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Science in the public process of ecosystem management: lessons from Hawaii, Southeast Asia, Africa and the US Mainland

John Gutrich[a,b,*], Deanna Donovan[c], Melissa Finucane[d], Will Focht[e], Fred Hitzhusen[f], Supachit Manopimoke[g], David McCauley[h], Bryan Norton[i], Paul Sabatier[j], Jim Salzman[k], Virza Sasmitawidjaja[l]

[a]Environmental Studies Program, Dartmouth College, 6182 Steele Hall, Hanover, NH 03755, USA
[b]Environmental Science Program, Hawaii Pacific University, 45-045 Kamehameha Hwy, Kaneohe 96744, Hawaii
[c]World Water Assessment Programme, UNESCO, Paris, France
[d]Center for Health Research, Hawaii, Kaiser Permanente Hawaii, Honolulu, Hawaii
[e]Department of Political Science, Oklahoma State University, Stillwater, OK, USA
[f]Department of Agricultural, Environmental and Development Economics, Ohio State University, Columbus, OH, USA
[g]Faculty of Economics, Thammasat University, Bangkok, Thailand
[h]Asian Development Bank, Manila, Indonesia
[i]School of Public Policy, Georgia Institute of Technology, Atlanta, GA, USA
[j]Department of Environmental Science and Policy, University of California, Davis, CA, USA
[k]Nicholas School of the Environment, Duke University Durham, NC, USA
[l]Natural Resource Management Program Jakarta, Indonesia

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Abstract

Partnerships and co-operative environmental management are increasing worldwide as is the call for scientific input in the public process of ecosystem management. In Hawaii, private landowners, non-governmental organizations, and state and federal agencies have formed watershed partnerships to conserve and better manage upland forested watersheds. In this paper, findings of an international workshop convened in Hawaii to explore the strengths of approaches used to assess stakeholder values of environmental resources and foster consensus in the public process of ecosystem management are presented. Authors draw upon field experience in projects throughout Hawaii, Southeast Asia, Africa and the US mainland to derive a set of lessons learned that can be applied to Hawaiian and other watershed partnerships in an effort to promote consensus and sustainable ecosystem management.

Interdisciplinary science-based models can serve as effective tools to identify areas of potential consensus in the process of ecosystem management. Effective integration of scientific input in co-operative ecosystem management depends on the role of science, the stakeholders and decision-makers involved, and the common language utilized to compare tradeoffs. Trust is essential to consensus building and the integration of scientific input must be transparent and inclusive of public feedback. Consideration of all relevant stakeholders and the actual benefits and costs of management activities to each stakeholder is essential. Perceptions and intuitive responses of people can be as influential as analytical processes in decision-making and must be addressed. Deliberative, dynamic and iterative decision-making processes all influence the level of stakeholder achievement of consensus. In Hawaii, application of lessons learned can promote more informed and democratic decision processes, quality scientific analysis that is relevant, and legitimacy and public acceptance of ecosystem management.

Keywords: Watershed management; Partnerships; Valuation; Consensus building; Environmental risk; Hawaii

1. Introduction

Partnerships and co-operative ecosystem management are increasing worldwide with greater community involvement in natural resource decisions (Loope and Reeser, 2001; Steel and Weber, 2001; Leach et al., 2002; Plummer and FitzGibbon, 2004). At the same time, there is an increasing

* Corresponding author. Address: Environmental Science Program, Hawaii Pacific University, 45–045 Kane haneha Hwy., Kaneohe, H1 96744, USA. Tel.: +1 808 236 7906; fax: +1 808 236 3590.

E-mail addresses: john.j.gutrich@dartmouth.edu (J. Gutrich), jgutrich@ hpu.edu (J. Gutrich).

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demand for science-based environmental decision-making at the local, regional, national and international levels (Sarewitz et al., 2000; Steel and Weber, 2001). Scientists are being called upon to estimate the probability, magnitude and impacts of natural and human-induced environmental factors, articulate and identify tradeoffs of ecosystem goods and services, and interpret scientific findings for management decisions (Daily, 1997; Sarewitz and Pielke, 2000; Steel et al., 2004). Recent studies even suggest that decision-makers, citizens and interest groups prefer scientists to take a more active role interpreting and integrating science into management decisions (Steel and Weber, 2001; Steel et al., 2004).

In Hawaii, watershed partnerships serve as one example of a trend toward greater community involvement in ecosystem management. Private landowners, non-governmental organizations, and state and federal agencies across Hawaii have formed partnerships in an effort to conserve and better manage the state's valuable forested watersheds. Upland forested watersheds of Hawaii are vast reservoirs of biological diversity, recharge critical underground aquifers, and supply billions of gallons of surface water to agricultural, residential and commercial sectors each year (Scott et al., 1988; Krulce, 1997; Gingerich, 1999). However, the Hawaiian rain forest has been significantly degraded and reduced to 58% of its original cover (DLNR, 2000). Hawaii's forested watersheds are under great pressure from an increasing demand for water and continued environmental degradation due to feral and invasive alien species. Public investment at the state level remains minimal. Only 1.5% of the annual state budget, approximately US$72 million ($73 per capita), is allocated to natural resource management each year (DBEDT, 2000). Thus, stakeholders across Hawaii are collaborating in an effort to better manage upland forested watersheds by voicing their concerns, generating and implementing action plans and petitioning for greater support.

Formation of watershed partnerships in Hawaii and the growing demand for science-based input in natural resource decision-making led to collaboration between research groups of the East–West Center (EWC) and the Institute of Pacific Islands Forestry (IPIF) of the US Forest Service (USFS). The collaborative project was to detail a process by which the value of natural ecosystems could be articulated and clarified with scientific input for better natural resource decision-making in Hawaii and the Asia–Pacific Region. Acknowledging that other partnerships and scientists across the globe were addressing similar problems and that the Hawaiian partnerships might benefit from their experience, the EWC and IPIF organized an international workshop entitled Valuation of Environmental Resources: Lessons from the Field'[1]. The workshop brought together scientists and researchers from a variety of disciplines, including environmental scientists, foresters, ecologists, political scientists, philosophers, economists, psychologists, lawyers and resource managers. Here, we present the findings of the workshop addressing the critical question: how can science and partnership processes build consensus and augment the process of co-operative ecosystem management? Our discussion proceeds by (1) setting the context with a review of Hawaiian watershed partnerships (2) providing a set of 'lessons learned' when attempting to augment the public process of ecosystem management with scientific input (3) a discussion of relevant illustrations from Southeast Asia, Africa, and the US Mainland and (4) the potential for application of insight from 'lessons learned' in the context of Hawaiian watershed partnerships.

