JRAP (1998) 28, 2, 13-34

Economic impacts of water reallocation: A CGE analysis for the Walker River Basin of Nevada and California

Chang K. Seung, Thomas R. Harris, Thomas R. MacDiarmid, and W. Douglass Shaw*
University of Nevada, Reno

Abstract. This study uses a regional computable general equilibrium (CGE) model to examine the impacts of reallocating water from agriculture to recreational use in rural Nevada and California. Unlike previous studies of water reallocation, this study considers water rights compensation as a positive effect in the regional economy. In addition, three different model variants are specified depending on the assumptions about interregional factor mobility. Model results show that the combined effect of water rights compensation and an increase in recreation-related expenditures does not offset reduction in agricultural production and that sectoral effects are sensitive to assumptions about interregional factor mobility.

1. Introduction

This study examines the impacts of reallocating surface water from irrigated agriculture to recreational use in the Walker River Basin located in northwestern Nevada and northeastern California. This study employs a regional computable general equilibrium (CGE) model. Model results show that the combined effect of water rights compensation and increase in recreation-related expenditures does not offset reduction in agricultural production and that the sectoral effects are sensitive to assumptions about interregional factor mobility.

The Walker River Basin includes Lyon and Mineral counties in Nevada and Mono County in California (Figure 1). The Walker River System consists of the East and West Walker River in the upper watershed, both of which rise in the Sierra Nevada Mountains in Mono County (Figure 1). Bridgeport Reservoir on the East Walker and Topaz Reservoir on the West Walker provide water storage

---

* We would like to thank the editor and the anonymous referees for their constructive comments. We also acknowledge the Walker River Basin map provided by Shawn Stoddard.

