monitoring and evaluating watershed management. Several countries in the region have a legacy of central planning and lack the participatory skills to make programmes people-friendly. Shortage of funds is also a major hindrance. Upland areas also tend to lack political power as they usually lie far away from the centres of power. They are generally poor and are unable to mobilize internal resources. Owing to lack of sustainable funding, the consolidation and replication of watershed management is a big problem.

In spite of these difficulties, most watershed management projects and programmes have been environmentally sustainable, economically feasible and socially acceptable. Most have succeeded in stopping the degradation of critical watersheds, creating awareness about the need to sustainably use natural resources and improving the livelihoods of deprived communities and ethnic minorities. Watershed management practices are evolving, and it has yet to become a mainstream development concept. The next generation of watershed programmes should be designed to address the many constraints.

A major strength of watershed management is its recognition from all development practitioners, politicians, planners, sociologists, technical experts and beneficiaries. Watershed management has many benefits if it is properly designed and implemented. Programmes need to promote the environmentally sound, economically sustainable and socially acceptable development of upland areas. Governments need to capitalize on the credibility earned by watershed management projects over the last two decades.

## **RECOMMENDATIONS**

The following recommendations need acting on by the next generation of watershed management programmes and projects.

### **Technical issues**

Future watershed management programmes and projects need to:

- develop quantitative auditing models to measure the costs and benefits of strengthening upland–lowland linkages;
- improve technical skills to separate out human and natural causes of environmental change and damage;
- strengthen technical infrastructure to make better inventories and carry out data analysis, planning and the monitoring and evaluation of biophysical resources;
- document best management practices;
- improve awareness of the watershed management concept and practices among planners, developers and beneficiaries;
- better coordinate the work of technicians, development practitioners and administrators to improve relationships among watershed management practices that benefit land conservation, food security, employment, economic growth and poverty alleviation; and
- provide more training and capacity building, including carrying out research and education to improve analytical skills for assessing watershed conditions.

### **Institutional and organizational issues**

Up-coming watershed management projects and programmes need to address the following institutional and organizational issues:

- They can continue to be planned over administrative rather than watershed boundaries as long as the capacity of countries to audit input–output relationships of soil erosion and runoff and to analyse cost and benefits does not exist.
- Consider implementing projects with a more manageable number of administrative units and local functionaries, especially for participatory watershed management projects that focus on increasing productivity across a range of productive resources.

In upland areas, work should focus on sustainable forest management. In more densely populated watersheds, projects should aim to improve overall resource productivity by continuing their focus on integrated rural development.

Create watershed management infrastructure to support both umbrella and interagency projects by establishing nodal points at the national, provincial and district levels.

Future projects should work more closely with existing national policies, programmes and procedures, including environmental legislation and poverty alleviation policies. Where appropriate, they should support the decentralization of local government.

Future projects should aim to attract the full support of local people and local government. They should reduce their reliance on external inputs and aim to institutionalize participatory principles and methods at all levels by giving more priority to supporting organizational strengthening.

### **Investment in watershed management**

The improved funding of watershed management initiatives must involve mobilizing more internal resources and getting longer commitments from donors. All countries need to put in place mechanisms to raise funds by, for example, requiring that a certain percentage of revenue from hydropower, ecotourism, irrigation water fees and forests goes to fund watershed management.

In several cases donors have made long-term commitments to fund watershed projects. Bhutan's Environmental Trust Fund (Government of Bhutan, 1994) was set up to fund nature conservation and biodiversity projects. The Government of Bhutan established a core fund and several donors contributed further funds to implement different environment-related activities under the government's national programme.

The interest from this fund is spent on the projects, and the capital has been locked to generate additional funding for the future projects. Viet Nam's Forest Sector Support Programme and Partnership for 2001 to 2010 is another example (Government of Viet Nam, 2001). It consists of portfolios of different investment projects. Donors are invited to make pledges to a trust fund or to a subsector activity in the programme document. A similar approach could be tried to fund the next generation of watershed management projects and programmes in other countries.

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## CHAPTER 4

# WOCAT: A STANDARD METHODOLOGY FOR DOCUMENTING AND EVALUATING SOIL AND WATER CONSERVATION

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### INTRODUCTION

The World Overview of Conservation Approaches and Technologies (WOCAT) programme was started in 1992 by a group of soil and water conservation specialists. It has since developed a global network of institutions and individuals involved in soil and water conservation (SWC). WOCAT's mission is to provide tools that enable soil and water conservation specialists to share their professional knowledge. Such tools can help them to identify appropriate technologies and approaches and support them in field planning and implementation.

