

FUTURE OUTLOOK OF WATERSHED MANAGEMENT

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ABSTRACT

Watersheds consist of a complex array of resources such as trees, water, herbage, wildlife, soil, minerals, and historical, cultural, and aesthetic values, and other components. All watershed components are intimately intertwined, therefore, a change in one of them may have profound effects upon the conditions of the other components. Despite such connectivity and interrelatedness, watersheds are managed to optimize one or a few resource outputs at the expense of the other components. This approach is unsatisfactory for the overall productivity of resources, environmental quality, and the ability to satisfy the needs of various watershed interests. This paper discusses how to develop a holistic and sustainable approach to watershed management that addresses watershed resources and other components, while equitably satisfying all interested parties.

INTRODUCTION

Watersheds consist of a complex array of resources such as trees, water, herbage, wildlife, soil, minerals, and historical, cultural, and aesthetic values, and other components. All watershed components are intimately intertwined, therefore, a change in one of them may have profound effects upon the conditions of the other components and may also affect relevant social, cultural, political, and economic structures. Therefore, to minimize any inadvertent adverse effects on watershed resources, watersheds must be managed, as recommended by the National Research Council in its recent study, in an integrated, holistic, and a sustainable manner (National Research Council 1990). Additionally, the USDA Forest Service has formally issued management guidelines that stipulate that management of forested watersheds must provide for the multiple use and sustained yield of goods and service to maximize long-term net public benefits in an environmentally sound manner (USDA Forest Service 1980a, b).

However, the diversity of watershed components, and their competitive sharing of limited needs such as space, nutrients, water, air, and light, make the sustainable and holistic management of all the watershed components a challenging task. Conflicts that arise between environmental groups and resource users further complicate this problem (Teclé et al. 1995, Bowling et al. 2000). Hence, development and application of a management scheme that considers tradeoffs between the watershed resources and interested parties is needed. Multi-objective decision analysis would likely succeed in solving such a complex problem in a

holistic and sustainable manner (Teclé et al. 1988, 1994, 1998). Figure 1 represents important multi-resource components of a watershed, with their specific products or uses. Obtaining these goods and services will likely be accomplished by one or more of the following management options.

- Concurrent and continuous resource use to obtain the goods and services.
- Alternating a resource use or a combination of uses to obtain goods and services through time.
- Geographically separating a resource use or a combination of uses to obtain the goods and services within a mosaic of management units

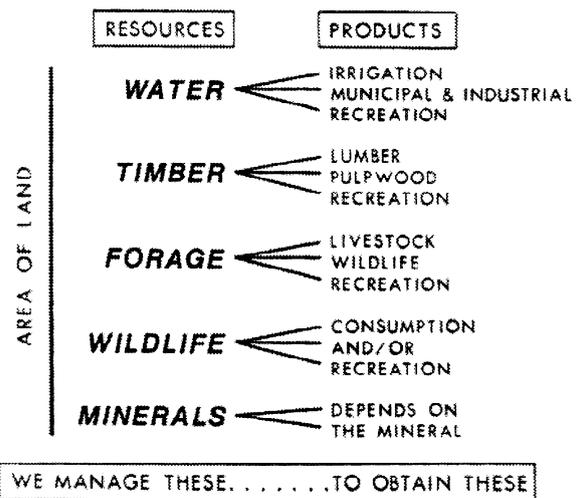


Figure 1. Holistic management of the water and other natural resources on a watershed will result in a variety of natural resource products and uses that are demanded by people (from Brooks et al. 1997).

on a watershed, and managing each unit for the particular resource use that the unit is best suited.

For future effectiveness, watershed management must also broaden its past emphasis on forests, woodlands, and shrublands to include the increasingly populated wildland-urban interface and urban areas. In Arizona, this broadening of scope is necessary because it is likely that Arizona will experience ever increasing urbanization, and the subsequent movement of people to urban areas. Therefore, watershed management must be designed to respond to political, social, cultural, and economic realities by including resources in the watershed and all interested parties. We describe some specific justifications for the need to adopt a holistic and sustainable watershed management approach below.

JUSTIFICATION FOR HOLISTIC AND SUSTAINABLE WATERSHED MANAGEMENT APPROACH Interacting Multiple Resources and Conflicting Interests

A future approach to watershed management must be one that is integrated, holistic and sustainable. This would involve both time and space in managing watersheds, and must be done at the landscape scale using a dynamic approach that considers changes in watershed components and the opinions of interested parties (Teclé 2000).

Future watershed management practices must minimize adverse impacts, sustain high-quality water flows, and rehabilitate degraded watersheds. The need for these practices will intensify as continuing monitoring activities indicate that more watershed lands require remedial actions to restore the hydrologic processes (Baker et al. 1999). The implementation of best management practices (BMPs)¹ at the watershed scale should help achieve these objectives. The BMP approach to sustaining the flows of high-quality water involves identification and implementation of holistic and sustainable watershed management practices to reduce or prevent nonpoint

and point source pollution (Brown et al. 1993) and other environmental degradation.

