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Essays on Common-Pool Resources: Evaluation of Water Management and Conservation Programs

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Essays on Common-Pool Resources:
Evaluation of Water Management and Conservation Programs

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by

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Abstract

This dissertation is comprised of three essays that examine water management and conservation programs through the context of sustainable development. These essays are distinct case studies of national, state and local policies. Their common approach is that they all use common-pool resources theory to generate specific recommendations for policymaking and water management.

The first essay explores opportunities for developing policy measures to prevent the collapse of the vital irrigation infrastructure in the Aral Sea region. The paper looks at the economic efficiency of various policy options, impacts on the country's agricultural sector, and the regulations needed to make the cost-sharing irrigation system viable. The results define institutional changes necessary to make reforms feasible. The rationale for policy reform is based on the need to (i) facilitate the transition from a centrally planned agriculture to a market-oriented system; (ii) mediate, if not resolve, land tenure and water management issues; and (iii) analyze the importance of the irrigation infrastructure for sustainable agricultural development.

The second essay examines opportunities for integrating conservation in Arkansas water policy. The paper defines institutional factors and rules-in-use as affecting actions at a state level policy for long-term water management. The findings identify the opportunities for integrating conservation in Arkansas water policy, and the need for re-conceptualizing the nature of state policy towards water resources. It proposes to identify goals and strategies, socioeconomic indicators, and resource indicators to determine if the state is moving toward sustainable water resources, as well as to categorize appropriate management tools.

The third essay examines efforts to protect the environment and ensure adequate water to sustain irrigated agriculture in the Bayou Meto Basin, Arkansas. The paper analyses economic

and distributional effects of the project to evaluate the policy outcomes in terms of benefits and costs on different stakeholder groups. The findings show the need for integrated water management and to account for opportunity costs of water, including costs associated with economic and environmental externalities. Kaldor-Hicks tableau displays net benefits and impact on all stakeholders, which can help to identify the right kinds of incentives for stakeholder participation to make the project politically feasible.

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List of Abbreviations

ADEQ	Arkansas Department of Environmental Quality
AGFC	Arkansas Game and Fish Commission
ANRC	Arkansas Natural Resources Commission
AOGC	Arkansas Oil and Gas Commission
APSC	Arkansas Public Service Commission
ASWCC	Arkansas Soil and Water Conservation Commission
AWP	Arkansas Water Plan
BCR	Benefit-cost Ratio
BISA	Basin Irrigation System Authority
BMWMD	Bayou Meto Water Management District
CGWA	Critical Ground-water Area
CPR	Common-pool Resources
FAPRI	Food and Agriculture Policy Research Institute
GDP	Gross Domestic Product
HME	Hydrological Melioration Expedition
IAD	Institutional Analysis and Development
IPA	Improvement Project Area
ISA	Irrigation System Authority
IWRM	Integrated Water Resources Management
KHT	Kaldor–Hicks Tableau
MAWR	Ministry of Agriculture and Water Resources
MB	Marginal Benefit

MEC	Marginal Externality Cost
MPC	Marginal Private Cost
MSC	Marginal Social Cost
NED	National Economic Development
NER	National Ecosystem Restoration
NRCS	Natural Resources Conservation Service
O&M	Operation and Maintenance
OMB	Office of Management and Budget
PPP	Public-private Partnership
PSA	Pump Station and Electrical Communication Authority
RWDD	Regional Water Distribution District
UACES	University of Arkansas Cooperative Extension Service
UNDP	United Nations Development Programme
USACE	United States Army Corps of Engineers
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UZS	Uzbekistan National Currency *Soum*
WMA	Wildlife Management Area
WUA	Water Users Association

List of Published Papers

Paper 1: Bektemirov K.K. (2012). Common-Pool Resources Management: Needs Assessment for Irrigation Policy Reform in the Aral Sea Region. *Southwestern Journal of Economics, 11(3)*, 86-99.

Paper 2: Bektemirov, K.K. and Wailes, E.J. (2012). Integrating Conservation in Arkansas State Water Policy. *Journal of Soil and Water Conservation, 67(3)*, 80A-83A. doi: 10.2489/jswc.67.3.80A

Paper 3: Bektemirov K.K., and Wailes E.J. Integrated Assessment of Welfare and Distributional Effects of the Bayou Meto Basin Project in Arkansas (Accepted for presentation at the Soil and Water Conservation Society's 72nd International Annual Conference, July 30-August 2, 2017 in Madison, Wisconsin).

Chapter I. Introduction

The overarching theme of this dissertation is investigation of common-pool resource policy for water management and conservation programs. This work contributes to the public policy debate and to our understanding through the context of economic development and the environment. The substantive policy areas for my research are agricultural policy, environmental policy, natural resources management and community development. By grounding myself in regional economics and combining my training in public policy, as well as my interests in sustainable development and natural resource management, I have conducted research that is interdisciplinary in nature, and relevant to current policy issues.

This dissertation is accomplished using a three-essay format. By incorporating case studies and institutional and benefit-cost analyses, the dissertation brings a well-rounded approach to the study of public policy issues associated with common-pool resources. The introductory chapter summarizes the literature on open-access common-pool resources, describes the research problem, provides background information, and reviews the study design and data sources. The following three chapters are case study analyses of regulation of common-pool water resources at national, state, and local levels. Essay 1, titled "Common-Pool Resources Management: Needs Assessment for Irrigation Policy Reform in the Aral Sea Region" is a national level policy analysis. Essay 2, titled "Integrating Conservation in Arkansas State Water Policy" is a state level policy analysis. Essay 3, titled "Integrated Assessment of Welfare and Distributional Effects of the Bayou Meto Basin Project in Arkansas" examines national-state-local partnerships addressing a common-pool resource problem in Arkansas. The final chapter summarizes the general themes of essays analyzing common pool resources, policy implications, limitations of the study, contribution to the literature, and suggestions for future research.

Literature Review

Overdrawing of critical aquifers and irrigation resources, depletion of valuable fisheries, and dumping of pollutants into the air are examples of common pool problems. Unfortunately, many of these open-access problems persist, and the discussion here suggests why that is the case. Throughout this chapter, the terms common pool, commons, and open access are used interchangeably. According to Elinor Ostrom (1990), a common-pool resource is a "…natural or man-made resource system that is sufficiently large to make it costly (but not impossible) to exclude potential beneficiaries from obtaining benefits from its use" (p. 30). However, John Baden (1998) defines common-pool resources as "resources for which there are multiple owners (or a number of people who have nonexclusive rights of use to the resource) and where one or a set of users can have adverse effects upon the interests of other users" (p. 52).

Common-pool resources often require some type of regulation of access and use to avoid wasteful exploitation. H. Scott Gordon (1954) examined the economic theory of natural resource utilization by considering a single, open access fishery to illustrate the problem of overuse (Gordon, 1954). Garret Hardin (1968) put forward the notion that in situations where there are no effective institutions for managing common-pool resources there will be a "free for all" and the resources will quickly be depleted, to the detriment of all users. Hardin's theory became the basis for how scholars (mostly ecologists) thought about common-pool resource management and distribution. It proved, through what is known as the Prisoner's Dilemma (Flood, 1952) that in instances where there are no institutions (formal or informal) governing resource use, there is a lack of trust among, and a lack of knowledge among users of their fellow resource users' motives. In such cases individuals will forgo possible yet uncertain long-term stability and limit

access to a common-pool resource (through the formation of an institution) in favor of maximizing certain, yet lesser, short term gains.

Following a set of assumptions about self-interest, communication, and resource ownership, Hardin (1968) modeled a case where strategic actors' rational decisions led to collective ruin. Hardin's solution to the tragedy of the commons is coercive regulation of individual behavior - "mutual coercion, mutually agreed upon" to escape the "horror of the commons" (p. 1247). And he notes, but does not develop, the critical problem of regulating the commons - distributional outcomes that are not acceptable to key parties. He asserts, however, that "injustice is preferable to total ruin." But total ruin is not so obvious to all parties in many common-pool settings. The parties often disagree with the timing and appropriate form of intervention, and they object to the allocation of the costs and benefits associated with regulating the commons. These concerns raise the transaction costs of reaching agreement on the commons problem, affecting both the timing and nature of the action taken.

A few years earlier, Olson's (1965) analysis of interest group formation had pointed to similar problems associated with individuals acting collectively, even when they have shared interests. Both seminal works suggested a pessimistic view of the likelihood that individuals can manage their own affairs effectively in the context of shared resources. Hardin's argument, in particular, that an outside central authority was needed to impose sanctions on individual strategic behavior led to calls for greater government control over resource management (Ophuls, 1973; Heilbroner, 1974; Carruthers and Stoner, 1981). Other scholars argued that successful natural resource management would require free market mechanisms (Smith, 1981; Baden and Stroup, 1981). The questions for debate among scholars then became: what are the best means of managing these resources? And, should the responsibility for managing them

remain in public or private hands? Some scholars have claimed that only governments have the ability to effectively regulate common-pool natural resources, and protect them for all users. According to Wittfogel (1957), a centralized, and indeed despotic power, is needed to build and operate large-scale infrastructure.

According to Ostrom (1990), if a common resource is accessed locally by a comparatively small number of parties with similar or generally homogeneous objectives and production costs, then the problem of overuse often can be effectively addressed through informal rules or norms that constrain individual actions. Under these circumstances it can be relatively easier for a small group of similar people who have a history of interaction with one another to gather and interpret information about the resource's status and to agree upon the types of uses and constraints necessary to conserve it. They also can accept the distribution of the costs and benefits (and ultimately, of wealth and political power) within the community that is inherent in any definition and assignment of use privileges, even under informal arrangements. Community management of regional agricultural irrigation water, pastures, or inshore fisheries provide examples of successful mitigation of the losses of the commons.[1]

Economists, most notably Elinor Ostrom (1990), contend that common-pool resources (CPR), regardless of the size of their infrastructures, are often times better "operated" when they are controlled directly and collectively by the users of the resources, rather than by remote, central government bureaucrats. What is meant by "better" is that the resources are allocated more equitably, used more efficiently, and hence the long-term sustainability of the resource is

[1] Ostrom (1990) provides a theory and empirical evidence regarding successful local collective action to address common-pool resource problems. Experiments and more field studies are included in Ostrom et al. (1994). Other case studies and conceptual arguments are in the readings included in McCay and Acheson (1987); Ellickson (1991); Hess (1996); Burger et al. (2001); and Ostrom et al. (2002).

ensured. Efficiency of use can be defined in two ways. First is the idea that when resource users realize the scarcity of a resource, they voluntarily impose rules and regulations governing its use. They accept the fact that they must contribute in some form or another for the privilege of access to the resource. They will use only the minimal amount necessary, and thus reduce the amount of production costs and/or maximize net returns. Second is the idea that when resources are managed directly, operation and/or transaction costs go down. This is because the government, which is regarded as an unnecessary third party, is not present to interfere with direct, one-to-one bargaining and negotiation among users, thereby reducing transaction costs. Ostrom (1990) and those who have followed in her footsteps believe that user organized institutions, based on trust and cooperation, are inherent to common pool resources, and must be allowed to develop, be defined and formalized, and thus strengthened and empowered by users.

The body of literature drawing on CPR theory shows that common property institutions are socially-constructed systems of norms and rules that allocate rights, limit access, and regulate the use of commonly held resources. Resource users hold clear and secure rights to resources, and overarching rights and management decisions are vested in the group of users as a whole; both rights and responsibilities for joint use are specified, and non-compliers are sanctioned (Bromley, 1992; McCay and Acheson, 1987; Oakerson, 1992; Ostrom, 1990; Runge, 1992). According to McKean (1996), in this way common-property institutions can "make resource protectors out of potential resource destroyers, and offer us a way to reap the advantages of private property rights on resources without parceling resources that are most productive when kept intact" (p. 227).

Ostrom et al. (1994) provided substantial insight into regularities of human action for small-scale CPRs whose sustainability was salient to the community of resource users. Since

then numerous scholars have extended Ostrom's ideas to larger, more complex CPRs such as aquifers shared by many users, ocean fisheries, forest ecosystems, and global climate. Dolsak and Ostrom (2003) include empirical and theoretical results from studies of complex, large-scale CPRs embedded in economic, political, and legal environments. Leach and Pelkey (2001) found support for several variables from the Institutional Analysis and Development (IAD) framework to be important contributors to successful well-defined decision rules. These include adequate technical information, leadership by local stakeholders, recognition by external authorities of the users' right to self-organize, an ambitious scope, and a focus on specific, tangible issues. The IAD framework emphasizes physical attributes, community attributes, and rules-in-use as affecting actions and patterns of interaction, which ultimately affect outcomes (Ostrom et al. 1994).

These theoretical links recognize the multiple-scale, diverse, complex nature of many important CPR systems today. Several of these items center on users as the primary decision-makers rather than institutionalized management. However, the management authority over many CPRs is not vested primarily in those who use the resources. Instead, government regulatory authority at the national or state level may play a dominant role in establishing rules affecting the CPR. In contrast, resource users may have substantially less authority, and their ability to change rules may be indirect, accomplished, if at all, through communicating with government officials who set the rules. Furthermore, shifting from "users" who directly use a CPR to "stakeholders" with an interest in the CPR complicates questions about who should and does have a say in management. For example, a CPR may be used intensively by some individuals or groups, but less intensively by others, who perhaps live far away and are not engaged in regular communication with other users. Thus, the stakeholder community may not

constitute a social community in the sense of frequent interactions or shared geographic space. In such cases, governmental actors might take a central role in coordinating input from a diverse array of stakeholders and ultimately be responsible for making decisions about managing the resource. Such an arrangement represents not user self-governance, but rather mediated governance through government officials who are not the primary resource users.

Success and failure in solving commons problems have been widely studied for local surface irrigation systems, among others, especially in Asia (Ostrom, 1992; Wade, 1994; Lam, 1998). However, the focus of these studies has not been on aquifer management. Indeed, studies of self-governance for whole aquifers are not common, but this is changing rapidly (Schlager, 2007; Lopez-Gunn, 2009). Cases from California show that sustainable groundwater management can be achieved utilizing collective action (Blomquist, 1992). Although groundwater plays an important role for domestic use, its major share is devoted to agricultural activities. The United States, China, India, and Pakistan together account for more than 75% of the total reported groundwater extraction for agriculture (Moench, 2004). This illustrates the importance of research such as this.

Aquifers are a source of relatively inexpensive, reliable irrigation that can be developed by individuals once either technology or energy is accessible (Schlager, 2007). Aquifer's subtractability and low excludability characteristics lead to the so-called tragedy of the commons, that is, the environmental degradation that occurs whenever a large number of individuals share a subtractable resource (Theesfeld, 2010). However, Feeny et al. (1990) show that it is the "tragedy of open access" that matters. In regions where depletion of groundwater is in progress, either minimally enforced rules related to withdrawing resource units lead to de

facto open access regimes, or unrestricted open access has been the general rule (Giordano and Villholth, 2007). This study intended to demonstrate this for Arkansas.

As Vincent Ostrom (1962) stated, “Few areas of American political and economic experience offer a richer variety of organizational patterns and institutional arrangements than the water resource arena” (p. 450). In Arkansas, special governmental districts provide basic public services, including supply of water for both urban and agricultural uses. Such districts, described as “quasi-governmental,” have special or limited powers. According to ANRC (2011), the Arkansas Irrigation, Drainage and Watershed Improvement District Act authorizes “the acquisition by purchase, lease, gift or condemnation of water rights and all other properties . . . and all other rights helpful in carrying out the purposes of the organization of the district” (p. 26). The governing boards of such districts are authorized to make regulations for “the delivery of water owned or acquired by it to users. . .” (ibid, p. 27).

In Arkansas, the 1957 Regional Water Distribution District Act allows creation of a nonprofit regional water distribution district (RWDD) with authority to participate in Congressional projects. These districts were originally used to supply water for municipal and industrial uses. However, this Act has also been used to create districts for the specific purpose of supplying agricultural water (ANRC, 2011). As result, there are approximately thirty RWDDs formed under this Act in Arkansas. Because the primary purpose of the Act was water distribution, the only authorized source of district revenue was the sale and distribution of water. However, in 1995, the General Assembly authorized the districts to levy assessments. A district is now authorized to develop improvement project plans for improvement project areas within the district (ANRC, 2011). If the improvement plan is approved by the Arkansas Natural Resources Commission (ANRC) and by the circuit court which originally established the water

district, an assessment of benefits accruing to land with the improvement project area is made and a tax may be levied against the benefited land to pay for the costs of works of improvement for the supplying of irrigation water.

Research Problem Definition

The historical and contemporary record of common-pool resources is not a happy one. Multiple users each have incentive to deplete shared water resources in the regions that I am interested in -- the Aral Sea region of Uzbekistan and the Arkansas Delta region of the United States. I investigate factors that drive the demand for water by irrigated agriculture and other sectors in these regions through the lens of common-pool resources theory, and evaluate policy options to sustain socio-economic development and preserve the environment in these regions.

The shrinking of the Aral Sea in Central Asia is considered one of the planet's worst environmental disasters. Formerly one of the four largest lakes in the world, the Aral Sea has been steadily shrinking since the 1960s after the rivers that fed it were diverted to irrigate crop production in the region (Bektemirov and Rahimov, 2001). The implication of this human alteration of the environment is that certain characteristics of the region account for the dramatic consequences since the canals were dug. Those consequences range from unexpected climate feedbacks to public health issues, affecting the lives of millions of people in the region.

Water resources in Arkansas, particularly the groundwater in eastern and southern parts of the state, are under pressure from increased usage for crop irrigation. Arkansas supports about 4.5 million acres of crop production under irrigation, including water demanding crops such as rice and cotton. Groundwater is 73% of the total water used in the state of Arkansas, and the state is the fourth largest user of groundwater in the United States (Schaible and Aillery, 2012).

The eastern central part of the state is experiencing depletion of the Mississippi Alluvial and Sparta aquifers due to pumping at unsustainable rates (ANRC, 2016).

I believe that these cases are examples of common-pool problems where multiple users each have an incentive to deplete a shared resource. A central research question surfacing in the wake of the water crises in these regions has been: how do specific combinations of rules, regulations and policies affect the incentives of stakeholders for resource use in different institutional settings? It is hoped that the study will enhance our understanding of the intended and unintended consequences of farm, food, and environmental policies that can affect the water supply, environmental quality and economic conditions in these regions.

Research Goal, Design and Data Sources

The goal of this study is to explore the institutional aspects of policy implementation on sustainable qualitative and quantitative water use by, first, taking into account the attributes of CPR and, second, undertaking a systematic review of well-documented policies. As such, this research is inspired by the idea of the nested multitier framework developed by Ostrom (2007), which considers the attributes of a resource system, the resource units generated by that system, the users, and the governance systems that affect the outcomes. In this context, the resource system might be an irrigation system with a certain amount of water to be extracted, the latter defined as the resource unit. This study explores the factors leading to better governance as it develops new institutional insights in policy implementation by a joint consideration of ecological and socio-political characteristics.

Research design incorporates a case study method to examine important questions associated with regulatory policy. I consider the approach suggested by Agrawal (2001) to

research design and construction of causal mechanisms relevant to institutional arrangements to manage water resources as CPR. I believe that a case study approach can provide deeper insights into processes and background influences on local community level resource management. I employ the embedded single case study design suggested by Scholz and Tietje (2002) and Yin (2003) to develop the research strategy based on certain critical areas in Uzbekistan, as well the designated Critical Groundwater Use Areas and specific water projects in Arkansas. Also, I utilize qualitative inquiry as a complement to quantitative examination of national and state level policies.

This dissertation is prepared in a three-paper format. In the first paper, entitled "Common-Pool Resources Management: Needs Assessment for Irrigation Policy Reform in the Aral Sea Region" I explore opportunities for developing policy measures to prevent the collapse of the vital irrigation infrastructure in the Aral Sea region by examining agriculture irrigation through the lenses of CPR theory. The study draws on the data from surveys and socioeconomic information obtained in the region, as well as from other data sources and publications. I utilize quantitative and qualitative methods to investigate how farmers maintain irrigation infrastructure and use water resources in their environment. The research framework that I utilize for this study includes the IAD and social capital theories. Using data obtained from government agencies and collected through a water cost-sharing program study in Uzbekistan, I investigate the impact of social capital on the conditions of economic capital (irrigation infrastructure) and natural capital (water resources) for a cohort of farmers.

Based on these data, I assess options for a national program in public sector and private sector cost-sharing investment and management for irrigation water supply in Uzbekistan. Potentially such a program can be a win-win situation for both the government and farmers, and

can benefit the environment by creating incentives to seek better investments in water saving technologies. Once assured of proper irrigation system operations resulting in sustainable production levels, farmers would assume more responsibility over agriculture and water management. At the same time, government costs could be reduced so it could share the "gains" from water cost-sharing with the farmers by adjusting the existing state controlled procurement system. The paper looks at the economic efficiency of various policy options as well as impacts on the country's agricultural sector and the regulations needed to make the cost-sharing irrigation system viable. The results identify the institutional changes necessary to make reforms feasible. The rationale for policy reform is based on the need to (i) facilitate the transition from a centrally planned agriculture to a market-oriented system; (ii) mediate, if not resolve, land tenure and water management issues; and (iii) recognize the importance of the irrigation infrastructure for sustainable agricultural development.

In the second paper, we examine the state regulation of water usage by different sectors in Arkansas through the statewide water planning process. Water allocation, reserved uses, and allocation preferences in the State of Arkansas are analyzed. Regulated riparianism is the water allocation arrangement in Arkansas, which treats groundwater as a natural resource that must be publicly managed (Dellapenna, 2002). In considering management strategies for water, both surface and groundwater need to be evaluated together because they are commonly interlinked. Involvement of multiple agencies in water management creates implementation problems because one agency's actions conflict with those of another. These conflicts involve public policy concerns as well as the interests of the particular parties that may be competing over available water. The existing legislative and institutional frameworks for sustaining water

quantity and water quality in the State of Arkansas are defined and explanations for institutional challenges in the management of water resources are provided.