WOCAT is a global network of soil and water conservation specialists. It is organized as an international consortium coordinated by an international management group, and is supported by a secretariat based at the Centre for Development and Environment, Bern, Switzerland. A wide range of international and donor organizations in the field of sustainable agriculture and environment are represented in the network. These include FAO, ICIMOD, United Nations Environment Programme (UNEP), the Swiss Agency for Development Cooperation (SDC), DANIDA, the International Atomic Energy Agency (IAEA), the Regional Land Management Unit (RELMA) and national partner institutions in more than 35 countries. The latter consist of government departments, universities and NGOs. Recently, collaboration has started with commercial companies; a prominent one being Syngenta, the United Kingdom.

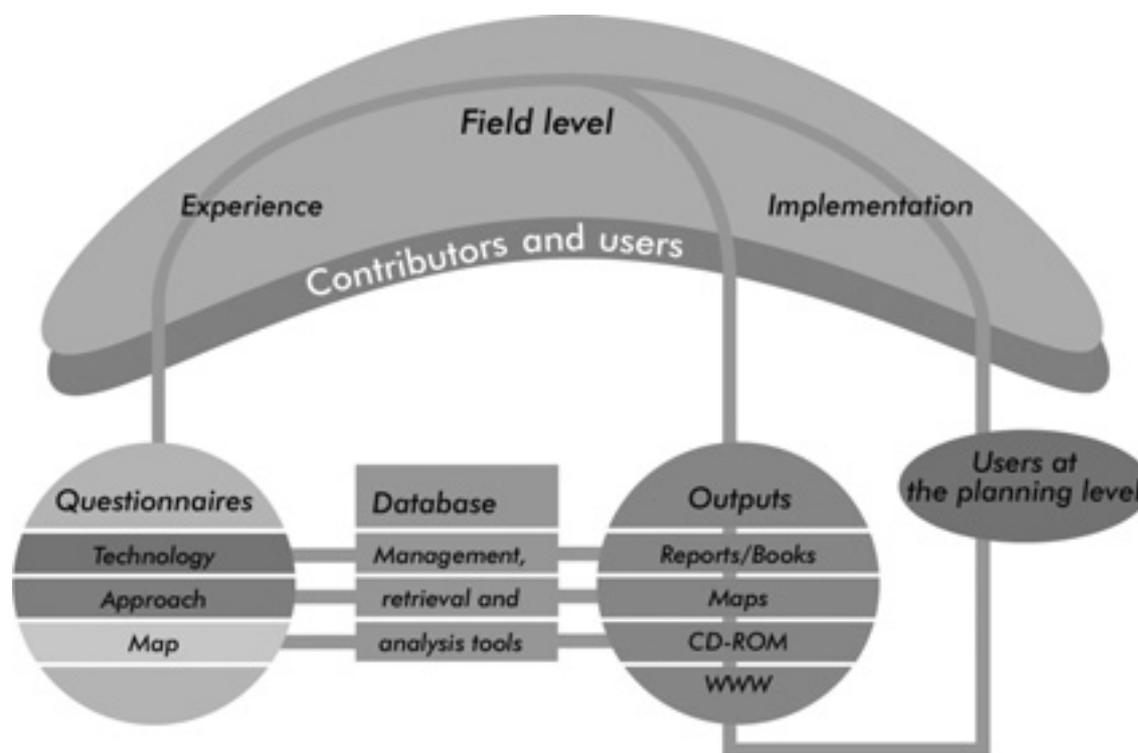
Although much is known about soil and watershed conservation, this knowledge tends to be scattered and not easily accessible. This is recognized as one of the reasons why soil degradation continues in many parts of the world, despite decades-long efforts and large investments in soil and watershed conservation. WOCAT is contributing to overcoming this problem by documenting and disseminating knowledge. The aim is to enable practitioners to learn from each others' experiences and to provide a source of reliable information over many geographic and subject areas. The information gathered helps to identify research needs and suggests how ongoing practices can be improved.

### METHODOLOGY

WOCAT has developed a set of three comprehensive questionnaires to capture information about soil and water conservation technologies and field-level approaches. The questionnaires

are quite complex and so WOCAT runs training courses to show how to use them and the associated database. Participation in these training courses leads on to identifying what data trainees will collect to contribute to WOCAT.