Many BMPs that are designed to mitigate erosion-sedimentation processes caused by silvicultural treatments, livestock-grazing practices, road-related disturbances, and agricultural practices are practiced (Lynch et al. 1985, Chaney et al. 1990, Lafayette et al. 1992, Brooks et al. 1997), but the development of BMPs for other pollutants is incomplete. Whatever the situation, specifying BMPs to attain a designated water-quality standard for a designated beneficial use in a cost-effective and multi-objective framework requires understanding the cause-and-effect relationships between land disturbances on upland watersheds and the quality of downstream water, and the costs of alternative approaches to control. While this knowledge is available for some hydrologic systems and economic situations, future investigations of cause-and-effect relationships are necessary. The goal is to develop reliable hydrologic, water quality, and other resource response functions to natural and human disturbances at the watershed scale (Beschta 1998, Black 1998, Bonell 1998, Swanson 1998, Gelt 2000, Sidle 2000, Swank and Tilley 2000, Thorud et al. 2000). Another need is to develop a methodology for integrated and holistic resource management at the watershed scale (Teclé and Duckstein 1994, Neary 2000). This is especially important in the presence of interacting watershed components, conflicting management decision makers, and a multitude of other interested parties (Teclé et al. 1995, Baker and Ffolliott 1998, Pearce 1998, Fox et al. 2000, Towns 2000). We propose use of a multi-objective decision analysis to resolve conflicts among different interested parties and to holistically manage the watershed resources.

Psychological Basis for Holistic and Sustainable Watershed Management

There is a fundamental idea that deliberate decisionmaking generally requires that decision makers consider various viewpoints. For example, when evaluating feasible sets of alternative watershed resource management actions, decision makers should try to relate their choices to the multiplicity of the objectives or options under consideration (Blin and Dodson 1978; Teclé et al. 1994, 1998). A model that shows individual behavior to be a function of environmental stimuli and a combination of motivational, cognitive and emotional conditions of the concerned individual can describe the multiplicity of objectives. Thus, even if a watershed system were limited to a single resource management, and no other external motivation for using an integrated multi-objective

¹The practice or combination of practices that are determined (by a state or states, or representative area-wide planning agency, in case two or more states or other conflicting interests are involved) after problem assessment, identification and appropriate participation of all interested parties and clearly articulating their wishes and aspirations, examination of alternative practices, and selecting the most effective and practicable (with respect to criteria that include technological, economic, cultural and institutional considerations) means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals.

analysis approach existed, the psychological perspective of the decision maker could be sufficient to warrant holistic and sustainable watershed management.

APPROACHES FOR HOLISTIC AND SUSTAINABLE WATERSHED MANAGEMENT Increasing Emphasis on Watershed Resource Demands

To date, most decisions concerning watershed resource development have linear characteristics specifically designed to meet a one or a few narrowly defined objectives. As a result, much of the past watershed-research focused on the supply side of watershed management, for example, attempting to increase flow of high-quality water from watershed lands to downstream points of use. On a smaller scale, other approaches, including water harvesting, accessing deep aquifers, enhancing aquifer recharge, and modifying storage techniques to reduce evaporation and seepage rates, have also been explored (Fox et al. 2000). These supply side efforts will probably continue to be a focus of watershed management in situations where realistic opportunities are present. However, watershed management practices must also emphasize the demand side of the resource-availability equation. This is especially true when resources are scarce, or when environmental and cultural considerations limit their production.

Innovated technological approaches to reduce the anticipated demands for water and other natural resources on a watershed do not solve future scarcity problems. Importantly, the unequal distribution of water and other natural resources on watershed lands could be more limiting than a failure to implement improved technologies (Gregersen et al. 2000). A lack of institutional capabilities and effective planning and managing for scarcity, and a failure to incorporate market forces into future allocation plans also contribute to this problem. Decision makers should develop approaches that reduce the demand for water and other land resources by adopting water-conserving land-use practices such as vegetation conversion and water-saving economic and cultural activities.

Figure 2 shows response mechanisms to high-water demand during times of scarcity. The mechanisms are categorized into two types. One type of response is geared to reduce per capita water demand, while the other represents different ways of augmenting the water supply to meet the increasing demands for water. However, a management scheme that includes both types is the most appropriate management approach. Nevertheless, if a decision

maker selects only one approach, using multi-objective decision-analysis procedures to evaluate all feasible management alternatives may help determine preferred practices.