2. The context: Hawaiian watershed partnerships

In 1991, the East Maui Watershed Partnership was created through a joint initiative of state and federal agencies, private landowners, environmental non-government organizations, local water supply boards, and the National Park Service. By the end of the decade additional partnerships had been created with public and private landowners collaborating to form the Ola'a-Kilauea Partnership on the island of Hawaii, the West Maui Mountains Watershed Partnership, the East Molokai Watershed Partnership and the Ko'olau Mountains Watershed Partnership on Oahu. Since 2000, new watershed partnerships have also formed on the islands of Hawaii, Kauai and Lanai. Fig. 1 is a general schematic of geographical boundaries and relative size of primary watershed partnerships. Partnerships vary according to size, number of partners, consensus of landowners within the watershed, percent of land managed by watershed partners, amount of funding, and the phase of completion of partnership objectives (see Table 1).

A partnership can be defined as a dynamic relationship among actors, based on mutually agreed upon objectives, pursued through an understanding of division of labor based on the respective comparative advantage of each member (Brinkerhoff, 2002). Meefe and colleagues (2002) define ecosystem management as 'an approach to maintaining or restoring the composition, structure, and function of natural and modified ecosystems for the goal of long-term sustainability. It is based on a collaboratively developed vision of desired future conditions that integrates ecological, socioeconomic and institutional perspectives, applied within a geographic framework defined primarily by natural ecological boundaries'. Stakeholders in Hawaii established a foundation for the partnerships by agreeing on common beliefs such as forested watersheds are valuable sources of water, native species and ecosystems, and recreational opportunities (e.g. hunting, hiking; EMWP, 1993). In turn, ecosystem management plans were established and implemented to conserve the valuable services identified

[1] The workshop was held at the East–West Center, Honolulu, Hawaii.

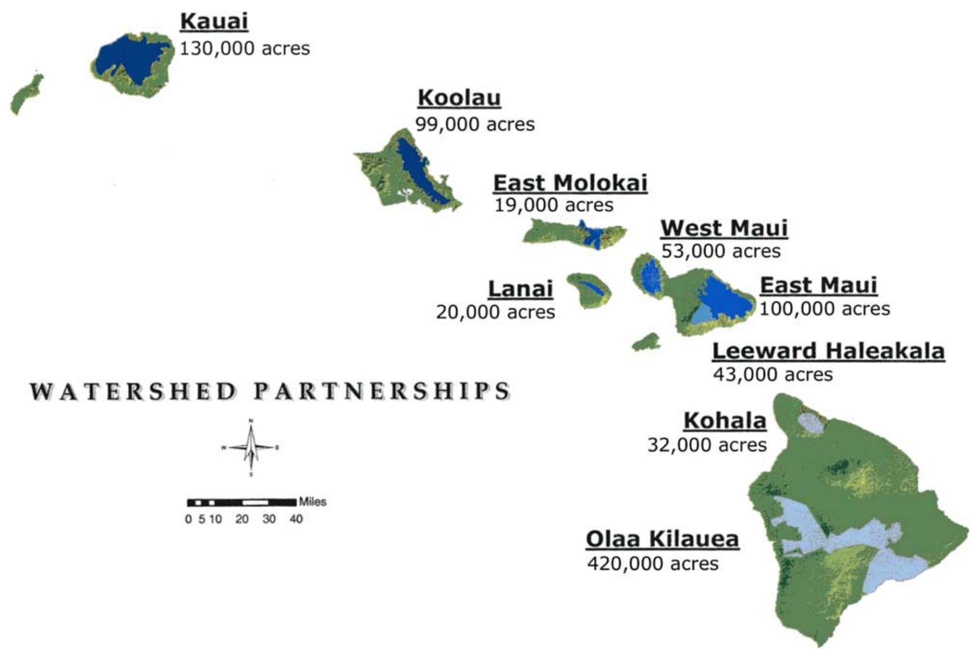

Fig. 1. Main Hawaiian watershed partnerships (after DOFAW, 2004).

by the partnerships and provided by the upland forested watersheds.

The East Maui Watershed Partnership was the first to formulate an action plan to foster long-term protection of upland forested watersheds by: (1) constructing a fence to exclude feral ungulates from higher elevations, (2) removing pigs and goats from within fence boundaries (by hunting and trapping), and (3) removing and impeding the spread of exotic plant species (EMWP, 1993). Other partnerships followed with management plans focused similarly on

Table 1
Hawaiian watershed partnerships: conservation of upland forested watersheds

Watershed partnerships	Year est.	No. of partners[a]	Approximate size (acres = 0.4 ha)	Management plan	Phase of completion[b]
East Maui	1991	7	100,000	Exotic species and feral ungulate control w/ fence and removal; invest in mgmt infrastructure; public education programs	Fence completed; exotic species and feral ungulate removal; community outreach program
Ola'a-Kilauea (Hawaii)	1994	8	420,000	Exotic species and feral ungulate control w/ fence and removal; rare plant restoration; community planning effort; baseline surveys of rare and endangered species	Fence completed; active firal animal control; exotic plant sp. removal; rare plant restoration;
West Maui	1998	10	50,000	Exotic species and feral ungulate control w/fence and removal; reduce spread of exotic plant species – herbicides	Constructing fence community planning
East Molokai	1999	14	19,000	Exotic species control w/ fence and removal; water/soil monitoring recovery	Fence completed; goat reduction; observing vegetation
Ko'olau mountains (Oahu)	1999	15	99,000	Exotic species control w/ fence and removal; reforestation w/ native spp. water monitoring; community outreach	Feral ungulate removal; constructing fence enclosure; reforestation projects; biological surveys
Lanai	2001	11	20,000	Drafting management plan	Draft in progress
Kauai	2003	8	50,000	Drafting management plan	Draft in progress
Kohala (Hawaii)	2003	9	32,000	Drafting management plan	Draft in progress
Leeward Haleakala (Maui)	2003	11	43,000	No management plan activities yet	Agreement signed

[a] Number of partners as of January 2004 (HAWP, 2003; TNC, 2004).
[b] Phase of completion as of November 2003 (HAWP, 2003).

removing feral ungulates and halting the spread of invasive exotic plants (see Table 1). Further, proposed action of the watershed partnerships extends beyond exotic species management to include development of management infrastructure, public education and environmental awareness programs.