FIGURE 1  
The WOCAT process



The three types of questionnaires cover technology, approaches and mapping. These questionnaires are the main tools for collecting, recording and analysing data in a systematic and standardized manner. The technologies questionnaire asks about field activities. Technologies may be technically ideal but their successful implementation often depends on a wide range of non-technical issues. The approaches questionnaire therefore asks about factors such as required skills and technical knowledge, required and available resources, socio-economic and cultural aspects, and perceptions and acceptance by land users. The standard WOCAT definitions of important terms are given in Box 1.

Patterns of soil degradation vary at all spatial levels from the village to the global scale. The map questionnaires are designed to gather geographic information. They ask about planning issues and aim to build up a spatial overview of degradation and conservation in defined areas. This questionnaire complements the technologies and approaches questionnaires.

Responses to the mapping questionnaire show that although patterns of degradation have been mapped in many areas, there are hardly any maps on conservation achievements. Such maps are needed to identify where soil and watershed conservation measures have been effective and where they are most needed and could be effectively implemented.

**BOX 1**

**WOCAT DEFINITIONS**

**Soil and water conservation (SWC)** refers to local-level activities that maintain or enhance the productive capacity of the land in areas affected by, or prone to, degradation. These include activities that prevent or reduce soil erosion, compaction and salinity; conserve or drain soil water; and maintain or improve soil fertility. The WOCAT methodology was originally designed to focus mainly on soil erosion and fertility decline in erosion-prone areas. Since then it has evolved to cover other types of land degradation, such as salinization and compaction.

**SWC technologies** are agronomic, vegetative, structural and management measures that control land degradation and enhance productivity in the field.

**SWC approaches** are ways and means of support that help to introduce, implement, adapt and apply SWC technologies on the ground.

*Source:* WOCAT questionnaires (WOCAT, 2003a; 2003b; 2003c).

The information gathered from the questionnaires is entered into a database. WOCAT's database now includes more than 300 technology case studies and more than 200 approaches from 40 countries (some of which have still to be completed and validated). The information can then be fed back in various forms to users at the field or planning levels.

WOCAT has gathered information from more than 35 countries. It has collected most information from Africa (60 percent) and Asia (30 percent), and only a few case studies from Latin America. It has recently started to gather information from Europe. The database mainly comprises individual case studies. Efforts are under way to collect a number of these case studies into a synthesized and generalized description of specific technologies and approaches.

The WOCAT methodology has been tested and developed based on the needs and requests of collaborating institutions – most of whom are WOCAT users. Participants at national and regional workshops have evaluated the practicality and usefulness of WOCAT's questionnaires, database and outputs. The methodology has been tested and revised continuously since the first questionnaires were developed in 1994. Since 1998, the emphasis has been on collecting and using the data. The more than 30 national training workshops that have been held since 1999 have confirmed that the current questionnaires serve their purposes well, although some collaborators feel they are too complex.

**USES OF WOCAT**

WOCAT disseminates its information via its Web site, on CD-ROMs, in articles and at workshops. All of WOCAT's tools, data and outputs are accessible via the Internet at [www.wocat.net](http://www.wocat.net). The database can be searched for a specific technology or approach or for

specific conditions in which these are applied. Another facility enables a technology or approach to be evaluated. Some of the information is presented as case studies on soil and water conservation technologies and approaches gathered by WOCAT. It has produced CD-ROMs that contain much of the information from the Web site, including the database, questionnaires, published reports and general information. WOCAT-related articles and papers include Liniger and Schwilch, 2002; Liniger, van Lynden and Schwilch, 2002; Liniger *et al.*, 2002; and van Lynden, Liniger and Schwilch, 2002.

WOCAT is consolidating information by subject and area to make it more useful and accessible for planning exercises and in the field. It held its first regional training workshop in Kenya in 1995. Since then it has trained more than 400 experts in Africa, Asia and Europe to document and evaluate their knowledge. WOCAT questionnaires offer experts, technicians and extension workers a common framework and methodology for documenting and evaluating their experiences. Filling in the questionnaires encourages practitioners to analyse their achievements. The information gathered by WOCAT provides higher-level decision-makers such as planners and coordinating organizations with an overview of achievements, approaches and technologies.

The WOCAT tools and processes are being used by government departments, project staff, scientists and extension workers from across the world to help:

- monitor and evaluate individual technologies and approaches, and quantify costs and benefits;
- document, identify and transfer technologies and approaches from one area to another;
- identify key topics and gaps in the knowledge that need further research;
- evaluate the results of research trials, and assess the biophysical and socio-economic suitability of research-derived technologies and approaches; and
- disseminate information for use as an educational data resource.