Efficient Use of Limited Watershed Resources

Most existing land management practices and related environmental laws and regulations are single-objective oriented. As such, these practices inadequately address all aspects of a watershed ecosystem, which contributes to mismanagement of water and watershed resources. Therefore, we suggest use of a multi-objective decision analysis, which permits tradeoffs among multiple objectives to arrive at efficient management of scarce water and other watershed resources (Tecle et al. 1998, Poff 2002). The benefits of this watershed management approach to effective land stewardship will become evident through the increasingly efficient use of the limited watershed resources in the southwestern United States. To paraphrase Gregersen et al. (2000), greater efficiencies in watershed resource use is likely by implementing technologies that efficiently and effectively use the resources. Giving people greater responsibility over their use of limited watershed resources will encourage efficient conservation. Increasing the cost of water, livestock forage, wildlife habitats, and recreational opportunities to reflect their true scarcity-value, and the costs of supplying them to stakeholders, is also necessary.

Focusing on improving the stewardship of available water and other watershed resource supplies will be necessary despite any progress made to increase the resource supplies or reduce the demands. Efficient application of known watershed-management technologies and effective technology transfer mechanisms should be developed. Additionally, increased public awareness of the need to balance the economic and environmental values of available watershed resources is necessary to promote watershed resource stewardship.

Adopting Effective Policies and Policy Instruments

Policies in the southwestern United States guide responses to anticipated increasing demands for water and other natural resources. A watershed approach to land stewardship, as presented in Ffolliott et al. (2002), represents a framework that effectively applies, monitors, and enforces policies for holistic management and sustainable resource use. One or more of the following instruments

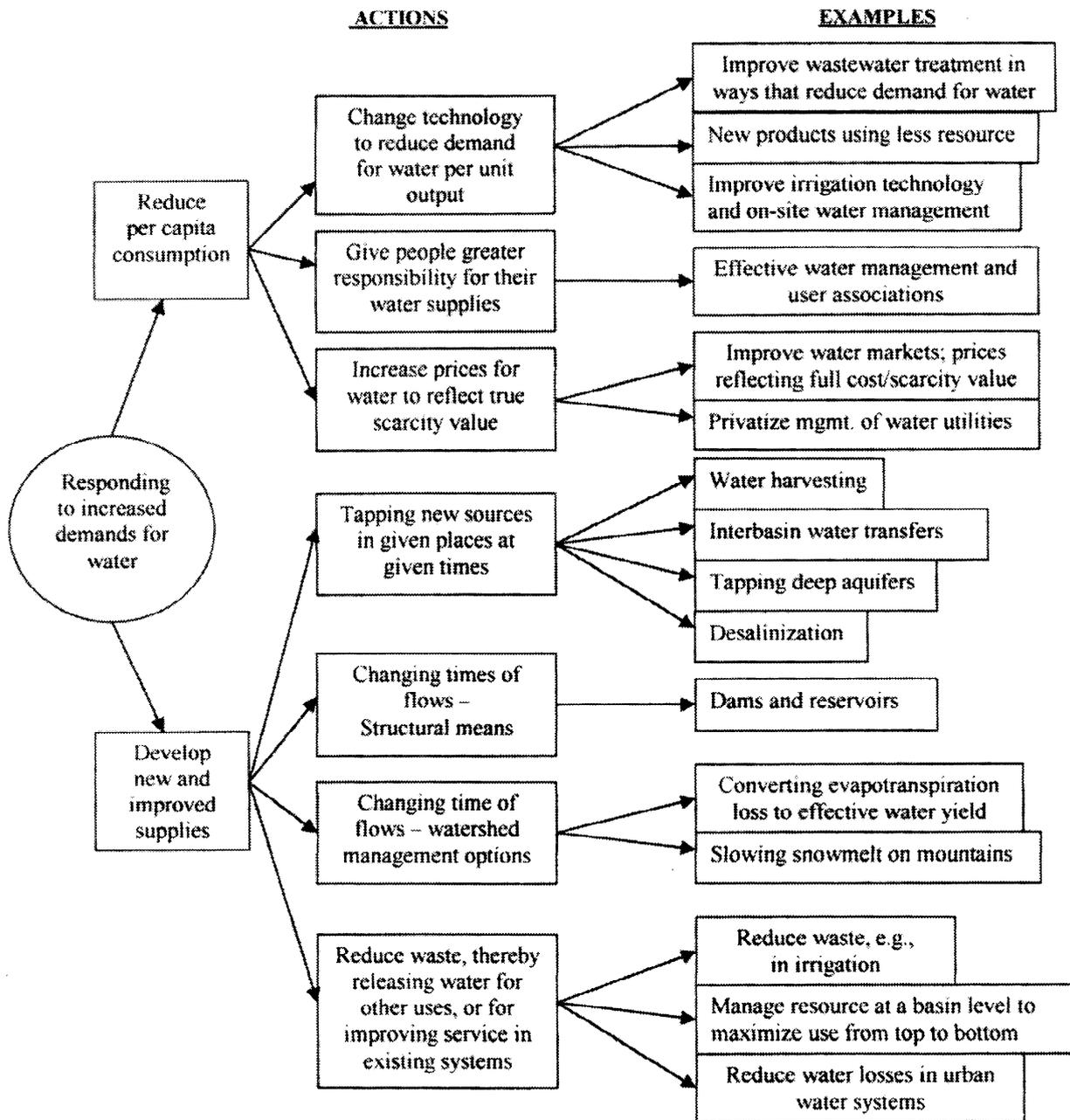


Figure 2. Examples of policy actions and outputs that effectively respond to increased demands for water (from Gregersen et al. 2000).