In 2003, the 'Year of the Hawaiian Forest' was declared by state legislators commemorating a one hundred year anniversary of historic forest restoration efforts. The governor of Hawaii also declared the formation of the Hawaii Association of Watershed Partnerships (HAWP)—an alliance of Hawaiian watershed partnerships—to engage in co-operative fundraising, enhance public and political support, and build the capacity of island-based mountain watershed partnerships. Many stakeholders in watershed partnerships took this opportunity to inform the public on the benefits of watershed management and the rationale for recent conservation efforts of partnerships. One non-governmental organization, The Nature Conservancy, provided estimates of the economic value of a watershed on Oahu generated from a team of hired researchers from the University of Hawaii (Kaiser et al., 1999; TNC, 2003). Watershed partnership members are informing the public and integrating scientists and researchers into the process of ecosystem management (TNC, 2003). The question remains: how can science and partnership processes effectively build consensus and augment the process of co-operative ecosystem management? Here, we present lessons learned when integrating science in the public process of ecosystem management from international projects and discuss the potential for science to foster consensus in Hawaiian and other watershed partnerships.

3. Building consensus with scientific input: lessons and illustrations

Lesson 1: Stakeholders may have a willingness to co-operate, but hold different mental models of resource management which results in failed communication. Interdisciplinary science-based models can serve as tools to identify areas of potential consensus.

Models usually refer to abstract representations of natural events and their causes and include both mental models and simulation models based on scientific inquiry. By accepting a set of simplified assumptions, a model permits us to navigate through a complex analysis in order to improve our insight of a more intricate, real-life system (Norton and Steinemann, 2001; Beck et al., 2002; Norton, 2002). Scientific inquiry involves both modeling and data gathering as scientists seek causal patterns in the natural world and empirical evidence that nature occurs in such patterns (Steel et al., 2004).

Stakeholders often rely on mental models or constructs of the mind for resource decision-making which may lead to inefficient or varying decisions with complex ecosystems. As Costanza and Ruth (1998) indicate, humans often base mental models on qualitative rather than quantitative relationships, think in terms of linear relationships, disregard lags in time and space, treat systems as isolated from their surroundings, and focus on the equilibrium of a system. Yet, non-linearities, spatial and temporal lags are characteristic of ecosystems (Gutrich and Hitzhusen, 2004). Reliance solely on simple mental constructs can hinder the ability of stakeholders to make proper decisions about complex ecological systems and their problems. By articulating and clarifying system complexities and the concerns of stakeholders with both qualitative and quantitative science-based models, scientific input can highlight dynamic interactions and unexpected results, thereby fostering consensus based on novel insights.

An excellent example of the potential of scientific models to foster consensus is the study of the fynbos watersheds in Western Cape Province, South Africa (Higgins et al., 1997). Fynbos is a hard-leaf, fire-prone shrub community in South Africa that is rich in plant species with a level of endemism that ranks among the highest in the world (Cowling et al., 1992). Historically, a poor understanding (simplified mental models) of the alteration and degradation to the watershed caused by alien species resulted in failure to invest in efficient management of this valuable natural resource (Cowling et al., 1997). Yet, an ecological-economic computer simulation model of the fynbos system was constructed to analyze the dynamics of vegetation, hydrology, fire, economics and management (Cowling et al., 1997).

Invasive plant studies found that alien woody species spreading with the aid of fire events displace native fynbos, increasing biomass between 50 and 1000percent (Versfeld and van Wilgen, 1986; Richardson, 1992). Simulation results indicated that invasive alien plants reduce native plant biodiversity, utilize greater amounts of water to maintain substantial biomass and thereby decrease streamflows in the fynbos watershed (Cowling et al., 1997; Higgins et al., 1997). Costs of proactive management (primarily alien species removal) amounted to just 4.8% of the value of the services provided by the watershed to society (Cowling et al., 1997). Decision-makers realizing the net loss of ecosystem benefits increased funding substantially to properly manage the fynbos watershed (Higgins et al., 1997).

From an ecosystem management standpoint, many similarities exist between fynbos watersheds and forested watersheds in Hawaii. Both watersheds contain high levels of plant diversity and endemism, both are highly threatened by exotic plant species invasion, and both have been degraded due to a lack of funding for effective management. Hawaiian partnerships have the opportunity to support arguments for funding and continued investment with science-based analyses of watershed dynamics.

Fig. 2 presents a conceptual diagram of forested watershed management in Hawaii and the dynamics of