The Arkansas Water Plan (AWP) update process provides opportunities for integrating conservation in state water policy, involving exploration of policy issues to determine the role of the state in the management of water resources, re-conceptualizing the nature of state policy towards water resources. For complete revision of the AWP, we identify goals and strategies, as well as socioeconomic and resource indicators to determine if the state is moving toward sustainable water resources, as well as to categorize appropriate management tools. Analysis of public water supply in Arkansas indicated that just a few cities are implementing inclining block rates, under which consumers have an incentive to conserve water. Meantime, the majority of analyzed municipalities implement declining block rates, which are regarded as non-conservation pricing mechanisms. There is a need for coordination of water utilities to implement a conservation-oriented rate structure for different water-use sectors through state agencies such as ANRC and Arkansas Public Service Commission (APSC).

In the third paper, we assess the federal-state-local partnership efforts to protect and conserve water in the Bayou Meto Basin in Arkansas. The Bayou Meto Basin is a highly productive area for both agriculture and waterfowl. Located in east central Arkansas, it extends from northeast Pulaski County through Lonoke, Prairie, Jefferson, and Arkansas counties. Agriculture accounts for most of the economic activity in the Bayou Meto Basin: it traditionally generates approximately one-tenth of the six billion dollars in revenues generated statewide by the agricultural industry (Popp et al., 2005). Irrigation is essential for maximum crop production in this region. The Mississippi River Valley Alluvial Aquifer (also called the Alluvial Aquifer) is the principal source of water for irrigation. The ground water supply is declining rapidly and

the only other sources are rainfall and runoff captured in on-farm reservoirs, although some farmers have access to lagoons and streams. Crop yields and the agribusiness interests of the area that have interest in crop production will be adversely impacted as irrigation declines. Crop yields are lower and much more variable under dry land farming conditions compared with irrigated farming.

The consequences of aquifer depletion can be limited by providing a supplemental source of irrigation water, thereby maintaining the aquifer at a level which would allow for a sustained yield. A potential solution to eastern Arkansas' groundwater problem could be the development of alternative water supplies. The Federal and state governments proposed to construct the Bayou Meto Basin project, which includes a system of irrigation canals and pipes to bring surface water to farmlands in the area as alternative to groundwater for crop irrigation. This evaluation of the Bayou Meto Project expands upon an economic assessment of the on-farm analysis conducted by the Army Corps of Engineers (USACE, 2007). The reassessment of the on-farm benefits and costs increased the benefit-cost ratio (BCR) from 1.10 to 1.25 (Wailes and Young, 2005). Implementation of this project is essential to sustain irrigation in parts of the five counties that are included in the Bayou Meto Basin. Continued degradation of wildlife habitat will occur without the project. This research finds that the project can provide economic and environmental benefits to sustain irrigated agriculture and wildlife habitat in the project area.

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Chapter II.

Common-Pool Resources Management: Needs Assessment for Irrigation Policy Reform in the Aral Sea Region

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Abstract

This paper explores opportunities for developing policy measures to prevent the collapse of the vital irrigation infrastructure in the Aral Sea region by examining agriculture irrigation through the lenses of the common-pool resources (CPR) theory. The study draws on the primary data from surveys and socioeconomic information collected in the region, as well as secondary sources. The paper proposes a national program in public sector and private sector cost-sharing investment and management for irrigation water supply in Uzbekistan. Potentially such a program can be a win-win situation for both the government and farmers, and can benefit the environment by creating incentives to seek better investments in water saving technologies. Once assured of proper irrigation system operations resulting in sustainable production levels, farmers would assume more responsibility over agriculture and water management. At the same time, government costs could be reduced so it could share the "gains" from water cost-sharing with the farmers by adjusting the existing state controlled procurement system. The paper looks at the economic efficiency of various policy options, impacts on the country's agricultural sector and the regulations needed to make the cost-sharing irrigation system viable. The results define institutional changes necessary to make reforms feasible. The rationale for policy reform is

based on the need to (i) facilitate the transition from a centrally planned agriculture to a market-oriented system; (ii) mediate, if not resolve, land tenure and water management issues; and (iii) analyze the importance of the irrigation infrastructure for sustainable agricultural development.

Introduction

Central Asian economies and their national living standards rely heavily on agriculture. Because of the region's arid climate, agriculture is totally dependent on irrigation. With a population of more than 28 million in 2010, the Republic of Uzbekistan is the most populous country in Central Asia. Total area of Uzbekistan is 448,900 km^2, but only about 10% of it is arable lands (UzComStat, 2010). The country withdraws more than 50 km^3 of water annually, which is about a half of the total water resources available in the Aral Sea basin (Dukhovniy and Sokolov, 2003). While the irrigated acreage appears relatively small within the context of overall land utilization, irrigation in fact accounts for 90% of all water use in the country. According to the World Bank, the 2010 GDP of Uzbekistan is estimated at US$ 39 billion, of which 45.1% is generated in services, 35.4% in industry, and 19.5% in agriculture (World Bank, 2011). However, many sectors of the national economy are related to agriculture, and the majority of population lives in rural areas and rely on agriculture for their livelihoods.

The dramatic decline of the Aral Sea is one of the biggest environmental disasters in the world, and is often highlighted as a classic case study in the impact of water scarcity (Micklin, 1988). The Aral Sea's decline was the consequence of agricultural expansion in Central Asia, which diverted the waters of Amudarya and Syrdarya rivers using the large-scale irrigation projects built in 1960-80s. Uzbekistan was designated as the former USSR's main cotton producer, and cotton was grown on about 60% of all sown land. Because of this designation,

Uzbekistan became the world's fifth-largest producer and second-largest exporter of cotton. Since its independence in 1991, Uzbekistan has adopted a gradualist state-led development approach, in which features of an open-market economy are introduced to the existing command-administrative economy in a step-by-step manner. Agricultural lands in Uzbekistan are owned by the state, and land plots are leased to farmers for a long term (up to 49 years) or heritable use. However, the land tenancy rights can be cancelled if farmers do not fulfill production agreements three years in a row (Abdullaev, Fraiture, Giordano, Yakubov, and Rasulov, 2009). The Uzbekistani farm sector produces 3.5-3.7 million metric tons (MT) of unprocessed cotton per year, which after ginning yields 1.0-1.2 million MT of raw fiber, and about 80% of that is exported. Chapagain, Hoekstra, Savenije, and Gautam (2005) estimates that each year Uzbekistan exports essentially the entire runoff to the Aral Sea basin in the form of the virtual water embedded in the cotton trade. Even if this is an overestimate, the implicit suggestion is that a reduction in cotton exports and the production behind them might free some more water to supply the Aral Sea.

The water sector of Uzbekistan consists of 10 Basin Irrigation System Authorities (BISAs), a number of large water facilities, pump stations' cascades, etc. All water organizations are state owned, their operations are financed from national budget through the Ministry of Finance and managed by the Ministry of Agriculture and Water Resources (MAWR) of Uzbekistan. Among the budget funds allocated to economic sectors financing of water sector takes about 60% without capital investments. The capital assets of all operational water organizations in Uzbekistan are valued at 550,944 million *soums* (UZS)[2], and their aggregate

[2] National currency of the Republic of Uzbekistan, UZS. The official exchange rate was around 1,600 UZS = 1 USD in August 2005

costs are UZS 179,326 million per year (Abaturov and Shadybaev, 2003). Annual government expenses for agriculture amount to more than US$ 258 million, while the water sector financing consists of 6–8% of gross spending of the national budget for the economy (USAID, 2005). Budget shortages during the period of transformations are making it difficult for the MAWR to maintain quality service and continue to invest in the infrastructure development of the irrigation system. According to expert estimates, the water sector is underfunded by 65-70% (USAID, 2005). As a result, more than half of irrigated lands have no hydro-melioration (drainage) systems, while the depreciation period of existing systems have expired. Due to the shortage of financial resources to maintain the water facilities, the irrigation system has been deteriorating and water delivery has become a serious challenge (Abdullaev et al., 2009). Therefore, the government's role in agriculture, and particularly, in the management of irrigation water, needs major policy change.

The rest of the paper is organized as follows: Section 2 provides a brief review of the literature. Section 3 presents the research design and data collection methods. Section 4 examines the relative affordability of various policy options in economic terms, demonstrating how a particular BISA and the national irrigation system would function. Section 5 illustrates the strategy and institutional arrangements needed to make the system viable. Section 6 provides the main conclusions, and Section 7 references.

Review of the Literature

This section presents an overview of the literature and analysis of the potential for water user participation in irrigation management and more generally of agricultural policies, which impinge on user participation in Uzbekistan.

The Aral Sea desiccation resembles the "Tragedy of the Commons" model described by Garret Hardin (1968). According to Godwin and Shepard (1977), the tragedy of the commons presents a dilemma that "results from an incentive structure in which the benefits to an individual who increases his use of the resources exceed the costs to him even though the sum of the benefits of the action to all users is less than the sum of the costs to all users" (p. 231). Some scholars have claimed that only governments have the ability to regulate effectively common-pool natural resources and to protect them for all users (Keohane, Revesz, and Stavins, 1998). Other scholars have concluded that common property resources require public control if economic efficiency is to result from their development. This scenario provides a context for understanding policy problems that involve collectively-owned goods such as irrigation water, grazing land, fisheries, and etc. The policy advice to centralize the control and regulation of these kinds of resources had been followed extensively in the former Soviet Union. In the area of irrigation water management, this theory was supported most notably by Karl Wittfogel's "hydraulic state" thesis. Wittfogel (1957) argued that only "centralized, and indeed despotic power, is needed to build and operate large-scale infrastructure" (p. 101).

Ostrom (1990) contends that CPR, regardless of the size of their infrastructures, are often times better operated when they are controlled directly and collectively by the users of the resources, rather than by remote, central government bureaucrats. What is meant by 'better' is that the resources are allocated more equitably and used more efficiently, and hence the long-term sustainability of the resource is ensured. Efficiency of use can be defined in two ways. First is the idea that when resource users realize the scarcity of a resource, they voluntarily impose rules governing its use. The users accept the fact that they must contribute in some form (e.g. money, labor or services) for the privilege of access to the resource. The users will use only

the minimal amount necessary and thus reduce the amount of their subsequent production costs. Second is the idea that when resources are managed directly, operation costs go down. This is because the government, which is regarded as an unnecessary third party, is not present to interfere with direct, one-to-one bargaining and negotiation among users.

The theory that decentralized user management is both more efficient, equitable, and cost-effective finds support in many real-world cases over the past twenty years, particularly with regard to irrigation management. International development and donor organizations such as the World Bank, UNDP, and USAID have put the theory into practice. They have worked with national governments to enact policies and programs which have shifted control over irrigation structures from national water ministries to users. Countries commonly cited as examples of the successful transfer of irrigation water management are diverse and include Mexico, the Philippines, Egypt, Pakistan, and Nepal. The impacts of these management transfers are generally regarded as positive, in terms of improved irrigation water efficiencies and equities.

In Uzbekistan, the agriculture and water resource sectors in general, and irrigation management in particular, is the responsibility of national government. Because the country depends on cotton to earn "hard currency", government uses the "state order" procurement system to engage farmers in the cash crop production. Government subsidizes costs of inter-farm irrigation and drainage services[3] in exchange for cotton and wheat procured at low prices. The subsidized water that could be used to grow other profitable crops is provided as a means of compensation to farmers for growing cotton. Under the "state order" system farmers have little interest in saving water; therefore, about 70% of water is being lost before it reaches the fields through on-farm and inter-farm irrigation systems or is wasted in drainage. On average,

[3] Introduced in 1997 subsidized fee for irrigation water is between 0.01 - 0.02 USD/m^3

Uzbekistan's irrigation system operates at 25-30% efficiency, whereas well-managed irrigation systems in arid regions of the world run at about 70% efficiency (Postel, 1996). The water efficiency problems in Uzbekistan are related to its poor management and the resulting impact of poor management on the quality of land resources. Around US$ 2 billion is needed for the rehabilitation of irrigation and drainage systems in Uzbekistan (World Bank, 2003).

The efficient flow of water through an irrigation system to a farmer's field depends not only on the system's physical structures, but also on economics, institutions and social structures that facilitate the construction, operation, and maintenance of the physical structures. Economic theory suggests that water is efficiently used when the incremental benefits generated by another unit of water is exactly equal to that unit of water's incremental cost. Many articles, books and reports are available describing the economic theory of water resources management.[4] The basic premises of most of these works are (1) that incentives to efficiently manage water resources are critical to farmer participation; (2) that institutions affect the way in which and the extent to which farmers participate; and (3) that efficient management of large-scale irrigation systems is a complex and difficult task, with many alternative approaches.

The primary factor in efficient water use is the relationship between benefits generated by water availability and the costs associated with making the water available. Most of the literature on the economics of water management focuses on the pricing of water. For example, Johansson (2000) states that "…getting the prices *right* is the…" principal problem in water economics (p. 7). Discussions of setting water prices or tariffs are abundant. Much of this discussion revolves around how to price water – that is, the pricing approaches which could be used and how each meets the standards of economic efficiency. Moreover, water conservation is

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[4] See Dinar (2000) for a good summary of studies of water management in irrigation systems.

an important part of efficient water management, and pricing usually provides users with the incentive to conserve water, while subsidies encourage inefficiencies.

The methodologies used to calculate the water charges are as varied as the prices themselves. Most irrigation water pricing reflects much less than full cost recovery and probably less than operation and maintenance (O&M) costs, although the specifics of any case are often difficult to determine. In many countries subsidized agricultural water is viewed as one way to assure self-sufficiency (or at least food security in a more limited sense). It is argued that the country's citizens benefit from irrigated agriculture and therefore government should subsidize the water. Moreover, most countries are, to one degree or another, committed to making farming sustainable for rural populations and are, as a consequence, reluctant to charge full cost for large scale irrigation development.

Most economic analyses of water delivery systems distinguish between cost allocation and cost sharing. Cost allocation is the distribution of costs among users in a system in such a way that they will pay the total cost (or at least the total O&M costs) of the system. Cost sharing, on the other hand, is the assignment of costs to users without the requirement that total cost be assigned. Therefore, cost sharing refers to water pricing in which only a portion of the full cost of the project or service(s) are borne by the user. The proportion of total costs which are covered is variable, and there is no firm "rule" about selecting that proportion. Moreover, in many cost sharing schemes, it appears that agriculture has not been assigned responsibility, not even for its "separable" cost,[5] which implies that there are significant cross subsidies in the pricing (Tsur, Roe, Doukkali, and Dinar, 2004).

[5] Costs, which can be identified as providing the service(s) to one user or group of users.

In most large-scale irrigation projects around the world, the O&M and replacement costs are shared by farmers and the public at large, which is represented by the government. The extent to which farmers bear the burden of these costs depends on many factors, including economic and financial characteristics, institutional settings, and operational characteristics of the system. The manner in which costs are "shared" varies from farmer ownership of and responsibility for the entire system to fully centralized management (Perry, 1996). Over the past twenty years, increasing costs of system development and maintenance, coupled with globalization of competitive markets for agricultural products, have forced governments to look to users for increasing financial participation. Economists often argue that the efficient use of resources, including water, is accomplished through this "devolvement" of responsibility.

Water cost-sharing between users and government is a major feature of irrigation delivery in many countries. In some countries it is implemented through a direct user taxation process, the proceeds from which are then transferred to the government central treasury for further reallocation to the water delivery authority. The common trend in recent years in many developing countries is to transfer management and operations to users, including costs for operations and maintenance and delivery, so that government expenditures can be reduced at the same time ensuring that the funds farmers pay are put to direct use. Ostrom (2005) found that trained Water User Associations (WUA) are able to perform many of the O&M functions at lower cost and with higher quality than government agencies.

Research Design and Data Collection

This research is designed as a structural analysis of agriculture and water sectors, and a case study of a typical BISA in Uzbekistan. This section is based on the data collected by the

author for the Uzbekistan water cost-sharing project (USAID, 2005). In order to introduce water charges, the costs associated with making the water available have to be determined. In theory, water charges can be determined using national statistical data on average expenses of the water sector. In conditions of Uzbekistan, the current expenditures for operational water structures financed through MAWR could be used for such a calculation. For example, the total amount of operational expenses of water sector divided by the total volume of water supply or by the area irrigated land during a year would give us an average cost for water supply in Uzbekistan. It could be used as a uniform tariff on irrigation water delivery per 1 m^3 of water or per 1 hectare of irrigated area within the country. However, the national level uniform pricing of water services would not take into account sectoral and regional differences, and cannot reflect important specific interests of different target groups. Therefore, in order to make the study feasible, all operational water organizations in Uzbekistan are analyzed by classifying them into the following five groups:

1) BISAs, consisting of several Irrigation System Authorities (ISA);
2) Authorities of large water structures, consisting of reservoirs, barrages, pump station cascades, etc., including structures at the Fergana Dispatch Center;
3) Authorities of Pump Stations and Electrical Communications (PSA);
4) *Viloyat* [6] Hydrological Melioration Expeditions (HME), and,
5) Other organizations, including the Water Inspectorate.

These water sector organizations have different expenses depending on regional circumstances. According to data compiled for this study, operational expenses for PSA, large

[6] Administrative-territorial unit or province

water structures, HME and water enterprises of BISAs vary substantially by regions. Therefore, it would be appropriate to differentiate payments for water by the distinct costs of water delivery in various regions of the country. In order to estimate irrigation charges, the following five options of cost sharing between the government and water users are considered:

1. Payment for operational costs of all water structures by water users, assuming the possibility of discontinuation of the state budget financing;
2. Payment from the state budget for expenditures for machine irrigation operation, i.e. operation of pump stations, while all other expenses are covered by water users;
3. Payment from the state budget for operation of large water structures and land reclamation, while all other expenses, including pump stations are paid by users;
4. Payment by water users for operation of water structures affiliated with BISAs, including personnel; while all other organizations to be financed by the state budget;
5. Payment by water users only for local irrigation systems by which they are served, with subsidies from the state budget to cover other water organizations.

Each of these options has different implications for savings to be created in the state budget and for burdens to be imposed on water users. Therefore, a cost-benefit analysis of these water cost-sharing scenarios is undertaken. In-depth interviews, focus group discussions and a national survey are implemented to identify feasible and sustainable policies on irrigation water delivery for five different regions of the country (Table 1).

Table 1. Sampling Plan

Target Groups	In-depth interviews	Focus group discussions	Standardized interviews
MAWR and local government officials	5	None	None
Farmers [7]	2	1	30
Dehkan [8] farmers	2	1	30
WUA personnel	2	None	None
Households [9]	None	1	60
Total for each region	11	3	120
Grand total for 5 regions	55	15	600

The national survey was conducted in the Fergana, Syrdarya, Samarkand-Bukhara, Kashkadarya-Surkhandarya, Khorezm-Karakalpakstan regions of Uzbekistan by a subcontractor (USAID, 2005). Study sites in these regions were defined in consultation with representatives of corresponding ISAs and local experts taking into account the peculiarities of rural farms' operating conditions. Survey respondents were classified in accordance with their target group affiliation and location of their land plots along irrigation canals. The respondent selection was performed using the probability procedure, - to be able to represent farms located in upstream, midstream, and tail-end areas of an irrigation system. The survey was designed as a willingness/ability to pay exercise. In addition to general socio-economic information regarding farmstead incomes and agricultural production values, the questionnaires determined stakeholder

[7] A farm operator registered with local authorities as a farmer and a user of a land plot leased for a long term or heritable use, having the rights to hire workers, and having a bank account.

[8] A family-based farm operating a land plot leased for a long-term use, having a bank account, but having no rights to hire workers, and for whom registration with local authorities is not required.

[9] A family or group of individuals registered with local authorities as users of inheritable land plots. The members are united under three '*K*'s – '*krysha'* (roof) - common ownership, '*kazan'* (pot) - common meals, *'kazna'* (purse) - common budget. No bank account required for this group.

attitudes towards agricultural production costs, irrigation and drainage cost-sharing, perceptions of fee collection mechanisms, water availability/scarcity and concerns for the environment, etc.

Results and Discussion

In order to determine potential savings in the national budget attributable to introducing water charges, calculations are made for each policy option of reimbursement regarding the water sector enterprises' operational expenses by agricultural producers (Figure 1). Although these calculations are based on USAID (2005) data, given the gradualist approach and stability of economic trends in Uzbekistan, this paper assumes that the data is still a valid estimator of the water sector's current financial parameters. Option #1 would discontinue budget financing to water sector at all, while options # 2 and #3 would generate almost equal budget savings. Option #4 would save about 15% of the budget, and savings associated with option #5 are nominal.