The main rationale for WOCAT is that the information it gathers is put to good use. It aims to promote the increased use of its information for extension, research and educational purposes. The fundamental requirement for this is that WOCAT has a volume of good-quality up-to-date information that has been checked and entered into its database. The next need is to link national and regional WOCAT activities with ongoing and potential government-, donor- and NGO-supported projects and programmes at all levels. Thirdly, WOCAT needs to tap the skills and knowledge of people and organizations involved in soil conservation and watershed management and help them to obtain technical and financial support to carry out their work. Finally WOCAT needs to broaden the common perception of its role, from being a questionnaire-filling process to being a field appraisal tool that enables research and extension workers to determine the environmental impact and socio-economic costs and benefits of technologies and approaches. WOCAT's strengths and weaknesses are listed in Box 2.

**BOX 2**

**WOCAT'S STRENGTHS AND WEAKNESSES**

**Strengths:**

- works at the field, national and global levels;
- considers both socio-economic and ecological aspects;
- fills a gap (nationally and globally) for the documentation and exchange of information;
- sets global standards for methods, tools and outputs;
- brings practitioners, researchers and planners together;
- provides tools and a platform for collecting a standard set of comparable information.

**Weaknesses:**

- questionnaires are quite complicated and some practitioners have difficulties in responding fully;
- low quality of some data.

**DATA QUALITY**

One of WOCAT's main concerns is the quality of the data it collects. One problem is that it is often difficult to tell whether incompletely filled questionnaires show important gaps in the data or just reflect a respondent not bothering to reply. A study on the potential for improving the data (Douglas, 2003) suggested that WOCAT should focus less on the correct filling in of questionnaires and more on providing specialists with the skills to evaluate the impacts and cost-effectiveness of their own activities. However, collecting the available data through questionnaires is an intrinsic part of this evaluation process.

Improving the quality of data received demands that respondents are more critical about their own knowledge, and that they fill in questionnaires properly. Respondents need to:

- review their knowledge and experience of technologies and approaches critically and systematically;
- recognize and challenge their technical preconceptions and biases, which often lead to wrong assumptions about problems and the effectiveness of technologies or approaches;
- avoid assuming that a technology or approach being implemented automatically means that land degradation is being controlled; and
- have a proper understanding of how land degradation processes operate under specific local conditions.

While filling in questionnaires, respondents should take care to:

- complete them in close consultation with other experts;
- undertake field verification and discussions with land users;
- provide detailed descriptions specific to the technology being documented, rather than generalized descriptions that could apply to similar technologies;
- give adequate details of technical specifications that explain how a technology performs;
- differentiate between the characteristics of the wider area in which the users of a technology are operating and the conditions specific to sites where technologies have been adopted;
- provide detailed cost breakdowns, as omitting key cost elements will give a false impression by underestimating actual costs; and

- make use of secondary data from project documents and technical manuals to document and check technical specifications and costs and benefits of particular technologies and approaches.

## CONCLUSION

WOCAT is the first large-scale attempt to document soil conservation and watershed management activities in a standardized way. It enables the comparison, evaluation and mapping of technologies and approaches. The comprehensive questionnaires encourage users and contributors to take a more inclusive attitude towards their work. The main challenge is for the information collected to be widely used in the field and for planning purposes.

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# CHAPTER 5

## NEW TECHNOLOGIES FOR WATERSHED MANAGEMENT

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### INTRODUCTION

A complex of factors determines the quality and availability of water supplies from watershed areas. The integrated watershed management approach goes a long way towards handling these complexities, and in many situations is accepted as the best approach to managing natural resource (Calder; 1998; 1999).

In India, policies have been developed and programmes run to address water problems in ways that promote equity and sustainability and alleviate poverty. Water resource management projects have ranged from major irrigation projects catering to millions of hectares of land, to small structures fulfilling the needs of one small community. Countrywide programmes have included the Drought-Prone Area Programme (DPAP), the Desert Development Programme (DDP) and the Integrated Watershed Development Programme (IWDP). Some of these programmes are still being implemented, but it is uncertain how far they have reached their objectives. Consistent evaluation has not been carried out and there has been no integrated framework for planning, monitoring and managing watershed management programmes. In addition, the integrated approach has often not been properly implemented.