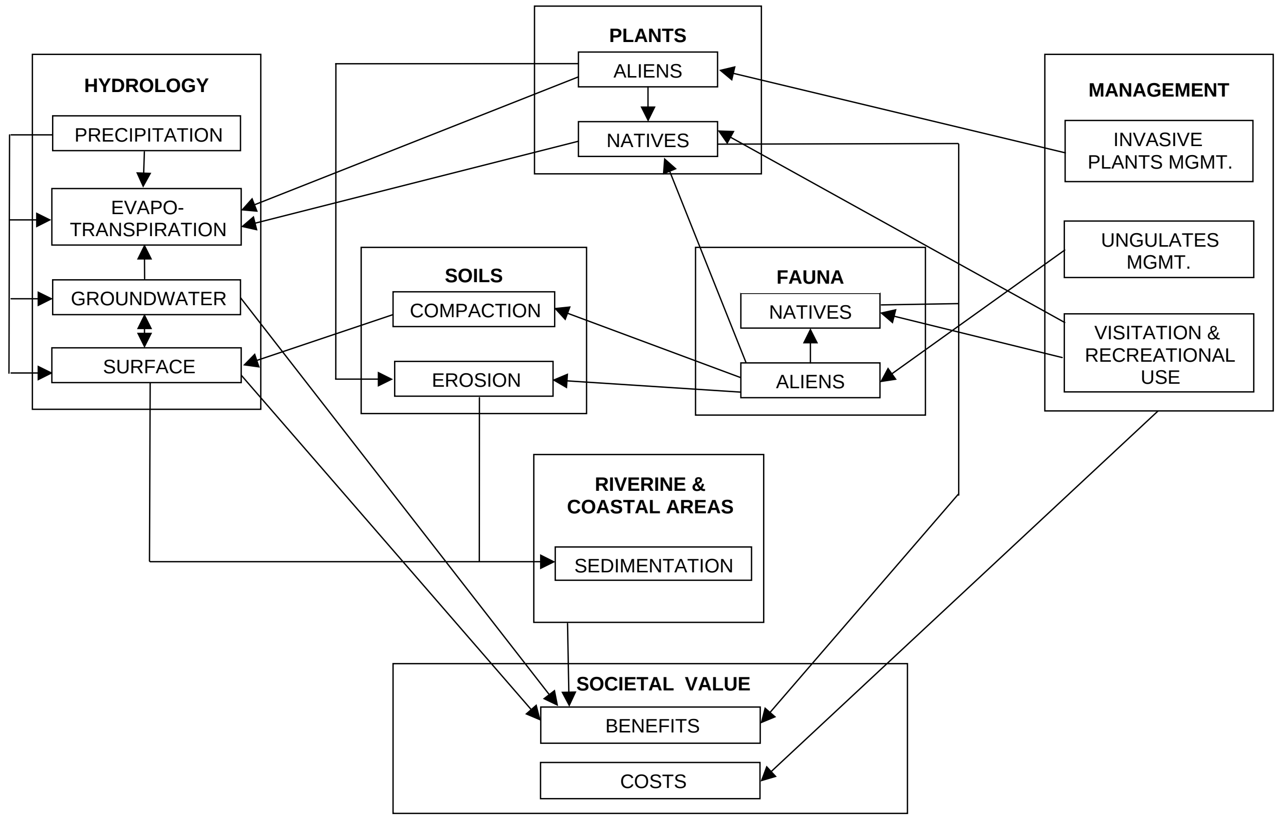

Fig. 2. Conceptual diagram of upland forested watershed management in Hawaii.

management activities with hydrology, flora, fauna, soils, coastal systems and societal value. Science can augment ecosystem management by addressing questions pertinent to stakeholders such as: what are the effects of invading species on the structure and function of native forests and subsequent watershed hydrology? What ecosystem goods and services do the forested watersheds provide and what is their value to society? How does the invasion of alien plants and different management strategies influence the flow of natural goods and services? Science-based research can highlight changes to flows of ecosystem goods and services from management activities extending decision-making models beyond simplified assumptions of historic use and management.

Lesson 2: Effective integration of scientific input in co-operative ecosystem management depends on the role of science, the stakeholders and decision-makers involved, and the common language utilized to compare tradeoffs.

Stakeholders bring diverse preferences for ecosystem goods and services to the process of deliberation regarding environmental management strategies (Keystone Center, 1996). Fig. 3 presents a general framework of the public process of ecosystem management, highlighting the opportunity for science to promote consensus building in Hawaiian watershed partnerships. The public process can be viewed generally in four phases, with stakeholders: (1) arriving at the table with held beliefs and values concerning environmental resources, (2) deliberating to identify a common goal and to formulate a management plan, (3) implementing the plan and monitoring success of the plan and (4) seeking funding and other sustaining support for the agreed management activities. Science can be utilized at each stage of this process to inform decision-making, prioritize actions, justify actions undertaken, support requests for funding for environmental protection, generate better policy and increase public awareness to mobilize support for environmental protection.

The National Research Council indicates that effective incorporation of science into the public process requires a recursive integration of scientific analysis and political deliberation whereby analysis is used to inform deliberation and deliberation is used to frame analysis (Lee, 1993; Stern and Fineberg, 1996). Science can serve as a communicative device by informing stakeholders and articulating stakeholder values of ecosystems in an understandable, common language. Yet, socio-cultural context greatly influences the efficacy of incorporating scientific approaches and determines the extent to which science can be utilized to build consensus.

A common valuation approach taken primarily by environmental economists is to estimate the value of natural resources as a willingness to pay by stakeholders in monetary terms. In East Kalimantan, Indonesia, returns from customary forest practices were monetized and compared to