Figure 1. Proportions of state budget and water user cost-sharing options

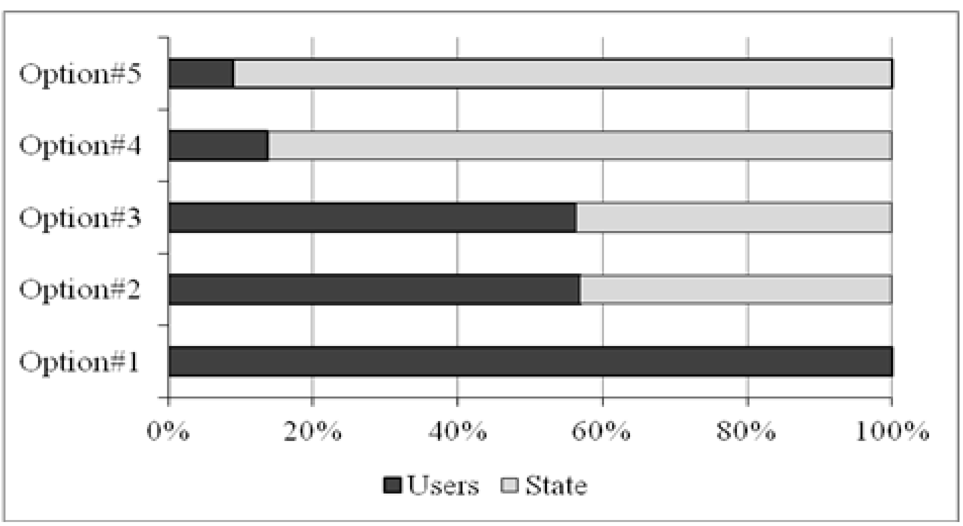


Figure 1 indicates that the better the government budget savings are in a particular option, the greater the burden that option would impose on users. Thus, the study should identify an

option that represents optimal trade-off supporting two objectives -- generating budget savings and not imposing too high a cost on water users. However, not all of the listed options meet these goals of water cost sharing. Calculations confirm that options #1 and #3 would considerably increase production costs and decrease revenues of agricultural producers in many regions. Although option #5 can be used at the initial stage of reforms, it would not generate sufficient effect on reduction of the state budget expenses. Since options #2 and #4 have almost equal effect in terms budget savings, only these options are considered for further analysis.

As it was mentioned already, operational expenses for pumped irrigation, large water structures, land reclamation services on irrigation lands and BISA enterprises vary substantially in Uzbekistan. Therefore, payments for water should be differentiated by the distinct costs of water delivery in various areas of the country. All the operational water organizations, such as the enterprises managed by a BISA itself, viloyat level PSA, HME and large water facilities, are classified as separate groups within every BISA area. Table 2 presents the resulting differences of five cost-sharing policy options in one BISA area, while Table 4 illustrates the tariff variations among all BISAs under a selected option analysis, based on information received by the author from water and statistical organizations in the region. The service area of Lower-Syrdarya BISA is located in the middle part of country. Cost of water delivery in this area and the proportion of costs that would be borne by water users and state budget differ under different scenarios (Table 2). Water unit cost and water user cost sharing are in descending order from options #1 through #5. Under option #4, this BISA has a unit price of 0.77 UZS/m3 which would generate a 24.6% share of the total water cost of UZS 12.6 billion within the BISA boundaries. By contrast, option #2 has a unit price and cost share (2.39% and 76.6% respectively) that is three times more than their counterparts under option #4.

Table 2. Water supply costs under different options, Lower-Syrdarya BISA area

Option	Group Classification	Irrigated area	Water delivered	Total cost of delivery	Unit cost of water		Cost sharing	
		000' ha	000' m³	000' UZS	UZS/ha	UZS/m³	Users, %	State, %
1	Operations of all water enterprises in the area	515.1	4,054,200	12,635,953	24,532.12	3.12	100.00	0.00
2	Operations of all water enterprises, excluding machine irrigation	515.1	4,054,200	9,680,359	18,793.97	2.39	76.61	23.39
3	Operations of all water enterprises, excluding big structures, reservoirs and melioration	515.1	4,054,200	6,063,920	11,772.82	1.50	47.99	52.01
4	Operations of all enterprises under the BISA	515.1	4,054,200	3,108,326	6,034.67	0.77	24.60	75.40
5	Operations "Shuruzak-Syrdarya" ISA	108.5	1,148,700	421,676	3,884.91	0.37	3.34	96.66
	Operations "Uchtom" ISA	166.3	1,136,500	256,922	1,545.37	0.23	2.03	97.97
	Operations "Havas-Zamin" ISA	99.8	695,900	419,315	4,201.64	0.60	3.32	96.68
	Operations "Bayaut-Arnasay" ISA	140.5	1,073,100	254,573	1,812.10	0.24	2.01	97.99

Source: USAID (2005).

The unit costs presented in Table 2 reflect only the primary cost of water delivery. In order to derive unit costs that more fully reflect true resource costs -- estimates of profit, insurance and depreciation must be incorporated. The results from this adjustment are given in the following Table 3. Under option #4, the full unit cost would be 1.39 UZS/m^3 rather than 0.77 UZS/m^3. This higher figure would be the charge we recommend for the Lower-Syrdarya BISA under the current scenario.

Many aspects of the potential introduction of water cost sharing and of appropriate forms of tariffs were the topic of focus group discussions with specialists from the BISA, ISA, OHGME, PSA, and WUA, and authorities of MAWR in corresponding regions. They provided important feedback on the prospective concerns that may arise with the introduction of a water cost sharing program in Uzbekistan. For example, the concept of calculating tariffs for water delivery services on the basis of operational costs of the irrigation system received support from many representatives from both the irrigation and the agricultural sectors. Local specialists in irrigation also confirmed the necessity of taking estimates of normative profits, assessments for insurance funds and amortization into account when constructing a cost basis for tariffs.

Table 3. Water charges in Lower-Syrdarya BISA under options #2 and #4

Parameters	Option #2		Option #4	
	UZS/ha	UZS/m³	UZS/ha	UZS/m³
Prime cost of water delivery	18,793.97	2.39	6,034.67	0.77
Normative profit *	4,698.49	0.60	1,508.67	0.19
Capital investment depreciation **	4,337.22	0.55	2,774.88	0.35
Insurance fund ***	1,879.40	0.24	603.47	0.08
Full charge for water delivery	29,709.07	3.77	10,921.69	1.39

Source: USAID (2005).
*Normative profit is calculated as 25% of the prime cost (Melioratcja i Vodnoe Khozjaystvo, 1984).
**Capital depreciation is calculated at 6% of long term assets balance-value (Ibid).
***Insurance fund allocations are calculated as 10% of the prime cost.

Although these calculations hold true under the presence of state order for cotton and wheat, there may be very good reasons for revising this procurement system to help agricultural producers to adjust to the new water pricing policy. Currently farmers have not been paid what it costs them in terms of their labor to cultivate the state order crops, but they in turn have not been charged the "true cost" of the irrigation water.[10] In reality, water costs a lot of money to water

[10] The cost that is paid by society in general, either through government subsidy/support mechanism or private direct payments.

users. The majority of farmers have large sums of accounts payable, limiting their cash on hand and ability to pay. Some farmers incur huge costs to access irrigation water, such as the cost of electricity to pump water, the cost of laying new canals towards farmers' land plots, the cost of fixing irrigation systems near their farms. While irrigation water delivery at the system level is free of charge, WUA, who distribute water at the farm level must charge for their services in order to generate operating funds. The fixed low prices at which cotton and wheat are procured simply do not leave enough money with farmers to pay for WUA services and, as a result, many of WUAs are unable to pay for operations and maintenance and are in effect non-operational (Djalalov, 2004). Therefore, farmers' profit base needs to be increased slightly by increasing the government purchase prices in the state order system by at least 5-6%. This level is high enough to cover the increased costs associated with higher payments for water delivery.

According to Abdullaev et al. (2009), reforms which increase the profitability of farming and reward farmers for efficiency are likely to lead to additional investments in both land and water management. In turn, these will lead to higher yields through better management practices, higher levels of input use and thus higher levels of water use and increased water productivity. However, it is also possible that improved management can reduce overall water use, even in the face of higher crop output, by improving the way water is applied and recycled, or through better plant varieties. This paper assumes that the reform under proposed scenario would not lead to higher water use because the area and output will remain relatively unchanged, and the survey respondents are told that water use will not increase. Moreover, it will probably create incentives for water users to seek better alternatives for water use, invest in water saving technologies or make capital investments where needed.

Table 4. Proportions of tariff in production costs and revenues under option #4

BISA	Tariff		Farmers	
	UZS/ha	UZS/m^3	Tariff share in production costs	Tariff share in revenue
Amu-Bukhara	7,101.5	0.81	1.54%	1.29%
Amu-Kashkadarya	8,076.9	0.90	4.14%	3.29%
Amu-Surkhan	10,447.3	0.78	2.14%	1.78%
Lower-Amudarya	11,518.9	0.88	5.50%	10.17%
Lower-Syrdarya	10,921.7	1.39	7.68%	6.10%
Naryn-Karadarya	16,902.1	2.12	6.58%	3.71%
Naryn-Syrdarya	15,917.5	1.69	7.91%	5.33%
Syrdarya-Sokh	7,333.2	0.79	2.77%	2.35%
Zaravshan	13,355.2	1.29	7.24%	5.73%
Uzbekistan average	11,286.0	1.18	5.06%	4.42%

Source: USAID (2005).

In order to assess the impact of the water pricing options on the economic conditions of agricultural producers in various regions of Uzbekistan, proportions of new water tariffs in the production costs and revenue are estimated under the considered two policy scenarios. A benchmark of 5-6% “permissible level” (Perry, 1996) used for developing countries is adopted for these comparisons. With exception of some areas, the burden of costs to be borne by water users under option #4 stays within the “permissible level”. This is less often the case with the burden of costs estimated under option #2, and these tariffs are not shown here due to space limitation. Given these results, option #4 is recommended as the basis for the initial design of a water pricing framework in Uzbekistan (Table 4). Nevertheless, for some farmers located in the Lower-Amudarya BISA service area, for example in the Republic of Karakalpakstan, where low

yields are caused by environmental factors of the Aral Sea disaster, it will be necessary to subsidize water costs. At the outset of this new policy, it makes sense to use some of the funds meant originally for the operational costs of BISA to serve as an interim source of financing selected subsidies.

Implementation Strategy

Using financial instruments, such as tariffs for water delivery would encourage all water users to reduce their water demand. At the same time, "governance" would encourage to use social instruments – traditional methods of economically sound water use, and public participation in decision-making (Ostrom, 1990). These and other factors should be taken into consideration for establishing rules of game. This section sheds light on desirable features to be included in the policy design and implementation structures in Uzbekistan. These relate to assigning a new role to BISAs, new tariff structure, and payment mechanisms.

As Uzbekistan moves toward a market-oriented economy, the participation of stakeholders in irrigation system management is desired. Transfer from MAWR to stakeholders of managerial and operational cost bearing for major sections of the irrigation system would represent a bold step toward the participatory management of irrigation systems. There is the need for a national program in public sector and private sector cost-sharing investment and management for irrigation water supply in Uzbekistan. Potentially such a program can create a win-win situation for both government and farmers, and benefit the Aral Sea by creating incentives to seek better investments in water-saving technologies. Once assured of proper system operations resulting in sustainable production levels, farmers would assume more direct control over agriculture and water management. At the same time, government costs could be

reduced so it could share the “gains” from water cost-sharing with the farmers by adjusting the state-controlled procurement system for agricultural products.

The new role of BISAs derives extensively from the assumption that they might be transformed into enterprises that are managed on a paying basis, functioning on principles of self-reliance based on payments received from water users for water delivered. However, the national budget financing should be continued to HME, PSA, large water facilities of main systems and water reservoirs. It is because of the public goods nature of their services, also in order to prevent excessive growth in the tariffs for agricultural producers at the initial stage. In subsequent stages of the introducing of water cost-sharing policy these costs also might be shifted to water users, starting from HME.

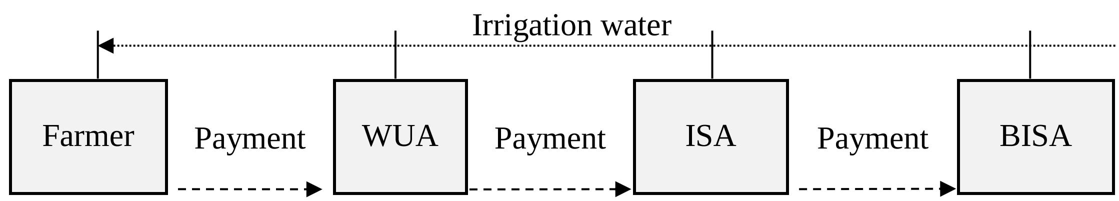
With regard to tariff structure, greater economic efficiency is possible with the establishment of tariffs customized to the cost structure of specific BISAs. A single tariff should be applied to water supply services within the boundaries of a given BISA. In this analysis, option #4 makes that assumption (as do options #1 through #3). Tariffs must be the same for the vegetation and inter-vegetation periods as well as across producers of different crops.

From the agriculture and irrigation sector perspectives, the preference of using volumetric and per-hectare tariffs may be different. Farmers may prefer the volumetric based calculations of tariffs while irrigators may favor the per-hectare tariffs. A combination of both approaches should be applied during the initial implementation of the water cost-sharing policy (such as 25% of tariffs on a volumetric basis and 75% on an area basis). However, ultimately, the volumetric approach should prevail over the per-hectare approach since the former is the most efficient economically. Such a two-tier tariff system would allow a consideration of variability of water

availability during different years, the current condition of the irrigation network, as well as the availability of water metering devices at various system levels.

Although the water cost-sharing can be economically feasible, there are feasibility issues related to how the new system would actually work. We propose the following payment scheme for irrigation water delivery from BISA through farmers under the new water policy (Figure 2):

Figure 2. Water and money flows in major sections of irrigation system



According to proposed scheme in Figure 2, a farmer would transfer payments to the WUA account. The WUA may deduct a charge from this payment in order to pay for the services it provides. The remainder of the funds should be transmitted to the ISA in accordance with the received volume of water. The ISA may function as a regional subdivision of its respective BISA or it may stay a self-reliant enterprise, running on a pay-as-you-go basis. In this case, the ISA will set aside funds to maintain the costs of the BISA as its supervisory entity. The BISA will pay funds to the state budget from its proceeds. HME, PSA, MAWR and other personnel will be paid from the state budget. Finally, taking into consideration the current problems with payments, a possible mechanism for the processing of payments for water could be created by tapping into the existing system of agricultural credit, which currently maintains payments for fuel and lubrication inputs, chemical fertilizers and machinery.

Conclusions

The findings reported in this paper support the cost-sharing program for the reform of agriculture and water policies in Uzbekistan. Water cost-sharing between users and government is being introduced step-by-step through formation of networks of WUAs in different parts of country. Government has adapted the Welfare Improvement Strategy of the Republic of Uzbekistan for the period of 2008-2012, one of the objectives of which is "improving the system and increasing the efficiency of water resource management including investment in land improvement" and "development of an integrated sustainable water management system for supply of irrigation water" (IMF, 2008). Implementation of water cost-sharing activity will be a major turning point for this process to take hold at the grass-roots level in Uzbekistan.

Sharing the costs of delivering irrigation water has potential advantages and dis-advantages. Cost-sharing might improve the allocative efficiency of water resources by sending economic signals to users and suppliers alike about the value of water and the quantities needed. It will create incentives to seek better alternatives, invest in water saving technologies and make capital investments where needed. However, cost sharing has its potential drawbacks. Agricultural producers will be paying higher prices than they currently pay for water. This compounds the problem that producers are already experiencing challenges in managing their cash flows. The increased costs to water users could be offset by reforming of the state order procurement system or by selective subsidies. Under the proposed water cost-sharing scenario, WUAs would be supported by water users, and BISAs would become self-sustaining, receiving funds from their respective ISAs, which in turn, would have been paid by their WUAs.

In order to make the proposed program feasible, the existing institutions should be adjusted for nationwide policy implementation strategy. Some regulations will be required to

make the system viable, including the law on WUA and normative documents needed to empower WUAs. It must be realized that the systemic change cannot be made in a piecemeal approach. For example, WUAs cannot become viable without a “package” of institutional changes that would free up farmers and increase their profitability. Cost-sharing of the water system is only a part of the strategy to give operational freedom to farmers; other aspects, such as agricultural production and markets also must be included.

The expected outcome of the program would be the social welfare enhancing due to efficient allocation of resources between water users and the government. The program impacts can be estimated as a reduction in MAWR costs, enhanced financial self-reliance of BISA, expansion of WUA service areas, greater irrigation water efficiency, higher quality technical services to water users, and increase in crop intensity and yields. In exchange for higher water delivery prices, water users would receive better service and achieve better output. At the same time, adjustments in the state order procurement pricing would ease the loss of economic efficiency and thus government share the “gains” from water cost-sharing with the agricultural producers. Therefore, the transfer from the government agencies to stakeholders of operational cost bearing for the irrigation infrastructure in Uzbekistan would be advancement toward the participatory management of the common-pool resources in the Aral Sea region.

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Chapter III.

Integrating Conservation in Arkansas State Water Policy

Kuatbay Bektemirov and Eric J. Wailes

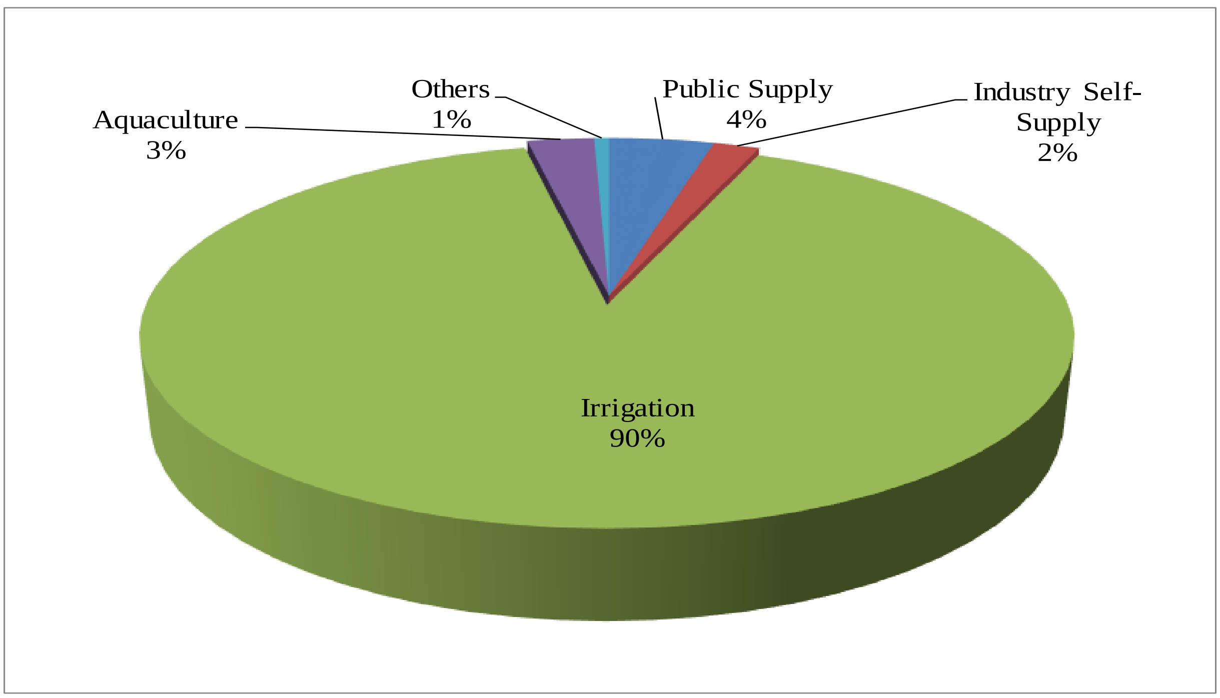
Introduction

There are abundant water resources in the State of Arkansas consisting of rivers, lakes, reservoirs, wetlands, and aquifers. A 30-year annual rainfall in the state ranges between 813 and 1,981 mm (32 and 78 in). According to the Arkansas Geological Survey, the average daily flow of 5 major river systems (White River, Arkansas River, Ouachita River, Red River, and the Mississippi River) and other streams in Arkansas totals approximately 1.06 km^3 (280 billion gal) (AGS, 2011). Also, there are numerous reservoirs with total storage capacity of about 18.93 km^3 (5 trillion gal) of water, and 12 major aquifers are used for water supply in Arkansas. The largest groundwater sources are the Mississippi River Valley Alluvial Aquifer (Alluvial Aquifer) located in eastern Arkansas and the Sparta/Memphis Sand Aquifer (Sparta Aquifer) located in eastern and southern Arkansas.

The main water resource issues in Arkansas include increased water demand in agricultural, municipal, and mining sectors; increased numbers of water shortages in many parts of the state; and declining water tables and lower stream flows (USACE, 2009). Water withdrawals in Arkansas increased by 60% since 1980 and have reached 0.043 $km^3\ d^{-1}$ (11.4 billion gal day^{-1}), of which 0.028 km^3 (7.5 billion gal) is groundwater (Holland, 2007). Sustainability of groundwater withdrawal ranges between 40% and 50%, depending on the aquifer location, less percentage means the more unsustainable withdrawal.

According to the U.S. Geological Survey (USGS, 2007), the Alluvial Aquifer can supply groundwater up to 0.01 km^3 d^{-1} (2.7 billion gal day^{-1}) north of the Arkansas River and 0.002 km^3 d^{-1} (526 million gal day^{-1}) south of the Arkansas River, while the Sparta Aquifer can supply only 0.0003 km^3 d^{-1} (89 million gal day^{-1}). Approximately 0.032 km^3 d^{-1} (8.5 billion gal day^{-1}) or 90% of consumptive water use is attributed to irrigated agriculture, the majority of which comes from aquifers. Hydro- and thermoelectric power generation use 0.235 and 0.008 km^3 d^{-1} (62 and 2 billion gal day^{-1}) of water, respectively. However, after usage, these waters return back to the rivers and lakes; therefore, we do not include them in our calculation of the proportions of total water use by sectors in Arkansas (Figure 1).

Figure 1: Proportions of water consumption by sectors in Arkansas, 2005



Source: USGS, 2007.