The Government of India adopted integrated watershed management in its National Water Policy, 2002 (MoWR, 2002) as a key strategy to conserve natural resources. The policy calls for involving local users in planning and managing natural resources at the watershed level. However, the mechanisms to achieve this have been inadequate, and new tools need to be developed to handle the complexities of integrated watershed management. It is important that the information they produce is accessible in order to help planners arrive at appropriate decisions.

This paper shows how Geographic Information System (GIS)-based modelling of information on water, land, forests and other variables can be used in local planning to prioritize watersheds and site structures. It presents a technique for prioritizing watersheds scientifically. It also discusses the authors' efforts to account for socio-economic factors in watershed management.

### INTEGRATED WATERSHED MANAGEMENT

Integrated watershed management planning should facilitate all stakeholders within a watershed to identify local natural resource issues and then to develop and implement watershed plans that promote environmentally, socially and economically sustainable development.

Integrated watershed management began in India in the 1970s. Since then there have been many changes in how it has been implemented. Until 1995, watershed development projects were coordinated within multi-sectoral programmes. A 1999 review by the Ministry of Rural Development (MoRD) and the Ministry of Agriculture (MoA) led to the 2001 introduction of common operational guidelines, objectives, strategies and expenditure norms for watershed development programmes in India. These encourage the involvement of NGOs, semi-governmental institutions, private enterprises, universities and training institutes. However, concerns are being raised that watershed development programmes are still based around the misconception that water is an infinite resource, with the collection and extraction of ever more groundwater to meet human needs (KAWAD, 2001).

Integrated watershed management does not merely involve running an inventory of different activities. It is also necessary to evaluate the impacts of proposed actions. Watersheds are the smallest units for evaluating human-induced impacts on natural resources. Therefore, although the administrative unit of panchayat village clusters remains as the implementation unit for watershed management programmes, impacts need to be assessed at the watershed level.

The main shortcomings of watershed management in India are that it often:

- does not pay enough attention to watershed hydrological boundaries;
- ignores the connectivity of watersheds and treats each one as a stand-alone unit, irrespective of downstream relations;
- ignores the hydrological characteristics of watersheds when deciding on interventions;
- ignores environmental sustainability aspects; and
- fails to monitor and evaluate impact properly.

These shortcomings are due to a number of factors, including the lack of a unified framework to account for the influence of all the elements that influence an area's hydrology. In India, a watershed is considered as the smallest unit of a drainage basin. It is essential to develop a hydrological framework to track the interconnectivity of these units. The impacts of actions at the watershed level will be experienced within the containing drainage basin. A framework is needed to assess these impacts. Such a framework needs to be well-maintained and updated to serve the needs of planning agencies and line departments. This is best done using computer modelling.

The second major problem encountered in watershed management programmes is that much of the information needed for integrated planning and management is not available at the watershed scale. This especially applies to the quantities of surface water and groundwater. It is not financially viable to measure directly local water availability and its variability over time. Hydrological simulation modelling is a very effective tool that helps to estimate water quantities in watersheds. The present study demonstrates the application of one such model that simulates the quantity of water and sediment erosion in a watershed.

## **SWAT HYDROLOGICAL MODEL**

The Soil and Water Assessment Tool (SWAT) was developed by the United States Department of Agriculture (USDA) Agricultural Research Service (Arnold *et al.*, 1990) to simulate the land phase of the hydrologic cycle in daily time steps. It can also simulate the detachment of sediments from watersheds and model their transport through drainage systems. The SWAT

model simulates the passage of water and sediments from individual watersheds through river systems. It can factor in the effects of off- and onstream tanks, reservoirs, check dams and different agricultural practices. Its major advantage is that unlike conventional simulation models, it needs little calibration and so can be used on ungauged watersheds.

The model can show water availability under different demand and use levels, with both domestic and agricultural use factored in. It can show the situation for existing and anticipated water uses and indicate under what circumstances water shortages will occur. It completely accounts for the quantities of water that: 1) are supplied to the land by precipitation; 2) enter streams as surface runoff; 3) are used and returned to the atmosphere by natural vegetation, agricultural crops and evaporation; and 4) percolate through the root zone to recharge groundwater.

Macro-watersheds (catchment areas) are made up of a number of micro-watersheds. The use of a number of discrete watersheds in a simulation is particularly beneficial when different areas of the macro-watershed are dominated by different land uses or soils that have differing impacts on the hydrological response. In the SWAT model, the input information for each watershed is grouped with respect to weather; unique areas of land cover, soil and management practices. These are called hydrologic response units (HRUs).