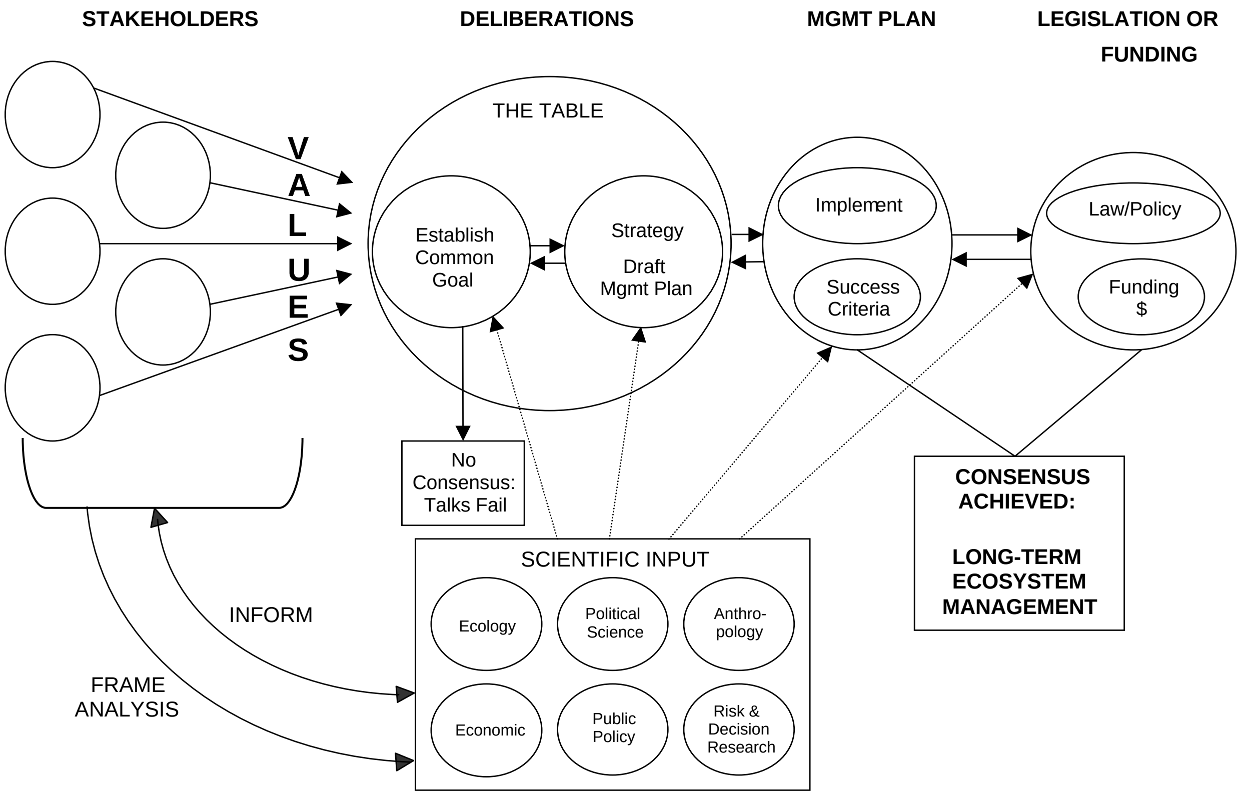

Fig. 3. A general framework of the public process of ecosystem management.

estimated production from the same areas converted to oil palm plantations. By translating local forest management activities into a common 'monetary language', economists revealed three important facts: (1) economic benefits derived from customary forest management are comparable to average income levels per person in Indonesia; (2) customary forest management provides a greater return to labor than an oil palm plantation would; (3) the customary forest management system is relatively resistant to market shocks and does not require long time horizons nor large initial investments to realize returns (Sasmitawidjaja, 2001). By assisting local communities in articulating their values with regard to environmental resources, social scientists can provide local communities and governments with more detailed information for better informed land-use decisions.

Environmental valuation can extend to non-market ecological goods and services. Rivers, a key watershed component, play an important role in the economic development of a region by providing services such as water supply, transportation, waste assimilation, and an array of recreation and tourism activities. In Ohio, a team of economists estimated the market and non-market benefits and costs of river corridor improvements as a guide to public policy. Utilizing economic approaches such as benefits transfer (benefit/cost estimates of similar sites), hedonic pricing (implicit valuation of specific river characteristics) and contingent valuation (surveys), the value of non-market river functions was integrated into the decision-making process (Hitzhusen et al., 2000). Articulating the value of different segments of the river in a common metric allowed stakeholders and policy makers to evaluate tradeoffs for different river corridor interventions.

In Hawaii, Gutrich and Donovan (2001) estimated that returns from watershed conservation maintaining groundwater recharge (preventing a decrease from 5 to 20%) would protect annual flows of groundwater recharge to critical aquifers valued at US$390 thousand to US$3.5 million annually. Protection of the East Maui watershed was also substantiated by economic analysis indicating that efforts to halt the invasive tree, *Miconia calvescens*, from spreading through the biological hotspot, Haleakala National Park (HNP), would generate net benefits in the millions of dollars annually over a 20-year period (Gutrich and Donovan, 2001). Representatives of the US Park Service utilized the economic analysis to substantiate further allocation of federal funds by US Congress to halt the spread of the invasive *Miconia* in the East Maui Watershed. Here, ecological economic simulation results supported requests of funding for continued watershed management in Hawaii.

Decisions on environmental resources can also be made on cultural, historical or moral bases, aspects that often defy quantitative evaluation. Certain cultures and people do not wish to discuss tradeoffs of environmental resources in monetary terms and may be offended by attempts to measure the value of an environmental resource by a person's willingness to pay (Baron and Spranca, 1997; Sagoff, 2000). In such cases, integration of economic analysis may actually undercut efforts to build consensus with local communities either unfamiliar with monetary tradeoffs or simply unwilling to consider or compare culturally valuable environmental resources in monetary terms. In these instances, alternative valuation methods must be explored (e.g. Satterfield, 2001; Finucane and Satterfield, 2005).

In Hawaii, certain watershed partnerships have emerged based on traditional Hawaiian land divisions known as *ahupua'a*. Ahupua'a were land management units extending from mountain ridge to coral reef providing a valuable mix of terrestrial and marine products for local inhabitants, serving cultural needs and linking both natural and social systems. Today, watershed partnerships based on the ahupua'a concept attempt to address a variety of community needs, including the indigenous economy, governance, social structure, traditional food systems, spirituality and ethics (Derrickson et al., 2002). Monetary estimates of the physical benefits of watershed management may have little significance to stakeholders of an ahupua'a-based partnership that wishes to restore or maintain valued cultural practices in conjunction with sustainable use of natural systems.

Scientific approaches can also offer the opportunity to address tradeoffs in a common language beyond monetary terms. Scientists can aid in the development and assessment of environmental 'umbrella' indicators, still quantifiable and scalable, that can be utilized to monitor the status of a resource (Salzman and Ruhl, 2001; Wainger, 2001). Stakeholders can agree to base success criteria on environmental or socio-cultural indicators eliminating the need for an assessment of economic efficiency. Examples include physical and ecological indicators (e.g. plant species richness, number of endemic plants, groundwater recharge, distribution of stream flow), social indicators (e.g. maintenance of historic cultural sites, equal access) and functional use values (e.g. hunting, hiking, fishing; Wainger, 2001). By developing non-monetary indicators, science can contribute to the delineation and consideration of quantifiable tradeoffs while building trust through the respect shown for cultural values.

Lesson 3: Trust is essential to consensus building and the integration of scientific input must be transparent and inclusive of public feedback.