Water Allocation, Reserved Uses, and Allocation Preferences

If there is water shortage in any stream to meet requirements of all water needs, water can be allocated among the competing uses so that each use obtains an equitable portion of the amount of water available. However, the following reserved uses are excluded from the amount available for allocation: domestic and municipal-domestic, minimum streamflow, and federal water rights. Domestic and municipal-domestic water uses include ordinary household purposes including human consumption, washing, the watering of domestic livestock, poultry and animals and the watering of home gardens, and fire protection. Minimum streamflow refers to the water necessary to support aquifer recharge, fish and wildlife, interstate compacts, navigation, and water quality. Federal water rights are considered as "there may be some water over which the United States has a preemptive right that is superior to rights of others" (ASWCC, 1990). Arkansas is a member of two interstate compacts—the Red River Compact with Oklahoma, Texas, and Louisiana and the Arkansas River Compact with Oklahoma. Use of the Arkansas River watercourse for navigation purposes is authorized by the U.S. Congress (ASWCC, 1990). The remaining water can be allocated in the following order of preference: (1) agriculture, (2) industry, (3) hydropower, and (4) recreation (ASWCC, 1990). It should be noted that this order holds for both riparian and non-riparian uses, with riparian diversions having priority.

Legislative Framework

Water laws in Arkansas, like in many other eastern states, are based on the riparian rights doctrine. The basic principle of the riparian doctrine is that landowners who own property next to a stream, or land over any groundwater, have the right to free and reasonable use of the water, but no one owns water resources. Integrated legal systems combining riparian rights with

regulatory processes of planning, management, and allocation are known as “regulated riparianism.” The Arkansas system is typified as regulated riparianism because “the administrative permit process proceeds on essentially riparian principles and that the system is a regulation of—rather than a taking of—riparian rights” (Dellapenna, 2002).

A number statutes and regulations serve as milestones of the regulated riparian system in Arkansas. The Act 81 of 1957 initiated annual registration of surface water diversion, while Act 1051 of 1985 instituted annual registration of groundwater withdrawals over 189,270 L d^{-1} (50,000 gal day^{-1}) (ANRC, 2011a). State laws enacted in 1991, 1999, and 2004 address the aquifers in southern and eastern Arkansas. According to Act 1426 of 2001, any well withdrawing groundwater from a sustaining aquifer shall have a properly functioning metering device (Arkansas State Legislature, 2001). The aquifers affected are nine “sustaining aquifers,” including the Sparta Aquifer; however, the Alluvial Aquifer is not affected since it is not considered a “sustaining aquifer.” Domestic wells are exempt (ANRC, 2011b). The 1995 Act 341 on Water Resources Conservation and Development Incentives provides income tax credits for construction of water impoundments with capacity of over 24,667 m^3 (20 ac-ft.) for projects that convert groundwater use to surface water use, and for the leveling of agricultural lands in order to conserve irrigation water (ANRC, 2011c).

Institutional Framework

In Arkansas, management responsibilities for sustaining water quantity and water quality are apportioned among several agencies. The Arkansas Natural Resources Commission (ANRC) has primary responsibility for water quantity, while the Arkansas Department of Environmental Quality (ADEQ) monitors water quality. Other Arkansas state agencies (Department of Health,

Natural Heritage Commission, Game and Fish Commission, Forestry Commission, and Public Service Commission) include water resources management as part of their mission. Federal agencies with interests in Arkansas water resources include the U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Department of Agriculture, and United States Geological Survey (USGS). Local institutions include county-based conservation districts; regional water-distribution districts; irrigation, drainage, and watershed improvement districts; levee districts; etc. Such a variety of institutions can create coordination problems because one agency's actions may conflict with those of another.

Critical Groundwater Areas

Arkansas Groundwater Protection and Management Act of 1991 enables designation of critical groundwater use areas (CGWAs). This establishes the authority for groundwater withdrawals, groundwater rights, fees, and a mechanism for local groundwater management. Criteria for the designation of CGWA status include the following:

- Less than 50% of the saturated thickness in unconfined aquifer formation (Alluvial) or potentiometric surface below the top of the confined aquifer formation (Sparta)
- Average annual decline of groundwater level is one foot or more for the preceding five years
- Degradation of groundwater quality that would render the water unusable as a drinking water source (ASWCC, 1990)

CGWA designation brings about enhanced tax credits for conservation activities and educational programs and makes it possible to obtain federal programs and funding. Currently, there are three designated CGWAs in Arkansas. The first CGWA consisting of the five south

Arkansas counties (Bradley, Calhoun, Columbia, Ouachita, and Union) was designated in 1996. The Sparta aquifer water levels in these counties had dropped below the critical level, but the situation was worst in Union County. Therefore, Union County officials with county stakeholders supported legislation that authorized formation of the Union County Water Conservation Board in 1999. The Sparta Aquifer Critical Groundwater Counties' Remediation Act authorizes the board to levy a water conservation fee in the amount up to 96 cents per 3.79 m^3 (1,000 gal) of aquifer water withdrawn to discourage the withdrawal of aquifer water by water users. A water user may be assessed a conservation fee determined by the board until the water user connects to an alternate water source provided by the board to the property line of a water user (Johnson, 2006). The money raised from the conservation fee, coupled with revenue from a temporary county sales tax and private contributions, funded 90% of the planning, design, and construction of a $65 million project to provide water from the Ouachita River to the three largest industrial users of groundwater in the Union County. Because the three industries now use the alternative surface water from the Ouachita River, the Sparta Aquifer is recovering; groundwater levels are rising and threats to drinking water quality appear to have been halted (Johnson, 2006). However, other users of Sparta Aquifer outside of this CGWA project area are still experiencing significant water level declines.

The Grand Prairie CGWA was designated in 1998 to prevent declines of the Alluvial and Sparta aquifers water levels in six southeast Arkansas counties (Arkansas, Jefferson, Lonoke, Prairie, Pulaski, and White). The Cache CGWA, designated in 2009, includes the Alluvial and Sparta aquifers in seven counties (Clay, Craighead, Cross, Greene, Lee, Poinsett, and St. Francis) west of Crowley's Ridge in eastern Arkansas. However, sampling data from these areas show that the groundwater level is still declining (ANRC, 2011a). The general trend throughout the

state is that groundwater levels are declining due to continued withdrawals at rates that are not sustainable (ANRC, 2011d).

State Water Planning

Planning for water resources has been done in many states, although their approaches vary depending on local circumstances. The initial development of the Arkansas Water Plan dates back to 1975, when Arkansas was considered a water-rich state. Updates were made to the Arkansas Water Plan between 1986 and 1989; however, the state water policy framework still remains under the perception of water-resource abundance. This 25-year old document cannot adequately address current water concerns driven by population growth, climate change, irrigation, natural gas fracturing, and other recent developments in Arkansas. Balancing demands for water volume while maintaining water quality to support a prosperous population and continued economic growth requires active management of the state's water resources. An appropriate update of the state water policy, authority, and infrastructure should be in place to effectively manage water resources to meet contemporary challenges in Arkansas.

A new Arkansas water plan should identify explicit goals and strategies, socioeconomic indicators, and water indicators to determine if the state is moving toward sustainable water resources. Several states, including the neighboring states of Texas and Oklahoma, have developed indicators that possibly could be modified and adapted for Arkansas. An update to the Arkansas water plan will need to involve an exploration of policy issues to determine the role of the state in the management of resources and to identify what management tools are needed. In addition, there should be more public outreach in the development of a new state water plan to

allow citizens to express their needs and concerns and to convince the public of the need to make changes to the existing laws and mechanisms of state water resource planning and management.

Incorporating Conservation into Water Policy

The importance of the conservation of waters in maintaining adequate water supplies to meet the state's water requirements is recognized in Arkansas. Conservation plans are required to be developed and implemented by water diverters as a part of the allocation plan (ASWCC, 1990). Water conservation measures need to be implemented as an alternative to water development projects to meet future demands, rather than being a part of the allocation plan during the water shortage times only. Conservation principles can be incorporated into the Arkansas Water Plan to meet water needs in all areas of the state. Meeting water conservation criteria should be a condition of eligibility for ANRC programs; it should be encouraged by providing education about current methods and technical assistance from ANRC and conservation districts. Water conservation plans should include conservation goals, benchmarks, and best management guidelines for water use sectors.

Water scarcity may be mitigated by either increasing the water supply or decreasing the demand for water. Water demand can be manipulated by price to some degree. The range for price elasticity of residential demand is between -0.30 and -0.40, meaning a 10% increase in price lowers demand by 3% to 4% (Olmstead and Stavins, 2009). However, it should be noted that within the residential demand, water for necessities such as sanitation, cleaning, and cooking is less responsive to price than water for more discretionary uses such as lawn watering, car washing, and swimming pools. While the price elasticity of industrial demand could vary from -0.45 to -0.72, agricultural use demand price elasticity is only in the range from -0.08 to -0.14

(Rosegrant et al., 2002). A comprehensive state plan can encourage conservation or restrict use to a level that conserves the resource. During times of shortage, the plan should allow allocation of available water resources to the highest valued uses from the society's point of view.

Economic incentives can decrease water use so additional water resources do not need to be developed. A number of states provide tax credits to residential or commercial users who install water-conservation equipment. Federal agencies pay individuals and organizations to protect water resources under some programs and projects. However, in Arkansas, income tax credits can be provided mostly to the projects that convert groundwater use to surface water use. In Arkansas, 1,089 farms with 809,371 ha (2 million ac) of land received payments for irrigation improvements from USDA programs, while only 130 farms with 62,171 ha (153,628 ac) of land received payments from state, local, or district programs (USDA-NASS, 2010).

Demand for water is driven by many variables, including water-intensive industries, irrigated crops, and implementation of water-saving technologies. Arkansas' water-intensive crops are among the nation's key agricultural products. For example, with more than 526 thousand ha (1.3 million ac) harvested area in 2008, the state was the leading producer of rice in the nation and ranked second in cotton with its share of 16.6% of national production (USDA-NASS 2010). The single largest user of irrigation water is rice, followed by cotton, corn, and soybeans. Rice is cultivated mainly in the Mississippi River Delta and consumes about 55% of the total water for these four crops in the state. We estimate average annual water use for rice production in Arkansas from 2005 to 2009 to be about 3.4 km^3 (2.8 million ac-ft.), which costs producers around US$96 million annually. Soybeans are the second largest agricultural water user in the state, accounting for 26% of the water use by these four crops and estimated irrigation cost of more than US$62 million annually. The cost estimation includes the energy, equipment,

and labor costs and is an average for flood irrigation over different soil types, based on the University of Arkansas Cooperative Extension Service data (UACES, 2009).

In 2008 only 25 Arkansas' farms have transferred more than 0.02 km^3 (17,500 ac-ft.) of water to municipal or industrial users by renting or leasing on-farm wells (USDA-NASS, 2010). Arkansas can move toward the efficient transfer of water from areas with a surplus to areas with a shortage by adopting new criteria for prioritizing water use. The new criteria should encourage use of economic tools such as water trading and water markets for cost-effective redistribution of water from areas or uses with surplus to those experiencing water shortage.

Public Water Supply Rate Structures

Water is "priceless" because of its importance to human survival; however, in Arkansas it is literally so because of the existing state water law. The applicants can be required to contract for the transportation of specified quantity of water at a reasonable price to users within the immediate vicinity of the proposed route of transportation. The term "reasonable price" means only the cost of transportation of the water, not the water itself (ASWCC, 1990). State law requires any utility "charges, rates, etc., to be just, reasonable, and in compliance with Acts 1919, No. 571, and Acts 1921, No. 124" (A.C.A. 2011). Although the Arkansas Public Service Commission (APSC) is empowered to find and fix just, reasonable, and sufficient rates to be thereafter observed, enforced, and demanded by any public utility, this agency regulates only a few private utilities selling water to the public (APSC, 2011). Analysis of data from 18 Arkansas' cities indicates that municipal water rate structure is heterogeneous. Inclining block rates, under which consumers have incentive to conserve water, are being implemented in four cities with more than 20,000 populations, while another four cities with populations less than

20,000 are implementing uniform block rates (conservation neutral). Ten cities implement declining block rates, which are regarded as non-conservation pricing mechanisms.

Water Use in Natural Gas Mining

As of March 4, 2011, there were 12,449 natural gas wells in the State of Arkansas, 4,089 of them located in the Fayetteville Shale Play, with 3,478 being in the status of active wells (AOGC, 2011). Production of natural gas in economic quantity can be stimulated by hydraulic fracturing, i.e. pumping fluid consisting of a large amount of water and chemicals into gas wells. A well may be fractured in as many as eight stages, and each fracturing effort requires approximately 8 thousand m^3 (2.1 million gal) of water (Arthur et al., 2008). Water for fracturing is typically drawn from surface water storage designed for the purpose, also purchased from landowners with private lakes, ponds, stock tanks or holders of riparian rights at negotiated prices. This demand for water in most cases requires non-riparian permits because of the location of gas wells. As of March 3, 2010, ANRC received 726 non-riparian permit applications from gas companies, which is a huge increase compared to 16 permits issued between 1985 and 2007 for non-riparian municipal, agricultural and industrial water use (ANRC, 2011a). Despite that the disposal of used water is regulated by the AOGC and ADEQ, this water use should be considered as a consumptive use. Water availability and the consequent disposal of wastes are emerging concerns, along with potential impairment of water quality in Arkansas. While fracturing uses a relatively small amount of available water in the Fayetteville Shale area, the combined effect of agriculture irrigation, municipal supply, and natural gas mining could be significant in Arkansas. Therefore, the new water needs from the natural gas production in Arkansas require adequate attention and solution within the framework of state water planning.

Conclusions

Arkansas water resource challenges limit economic potential of the state and the livelihoods of its population. State water policy should be consistent to water use opportunities. Water management should incorporate resource conservation into planning to balance demand for water and to minimize the development of shortages. A comprehensive system of water planning can restrict water use to a level that conserves the resource. The state should be able to allocate available water not only during times of shortage, but designate water resources to the highest valued uses from society's point of view.

Agricultural water users should be actively encouraged to use the most efficient, feasible irrigation practices (e.g. conservation tillage) and on-farm surface water infrastructure to store and recycle water. Economically efficient water conservation techniques should be promoted across the state. Water conserving research and extension services should be expanded with an emphasis on healthy rivers, lakes, and aquifers using sustainable in-stream flows.

The State water planning process should be clearly defined, transparent, accountable, and include the public and all stakeholder groups. Currently, policy decision of water pricing is done at the municipal level, which is different from city to city. There is a need for coordination of water utilities to implement a conservation-oriented rate structure for different water-use sectors through state agencies such as ANRC and APSC. Also, rapidly increased water use for natural gas drilling in the Fayetteville Shale should be reflected in state water policy.

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Chapter IV.

Integrated Assessment of Welfare and Distributional Effects of the Bayou Meto Basin Project in Arkansas

Abstract

This study examined Bayou Meto Basin, Arkansas project to analyze the benefits and costs of regional development. It seeks to assess the economic and distributional effects of the project, which designed to protect the environment and ensure water to sustain irrigated agriculture in the region on different stakeholder groups. Kaldor-Hicks tableau is an effective tool used to analyze distributional effects and explore the outcomes of policy in terms of benefits and costs. The results showed that some stakeholders in the project would "win", meantime the others would incur some "loss" in the result of project. The regional sustainable development will need the project's integrated water management approach, which in turn demands the integration of the efforts of all stakeholders; participation of all stakeholders, particularly the beneficiaries; and economic and financial stability to account for costs of withdrawing, delivering and opportunity costs of water, including costs associated with economic and environmental externalities. In addition, the findings exposed the limited stakeholder collaborations, the absence of a plan to mitigate water insecurity and lack of proactive strategies to address the impact of new challenges such as climate change.

Keywords: sustainable development, groundwater, cost-benefit analysis, stakeholder groups.

1. Introduction

Groundwater in eastern Arkansas represents one of the most valuable common-pool resources in the state. The primary water use of these resources is for agriculture, with crop irrigation accounting for 92 percent of water used in 2010 (USGS, 2014). The Mississippi River Valley Alluvial Aquifer (also called the Alluvial Aquifer) is the principal source of ground water for irrigation in the region. However, the Alluvial Aquifer is seriously depleted because of pumping rates that are much greater than the rate of recharge (ANRC, 2015). Some farmers have tapped the Sparta Aquifer as well, which is a low yielding, deep and high-quality source of water that is better suited for municipal and industrial use. These withdrawals are depleting the aquifers so they will no longer be viable sources of water by 2027 (USACE, 2007).

According to Ostrom (1990), groundwater sources are characterized as a common pool resource that can be accessed by multiple users who may ignore the future social and economic costs of resource depletion. It is individually rational for competitive users to deplete the groundwater resources as their marginal benefit equals the unit extraction cost, i.e. each user ignores the effect of individual extraction on other users. Common pool systems may prevent competitive markets from attaining optimal resource use and justify government intervention or other forms of collective action.

One of the important approaches to address the groundwater depletion in Eastern Arkansas has been surface water projects coordinated by the United States Army Corps of Engineers (Corps). Two important projects are the Grand Prairie Demonstration Project and the Bayou Meto Basin Project. These projects have multipurpose objectives but both include supplementation of surface water from major rivers in the region for crop irrigation. The objective of this paper is to analyze the Bayou Meto Basin project. The paper begins with an

overview of the governance framework and the role of the Bayou Meto Basin project. It examines the extent to which government intervention reflects stakeholder group perspectives and articulates strategies to achieve common pool resource sustainability. Then it outlines the methodology and data sources used for the analysis and finally, the paper presents an analysis and discussion of costs and benefits of project components and the findings that have implications on identified stakeholder groups. This analysis can help us to evaluate the current project, but more importantly, the research has implications for developing and achieving future water policy goals.

2. Background Information

Arkansas groundwater protection and management policy has long advocated the wise use of groundwater, and conservation, recognizing the holistic view of the water resources system (AWP, 2014). First authorized by Congress in the 1950s, the Grand Prairie Region and Bayou Meto Basin flood control projects were re-authorized in 1996 with a broadened scope to include ground water protection and conservation, agricultural water supply, and waterfowl management (USACE, 2007). The problem of groundwater depletion can be limited by providing a supplemental source of irrigation water, thereby maintaining the aquifer at a level which would allow for a sustained yield. The Corps, the Arkansas Natural Resources Commission (ANRC) and the Bayou Meto Water Management District (BMWMD) developed a plan to protect and conserve the groundwater resources of the Bayou Meto Basin. Major features of the project include 4 pump stations, 107 miles of canals, and 464 miles of underground pipelines.

Being the state agency with responsibility for protection and management of Arkansas' water resources, ANRC has the financial responsibility for the non-Federal share of construction costs. BMWMD is a legal entity with taxing authority in partnership with the State of Arkansas. It was created as quasi-public corporation deriving its powers "directly from the Legislature and exercising them as the agent of the property owners in the district whose interests are affected by the duties they perform" (ANRC, 2011). Federal funding for the project was allocated through the Corps. It took several years to get the project started because public funding had to be secured -- 65 percent federal and 35 percent state and local -- and the support of farmers who will have to pay for the water had to be won over. Lawsuits by environmental groups also delayed construction (Moritz, 2015). This project was first funded for construction in 2010, and it was still not complete as of mid-August 2016.

The ANRC has authority for establishing critical groundwater levels, aquifer safe/ sustainable yields, and water use allocations. Bayou Meto Basin was designated in 1998 as a critical ground water area with one or more of the following conditions: (1) saturated thickness is less than 50% of the aquifer thickness: (2) the water level shows declines of at least one foot per year within a five-year period, and (3) trends indicate degradation of water quality (ANRC, 2015). Also, the ANRC established an annual groundwater pumpage from the alluvial aquifer of 148,565 acre-feet as the safe yield. Yield and availability results were based on Arkansas Water Law[11] regulations and constraints, which have been implemented to protect and conserve groundwater resources (ANRC, 2011).

[11] Ark. Code Ann. § 15-22-915

3. Methodology and Data Sources

The research objectives include benefit-cost analysis of the Bayou Meto Basin project to re-examine and expand upon an economic assessment of the on-farm analysis conducted by the USACE (2007). Benefit-cost analysis is an effective tool for policy analysis, as it provides decision makers with a clear indication of the most efficient alternative that generates the largest net benefits to society, if all alternatives analyzed. This is useful information for decision makers and the public to receive, even when economic efficiency is not the only, or the overriding, public policy objective. However, benefit-cost analysis ignores the distributional effects and stakeholder impacts of a public policy. According to Krutilla (2005), "in providing a more complete representation of stakeholder impacts than aggregate efficiency analysis, the Kaldor–Hicks tableau offers insights about the political ramifications of a project or policy, as well as a better understanding of its economic effects" (p. 864). We believe that the Kaldor–Hicks tableau format is well suited to the integrated assessment of both the economic efficiency and distributional consequences of the Bayou Meto Basin project.

The study builds upon secondary data from various federal and state agency reports, publications and publicly available information. The main data source is USACE (2007) background data and projections, particularly: cropping pattern projections with and without the project; irrigated and dryland crop yield projections; crop price and yield projections; projected irrigation water sources with and without the project; projected crop enterprise production costs; projected irrigation energy costs with and without the project; project construction and operations and maintenance costs; and the estimated benefit-cost ratio (BCR) of the project.

Other data sources for this study include the U.S. Geological Survey (USGS), the U.S. Department of Agriculture (USDA), ANRC, and Arkansas Game and Fish Commission (AGFC).