(Brooks et al. 1992, Quinn et al. 1995, Gregersen et al. 2000) should be useful to encourage people to adopt the policies.

- Adopting regulatory mechanisms such as resource-use regulations, land and water rights, prohibitions, and licensing.
- Implementing fiscal and financial instruments including prices, taxes, fines, subsidies, and other incentives.

- Facilitating public investments by providing technical assistance, education, structure installation, infrastructure development, and adopting responsive and effective land stewardship.
- Developing and implementing a watershed resource management approach that is inclusive and watershed-based to consider the needs of present and future generations.

Promoting local commitment and participation within existing social, political, and institutional

settings also contributes to successful policy implementation (Gregersen et al. 2000). The goals and objectives of public management and regulatory agencies and the diverse interests of the public will continue to be incorporated into watershed partnerships, councils, and other locally led initiatives (Doppelt et al. 1996, William et al. 1997). One recent initiative of note is the Arizona Rural Watershed Initiative. This initiative focuses on current and future water resource issues and provides funds to develop regional and watershed-based solutions through locally driven and community-based partnerships (Endebrook 2000). The settings are unique to each locale and region in Arizona and, consequently, to the organization, regulations, and informal rules that influence the success of a policy or actions evolving from the policy.

Necessary Institutional Arrangements

Implementation of a policy statement can require modification of existing institutional arrangements or developing effective policy instruments. For example, efficient and equitable water resource management may require abandoning the pioneer-period water allocation doctrine of prior appropriation, which is still widely accepted in Arizona. Such legal and institutional rearrangements are important because they specify the benefits that people receive from water and other natural resource management on a watershed-basis. Efficiently functioning institutional arrangements should establish the rights to land, water, and other natural resources, pricing mechanisms, and government interventions by building interfaces between government and private sectors (Gregersen et al 2000). Watershed management in Arizona involves a combination of government and private sector activities. Therefore, policy actions and instruments that most effectively accomplish the goals and objectives of watershed management must be selected using multi-objective decision-making techniques, once the association has been determined. Inadequate institutional arrangements between government and private sectors will impede effective resource management and use.

Increasing Public Awareness

The public's increasing awareness of environmental issues and concerns about the conditions of the environment for future generations often results in increasing political consciousness and calls for action (Gregersen et al. 2000). The growing level of environmental awareness of people throughout Arizona also creates effective, acceptable, and equitable distributions of the benefits and costs of future watershed management programs; the distributions

should be the ultimate goals of these programs. Again, a holistic and sustainable watershed management approach to land stewardship provides a comprehensive and practical institutional framework for policy development and implementation (Brooks et al. 1992, Quinn et al. 1995, Tecle et al. 1995, Gregersen et al. 2002). More generally, this approach solves future problems associated with water and other natural resource management by using a multi-objective group-decision making framework (Tecle et al. 1998). However, the barriers to adoption of this approach, as discussed in Ffolliott et al. (2002), must be overcome for this framework to be effective.

SUMMARY AND CONCLUSIONS

Many present watershed management approaches are narrowly focused to respond to the short-term needs of decision makers or particular interest groups. This approach to watershed management maximizes the resource obtained, with little or no concern of the effect on the other watershed components or to the overall environment. The result is unsustainable overexploitation of some resources, decreases in the productivity of watershed resources, and environmental degradation. However, society and the scientific community are aware of these problems, and we recommend that the approach to future watershed management be more holistic and sustainable than what presently exists. One approach for the development and practice of holistic and sustainable watershed management is an increased emphasis on the demands for watershed resources. Demand-based watershed management would encourage development of policies and regulations to conserve and efficiently use limited resources and encourage development of programs to increase the public's awareness about the importance of resource conservation. Other approaches include development of mechanisms for sustainable and holistic watershed management through increased public participation and adopting a community-based approach to watershed management. Although many of our watershed resources are over exploited and tremendous environmental damage exists, we can develop a sustainable land stewardship through sustainable and holistic watershed management. This management approach is dynamic, watershed-based, socially inclusive, and it can be designed to empower and meet the needs and aspirations of all interested parties.

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