Trust is a social phenomenon and one critical component of social capital required for the success of any multi-stakeholder project (Knack and Keefer, 1997; Krishna and Uphoff, 1999; Reid and Salmen, 2000; Shalizi et al., 2003). Trust can be conceptualized as a willingness to defer to the competence and discretion of others in the public process of ecosystem management (Focht and Trachtenberg, 2005). Many times decision making on environmental issues is complicated by system complexity, scientific uncertainty, public controversy, and social distrust (Rhoads et al., 1999; Shaw, 2000). Too often the introduction of science into the public process has attempted to substitute quantifiable values and optimization strategies for messy and unpredictable political deliberations (Kaiser et al., 1999; Beck et al., 2002; Chee, 2004; Focht and Trachtenberg, 2005). Scientific quantification may provide novel information and common metrics for analysis, but if distrust exists among the stakeholders, the scientific information may never be considered. The situation becomes particularly problematic if some scientists are perceived as members of a coalition (such as an environmental coalition) rather than a third party providing scientific input. In such cases, their analyses will be heavily discounted by members of opposing coalitions (Sabatier and Zafonte, 2002).

A team of physical and social scientists set out to analyze the transport and fate of pollutants likely to affect the values of stakeholders utilizing the multi-use resource, Lake Lanier, in northwest Georgia (Beck et al., 2002; Norton, 2002). Yet, the polarizing effects of the preset beliefs of stakeholders regarding the sources of pollution (sewage treatment plants, lakeshore and upstream developments in the watershed, and/or septic tanks) and degradation to the lake resulted in the collapse of negotiations. Subsequently legal battles ensued and scientists lost the opportunity to contribute to consensus building once trust deteriorated.

In the Illinois River Watershed of Eastern Oklahoma, trust determined whether stakeholders preferred deliberative or consultative processes, as well as whether government officials should assume a lead role or a support role in watershed management (Focht and Trachtenberg, 2005). In situations of low trust, stakeholders prefer deliberative processes to exercise some measure of control over analyses and how information gained from analyses is used in decision making. In contexts of high trust, stakeholders are more open to consultative processes which allow decision-makers to determine proper analyses and how that information is used; as long as the ultimate decision is justified and approved by stakeholders. When government is trusted, stakeholders are willing to accept analyses without much reservation. However, if trust is low, stakeholders are more insistent that independent analyses be conducted for proper management. Trust influences the willingness of stakeholders to consider analytic information and how stakeholders perceive that information. Thus, trust is both a guide and a product of the public process of ecosystem management.

In Hawaii, establishing trust among stakeholders concerned with the use and management of water resources can be an arduous task. As Wilcox (1996) noted, the onset of sugarcane production diverted water via an extensive system of irrigation ditches from rainy, windward areas of the islands to dry, sunny leeward lands. Water has shifted from the traditional taro cultivation to sugar, and from public to private use. Many legal battles have contested the use and the ownership of water running over private lands with court decisions generally favoring water as a public good (Derrickson et al., 2002). Windward residents often call for the re-allocation of water to restore streams and native ecosystems, to enable taro farming to continue, to preserve Hawaiian cultural traditions, and to safeguard a rural way of life on the island. Leeward and central residents argue that water is needed for diversified agriculture and to stimulate development. Establishment of trust among Hawaiian stakeholders will require consideration of the historic debate over water usage as well as the myriad of goods and services deemed valuable by various stakeholders. Currently, most watershed partnerships in Hawaii are not yet engaging the public. Individual landowners (both public and private) within the partnership are still working to establish trust between members themselves in an effort to achieve stated watershed management objectives—which appears no small task (Sumiye, 2004). Trust is essential both within partnerships and with the general public to foster sustainable watershed management.

Lesson 4: Consideration of all relevant stakeholders and the actual benefits and costs of ecosystem management to each stakeholder is essential.

Benefits capture, that is, the incidence of who 'actually' wins and who loses, is a key issue that must be carefully assessed in any analysis of management alternatives. For example, research by Hitzhusen et al. (2001) found that river corridor and water quality improvements get capitalized into corridor residential property values which in turn increases property tax revenues to local school districts and governments. Exclusion of stakeholders or failure to recognize the full spectrum of benefits and costs to the different groups of stakeholders can undermine environmental management objectives. A partnership may reach consensus and implement a management plan, yet substantial costs borne by excluded stakeholders may result in these stakeholders acting to subvert or suspend the activities of the partnership. Examples include legislators enacting countervailing legislation in response to pressure from disgruntled constituencies, funders rescinding financial support, and local people taking personal action to undermine resource management objectives.

Khao Yai National Park, Thailand's oldest and most popular national park, was estimated to be worth US$68 million annually through contingent valuation surveys and travel cost analysis (Manopimoke, 2001). Overall, it was estimated that the benefits derived from the park exceeded the opportunity costs of developing the land. Loss of income from reduced access to forest resources (agriculture, timber and other forest products) was estimated at only US$3.6 million to US$7.3 million annually. An earlier study estimated similar opportunity costs to local villages at US$7 million per year (Dixon and Sherman, 1990) with benefits to society estimated.

Unfortunately, a majority of opportunity costs were incurred by local villagers as few ecotourism revenues went to locals. Limited employment opportunities created by the park-related hotels, golf courses, and restaurants did little to integrate local village economies with ecotourism development. The substantial welfare loss to the 200 local villages has led to encroachment on park lands and poaching. To compensate for the privileges and income lost, locals engage in a hidden or illegal economy fueled by resources from the park. Thus traditional products (fuelwood, medicinal plants, bushmeat, etc.) collected from the park for sale in local markets supplement farmers' low income. In reality, the 'protected' Khao Yai reserve is virtually at the mercy of the poachers and others pursuing illegal, but traditional, forest harvesting activities. As a result, the cost of park maintenance and protection has risen by 25–30% in recent years (Manopimoke, 2001).