Model outputs include all the water balance components of surface runoff, evaporation, lateral flow, recharge, percolation and sediment yield for each watershed. These are available at daily, monthly and annual time steps.

These technologies have been integrated and promoted through the UNDP-sponsored project GIS-Based Technologies for Local Level Development Planning, implemented by the Government of India's Department of Science and Technology. The techniques presented in the following case study were worked out by the authors during the course of this project (Gosain and Sandhya, 2001; Sandhya and Gosain, 2001)

#### **CASE STUDY OF DODDAHALLA WATERSHED**

A demonstration case study of the SWAT model was set up on the Doddahalla watershed in northern Karnataka. The aim was to show how the model can help to identify the micro-watersheds within a macro-watershed that are most in need of interventions, according to their hydrological, demographic and socio-economic status (CEE, 2001). This work was carried out in collaboration with the Centre for Environment Education, Bangalore, which was the lead organization handling the project on Prioritization of Micro-Watersheds for Better Management in Bijapur district of Karnataka under the World Bank's Water and Sanitation Programme.

The Doddahalla watershed in Bijapur district, northern Karnataka covers about 61 000 ha. It is in a chronically drought-prone area with a large agrarian population that depends on rainfed agriculture. The upstream part of the macro-watershed – covering about 31 000 ha – was considered as the area under treatment in the case study, while the 30 000 ha downstream area was the subject for the case study's detailed impact analysis. The downstream area covers the 30 villages of Indi and Bijapur taluks (subdivisions of districts).

### Gathering basic information

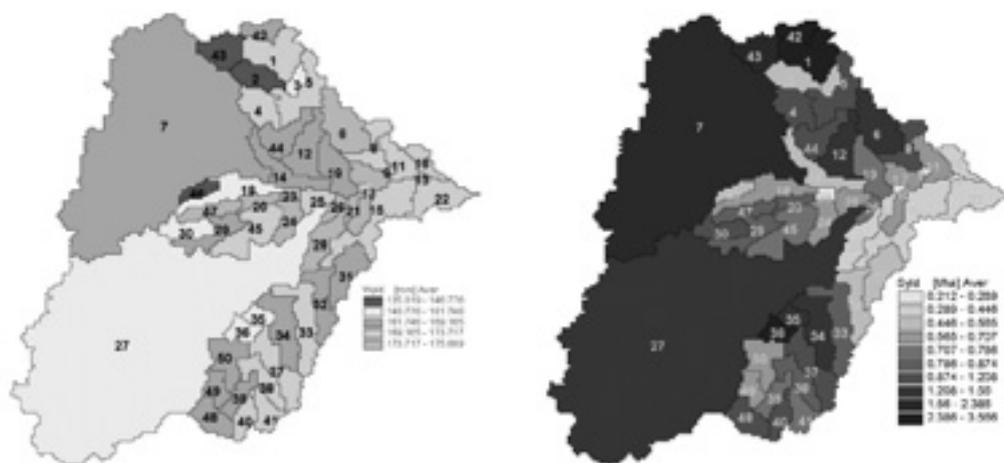
First, hydrological modelling was used to generate information on runoff and sediment yield. This and socio-economic parameters were used to prioritize the area's micro-watersheds.

GIS technologies were used as a pre-processor to the SWAT model in order to create spatial data and organize the other data on land use, soil and weather. The model gave the flow availability and sediment yield at drainage points of each micro-watershed. GIS overlay analysis was then used to prioritize micro-watersheds according to the MoRD's guidelines. This involved generating a digital elevation model (DEM) to delineate micro-watersheds automatically. This was then overlain with the land use and soil layers to derive HRUs – areas with uniform land use and soil characteristics.

The entire watershed area was divided into 50 micro-watersheds containing 175 HRUs. The upstream part of the watershed, although it is a contiguous part of the overall hydrological area, was not subdivided into micro-watersheds, but incorporated as a single unit. The daily rainfall and temperature data (1969 to 1990) for Bijapur station was then incorporated.

The water availability (mm/year) and sediment yield (tonnes/ha) are shown in Figure 1 for each micro-watershed, with the darker-coloured areas having the highest water and sediment yields.