The acre-feet of water in the Alluvial Aquifer are determined from the saturated thickness reported annually by the Arkansas Ground-Water Protection and Management Reports. The cost of production information is reported by the University of Arkansas Extension Service. Crop price information is based on the USDA's normalized prices and the Food and Agriculture Policy Research Institute (FAPRI) future forecasts. Estimates of annual expenditures for duck hunters and wildlife watchers are available from national surveys by the U.S. Fish and Wildlife Service (USFWS) to calculate the direct benefits of duck hunting and wildlife watching. This study is also based on the direct and total economic benefits of improving the wildlife habitat estimated by Wailes and Young (2005). The study addresses the economics of project construction, duck hunting and wildlife watching as these activities are identified as being important positive externalities. Because the Bayou Meto Basin project contains the Aquifer Protection and Agricultural Water Supply, Flood Protection, and Waterfowl Management components, this paper decomposes the project into these three parts and addresses each of these components separately in the following sections.

4. Aquifer Protection and Agricultural Water Supply

The Bayou Meto Basin in Arkansas is facing a major problem due to the lack of a dependable water supply to continue irrigation of cropland. Groundwater withdrawals in excess of recharge have resulted in several large cones of depression in the aquifer. The largest cone is centered in Arkansas, Prairie, Lonoke, and Jefferson counties, and is causing changes in elevation and flow of streams; damage to bridges, roads, private and public buildings; and compaction of fine-grained materials in aquifer systems. Declining groundwater levels have a

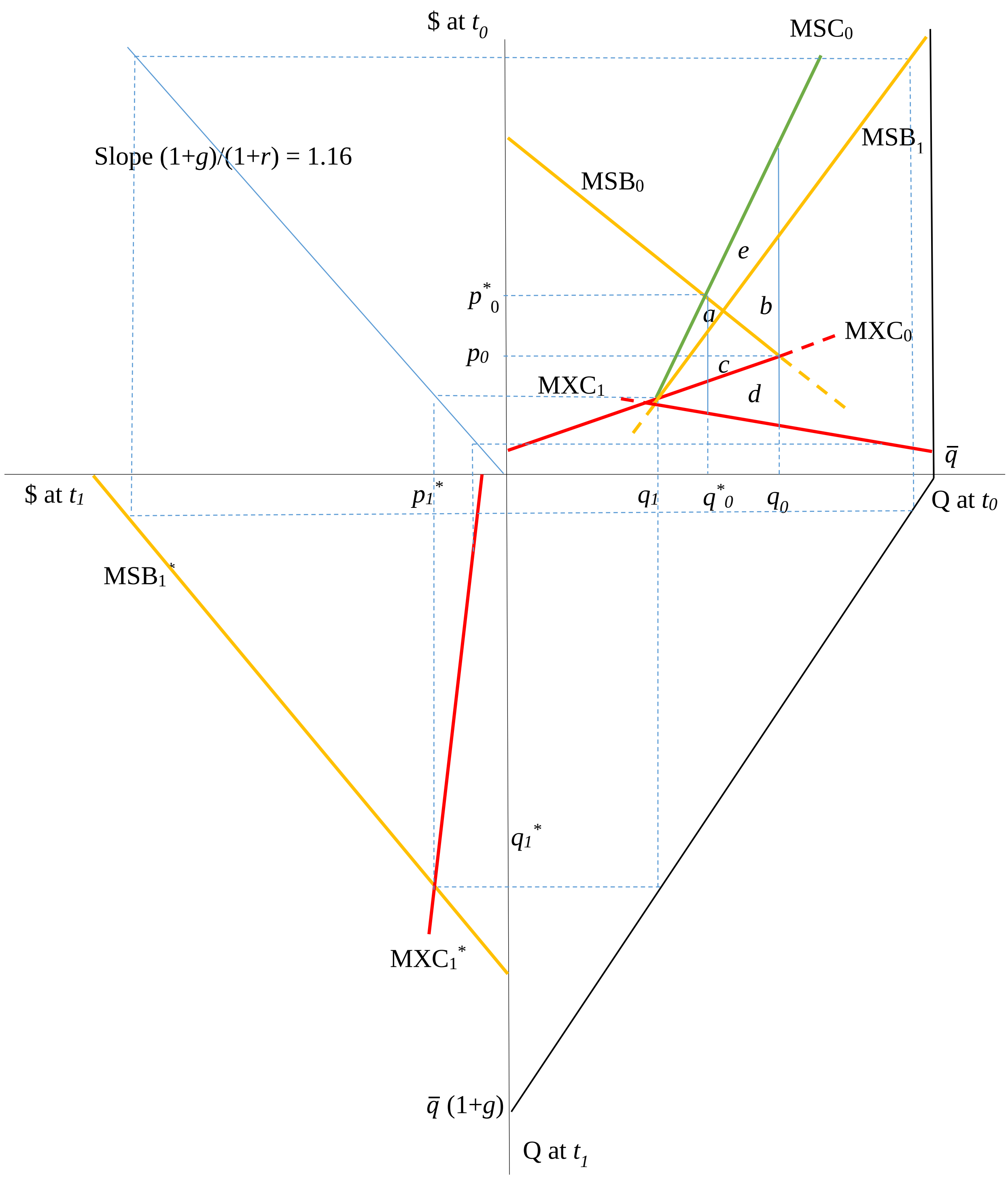
drying effect on the wetlands as recharge from the aquifer to natural streams decreases as the aquifer declines, thereby changing the ecology of the riverine system (Heitmeyer et al., 2004).

This section examines the economics of Bayou Meto Basin project's component that is designed to protect aquifers and provide a sustainable water supply for irrigation of 300,000 acres of cropland and for fish farming in the Bayou Meto Improvement Project Area (IPA). The IPA includes 433,166 acres, of which 267,982 are irrigated cropland and 22,079 are commercial fishponds. About 25% of the basin area is forested lands, 10% of which are contained in the Bayou Meto WMA. Timber production in the basin is less than 0.1% of state production (USACE, 2007). The identified irrigation water supply modules are (1) groundwater, (2) additional on-farm storage reservoirs, (3) conservation, and (4) an import water system.

In studies of policy issues related to water management, fundamental principles of resource economics must be combined with concepts from a variety of fields (e.g. hydrology, engineering, ecology). In resource economics, groundwater is commonly treated as a non-renewable resource, the management of which involves determining how to mine the stock in every period (Brown and Deacon, 1972; Gisser and Sanchez, 1980; Feinerman and Knapp 1983). However, recharge is a significant factor in the case of unconfined aquifers, like the Mississippi River Valley alluvial aquifer. Over time, a subsurface layer of water bearing, porous aquifer material is recharged naturally from precipitation that infiltrates below ground. It can also be recharged via irrigation flow, due either to canal leakage or excess applied water not consumed by crops. In some cases, water can also naturally discharge from the aquifer to adjacent water bodies. Therefore recharge/discharge, and hence the net growth function, are stock-dependent, and unconfined aquifer can be characterized as a renewable resource (Tsur and Zemel, 1995; Krulce et al., 1997; Pitafi and Roumasset, 2009).

Figure 1 is a schematic depiction of the welfare effects of regulation of intertemporal use of groundwater resources as they are meant to be understood conceptually in this section. Resource conservation is defined in economics as the efficient intertemporal use of natural resources. User costs can be considered in determining intertemporal marginal social cost at time t_0 with social discount rate by using a present value discount represented by a line of slope $(1 + g)/(1 + r)$ in the upper left quadrant (Just, 2004). The marginal social benefit curve MSB_1 is derived by deflating MSB_1^* by social discount rate r but then inflating by the recharge rate of g. The marginal extraction cost MXC_1 is derived similarly and then the marginal social cost at time t_0 is obtained as $MSC_0 = MXC_0 + MSB_1 - MXC_1$. Social optimality in Figure 1 can be obtained where $MSB_0 = MSC_0$ or at quantity q_0^*. Without some form of regulation or recycling, the market equilibrium in t_0 exceeds the social optimal quantity of q_0^*. This quantity of groundwater utilization at time t_0 can be obtained by establishing a sustainable quantity of 148,565 acre-ft/yr, which is the aquifer safe yield. The amount of groundwater that can sustainably support crop irrigation is about 22% of the Bayou Meto IPA (USACE, 2007). Therefore, g is considered to be 22%, and we consider r equal to 5.125%, which is the discount rate used by the Corps to calculate NPV for Bayou Meto project. In Figure 4, the line of slope $(1 + g)/(1 + r)$ is equal to 1.16. The welfare effects are a loss of the area $a + c$ at time t_0 and a gain of area $b + c + d$ at time t_1 assuming any tax revenues at time t_0 are redistributed in lump-sum payments to time t_0. The net gain from regulation is area $b + d - a$ = area $b + e$.

Figure 1. Welfare Effects of Regulation of Intertemporal Use of Groundwater in the Bayou Meto Basin

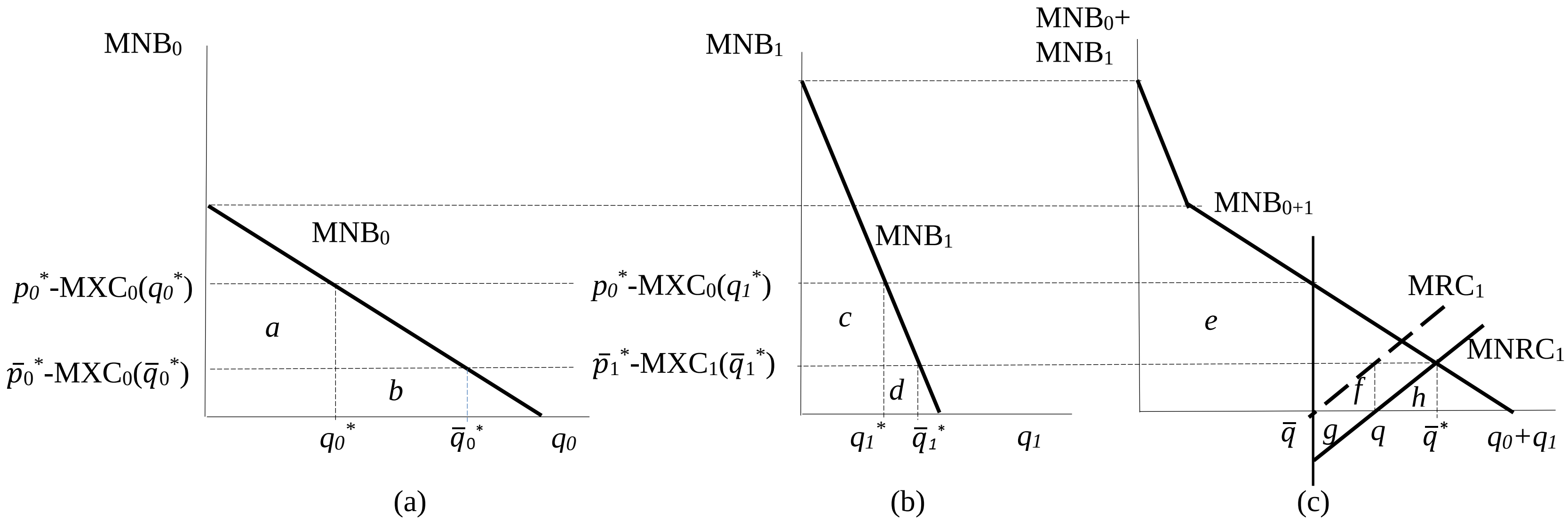


Source: Just et al. (2004)

Using recycled water in the agriculture sector can lower groundwater extraction costs and conserve water resources. On-farm reservoirs to mitigate unsustainable groundwater use and surface water pollution can receive water from rainfall, diverted surface water, and reused irrigation water from agricultural fields targeted for discharge into receiving streams (Kovacs et al. 2014). These systems are, in essence, a method of “recycling water.” Water recycling can reduce the scarcity of groundwater and increase intertemporal groundwater use beyond $\bar{q}$. This is because the use of q today leaves less q tomorrow, and this imposes and marginal user cost on the future generation. Note that in the recycling case present consumption need not deprive future generations.

Figure 2 is a representation of the welfare effects of intertemporal water recycling with on-farm storage reservoirs for rainfall runoff capture and tailwater recovery systems. The Bayou Meto project can recycle 80,051 acre-ft/yr water. Let MRC_1 represent the discounted marginal cost per unit of water resource recovered. The marginal net benefits for a unit of water resource recovered would be the marginal social benefits less the marginal recovery cost, $\overline{MNB}_1 = MSB_1 - MRC_1$, whereas the marginal net benefits in Figure 2(c) correspond to marginal social benefits less the marginal costs. Thus, $\overline{MNB}_1 = MNB_1 + MXC_1 - MRC_1 = MNB_1 - MNRC_1$, where $MNRC_1 = MRC_1 - MXC_1$. The marginal net resource cost of recycling, $MNRC_1$, is the marginal recycling cost less the marginal extraction cost that would have been incurred in the absence of recycling. The point of social optimality is at $\bar{q}^*$, where marginal net benefit is equal to marginal net resource cost, $MNB_{0+1} = MNRC_1$, which corresponds to recycling enough of the resource to support additional sustainable consumption of $\bar{q}^* - \bar{q}$ at over both time periods. Translating back into time periods in Figure 2(a) and (b), this implies optimal discounted marginal net benefits of $\bar{p}_0^* - MXC_0(\bar{q}_0^*)$ and $\bar{p}_1^* - MXC_1(\bar{q}_1^*)$, respectively.

Figure 2. Welfare Effects of Intertemporal Water Recycling with On-Farm Reservoirs and Tailwater Recovery Systems in the Bayou Meto Basin



Source: Just et al. (2004)

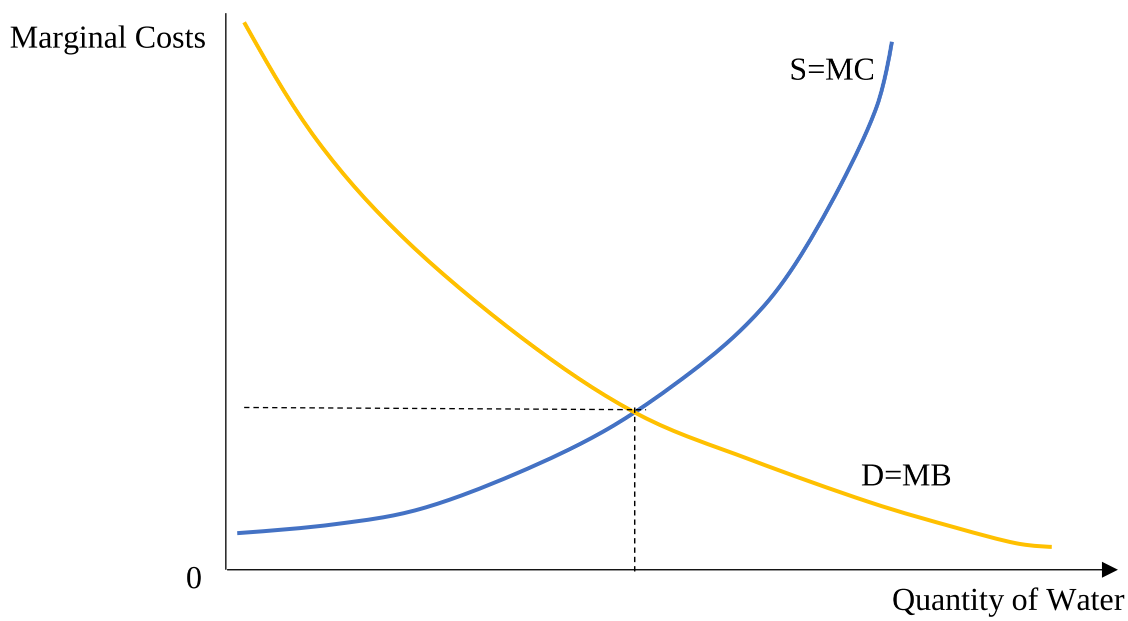
These diagrams in Figure 2 suppose the groundwater is used up in two periods, which is a simplification. However, this analysis can be generalized to the case where recycling takes in many time periods by replacing MRC_1 with the horizontal summation over time of all relevant discounted marginal recycling cost curves. The access to the recycled water lows the marginal user cost of the irrigation water use. Price $\bar{p}_0^*$ and quantity $\bar{q}_0^*$ would not occur unless appropriate regulations were imposed as with the with-project case.

Without recycling, net discounted consumer and producer welfare is the entire area under the MNB curves, represented by area *a* at time t_0, by area *c* at time t_1 and by area *e* for both time periods considered jointly. With recycling, the net present value of benefits over both time periods increases by area $f + g$. The gain at time t_0 is represented by area *b* in Figure 2(a), assuming that recycling costs are incurred only at time t_1. The net gain at time t_1 is area $d + g – h$, since area $f + h$ is equal to area $b + d$; hence, and area *f* is equal to area $b + d - h$. Substituting for area *f* in the overall gain of area $f + g$ and subtracting the gain at time t_0, area *b*, thus obtains the gains at time t_1 of area $d + g - h$. Area *g* represents a cost savings associated with recycling where marginal recycling costs are less than marginal extraction costs. Area *h* represents the higher cost that must be incurred for consumption at time t_1 when marginal recycling costs exceed marginal extraction costs. Since the marginal net benefit curve MNB_1 in Figure 2(b) relates only to groundwater extraction, both these adjustments to area *d* are required in calculating welfare effects of recycling at time t_1. This solution is valid only if the intersection of MNB_{0+1} and $MNRC_1$ is above the horizontal axis. Otherwise, recycling would be undertaken to the pint of supporting consumption $q - \bar{q}$ at time t_1. The Bayou Meto project plans to conserve 96,946 acre-ft/yr water by implementing conservation measures, including improvements in the on-farm water distribution system and/or changes in farm management practices such as

irrigation application methods and soil moisture monitoring that result in increased irrigation efficiencies. These also can be diagrammed similar to the recycling case as in Figure 2.

Figure 3 depicts long-run demand and supply curves for agricultural irrigation water. The demand curve shows at each level of quantity demanded, how much buyers are willing to pay for an extra unit of the input. This is a derived demand that relates the farmers' willingness to pay to the amount of irrigation water to produce crops.

Figure 3. Market Demand and Supply Curves for Irrigation Water



In Figure 3, the demand curve (D=MB) is downward-sloping from left to right, reflecting the diminishing marginal valuation of successive increments of water. The supply curve (S=MC) slopes upwards, reflecting the fact that increments of demand can normally be met only at rising cost to the irrigation system. The cost schedule is interpreted in the sense of long-run marginal costs of expanding the system to meet a permanent increment of demand. These basic notions are equally applicable to water 'mining', such as the excessive drawdown of aquifers,

where the benefit of reduced consumption is the avoided cost of alternative future supplies. In the market, decisions are based on the private costs and private benefits to market participants. If the consumption or production of goods and services poses an external cost or benefit on those not participating in the market, however, then the market demand and supply curves no longer reflect the true marginal social benefit and marginal social cost. Hence, the market equilibrium will no longer be the socially (Pareto) efficient outcome.

Figure 4 demonstrates the supply curve S_g for groundwater as perfectly inelastic at q_2, reflecting the assumption that the farmers are allowed to pump up to a particular quantity of groundwater. The supply curve S_s for surface water is drawn as perfectly inelastic at q^*, reflecting the assumption that a given infrastructure can only supply up to a specific quantity of project water.

Figure 4. Impact of the Aquifer Protection and Agricultural Water Supply Component

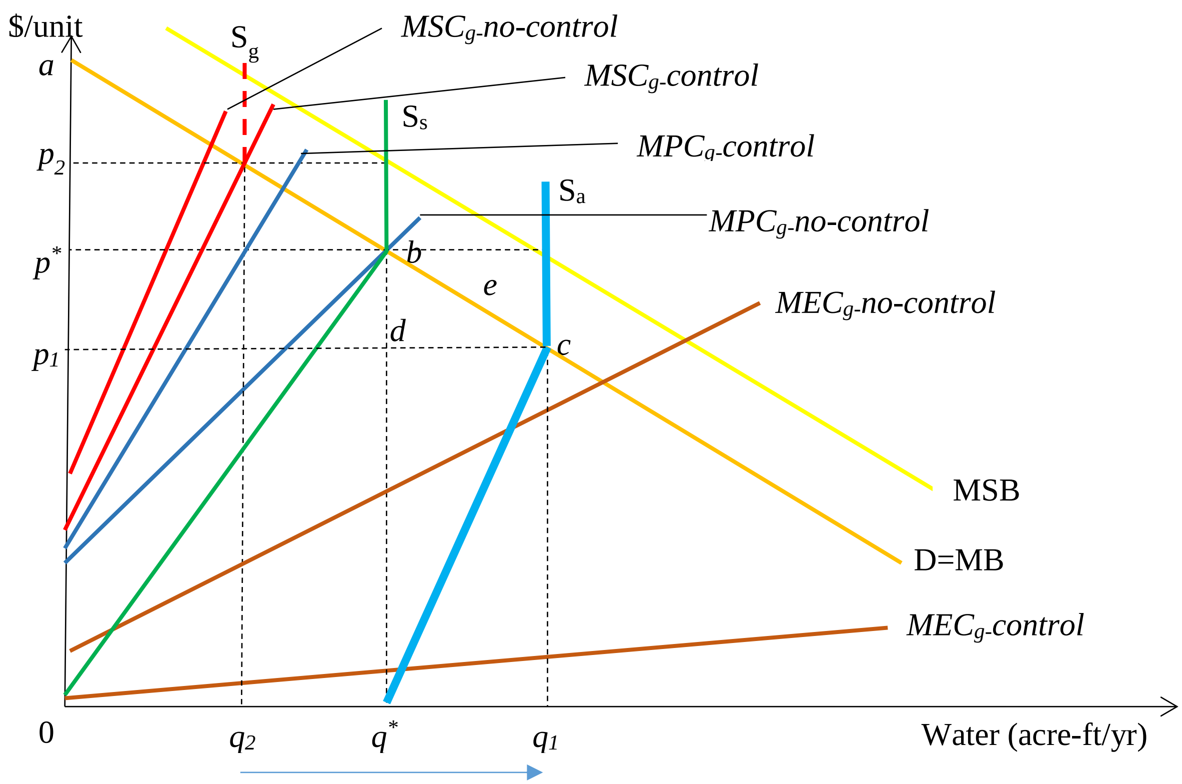


Figure 4 Label and Project Parameters:

- $q_1 = q^* + q_2$
- $q_2 = q_g + q_r$
- $q^* = q_i + q_c$
- q_1 = 649,175 acre-ft/yr (total water demand)
- q_g = 148,565 acre-ft/yr (aquifer safe/sustainable yield)
- q_r = 80,051 acre-ft/yr (storage and tailwater recovery)
- q_i = 323,613 acre-ft/yr (project import)
- q_c = 96,946 acre-ft/yr (project conservation)
- $S_a=S_g + S_s$
- S_g= MSC_g with control and limit
- S_s= supply of project surface water

In Figure 4, the supply curves *MEC_g-no-control* and *MEC_g-control* depict the marginal external costs of groundwater supplies in "no control" and "with control" cases, respectively. Groundwater over drafting involves negative externalities such as land subsidence, drying effects on wetlands and streams, decrease in waterfowl due to limited food and habitat availability, etc. Marginal external costs include these negative externalities, i.e. negative effect of groundwater pumping on the third parties, including neighboring farmers. Those marginal external costs are assumed to be higher in the case of "no control" compared to the "with control" case.