In Hawaii, management activities in the upper watershed will inevitably affect stakeholders downstream at lower elevations. As Derrickson et al. (2002) indicate many ahupua'a-related activities occur in the middle level of the watershed between upland forest reserves managed by the Hawaii Department of Land Natural Resources and coastal areas administered by the state. In the long run, effective watershed management will require upland watershed partnerships and ahupua'a-based partnerships to deliberate and collaborate over sustainable use and management of resources throughout the watershed. However, as the National Research Council's Committee of Watershed Management (1999) cautions, with an increase in the size of the partnership and the number of purposes it serves, so increases the complexity of equitably apportioning benefits and costs. Although challenging, collaborations between upland and lowland watershed partnerships in Hawaii can create opportunities to utilize economies of scale and develop multi-purpose management plans for integrated management of the entire watershed.

Lesson 5: Perceptions and intuitive responses of people can be as influential as analytical processes in decision-making.

All stakeholders, including highly trained scientists, bring to the table perceptions and understandings reflective of their social and cultural backgrounds. Gender, ethnicity, and the norms, value systems, and cultural and environmental systems of societies interact to create diverse perceptions of what could or should be done in ecosystem management. Differences in worldviews (general attitudes towards the world and its social organization), trust, control, and other sociopolitical factors are key determinants of perceptions of environmental risks (Slovic, 1998; Finucane et al., 2000; Slovic, 2001).

To be effective, public policies must be based on a thorough understanding of environmental risks (benefits and costs and the probability of their incidence) and individual differences in perceptions of those risks (Slovic, 2001). Effective approaches for considering the social construction of risk and aiding decision-making in complex situations include multi-attribute utility theory (Keeney, 1992) and the 'decision pathways' survey technique (Gregory et al., 1997), and possibly narrative valuation (Satterfield et al., 2000; Finucane and Satterfield, 2005). Correctly identifying and structuring stakeholders' values is crucial to making sound choices, but also provides a way of revealing new decision alternatives (Gregory et al., 1997; McDaniels et al., 1999). By facilitating public participation in both risk assessment and risk management, decision processes become more democratic, the relevance and quality of technical analysis is improved, and the legitimacy and public acceptance of the resulting decisions is increased.

Research has shown also that the intuitive responses, or 'gut reactions', of people are as influential as their analytical processes in decision-making (Finucane et al., 2001). Generally, these intuitions are useful because they essentially provide a pool of positive and negative feelings that decision-makers have developed and strengthened as a function of experience with a particular issue. While relying on intuitions is often an efficient way of choosing a course of action, an analytic assessment of decision options may permit a more thorough deliberation of the information and potential outcomes available.

In the watershed management of the Embarras River Basin of east-central Illinois, rural stakeholders were initially reluctant to interact with technical experts and scientists and disregarded information on the geomorphology and ecology of streams in the watershed (Rhoads and Herricks, 1996; Rhoads et al., 1999). Illinois farmers first trusted their ingrained perceptions that the best management strategy for the watershed was traditional dredging of streams to remove sediment, rejecting contrary scientific advice. Watershed management practices were based on an historic land-drainage ethic, in effect hedging the risk of re-flooding productive agricultural lands (Rhoads et al., 1999). Scientists proposing novel strategies for watershed management needed to understand the historical development of the farmers' position as well as the risk perception of local farmers in order to build the trust necessary to reach a consensus on stream naturalization.

Both intuition and analysis are important for good decision outcomes; balancing both modes of information processing is the key to accurate and acceptable ecosystem management. Scientific tools used to articulate environmental functions and values must seem logical to all stakeholders in Hawaii if the results are to be weighed fairly against intuitive responses. Demonstrating 'scientific soundness' of traditional Hawaiian watershed management of the *ahupua'a* may foster a balanced comparison of intuitive beliefs of watershed management versus findings of novel scientific analysis. Science-based projects assessing hydrologic and sedimentation effects of traditional watershed practices may highlight positive contemporary social returns from *ahupua'a* management of intuitive and cultural value thereby warranting a more effective balance of traditional and contemporary approaches to watershed management.

Lesson 6: Deliberative, dynamic and iterative decision-making processes influence the level of stakeholder achievement of consensus.

Iterations and feedback in the process are important as stakeholder knowledge, values, and perceptions change over time (Tversky and Kahneman, 1986). Studies have shown that individuals may decrease their willingness-to-accept compensation for loss of a particular good after several iterations of decision-making (Coursey et al., 1987; Brown and Slovic, 1988). Stakeholders' increased familiarity with the good, which may develop after repeated discussion, may alter stakeholders' valuation of the resource.

Stakeholders may even derive positive results from the process itself even in the absence of a consensus. A long-term study of multi-stakeholder watershed partnerships in California and Washington highlighted several unstated functions: education or knowledge development, defense or advocacy of a particular world-view, social interaction (making new friends or meeting old friends), conflict resolution, as well as the coordination of on-the-ground activities related to partnership objectives (Leach et al., 2002).

'Talking story' (*olelo kuka*) is an integral part of the public process in Hawaii and allows for the expression of viewpoints from a variety of participants, irrespective of the outcome of deliberations. *Malama Hawaii*, a network of concerned citizens, NGOs, private and public agencies formed with the objective of reconnecting Hawaii's people to their rich heritage and inspiring participants to make positive contributions in the areas of environment, health, education, economy, and justice. An essential function of *Malama Hawaii* is to foster social interaction and promote coordination between groups without concern for individual mandates. Positive results from stakeholder interaction may serve to promote future trust-building and consensus for resources that are currently the center of contentious debate.

Scientific studies can provide insight about the public process itself, for example, by examining the characteristics of stakeholders, how their values change over time, the processes influencing such change in values and perceptions, among other aspects. Current research underway in Ohio is utilizing structured elicitation groups to understand whether preferences are static or constructed regarding willingness-to-pay for dam removal (Abdul-Mohsen et al., 2004). Recent surveys in Hawaii have assessed public attitudes toward environmental conservation revealing that a majority of respondents favor protection of natural areas (67%; QRP, 2000) and funding for forests and watersheds (72%; WR, 2001). Future studies in Hawaii may address how values are formed and re-formed in deliberative contexts pushing the social sciences away from the currently static or passive stance toward preference formation to a new era of interdisciplinary research on environmental valuation and decision-making.