**FIGURE 1**  
**Water availability and sediment yield map (20-year average: 1969–1990)**



### Watershed prioritization

The watershed prioritization model uses the guidelines developed by the National Watershed Development Project for Rainfed Areas (NWDPRA). NWDPRA was initiated in 1990–1991 to improve agricultural production in rainfed areas and restore ecological balance. It is a centrally funded programme that operates through state-level departments of agriculture or watershed development. NWDPRA's guidelines combine physical and socio-economic criteria to prioritize watersheds for management interventions. The following are the criteria used, in order of importance:

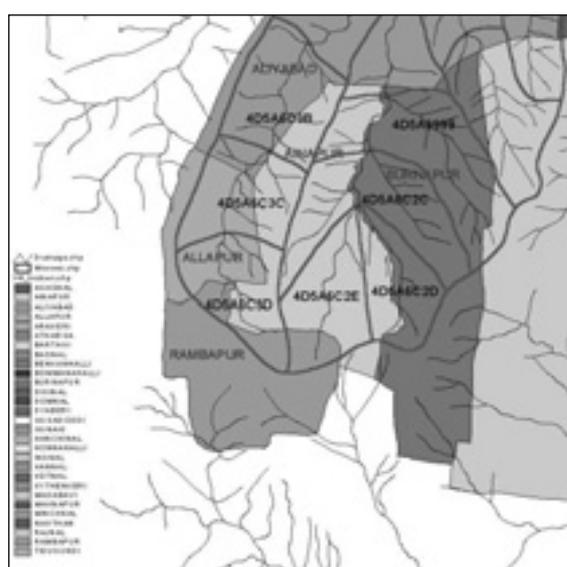
- highly eroded areas with much land degradation;
- a water scarcity problem;
- less than 750 mm rainfall per year;
- a net cultivated area of no more than 20 percent of the total area;
- an irrigated area not exceeding the state average or 30 percent of total land area; and
- no areas of long-duration or water-intensive crops.

The guidelines also recommend that priority is given to villages and watersheds that have more economically poor people and people with small landholdings. As budgets are allocated to administrative units (villages in this case), another criterion is to choose watersheds whose boundaries mostly coincide with village boundaries.

For the model, each element of these physical and socio-economic prioritization criteria was made into a GIS layer, taking the micro-watershed or village as the mapping unit. Overlay analysis was performed by taking up two layers at a time in the sequence of priority, as indicated in the list above. For physical criteria, the highest priority level was given to headwater watersheds and watersheds that had the most degraded land and minimum water availability. The hydrological modelling (Figure 1) showed that seven watersheds met these criteria.

The next step was to identify which of these watersheds cover a larger part of the involved villages. This was done by using GIS to overlay the seven selected watersheds on to the village boundaries. Four of them (4D5A6C2B, 4D5A6C2C, 4D5A6C2D and 4D5A6C2E) – areas mostly inside the green circle – were found to cover a large proportion of the two villages of Ainapur (63 percent of the area) and Burnapur (50 percent). Information was then gathered on these two villages' socio-economic characteristics, including the number of people below the poverty line, the scheduled caste and tribe population and the size of landholdings. The four watersheds all had similar levels of socio-economic development. These four contiguous watersheds were thus identified for priority treatment. Figure 2 depicts these watersheds and the village boundaries.

**FIGURE 2**  
**Watershed and village boundaries**



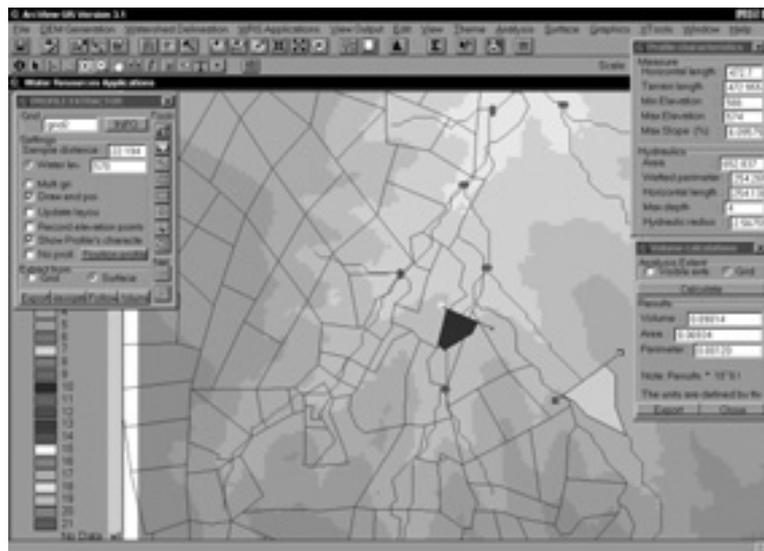
### Strategies for watershed development

The next step was to generate detailed information on the four watersheds in order to help to decide which management interventions were needed. A survey was carried out to obtain detailed terrain information in order to generate a reasonably accurate digital elevation model (DEM). This was crucial to enable the latest GIS technologies to be used to show hydrological processes, including the availability of water for harvesting. This model was used to generate a map of the local drainage indicating the best sites for placing water harvesting structures, such as dams, ponds and contour bunds.