In Figure 4, the baseline is the "no control" case, where demand for irrigation water (D=MB) equals the marginal private cost (*MPC_g-no-control*) of groundwater supply at p^*q^*. In the "control" case, the farmers will have to build on-farm storage reservoirs and tail-water recovery systems. These would involve some extra capital and land, therefore marginal private

costs (*MPC_g-control*) of groundwater supply with "control" case is assumed to be higher compared to the "no control" one.

In the absence of proper control and limits, many farmers, in their desperation for water, take a chance and invest in drilling deep wells, because their marginal private costs (*MPC_g no control*) is low. However, the supply curve for groundwater S_g (quasi-supply) is equal to the marginal social cost curve (*MSC_g-control*), which is obtained by adding marginal external costs (*MEC_g-control*) and marginal private costs (*MPC_g-control*). The Arkansas Ground Water Protection and Management Act authorizes the ANRC to impose a limit on groundwater use through the issuance of groundwater rights within critical groundwater areas (ANRC, 2011). Because of lower transaction costs, development of alternative sources might be the preferred way of groundwater protection than regulation. When the Bayou Meto project begins to provide supplemental surface water to the project area, the State is expected to begin regulating the groundwater use. As a minimum, new well drilling will not be allowed (ANRC, 2011).

In Figure 4, the price level p^* and quantity amount q^* reflect the situation before the project is introduced. In that case, p^* represents the marginal private cost of groundwater pumping without control (*MPCg no control*). Therefore, it would be acceptable for farmers if the import irrigation water would cost up to p^*. With this project in place, the State will be able to enforce the groundwater pumping limit to the amount of q_2, which is the Alluvial Aquifer's safe yield. Also, usage of the Sparta Aquifer is expected to decline because the surface water will be much cheaper than groundwater.

Managing groundwater and surface water conjunctively can be welfare enhancing. Widening the resource problem to a resource system instead of managing each resource independently can lower the scarcity value of groundwater. Assuming an average precipitation

amount in the area, sizes of the storage and tailwater systems, as well as the capacity irrigation canals and pumps are limited, supply of surface water in the region is limited up to quantity S_s, and the supply of the groundwater is limited to some S_g quantity set by the State, the aggregate supply curve S_a for water can be constructed by horizontally adding S_s to the S_g.

In Figure 4, introducing the Bayou Meto Basin irrigation project would cause the supply curve to shift to the right. The intersection of the aggregate supply curve (S_a) and demand curve (MB) determines the quantities and the marginal benefit of water consumption. Although it is assumed that there is a market determined price before and after the project, this could just be an illustration of water supply cost. In such a case, p^* would reflect the operation costs of extracting groundwater (per acre feet) before the project, and p_1 would be the sum of average ground and surface water costs after the project. If so, the project will result in a decrease in price from p_2 to p_1 and an increase in quantity from q_2 to q_1, meeting the total irrigation water demand in the region. Area abq^*0 measures the value of irrigation water when the quantity q^* of water is used to irrigate crops in the region, and area acq_10 measures the value when the quantity q_1 is used. This means that the value of the extra crops produced because of using the extra quantity of water q^*q_1 is measured by area bcq^*q_1, and, optimal social production is larger than optimal private production.

Krutilla (2005) suggests that secondary market effects can be ignored in project appraisal if the secondary markets are perfectly competitive and/or undistorted. This is even true when the project in question is large enough to change the equilibrium conditions in secondary markets. Besides being the largest producer of rice in the United States, eastern Arkansas region is a major producer of other irrigated crops, such as soybeans, corn and cotton. Assuming that the agricultural industry is competitive in those product markets, buyers of the input (water) will be

willing to pay the value of the marginal product of water for an extra unit of water; i.e., they are willing to pay for an extra unit of water because of the value of the extra output that will result from using that extra unit of input.

4.1. Stakeholder Analysis for Aquifer Protection and Agricultural Water Supply

There are five major stakeholder groups that might be affected by the Aquifer Protection and Agricultural Water Supply component of the Bayou Meto project: the public (consumers of food and the environment), private landowners/farmers/local businesses, the water authority (BMWMD), other state agencies, and the Federal government. Since the prices of crops are assumed not to change because of the project, food consumers receive no net benefit: they pay exactly what the extra food is worth to them. However, the public benefits because of lower environmental damage from reduced aquifer pumping. In Figure 4, the water authority revenues with the project is area p^*bq^*0. The supply of cropland in the region is fixed at the quantity of 300,000 acres. As a result of increased water availability, potential farmers are willing to pay more rent per acre because of the lower cost of irrigation water. Because of increased demand for land, the market rental value of the land rises and the annual return to landowners rises. Since area abp^* measures landowner income before the increase in availability of water, and area acp_1 landowner income after the increase in the supply of water, the area p^*bcp_1 represents the increase in income to landowners.

Since the Bayou-Meto Basin project is being funded by Federal and State governments, it can be classified as an input subsidy. Irrigation subsidies can lead to the underpricing of irrigated water, which in turn fosters the inefficient use of water (source). When water is subsidized this means that the water fee is lower than the price of water in a competitive market.

In Figure 4, the supply of water is shown as increasing from q^* to q_1, because of the project, and water is sold at price p_1, yielding additional revenue of dcq^*q_1 to the water authority. Since area bcq_1q^* represents the value of additional water sold, there must be an equivalent increase in income. The water authority's income rises by dcq^*q_1 so the income of the other factors of production, land, for example, must rise by *bcd*. Generally, low water fees increase land rent: the cheaper that the water can be obtained, the more the land is worth.

While many subsidies have unintended negative consequences on the environment (Just et al., 2004), well designed subsidies can be beneficial when they work to mitigate an environmental problem. Subsidies can raise total surplus when positive externalities are present. Just et al. (2004) defines positive externalities as "benefits generated outside of any market transaction, and they make someone better off without that person being required to reimburse the party responsible for the positive effect" (p. 527). The Bayou Meto project would provide a supply of irrigation water that will allow the aquifer to rebound above the minimum saturated thickness, which will, in turn, increase in stream base flows to benefit fish, wildlife and other natural resources. Also, rice fields will continue to provide a major source of grain for the waterfowl that utilize the area. Therefore, it is not necessarily the case that subsidies are always bad policy, especially for those stakeholders (the public) who would derive external benefit by gains to the area *e*, as shown in Figure 4.

5. Flood Control Component

In the Bayou Meto area, the majority of floods occur primarily in the first and second quarters of the year, the frequency of flooding occurrences is about two times annually, and flooding duration varies from 1 day to 97 days (USACE, 2007). The problems resulting from

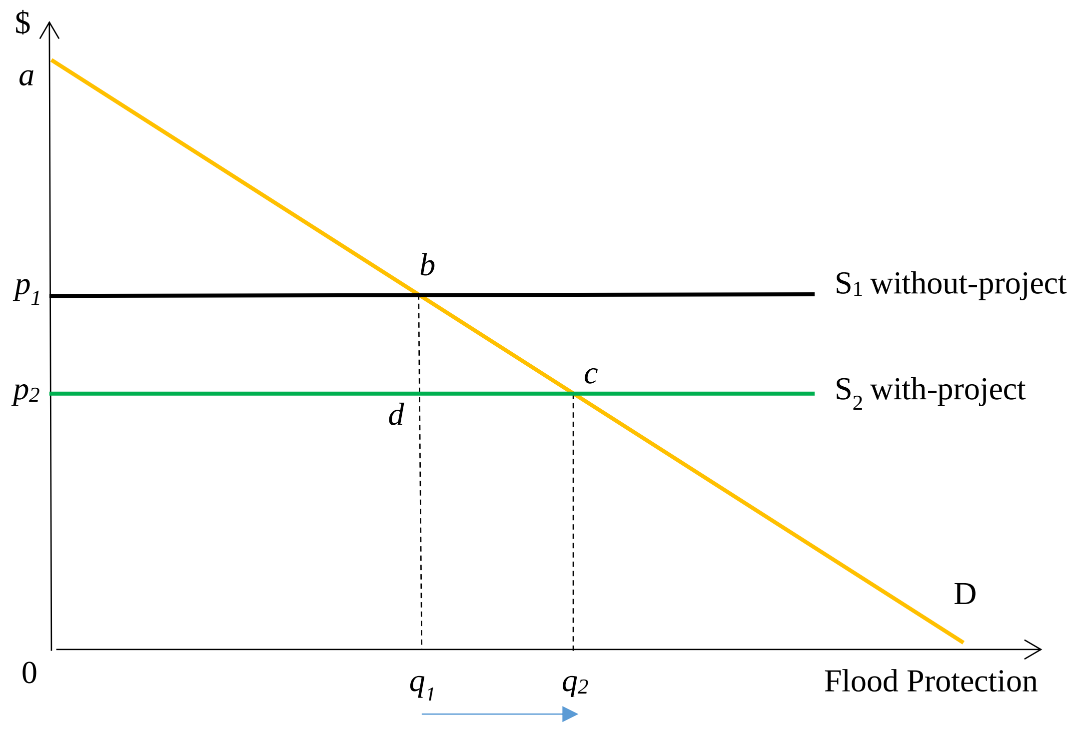
frequent flooding in the Bayou Meto Basin are include: (a) flood damage to roads and bridges, crops and non-crop items such as ditches, land leveling, irrigation systems, fences, farm supplies, grain bins, etc.; (b) a restriction on the ability of farm operators to apply production inputs and techniques; and, (c) flood damage resulting from quick concentration of rainfall runoff combined with the inadequacy of the existing channel systems to remove flood water from the low-lying areas and manage flows from the upstream areas. For instance, continuous development in and around Jacksonville, AR cause flooding problems in the northern area along Bayou Meto River (USACE, 2006).

In response to these problems, the U.S. Congress acknowledged flood control as essential for the protection of the Bayou Meto area's human and natural resources. The initial project, authorized by section 204 of the Flood Control Act of 1950, was for flood control in the area (USACE, 2007). However, this flood control project was re- authorized in 1986 with a broadened scope of responsibility. The resulting federal, state and local partnership approach led the Corps, ANRC and BMWMD to plan a Flood Control component in the Bayou Meto Basin project. Project activities include channel cleanout and enlargement in the Bayou Meto Basin, construction of a pumping plant, and water control structures on affected streams. Improvements to existing channels would reduce flooding and eliminate induced impacts from the agricultural water supply component. Measures to enhance water management for fish and wildlife, protect and restore bottomland hardwoods, provide for positive drainage, and restore natural flow regimes are integral parts of the planned improvements. These would be positive externalities generated by the flood control component. Also, it should be noted that the flood control is a public good: once a local flood control project is built, anyone in the protected area enjoys flood protection, and it is difficult to exclude anyone from the benefits. Since nonpaying users cannot

be excluded from enjoying a public good, there is a legitimate role for government to provide public goods and to create conditions for cost recovery.

Figure 5 is a market for flood protection, where S_1 is supply curve without-project, S_2 is supply curve with-project, q_1 is quantity of flood control without-project, q_2 is quantity with-project, area abp_1 is without-project social welfare, and area acp_2 is with-project social welfare. The quality of living depends on the price of living in the flood plain, which includes flood damages incurred while living on this land. Flood protection reduces annual flood damage which lowers the average price of living in the flood plain from p_1 to p_2. A price change increases consumer surplus - the value received in addition to the price paid. Change in social welfare with the project is given by the area p_1bcp_2.

Figure 5. Impact of Flood Control Component



Since the project area is relatively small compared to the overall U.S. agricultural areas, we assume that any alternative level of flood protection would not significantly affect total national agricultural production. Society would be willing to pay an amount of money equal to the increased consumer surplus they realize from flood protection in order to obtain the flood control. In Figure 5 it is shown as the change in consumer surplus due to existing q_1 and the change in consumer surplus due to increased q_2. Flood damage reduction benefits, measured as the area p_1bcp_2, are mostly attributable to agriculture and rural development. Besides agriculture and rural development, area *bcd* represents also the incidental benefits to the environment, such as reduced timber stress in the bottomland hardwood community, decreased damage from early fall flooding as well as damage from spring inundation of bottomland hardwoods, increased wetland and terrestrial resources through the reforestation of frequently flooded marginal farmland, and decreased aquatic resource exposure to chemical contaminants, etc. which can be explained as a positive externality. Without the project, the Bayou Meto WMA would continue to be flooded to cause greater deterioration of the waterfowl and wildlife habitat, primarily as a result of reduction in bottomland hardwoods that provide food for the waterfowl and wildlife in the basin (Heitmeyer et al., 2004).

There are clear crop sector benefits to be gained as well as environmental benefits. However, data were limited to assess the value of reduced damage to the environment. In the absence of market prices and demand curve, it seems reasonable to assume that land owners would be willing to pay up to the amount of damage they would avoid by this project. We are interested in changes that take place as a result of the project. Total average annual benefits for the flood control component were determined by the Corps to be $5.56 million (USACE 2007, p. 327). Annual flood damages to present development within the Bayou Meto Basin are estimated

by the Corps at $16.5 million. Then the Corps used their Computerized Agricultural Crop Flood Damage Assessment System (CACFDAS) to calculate the crop and non-crop flood damages, as well as the baitfish farming operation flood damages with-project condition. As benefits were derived by obtaining the difference in projected damage values for without- and with-project condition, and annualizing the projected benefit values, we think that it provide a reasonable estimate of the area p_1bcp_2 in Figure 5.

5.1. Stakeholder Analysis for Flood Control Component

There are five major stakeholder groups that might be affected by the Flood Control component of the Bayou Meto Basin project: the public (consumers of crop and fish), private landowners/crop and fish farmers, the water authority (BMWMD), other state agencies, and the Federal government. The project would provide inundation reduction benefits consisting of damage reduction to development expected to exist for present conditions and the reduction of damage to additional development without project installation. According to the NED/NER recommended plan, the reduction in annual flood damages for baitfish operations would be 69.1%, crops 23%, non-crop agriculture 20%, and public roads and bridges 1% (USACE, 2006, table F-40). The Corps have determined benefits from flood damage reduction to public roads and bridges by subtracting projected with-project damages ($126,000) from projected without-project damages ($124,000) and annualizing the difference. Average inundation reduction benefits ($4.1 million) to agricultural crops are based on an analysis of practices on lands not incurring changes in cropping patterns due to the project. Benefits from flood damage reduction to agricultural non-crop items, such as farm roads, fences, irrigation systems, drainage ditches, land forming and leveling, are determined as a difference between projected base flood damage

values projected with project damage values. With the Bayou Meto project, baitfish/catfish farm operations will be benefited to the extent that flood damages to these activities can be significantly reduced, which is estimated as a difference in projected damage values for without-project and with-project conditions. Since the cost of floodplain farming is assumed to decrease because of the project, the farmers and landowners receive benefits by an amount measured by area p_1bcp_2. In Figure 5, area acq_20 measures the total value of flood control in the region once the additional quantity of flood protection is available. Note also that area bcq_2q_1 measures the reduced damage once the project is completed.

6. Waterfowl Management Component

The Bayou Meto Basin area is one of the most significant waterfowl resources along the North American Flyway. The Bayou Meto WMA occupies 33,700 acres of bottomland hardwood wetland and is a very important wintering habitat for mallards (Heitmeyer et al., 2004). The Bayou Meto WMA has been owned and operated by the AGFC since the 1950s. The AGFC policy for many years was to impound as much surface water as possible for waterfowl hunting in fall and winter (Heitmeyer et al., 2004). There has been a severe loss of habitat and food supply for wildlife because of the prolonged flooding. This component of the project offers significant opportunities to restore and enhance 55,000 acres of fish and wildlife habitat, including the Bayou Meto WMA.

Wildlife watching and hunting are important recreational activities in the Bayou Meto Basin and are also a significant source of income to the state. According to Heitmeyer (2004), the Bayou Meto WMA helps to support the duck population in the whole Bayou Meto Basin and about half of all ducks in the basin are due to the presence of the Bayou Meto WMA.

Table 1. Sales of AGFC hunting licenses and duck stamps in Arkansas

Fiscal Year (end 6/30)	Total Licenses	Duck Stamps	Duck Season Length	Duck Stamps/ Licenses %
1984	313,545	46,451	50	14.8%
1985	310,491	46,465	50	15.0%
1986	302,661	52,432	40	17.3%
1987	332,934	51,820	40	15.6%
1988	293,465	47,673	40	16.2%
1989	316,596	37,586	30	11.9%
1990	305,674	37,530	30	12.3%
1991	293,467	40,507	30	13.8%
1992	311,088	39,356	30	12.7%
1993	313,982	41,315	30	13.2%
1994	314,668	46,702	30	14.8%
1995	319,070	54,953	40	17.2%
1996	322,780	62,438	50	19.3%
1997	319,011	70,703	50	22.2%
1998	330,665	76,037	60	23.0%
1999	343,483	80,849	60	23.5%
2000	326,838	85,086	60	26.0%
2001	332,651	92,892	60	27.9%
2002	336,235	95,863	60	28.5%
2003	319,056	89,454	60	28.0%
2004	306,545	85,104	60	27.8%
2005	305,978	83,412	60	27.3%
2006	304,823	71,696	60	23.5%
2007	330,113	78,140	60	23.7%
2008	339,901	77,659	60	22.8%
2009	381,958	80,206	60	21.0%
2010	372,124	76,501	60	20.6%
2011	375,698	79,096	60	21.1%
2012	382,436	86,319	60	22.6%
2013	396,192	92,025	60	22.8%
2014	404,453	98,115	60	24.3%
2015	411,162	104,145	60	25.3%
2016	405,085	99,973	60	24.7%

Source: Arkansas Game and Fish Commission data

Waterfowl seasons in recent years continue to exhibit unpredictable and sometimes inexplicable patterns of duck abundance, or lack thereof. According to the Midwinter Waterfowl Survey, in 2016 there were 125,780 total ducks and 84,035 mallards in Bayou Meto-Lower

Arkansas, whereas in 2017 these corresponding numbers were 250,439 and 219,106 (AGFC, 2017). Although waterfowl numbers have declined in Arkansas, as well as in the Bayou Meto Basin, the importance of waterfowl watching and hunting in the state has been increasing until recently (Table 1).

In the United States, each individual older than 16 years of age must purchase a Federal Migratory Bird Hunting Conservation Stamp (hereafter, duck stamp) before hunting waterfowl, which costed $25 in 2015-16 FY. Ninety-eight percent of the funding derived from duck stamp sales goes directly to the purchase or lease of waterfowl habitat within the National Wildlife Refuge system, including Wetland Management Districts and Waterfowl Production Areas (USFWS, 2015). In 2015-16 FY, Arkansas non-residential waterfowl stamps sold for $35 each, whereas the residential one sold for $7 only. Both the residential and non-residential duck stamp sales and their total revenues have increased during the past decade in Arkansas (Table 2).

Table 2. Sales of AGFC Resident and Non-resident Duck Stamps (Years 2006-2016)

Fiscal Year	Total Duck Stamp Sales	Resident Duck Stamp sales	Non-Resident Duck Stamp Sales	Non-Resident Sales %	Total Revenues $
2006	71,696	43,527	28,169	39%	868,069
2007	78,140	47,676	30,564	39%	944,312
2008	77,659	46,901	30,758	40%	943,467
2009	80,206	48,918	31,288	39%	968,186
2010	76,501	47,039	29,462	39%	918,513
2011	79,096	47,440	31,656	40%	965,200
2012	86,319	50,417	35,902	42%	1,070,959
2013	92,025	52,947	39,078	42%	1,706,349
2014	98,115	56,884	41,231	42%	1,841,273
2015	104,145	58,324	45,821	44%	2,012,003
2016	99,973	54,454	45,519	46%	1,974,343

Source: Arkansas Game and Fish Commission data

Wildlife recreation is economically important in the Bayou Meto Basin. Over 40 private hunting clubs and numerous hotels and restaurants benefit from recreational spending, primarily

duck hunting, during the hunting season. According to USFWS (2013), hunting by U.S. residents is a big business with estimated hunter expenditures of almost $1,018.8 million in 2011 in Arkansas. Duck hunting is especially important in the Bayou Meto Basin, with numerous private hunting clubs and other infrastructure, such as outfitters and guides, which are dependent on duck hunting clientele. The 2011 Survey also estimated that 852,000 U.S. residents participate in wildlife-watching in Arkansas, of those 137,000 are away from home participants, and 820,000 are around-the-home participants. All participants spent $216 million on wildlife watching in 2011 in Arkansas, which includes $34.52 million for trip related expenses and $181.55 million for equipment and other expenses (USFWS, 2013).