4. Conclusions: applying lessons learned to Hawaiian watershed partnerships

Lessons learned from watershed partnerships and co-operative ecosystem management efforts worldwide can provide novel insight to Hawaiian watershed partnerships (see Table 2). First, successful modeling efforts of the fynbos watersheds of South Africa highlight the potential to model Hawaiian watershed dynamics that are directly related to management efforts. Scientific analysis and monitoring of hydrologic, ecological and sedimentation changes from partnership efforts to control invasive species and feral ungulates may reveal gains from management efforts—returns from maintaining or increasing valued ecological goods and services (i.e. groundwater recharge, sediment trapping, and biodiversity). Monitoring and assessment of gains from watershed management efforts can be used to justify actions undertaken, support requests for funding, generate better policy and increase public awareness to mobilize support for partnerships.

Secondly, articulating the societal value of gains from partnership activities will foster full consideration of benefits and costs and allow for critical analysis of tradeoffs such as the decision for continued funding of ecosystem management. Studies of forest practices in Indonesia, river use in Ohio and watershed management in Hawaii all indicate that articulating values in economic tradeoffs fostered consideration of often ignored non-market ecological goods and services into decision-making. However, socio-cultural context dictates what constitutes a common language and the efficacy of utilizing (or not utilizing) certain economic, scientific and/or valuation approaches. At times, qualitative metrics of resource valuation and environmental 'umbrella' indicators that are quantifiable and scalable are more appropriate to articulate watershed management gains.

Thirdly, lack of trust undercuts useful application of scientific input. Case studies at Lake Lanier in Georgia and the Illinois River Watershed in Oklahoma highlight that trust is both a guide and a product of the process of ecosystem management. Scientists working with Hawaiian partnerships must realize any opportunity to contribute to consensus building greatly diminishes with the deterioration of trust among stakeholders. Low trust by stakeholders may lead to stakeholders demanding deliberative processes that

Table 2
Applying lessons learned to watershed management in Hawaii

Lesson	Study[a] (location)	Science fostering consensus and long-term ecosystem management (lessons learned)	Potential application to watershed management in Hawaii
1	Fynbos watersheds (Cape of Good Hope, South Africa)	Science-based modeling can highlight novel dynamic processes of ecosystems and mgmt	Model watershed functions and impacts of mgmt on the flow of ecological goods and services (i.e. hydrologic, ecological, economic)
2	Customary forest mgmt (E. Kalimantan, Indonesia)	Articulating values of customary practices vs. market goods in common metric can promote full consideration of benefits and costs	Articulate watershed values in a common metric; Assess value of customary watershed use vs. market goods
	River corridors (OH, USA)	Estimating non-market value of river functions vs. market goods/services incorporates non-market values into decisions	Estimate the range of ecological non-market goods/services of forested watersheds
	Forested watersheds (Oahu, Maui)	Estimating non-market benefits of watershed and invasive sp. mgmt can aid in rationalizing mgmt efforts	Extend analysis of value of watershed mgmt activities to all islands
3	Lake Lanier (GA, USA)	Lack of trust undercuts application of scientific input	Acknowledge that trust is critical for any useful integration of science
	Illinois River Watershed (OK, USA)	Low trust = deliberative processes High trust = consultative processes	Realization that low trust leads stakeholders to demand more control over analyses and info
4	Khao Yai National Park (Nakhon Ratchasima, Thailand)	Assessing benefits capture can allow for consideration of major disparities between stakeholders' gains from partnership activities	Assess any major disparity in benefits capture from watershed management activities
5	Embarras River Basin (IL, USA)	Intuitive responses and risk perception are as influential as analytical processes[b]	Ensure partnership activities consider the relevance of intuitive responses and stakeholders' perception of risk
6	Watershed management (CA, Washington, USA)	Positive results may be derived from the public process itself even in the absence of consensus	Lack of consensus in partnerships does not infer failure; 'talking story' = social interaction that can foster trust for future consensus

[a] Lessons: (1: Higgins et al., 1997; 2: Sasmitawidjaja, 2001; Hitzhusen et al., 2000; Gutrich and Donovan, 2001; 3: Norton and Steinemann, 2001; Focht and Trachtenberg, 2005; 4: Manopimoke, 2001; 5: Rhoads et al., 1999; 6: Leach et al., 2002).

[b] Also see Finucane et al. (2001) and Slovic (2001).

are highly inclusive and require much participation by stakeholders. In contexts of high trust, stakeholders may be more willing to accept consultative processes, allowing scientists and experts to determine proper analyses and how that information is used, as long as the ultimate decision is justified and approved by the partnerships.

Lessons 4 and 5 indicate that consideration of all relevant stakeholders, their intuitive responses, perception of environmental risks, and potential benefits capture is critical for sustainable watershed management in Hawaii. Illinois farmers of the Embarras River Basin reiterate the point that intuitive responses and risk perception are as influential as analytical processes. Scientific methods used to articulate environmental functions and values in Hawaii must seem logical to all stakeholders if the results are to be weighed fairly against intuitive responses. Use of social scientific approaches such as multi-attribute utility theory and the decision pathways survey technique in Hawaii can aid in the identification of stakeholders' values, social construction of risk and facilitate public participation in both risk assessment and risk management of watershed activities. Significant adverse impacts to local villagers near the Khao Yai National Park highlight the need in ecosystem management for determining who actually captures benefits of 'development' of ecosystems. In Hawaii, social scientists can direct research towards benefits capture from watershed management and indicate disparities among stakeholders that may undercut long-term management efforts.

Finally, iterations and feedback are important as stakeholder knowledge, values, and perceptions change over time in partnerships. Science can foster consensus building in the public process of ecosystem management in Hawaii with further investigations of how values are formed and reformed in deliberative contexts by examining dynamic preference formation among partners and stakeholders. Even in the absence of a consensus, stakeholders may derive positive results from scientific input and the public process such as education, advocacy of a world-view, social interaction, conflict resolution, and co-ordination of activities related to Hawaiian watershed partnership objectives. By facilitating public participation and scientific input in the process of ecosystem management, decision processes become more informed and democratic, the relevance and quality of scientific analysis is improved, and the legitimacy and public acceptance of watershed management in Hawaii is increased.

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