A demonstration facility was then made using ArcView software (Spatial Analyst extension) to help select the best sites for these structures. Profiles drawn on the digital elevation model give the hydraulic characteristics of the terrain, such as surface area and volume of impounded water behind a planned barrier. They show the area that would be inundated by water when superimposed on the plot or village maps. This rapidly provides the first level of feasible sites for locating structures, which can then be field tested to see their practical potential.

Figure 3 shows two alternative sites with different design parameters and resultant computations. Site 1 produced a storage volume of 0.8 ha million and a spread area of 3.02 ha for a crest height of 2.0 m, whereas site 2 produced a volume of 9.0 ha million and a spread area of 6.93 ha for a crest height of 4.0 m. This shows that site 2 is the best location for the dam as it will hold more than ten times the volume of water while inundating just over twice the area. Sites that give a comparable volume with less spread are preferred, as a larger spread leads to more evaporation and seepage loss.

**FIGURE 3**  
**Locating sites for water harvesting structures**



This case study shows how computer software can compute information to help local planning for integrated watershed management. This tool has the advantage of making the factors behind decision-making more understandable to stakeholders and allows for more local participation.

## **DFID PROJECT ON FORESTRY AND LOW FLOWS**

The project on Forestry and Low Flows, Spatial Modelling and Open GIS Dissemination of the Science Perception – India (DFID, 2002) was started in August 2002 and is due to run to March 2005. It is being funded under the United Kingdom Department for International Development (DFID) Forestry Research Programme.

The project is looking at the general perceptions of science of the interaction of water with landmasses. It aims to improve local understanding of natural resource management, improve scientific knowledge and promote improved watershed management. The goal is to help to direct development resources towards those projects that most improve the livelihoods of poor people. The project is working in pilot watersheds in Madhya Pradesh and Himachal Pradesh.

It is scientifically establishing the links between forests and low water flows. Many watershed development programmes promote large-scale afforestation in the belief that this will improve water resources, increase groundwater recharge and increase low water flows – a relation that is largely unsubstantiated.

The project is examining this relationship by setting up a hydrological model for different land uses in order to assess and demonstrate what impacts changes in land use, particularly forestry and irrigated agriculture, have on water availability. This should provide a decision support system. Water conservation structures such as check dams, percolation tanks and trenches retain storm flows and allow water to be used locally. However, when catchments or macro-watersheds reach a stage where water resources are fully used and, on an annual basis, there is little or no flow out of the macro-catchment, further investments in water conservation structures and other measures such as bunding become less cost-effective, as water that is being captured upstream is captured at the expense of other potential users downstream. The GIS-linked hydrological model that the project is developing will indicate the water quantity impacts of different kinds of decision-making relating to land use and water conservation for both watershed and downstream areas.

The project is also investigating the historical development of water policies at the state and national levels in India, and aims to assess public and donor perceptions of these policies' impacts. The project will combine this knowledge with the results of biophysical modelling of the pilot watersheds in order to recommend better water policies that take a more sustainable approach to catchment management. This will help to ensure improved water supplies, especially for the economically poor (Gosain and Calder, 2003).

The dissemination of these findings and the availability of land-use change simulations over the Internet will enable those responsible for land-use management to see the probable impact of alternative strategies. It is also proposed that the outputs of this exercise be disseminated over the Internet. This would allow local communities to see the local and basin-wide water resource implications of decisions that are made at the local level. This is practical in the light of rapidly increasing access to the Internet in India's villages, and will make it easier to carry out whole-catchment cost-benefit analysis of forests in relation to erosion, sedimentation and flooding.

## CONCLUSIONS

The ability to identify micro-watersheds that will most benefit from treatment is very important for watershed planning. The first step is to generate estimates of water and sediment yield at the micro-watershed level – information that is often unavailable. The study is developing applications for identifying the interactions between administrative and watershed boundaries, and for placing water harvesting structures. Besides helping to site structures, these spatial tools help to estimate related parameters such as water spread area and available water storage capacity. This helps to make watershed management interventions more science-based. Efforts are also being made by project partners to strengthen watershed management in the pilot watersheds by promoting policy change and using cost-effective GIS tools.

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