An economic assessment of the environmental recreation benefits is presented in the section below. First, estimates are provided of the value of duck hunting without and with the project. Second, estimates are provided of the economic value of improving the ecosystem to enhance wildlife watching. Finally, the aggregate net effect, with and without the project, is estimated. The assumptions used to make projections of the demand for duck hunting were based on recent trends in duck stamp sales in the five counties (Arkansas, Jefferson, Lonoke, Prairie, and Pulaski) in the Bayou Meto Basin, which were provided by the AGFC. Multiplier effects on total economic activity, employment, wages and salaries, state sales and income taxes and federal income taxes were based on estimates provided in Caudill (2014) and Southwick Associates (2003).

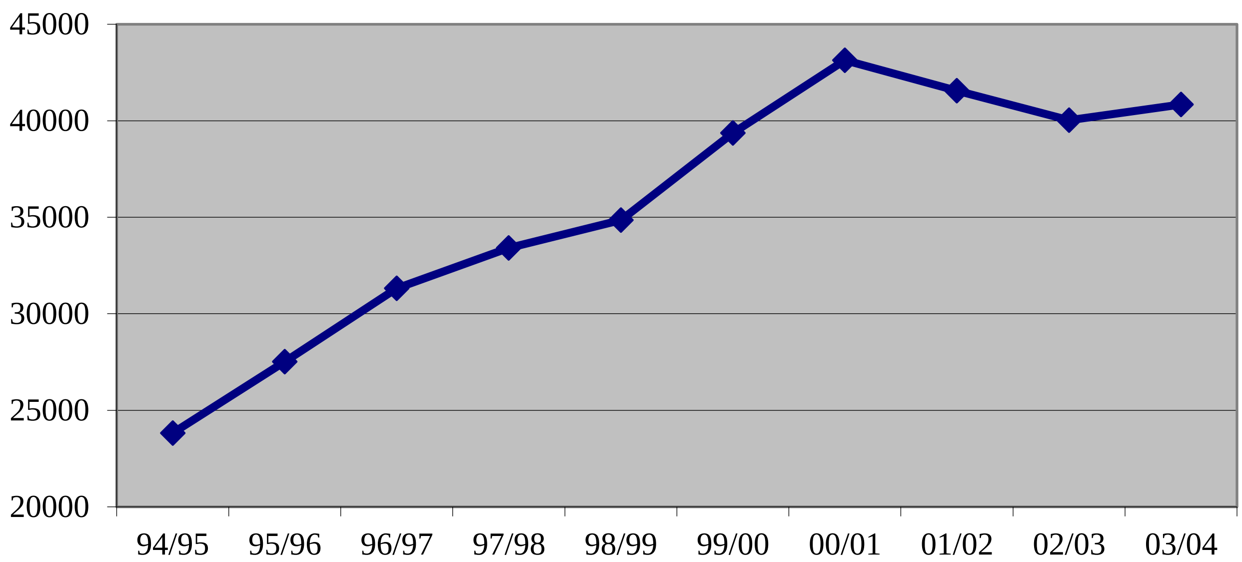
6.1. Economics of Enhancing the Bayou Meto Basin for Duck Hunting

The economic value of the Bayou Meto project for duck hunting is based on an analysis of increased duck use days potentially associated with waterfowl management features proposed

for the Bayou Meto Basin (Heitmeyer, 2005). In an earlier study, Heitmeyer et al. (2004) estimated that the degradation of the Bayou Meto WMA has resulted in a significant decrease in water bird numbers. For example, based on AGFC unpublished records, they note that "mid-winter inventories of ducks in the Basin have gradually decreased from over 100,000 during the 1960s and 1970s to less than 50,000 in the 1990s" (p. 28).

Figure 6 shows that duck-stamp sales in the five counties in the Bayou Meto Basin increased since the 1990s (Wailes and Young, 2005). However, in the previous years, duck stamp sales declined, as one might expect, as a result of the decline in the waterfowl habitat and duck inventories in the area.

Figure 6. Duck Stamps Issued in Bayou Meto Basin



Source: Wailes and Young, 2005

Without having reliable data to estimate the relationships between the demand for duck stamps and demand variables, a trend analysis of duck stamp sales data was conducted by Wailes and Young (2005). The equation, as presented below, provides the estimated coefficients that

are found to be significantly different from zero, with t-statistics given in parentheses, and a fit of the equation to the actual data that explains 95 percent of the year-to-year variation.

$$\ln \text{(Duck Stamp Sales)} = 10.058 + 0.273 * \ln \text{(Time)}$$

$$(283.704) \quad (12.126)$$

$R^2 = 0.954$

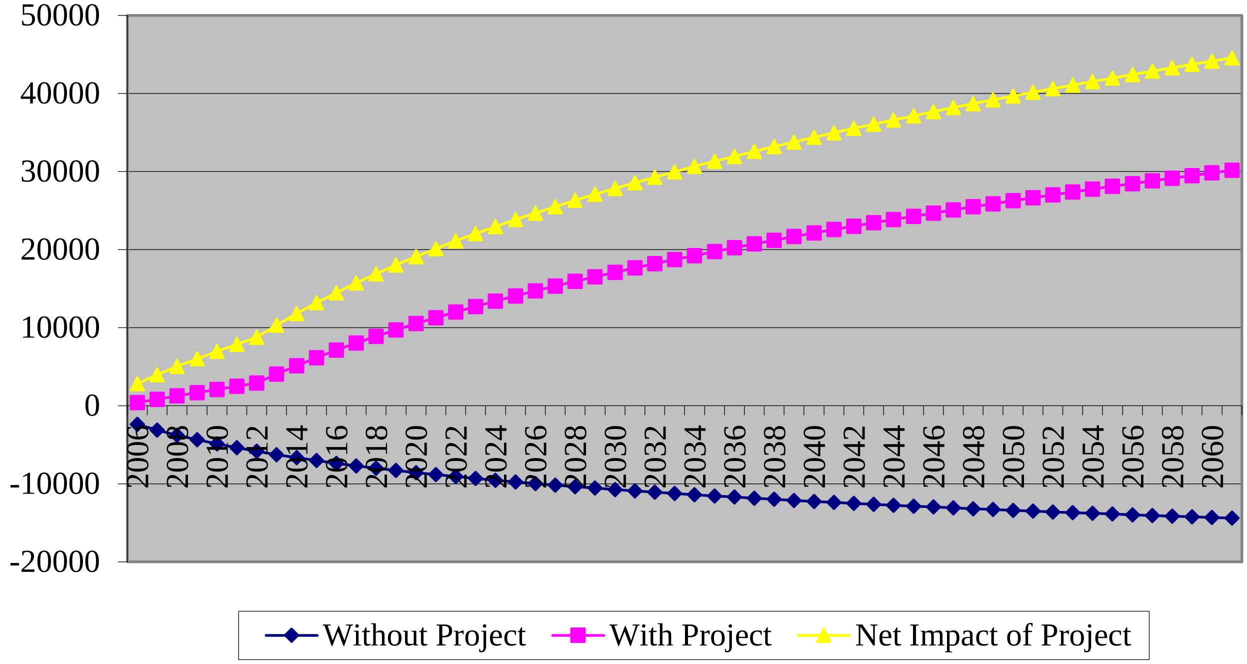
Where Time = 10, 11, 12, 13, 14, ….

Wailes and Young (2005) used this equation to project the future demand for duck stamps with the project, based on the assumption of successful restoration of the water bird habitat and maintenance of rice production in the basin area. Estimates of future demand for duck stamp sales without the project, with further degradation of the wildlife management area and significant decline in rice production in the area.

$$\ln \text{(Duck Stamp Sales)} = 10.058 - 0.2 * (\ln \text{(Time)} – 2)$$

On the base of this synthetically derived equation, the projections of duck stamp sales in the five counties are depicted in Figure 7 for the period 2006 to 2060 (Wailes and Young, 2005).

Figure 7. With- and Without Project Impact on Change in Duck Stamp Sales in Bayou Meto Basin



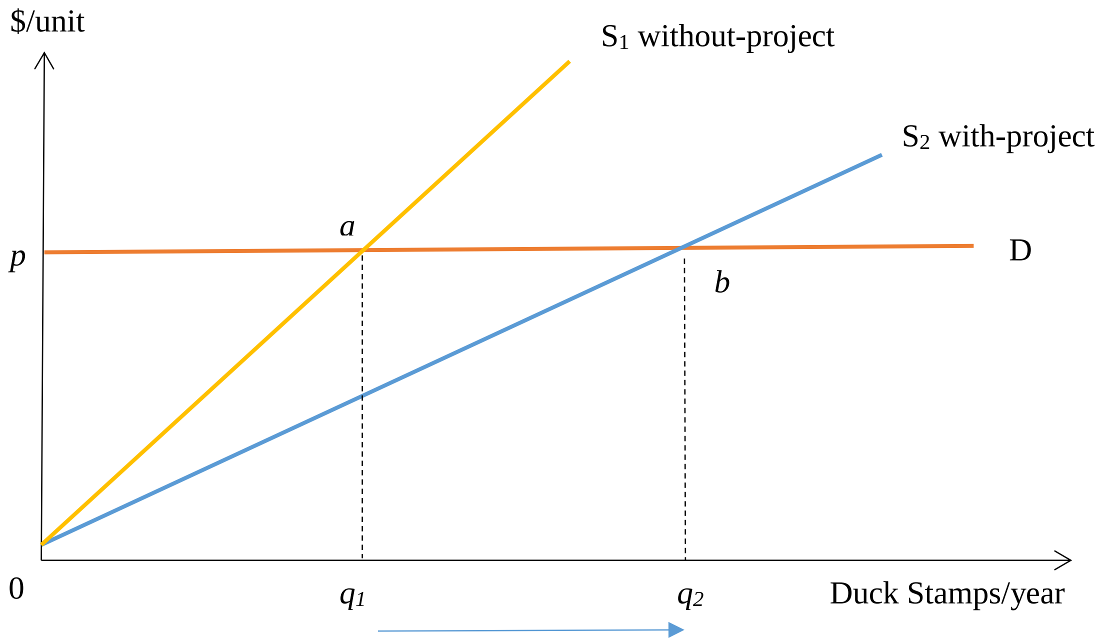
Source: Wailes and Young, 2005

The estimates of duck stamp sales were used to generate direct sales expenditures by duck hunters in the Bayou Meto Basin. Arkansas waterfowl stamp sales during the 2014-15 season rose for the fifth consecutive year to a new record high of 104,629 (up from 98,115 in 2013-14). Resident duck stamp sales rose to 58,827 (56,884 in 2013-14) while non-resident duck stamp sales rose to 45,802 (41,231 in 2013-14). Continued high waterfowl populations caused by improved habitat conditions likely encouraged increased duck stamp purchases especially among the non-residents (AGFC 2016).

Figure 8 is a market for duck hunting, where S_1 is supply curve without-project, S_2 is supply curve with-project, q_1 is quantity without-project, q_2 is quantity with-project, area *pa*0 is without-project social welfare, and area *pb*0 is with-project social welfare. Although the Bayou Meto Basin is one of the premier duck hunting areas in the world, we assume that the demand

curve in duck hunting market would be perfectly elastic. When the demand curve is perfectly elastic, there will be no consumer surplus.

Figure 8. Impact of Waterfowl Management Component



In Figure 8 a change in social welfare with the project is given by the area *pb*0, society would be willing to pay an amount of money equal to the increased producer surplus they realize from wildlife habitat enhancement. These surpluses are shown as the change in producer surplus due to existing q_1 and the change in producer surplus due to increased q_2.

The economic value of the Bayou Meto Basin project for environmental recreation is based upon ending the deterioration of waterfowl and wildlife habitat and restoring the area as one of the premier duck hunting and wildlife watching areas in the state of Arkansas and the nation. When the direct spending benefits of duck hunting and wildlife watching are added to the direct benefits to the crop sector, the calculated BCR for the project increases from 1.25 to 2.44 (Wailes and Young, 2005). The waterfowl management component of the project will

provide investment in structural improvements that will facilitate implementation of the Bayou Meto Wetland Management Plan described in detail by Heitmeyer et al. (2004).

6.2. Stakeholder Analysis for the Waterfowl Management Component

There are three major stakeholder groups that might be affected by waterfowl management component: consumers (duck hunters and wildlife enthusiasts), AFGC / game land owners in the region and the Federal government. Although the price of duck stamps is assumed not to change because of the project, consumers receive a net benefit due to increased wildlife availability, and they pay exactly what the extra duck stamp is worth to them. The AFGC / game land owners benefit by an amount measured by area $ab0$, which is the change in duck stamp revenues. Area $pbq_2 0$ in Figure 8 measures the total value of duck hunting in the region once the additional quantity of wildlife habitat is available.

7. Distributional Effects of the Bayou Meto Basin Project

According to Ostrom (1990), theory regarding collective action to regulate common-pool problems comes when: a) there is broad consensus or agreement on the aggregate benefits to be gained, b) the parties perceive positive net gains from agreement, and c) they are homogeneous with respect to bargaining objectives and in the distribution of the costs and benefits to be incurred. The term “distributional effect” refers to the impact of a policy or project across the population and economy, divided up in various ways (OMB, 2003). A Kaldor-Hicks tableau (KHT) is a matrix format that comprehensively displays a project’s economic and financial effects (Krutilla, 2005). Utilizing the KHT format, we can measure the distributional effects of the Bayou Meto Basin project by examining all impact channels among stakeholder groups

identified for each component of the project. The principal reasons for such an examination are to improve the accuracy of the efficiency analysis itself, recognizing that impacts on stakeholders influence the social production function upon which a project is based, and to better demonstrate the structure and distributional effects of the project components.

Figures 4, 5 and 8 are visual representations of the distorted market equilibrium which results from the implementation of the Bayou Meto Basin project components in three markets. First, it will protect ground water, and provide a sustained water supply for irrigation of about 300,000 acres of cropland and fish farming in the Bayou Meto IPA. Secondly, it will provide major flood control benefits in an important agricultural region of the state. Thirdly, it will enhance 55,000 acres of fish and wildlife habitat, including the Bayou Meto WMA.

Table 3 contains all the labels and values used to construct KHT for the Bayou Meto Project. Label B1 represents the net-value of the irrigation water supply to water users beyond water use charges; B2 shows the net value of reduced flood damage to beneficiaries of flood control. B3 represents the net-value of the wildlife and recreational benefits to duck hunters and wildlife enthusiasts beyond hunting charges. B4 shows the net value for the public the lowered environmental damage beyond any financial or other costs they incur.

In Table 3, supply-side costs are aggregated into the following categories: on-farm irrigation features, the opportunity cost of which is (–C1); off-farm infrastructure of new irrigation systems, the opportunity cost of which is (–C2); the O&M costs of on-farm irrigation, including the time opportunity cost of newly-employed farm workers, the total of which is (–C3); operational costs of new import system is (-C4) and O&M of flood control is (–C6); flood control infrastructure, the opportunity cost of which is (–C5);, and incremental infrastructure for

waterfowl management, the opportunity cost of which is (–C7); and, O&M costs of additional wildlife management services, the opportunity cost of which is (–C8).

The financial transfers associated with the project include water fees collected from water users (-T1) and duck stamp fees collected from hunters (-T2), which partially finance the project. The BMWD collects tax from landowners in project area T3, which is a dedicated property tax surcharge (assumed to be the project's impact). Businesses/workers also incur a larger income tax liability (-T4) that results from higher productivity the project stimulates. The federal government only receives the fraction a ($a < 0$) of the income tax receipts. The State collects the fraction of tax payments the federal government does not receive, i.e., (1 - a) T4. Numerical values for costs, benefits and transfer payments were obtained from USACE (2006), USACE (2007), and Wailes and Young (2005). These values are adjusted to 2016 dollars using consumer and producer price indices specific to each component.

The resultant KHT is illustrated in Table 4. The baseline against which this project is being compared is a "without-project" alternative. The bottom row, each entry of which is the summation of the cell entries in the column above, shows the net effects on the affected stakeholders, i.e., the conventional consumer surplus and producer surplus measures, and the tax revenue received by the public. Summing these net effects across columns yields the net-efficiency cost of the project, in the rightmost bottom cell of the tableau.

Table 3. Labels and Values Used in Kaldor-Hicks Tableau of Bayou Meto Basin Project

	Label	Original Value ($)	Adjusted* Value ($)	Reference	Note
Benefits					
Value of Irrigated Crops	B1	45,909,000	57,082,071	UCASE 2007, p. 327	difference between the with- and without-project conditions
Flood Damage Reduction	B2	5,559,000	6,911,918	UCASE 2007, p. 327	
Recreational Benefits	B3	34,880,000	43,368,895	Wailes & Young 2005, p. 37	
Lower Environmental Damage	B4	n/a	n/a	UCASE 2007, p. 312	16,076 Average Annualized Habitat Unit
Costs					
On-farm Irrigation Features	C1	4,751,000	5,907,271	USACE 2007, p. 137	Interest & sinking fund
Off-farm Import System	C2	21,997,000	27,350,505	USACE 2007, p. 137	Interest & sinking fund
O&M On-Farm Irrigation	C3	920,000	1,143,904	USACE 2007, p. 137	
O&M Off-farm Import System	C4	3,315,000	4,121,786	USACE 2007, p. 137	will be paid for as farmers receive benefits for the project
Flood Control Infrastructure	C5	2,510,000	3,120,870	USACE 2007, p. 327	Federal 75%, non-federal 25%
O&M Flood Control	C6	32,000	39,788	USACE 2007, p. 326	
Waterfowl Management Infrastructure	C7	6,814,958	8,473,544	USACE 2007, p. 298	Federal 65%, non-federal 35%
O&M Waterfowl Management	C8	1,466,000	1,822,787	USACE 2007, p. 326	
Transfers					
Water Fees	T1	25,510,000	31,718,479	USACE 2007, p. 379	BMWMD contracts with water users for 323,613 acre-feet.
Duck Stamp Fees	T2	1,500,000	1,500,000	Table 2 in this paper	
Property Tax Surcharge	T3	600,000	746,025	USACE 2007, p. 379	tax=($2.00*290,061 irri. acres) +($0.50*44,436 floodpl. acres)
State Sales & Fed Income Tax	T4	5,099,550	6,340,649	Wailes & Young 2005, pp. 27-29	Duck hunting & wildlife watching

*2016 dollars

Table 4. Kaldor-Hicks Tableau of Bayou Meto Basin Project, Million Dollars (2016)

	Hunters/ Watchers	Game Land Owners	Floodplain Land Owners	Crop Land Owners/ Farmers	Public	Federal Govern ment	Water District	Other State Agencies	Net
- million dollars -									
Benefits									
Irrigated Crops' Value				57.08					**57.08**
Flood Damage Reduction			6.91						**6.91**
Recreational Benefits*	43.37								**43.37**
Low Environmental Damage					B4**				**B4**
Costs									
On-farm Irrigation				-5.91					**-5.91**
Import System						-17.78		-7.70	**-27.35**
O&M On-farm Irrigation				-1.14					**-1.14**
O&M Import System				-4.12					**-4.12**
Flood Control System						-2.34		-0.78	**-3.12**
O&M Flood Control			-0.04						**-0.04**
Wildlife Management System		-2.97				-5.50			**-8.47**
O&M Wildlife Management		-1.82							**-1.82**

Table 4. Kaldor-Hicks Tableau of Bayou Meto Basin Project, Million Dollars (2016) (Cont.)

	Hunters/ Watchers	Game Land Owners	Floodplain Land Owners	Crop Land Owners/ Farmers	Public	Federal Govern ment	Water District	Other State Agencies	Net
- million dollars -									
Transfers									
Water Fees				-27.35		17.78		9.57	0
Duck Stamp Fees	-1.50	0.90				0.60			**0**
Property Tax Surcharge			-0.03	-0.72			0.75		**0**
Business/Income Tax		-6.34				3.80		2.54	**0**
Net	**41.87**	**-10.23**	**6.85**	**17.84**	**B4**	**-3.44**	**0.75**	**1.76**	**55.38+B4**

*Arkansas Game and Fish Commission and private land owners/farmers may capture some of these benefits in higher land values
**B4 – benefits of lower environmental damage, measured in average annualized habitat unit (USACE, 2006)

Table 4 represents a partially-specified, hybrid KHT for the Bayou Meto project. Cell entries in this KHT represent annualized values. Whenever it is available, numerical values are assigned to the benefits, costs, and transfers (note that the totals in the net columns may not sum at the single decimal place due to rounding error). Column titles in the KHT indicate stakeholder categories disaggregated at a selected level, while row titles represent the project's benefits, costs, and financial transfers. Within this matrix, the project's benefits and costs are distributed to the stakeholders who bear them, and financial transfers between stakeholders are also recorded. A summation across rows gives the net stakeholder impacts as the boundary row at the bottom of the KHT, while a summation across columns yields a final column on the right-hand side of the tableau, displaying the conventional benefit-cost valuation.

The right-hand side of the KHT shows the fundamental input-output valuation: the benefits of the project (B1+B2+B3+B4) and its costs (C1+C3+C4+C6+C7+C8). Also indicated are the opportunity costs of public finance (C2+C5). The bottom row of the KHT shows the net effects on the indicated stakeholders. These will sum to the fundamental economic evaluation (B1+B2+B3+B4) - (C1+C2+C3+C4+C5+C6+C7+C8), since the financial transfers exchanged among stakeholders cancel out in the summation. Within the KHT itself are indicated the benefit, cost, or transfer components that give rise to the net effects.

8. Discussion and Conclusion

The Bayou Meto Basin project is an adopted solution by federal, state and local interests to resolve many water and environmental management issues in eastern Arkansas (Sullivan, 2016). Generally, a good project should contribute to the country's economic output; hence it has the potential to make everyone better off. However, normally not everyone benefits from a

particular project or policy, and some stakeholders may lose. Moreover, groups that benefit from a project are not necessarily those that incur the costs of the project. Nevertheless, society as a whole is better off, even if some of its members are worse off. In welfare economics, the compensation principle recognizes the existence of “winners” and “losers”. It allows that if the winners gain enough from the project that they could, hypothetically, reimburse the losers, then the project is worth undertaking whether there is a reimbursement or not (Just et al., 2004). Identifying those who will gain, those who will pay, and those who will lose can give us ideas about the incentives that various stakeholders have to see that the project is implemented as designed.

KHT in Table 4 shows that all stakeholders within the project region at least don’t lose, with the project region net benefits total to $55.38 million and with lower environmental damage. Beyond revealing the complete structure of the project and stakeholder effects on all parties, this partially-specified KHT displays the degree of revenue shortfall in “Game Land Owners” and “Federal Government” that must be made up by some means. While the hunters and wildlife enthusiasts are the largest gainers of any single stakeholder group, the main loser is the “Game Land Owners” group. Although the AGFC and private land owners and farmers may capture some of the recreational benefits in higher land values, there needs to be thorough planning to implement price increases in an optimal manner to generate revenue while minimizing the potential loss in duck stamp sales due to price increases. According to Martin-Wilbourn Partners (2012), twenty-five percent of duck stamp purchasers in Arkansas indicated that they would not buy a duck stamp if the price was raised to $25. This suggests that the current user-pay system to conserve habitat to support waterfowl populations may be in

jeopardy, and requires separate discussion about what is necessary to sustain the North American Model of Wildlife Conservation as it pertains to waterfowl hunting (Geist et al. 2001).

As Wildavsky (1966) put it, "because the cost-benefit formula does not always jibe with political realities - that is, it omits political costs and benefits - we can expect it to be twisted out of shape from time to time" (p. 298). KHT displays that the "Federal Government," i.e. taxpayers out-of-state, incur the financing charges and their associated opportunity costs, with a loss in the amount of $3.44 million. KHT also shows that with annual net-benefit of $17.84 million, the "Crop Land Owners/ Farmers" are the second largest gainers among stakeholder groups. The Bayou Meto Basin land is predominately in private ownership, but there has been an increasing trend to absentee ownership over the past few years. With the project completed and in place, irrigated crop production can continue to be the dominant economic activity in the region, therefore benefits will be concentrated to landowners as discussed in Section 4.1 above.

Because environmental preservation is considered a common form of public good, there is a need for the government intervention to generate non-monetized B4 benefits, measured in average annualized habitat unit. Deductions with more than one missing value in the KHT will not necessarily be definitive. But portraying the partially-specified KHT can offer useful insights to decision makers about the nature of the tradeoffs, even if the conclusions are not definitive. One possibility would be to augment the standard efficiency analysis to incorporate not-typically monetized public goods related to "warm glow", as it is referred to in the valuation literature (see Portney, 1994; Hanemann, 1994). Preserving the environment could generate "warm glow", given that the level of damage is an important issue to local voters. Hopefully, the "Public" might derive "warm glow" from environmental preservation in the Bayou Meto Basin.

In general, as Haveman (1976) and others have pointed out, politicians prefer projects that concentrate benefits on particular interest groups, and camouflage costs or diffuse them widely over the population. The Bayou Meto Project benefits are localized, while the Federal share of costs comes from taxpayers across the country. Thus, though the "Floodplain Land Owners" are made better off by $6.85 million, some taxpayers are made worse off because they receive no benefits from the project and must pay some of the costs. The "Water District", i.e. the BMWMD is a quasi-governmental entity, is taking financial responsibility for and working with landowners and other state agencies to obtain the funds needed for the non-Federal construction costs of the project. Project funding for 2016 was $16.2 million less than 2015 even though the additional funding for ongoing work for 2016 was supposed to be $10 million more than in 2015. Awarding any new contracts for constructing the groundwater protection/water supply component of the project is excluded. The project was $15 million short in Federal funds to complete the construction needed to deliver the first water into the Basin and start generating some income. The BMWMD has collected assessed property taxes $350,000 per year to support the project for the past twelve years, and the non-Federal expenses on the project are more than $140 million (Sullivan, 2016).

The non-Federal construction costs for the irrigation and flood control components of the Bayou Meto Project are being funded with bonds issued through the ANRC and paid for through the sale of water and tax assessments on benefited acreage within the Bayou Meto IPA levied by the BMWMD. Water charges paid to "Other State Agency" are a payment by farmers to the "Water District" in exchange for the use of water. Whether a government levy is a payment for goods and services or a tax depends on whether the levy is directly associated with the purchase of a good or a service and accurately reflects the real resource flows associated with the use of

the service. Irrigation charges may not cover the true cost of supplying the service; thus, while they indicate a real resource flow as opposed to a transfer payment, the real economic cost would be better measured by estimating the long-run marginal cost of supplying the water and showing the difference as a subsidy to water users.

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Chapter V. Conclusions

This dissertation chapter summarizes the research findings encompassed by the previous three articles on water resources, and discusses the policy implications and limitations of the studies. The theory of common-pool resources provided the conceptual grounding to an understanding of the policy context of economic development and the environmental sustainability. The essays in this dissertation are focused on physical, institutional, economic and environmental variables that are often overlooked, but which policymakers can and should leverage to improve agricultural policymaking.

Irrigation is a major input to agriculture in regions where the evapotranspiration potential exceeds the moisture level available from rainfall. While physical factors determine the rainfall amount received by a region, the flow of water through an irrigation system to a farmer's field depends not only on water availability but also on the system's physical structures. It also depends on the system's social structures and the institutions that facilitate the construction, operation, and maintenance of the physical structures. The experience in different parts of the world has demonstrated that participatory irrigation management facilitates achievement of higher efficiencies of water utilization and equitable water distribution, promotes better and more cost-effective operation and maintenance, and helps improve cost recovery.

The transition of Aral Sea Basin countries to market economies and reengineering of the water resources systems to meet the requirements of the new realities provides a unique opportunity to promote participation and empowerment of the beneficiaries in design, implementation, and management of irrigation systems. Chapter 2 is designed as a structural analysis of agriculture and water sectors, and a case study of a typical Basin Irrigation System Authority (BISA) in Uzbekistan. It outlines the institutional, legal and policy environment for

implementing agricultural reforms, and highlights the main features of a framework that needs to be developed. An analysis of the sectoral policy discourse reveals that there are no clear strategies or consistent policy interventions designed to address the efficiency issues facing irrigation systems and also a lack of participatory irrigation management. Notwithstanding this, the Water Users' Associations (WUAs) within the sector were introduced as a partner in irrigation system management. These undertakings have very little impact on certain segments of the farming sub-population, because the government subsidizes costs of irrigation in exchange for cotton and wheat procured at low prices. Long-term success in reviving the country's economy can be based upon broad macroeconomic reforms, accompanied by microeconomic interventions in the agriculture sector, as well as specific reforms regarding water management and irrigation water use, in particular.

This study proposes a national program in public sector and private sector cost-sharing investment for irrigation water supply in Uzbekistan. In addition to rehabilitation of the physical infrastructure, the research identifies motivations for stakeholders to participate in irrigation management. Participatory irrigation management would be one of the ways of increasing agricultural productivity and providing needed flows to the Aral Sea and other endangered ecological systems in Central Asia through improved efficiency of water use and conveyance systems. Functional WUAs will be able to manage scarce water on an equitable basis. In the long-term it will be possible to raise awareness of the significance of water scarcity to induce shifts to more water saving techniques. This could lead to either further agricultural development or to water savings for the environment i.e. the Aral Sea. Currently there is a serious lag in the development of appropriate institutions to deal with the new environment of water scarcity. The challenge ahead lies in creating institutions that can:

(i) allocate water equitably among competing uses and users,

(ii) integrate irrigation management at farm, system, and basin levels to reduce upstream-downstream and head-tail conflicts,

(iii) integrate the management of ground and surface water irrigation, and

(iv) address problems of irrigation development on environmental health.

In Arkansas, if there is water shortage in any stream to meet requirements of all water needs water can be allocated among the competing uses so that each use obtains an equitable portion of the amount of water available. The remaining water can be allocated in the following order of preference: (1) agriculture, (2) industry, (3) hydropower, and (4) recreation. There are mounting pressures on the agricultural sector due to increased competition for water from the municipal, industrial and mining sectors in Arkansas, as well increased water shortages in many parts of the state. Chapter 3 details specifics of the legislative framework, and the environmental and sectoral obstacles that need to be considered during state water planning processes. Any pattern of water resource use, and attempts to govern that use, are partly a result of a confluence of different, and often independent, historical developments. As Shabman (1984) states "choices are made in response to opportunities and constraints understood to be effective at the moment a decision is made" (p. 53-54).

There are other institutional and sectoral deficiencies that constitute underlying causes of water insecurity in Arkansas. The research findings reveal that a majority of the small cities in this study had implemented declining block rates, which are regarded as non-conservation pricing mechanisms. Inclining block rates, under which consumers have incentive to conserve water, are being implemented in four cities with more than 20,000 populations, while another four cities with populations less than 20,000 are implementing uniform block rates (conservation

neutral). This finding was due to a combination of inadequate infrastructure and the lack of water conservation requirements in state law. Chapter 3 shows that there is a need for coordination between water utilities to implement a conservation-oriented rate structure for different water-use sectors through state agencies such as ANRC and APSC. Also, the use of economic tools such as water trading and water markets for cost-effective redistribution of water from areas or uses with surplus to those experiencing water shortage should be encouraged in state water policy.

Effective involvement and participation of the beneficiaries are the instruments for the success of any development project. The beneficiaries are considered to be important organizational units in a responsive management system that is essentially required for sustainable irrigated agriculture. Chapter 4 examines the extent to which government intervention reflects stakeholder group perspectives and articulates strategies to achieve a common-pool resource sustainability in Bayou Meto Basin, Arkansas.

In order for stakeholders to contribute more meaningfully to water security they must be able to access project information, adopt new technologies and maintain relationships with a wide variety of actors. This information is useful because it can allow policymakers to directly improve information flow by building on the existing user patterns and social processes. Wailes and Young (2005) believed, and this research confirms, that the project will provide large economic and environmental benefits that can help sustain irrigated agriculture and wildlife habitat in parts of the five counties that are included in the Bayou Meto Basin. However, we argue that the stakeholder impact and participation is the missing element.

The state remains a vital player in the agricultural sector in Arkansas but the discursive messages from various secondary data sources, combined with the calculated KHT values, have

shown that government interventions have failed to adequately mobilize resources to target a large segment of the stakeholders' population. Policymakers need to be mindful of the fact that stakeholders are not a homogeneous group and they all, to some degree, contribute to water availability. The project can ill-afford to alienate participants in the wildlife recreation and agriculture sectors, therefore these stewards of the local environment must be accommodated in plans for sustainable project outcomes.

Conspicuously, the decade-long project history discourse sparingly includes text salient to other significant issues, such as aquifer protection, waterfowl management, and flood control that are critical to reducing the problems associated with water insecurity. The absence of a comprehensive long-term plan for addressing water insecurity and the exclusion of a broad collaborative agenda between the federal and non-federal sponsors are notable oversights in the discourse emanating from decision makers. These are necessary to meet irrigation water demand and environmental outcomes in an important and dynamic project area.

Policy Implications

It was apparent, from the evidence emerging from this research, that many of the national level policy interventions in the water management and agricultural sector in Uzbekistan were top-down directives framed in economic terms. The data in this dissertation highlights the fact that there are some institutional, financial and technological variables that have substantial bearings on agricultural policy outcomes. These other factors include, but are not limited to, the use of WUAs, levels of management participation, and the nature of the cost-sharing scenario used for nationwide policy implementation strategy. Taken together these variables create synergies that are important for improving the sector's human resources but which, if ignored,

can impinge on the performance of key stakeholders. Hence, what is required is context-specific evidence for more collaborative approaches to agricultural policymaking. Approaches that will also use knowledge of the heterogeneity among the population to improve the allocation of resources and to foster sustainability through policymaking. Policies that exclude issues relevant to farmers' welfare, the environment, and social equity will ultimately fail to address key problems associated with water insecurity.

According to Imperial (2012), sustainable development and management of water resources requires the Integrated Water Resources Management approach, which in turn demands the integration of the efforts of all stakeholders as well as decentralization of management authority to ensure efficiency, accountability, best management practices, and the technical expertise of the private sector. Additionally, the participation of all stakeholders, particularly the beneficiaries, promotes the economic and financial stability to account for the opportunity costs of withdrawing and delivering water. This approach includes the costs associated with economic and environmental externalities. The drought in the United States over the past four years is a reminder that American agriculture is not immune to the problems that farmers in other parts of the world have been facing for decades now -- extreme weather, drought and flooding.

Policy responses to water insecurity need to be conditioned by a new perception of the problem. Redefining water insecurity as a problem connected to all dimensions of sustainable development, including agriculture, industry, and the environment, would help to focus attention on underlying causes and the inter-connected challenges associated with this very complex issue. Integrating conservation in Arkansas' state water resource policy through different frames would help to promote collaborative efforts for solutions across sectors of the economy. This multiple

actor-multiple sector approach may lead to a change in the policy venue, therefore traditional practices of agricultural exceptionalism will be expunged from the policy process. Policy changes occur whenever there are changes in institutional venue and/or problem definition and new policy entrepreneurs take advantage of ‘policy windows’ (see Baumgartner and Jones, 1993; and Kingdon, 1995).

There is a need, first and foremost, for a strong government commitment focusing on developing the capacity of key stakeholders. While the government provides the capital base for resource development, incentives are required to encourage private investment in resource processing, generating increased income potential. Theoretically, almost any policy could be employed to align private resource use rates with the socially optimal rates of use. Mandated standards could impose socially preferred practices on resource owners. A schedule of taxes, fees, or fines could be devised to raise the private, current cost of resource use to levels reflecting long-run social values. However, voluntary behavior in response to positive incentives has been the predominant mechanism for achieving agriculturally related resource conservation policy objectives. This study utilized categorical variables to handle the endogeneity of state policy choices and examined whether management and governance of water resources affects water use outcomes in irrigated agriculture.

The findings of this study have far reaching policy implications for institutional and infrastructural strengthening and capacity building. Policymakers should pay close attention to supporting the development of community–based associations that have emerged to satisfy the specific needs of their members. In this study, some WUAs in the Aral Sea basin, and BMWMD in eastern Arkansas received higher levels of participation from stakeholder farmers than did the larger more established interest groups. This is a clarion call for policies that will facilitate

training, group development, and capacity building strategies that harness and use the human and social capitals available within these local organizations. National agricultural policy outcomes are dependent on these successes. Whether the government and the institutions charged with the responsibility of delivering services to stakeholder farmers have the mechanisms, resources, and political will to provide these goods and services as public goods will be a pivotal consideration for the future of sustainable development in both study regions.

Limitations of the Study

The scope and depth of this study were limited by the funding available for its execution. Therefore, sampling was restricted to the Aral Sea region of Uzbekistan, and follow-up interviews or focus group discussions with the participants, which would have helped to provide more far-reaching analysis of farmers' experiences, were not done.

Additionally, this study did not take into account the impact of land tenure, which was referenced in the review of the literature as a long-standing issue of importance in the agriculture sector. Access to land and the availability of water are factors that could potentially influence the behavior of stakeholder farmers but the issue of land ownership in Uzbekistan is complex (see Abdullaev et al., 2009; Bektemirov and Rahimov, 2001; Wegerich and Bektemirov, 2001 for a discussion). Therefore, it was a deliberate decision to exclude overt references to the subject that is often examined with regards to social issues.

Contribution to the Literature

This work contributes to the policy debate in the growing field of program evaluation studies in water management and agricultural policy. It also increases our understanding of

project-specific indicators in common-pool resource management through the context of economic development and the environment. The research may serve to reorient the thinking of policymakers so that they recognize that there are local factors that must be included in efforts to mitigate to the impact of water insecurity. It illuminates the need for policymakers to be mindful of heterogeneity among the stakeholders and to use this knowledge to inform the efficient and effective allocation of scarce resources. Exploring the synergetic relationships between institutions and natural capital to enhance water availability are also key strategies for improving human well-being and socio-economic development, and for preserving ecosystems.

In addition to the foregoing, the data also highlights historical themes in policymaking that are embedded in sectoral policy discourse and the disjuncture between those interventions and current approaches needed to increase the capacity of stakeholder farmers in the study regions. Consequently, this research contributes to the debate on water security by advancing the notion that the examination of otherwise overlooked variables, which do not constitute dominant frames, can provide useful data for innovative context-specific approaches to guide water security policymaking and improve water security outcomes. According to UN-Water (2013), water security should be defined as "the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability" (p. 1).

Suggestions for Future Research

Where the research on agricultural development and water security strategies goes next is important to national level policymaking in Uzbekistan. Consideration of the fact that water is a social, economic, environmental and political factor should lead to research that transcends agriculture, to cut across many different ministerial, disciplinary and policy fields. Thus, addressing water security research in a collaborative inter-sectoral manner is crucial. Researchers would be well advised to examine factors influencing water insecurity for the complex issues that undermine achievement of water security. A re-definition of the problem to include input from other sectors in society is suggested. Policies formulated to achieve water security outcomes need to be coordinated across multiple government agencies. Following from that, future research should address the paucity of evidence pertaining to the impact of specific policies on target populations. Therefore, monitoring and evaluating policies in the agricultural sector is another important researchable area. These studies will provide feedback to policymakers and to allow for changes to be made to policies as deemed necessary.

At state and local level policymaking in Arkansas, I argue that projects like the one in Bayou Meto Basin could be categorized as a public-private partnership (PPP) in irrigation water supply. PPPs are a mechanism for governments to procure and implement public infrastructure and/or services using the resources and expertise of the private sector. PPPs should be encouraged in the irrigation sector for the processes of planning, development, and management. It has been observed internationally that PPPs are successful if the government or multilateral agencies contribute substantially to capital costs, and private parties are made to undertake O&M activities so as to introduce improved technology and achieve efficiency in the operations of the developed assets (Varma et al., 2012).

In conclusion, researchers and policymakers' emphasis on the biophysical factors that impact agricultural productivity often serve to detract from the other multifunctional dimensions of agriculture that potentially facilitate positive spin-off impacts on water security (Gibson, 2012). Case studies demonstrating the value and merits of agricultural multifunctionality, for instance, could expand discussion on water security to include other sectors of the economy and widen the range of possible solutions on common-pool resource problems.

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Appendix I

UNIVERSITY OF ARKANSAS

Office of Research Compliance
Institutional Review Board

November 30, 2016

MEMORANDUM

TO:	Kuatbay Bektemirov Eric Wailes
FROM:	Ro Windwalker IRB Coordinator
RE:	New Protocol Approval
IRB Protocol #:	16-11-231
Protocol Title:	*Sustaining Common-Pool Resources: Evaluation of Water Management and Conservation Programs*
Review Type:	☒ EXEMPT ☐ EXPEDITED ☐ FULL IRB
Approved Project Period:	Start Date: 11/28/2016 Expiration Date: 11/27/2017

Your protocol has been approved by the IRB. Protocols are approved for a maximum period of one year. If you wish to continue the project past the approved project period (see above), you must submit a request, using the form *Continuing Review for IRB Approved Projects*, prior to the expiration date. This form is available from the IRB Coordinator or on the Research Compliance website (https://vpred.uark.edu/units/rscp/index.php). As a courtesy, you will be sent a reminder two months in advance of that date. However, failure to receive a reminder does not negate your obligation to make the request in sufficient time for review and approval. Federal regulations prohibit retroactive approval of continuation. Failure to receive approval to continue the project prior to the expiration date will result in Termination of the protocol approval. The IRB Coordinator can give you guidance on submission times.

If you wish to make *any* modifications in the approved protocol, including adding datasets not discussed in your protocol, you must seek approval *prior to* implementing those changes. All modifications should be requested in writing (email is acceptable) and must provide sufficient detail to assess the impact of the change.

If you have questions or need any assistance from the IRB, please contact me at 109 MLKG Building, 5-2208, or irb@uark.edu.

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Appendix II

Table 91 BAYOU METO BASIN, ARKANSAS PROJECT Selected Plan – NED/Waterfowl Management Plan Summary of First Costs and Average Annual Equivalent (AAE) Benefits, Costs, Excess Benefits, and Benefit-to-Cost (BCR) Ratio (October 2005 Price Levels, 5.125% Discount Rate)	
BENEFIT/COST CATEGORY	**BENEFIT/COST ($)**
FIRST COST	
Agricultural Water Supply Component	$402,690,000
Flood Control Component	$40,169,000
Waterfowl Management Component 1/	$87,522,000
TOTAL	**$530,381,000**
ANNUAL BENEFITS	
Agricultural Water Supply Component	$45,909,000
Flood Control Component	$5,559,000
TOTAL	**$51,468,000**
ANNUAL COSTS	
Agricultural Water Supply Component	$30,983,000
Flood Control Component	$2,510,000
TOTAL	**$33,493,000**
EXCESS BENEFITS	
Agricultural Water Supply Component	$14,926,000
Flood Control Component	$3,049,000
TOTAL	**$17,975,000**
BCR	**1.54**
1/ Waterfowl Management Costs Not Used in Cost-Benefit Analysis	