Figure 1. The Walker River Basin

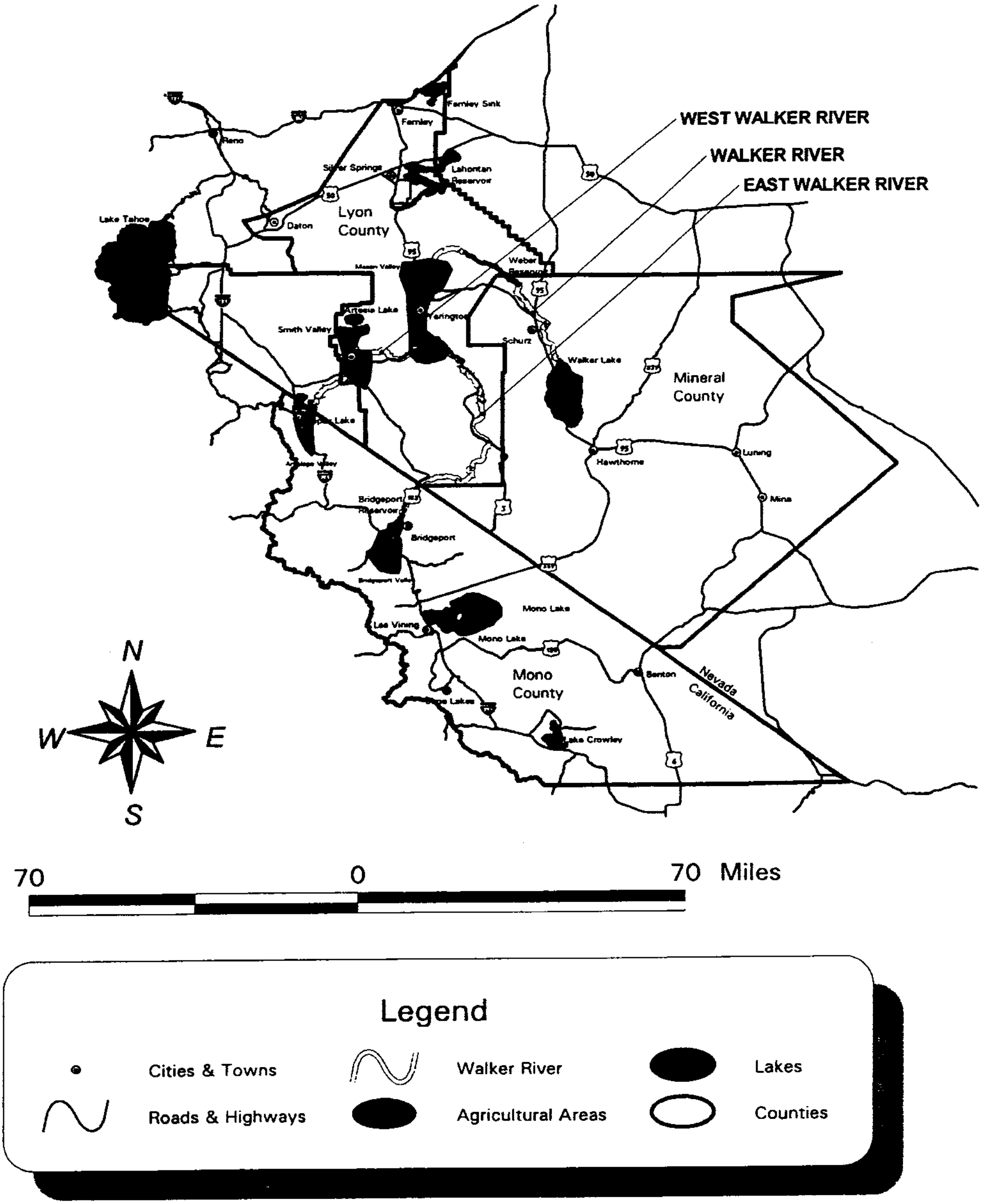


Table 1. Output and employment by industry in the Walker River Basin, 1994

	Output		Employment	
	($ Million)	(%)	(Jobs)[1]	(%)
Livestock	29.9	2.0	239	1.1
Other crops	23.3	1.5	324	1.6
Hay	17.4	1.1	388	1.9
Agricultural total	70.6	4.6	951	4.6
Mining	128.1	8.4	614	3.0
CMTCPU[a]	482.2	31.6	3878	18.8
Trade	156.5	10.3	3945	19.1
FIRE[b]	203.5	13.3	1238	6.0
Services	394.0	25.8	6943	33.6
Government	90.6	6.0	3081	14.9
Nonagricultural total	1454.9	95.4	19699	95.4
Regional total	1525.5	100.0	20650	100.0

[1] Full-time and part-time jobs

[a] CMTCPU = Construction, manufacturing, transportation, communication, and public utilities

[b] FIRE = Finance, insurance, and real estate

Source: Output in agricultural sectors is based on *1995 Nevada Agricultural Statistics* and 1994 IMPLAN data. Output in nonagricultural sectors is from 1994 IMPLAN data. Employment in agricultural sectors is based on 1994 *Regional Economic Information System* (REIS) and 1994 IMPLAN data. Employment in nonagricultural sectors is from 1994 REIS data

and excellent recreation such as fishing and boating. The two rivers flow into Nevada through the irrigated areas such as Bridgeport and Smith Valley. The West Walker joins the East Walker River south of the town of Yerington and becomes the Main Walker River. After the confluence, the Walker River changes course and flows into Walker Lake (Acton et al. 1998).

Under moderate flow conditions for calendar year 1993, surface water rights held by farmers provide total irrigation diversions of 319,974 acre-feet to 96,115 acres in the Walker River Basin (MacDiarmid et al. 1998). In 1994 the total agricultural production in the basin was worth about $70.6 million (Table 1). Of this total agricultural output, approximately 42 percent is derived from livestock production; about 25 percent from hay production; and the other 33 percent from other crops. In the same year the total nonagricultural production was approximately $1,454.9 million. The value of total output in the Walker River Basin economy is about $1,525.5 million, and the total agricultural output is about 4.6 percent of the total output in the basin's economy (Table 1). The Walker River Basin also supports various recreational activities, including fishing, boating, picnicking, and camping. Major recreational sites in the basin include Bridgeport Reservoir and Topaz Reservoir in the upstream of the Walker River System and Walker Lake. In 1996 the total recreation-related expenditure in the basin was estimated to be about $4.9 million.

Today the basin is faced with several critical water resource issues including declining water levels and deteriorating water quality in Walker Lake, sustaining profitable agriculture while protecting water rights of the irrigators, and recreational use at upstream reservoir, along the river, and at Walker Lake. These critical water issues are forcing a reallocation of water from existing agricultural uses to environmental and recreational uses. Reallocating water would involve water transfers. Water transfer could occur through a number of mechanisms—water banks, water leasing, or water marketing. Before such water transfers occur, however, information to determine economic values and trades between agricultural, environmental, and recreational uses should be known.

There are numerous studies of regional economic impacts of water management in western states that address the trades between alternative uses of water. Classic examples include Seckler (1971), Hamilton and Pongtanakorn (1983), and Dinar and Zilberman (1991). Berck et al. (1991) employ a regional CGE model to investigate the impacts of water reallocation in the San Joaquin Valley, California. More recent studies include Leones et al.'s (1997) investigation of the economic impacts of recreation in the Rio Grande River Basin near Taos, New Mexico and Seung et al.'s (1997) study of a water reallocation policy in rural Nevada.

In this study we investigate the impacts of reallocating surface water from irrigated agriculture to recreational use in the Walker River Basin using a regional CGE model. Unlike previous CGE studies of water reallocation (e.g., Berck et al. 1991; Seung et al. 1997), this study explicitly models the compensation for water rights as a positive direct impact on the regional economy. Specifically, we consider the following three effects in our study:

1. The reduction in water use in agricultural production;
2. The increase in landowners' income from compensation for water rights; and
3. The increase in recreation-related expenditures.

In addition, we specify three different model variants depending on the assumptions about interregional mobility of labor and capital.

2. Model description

This study uses a regional CGE model.[1] CGE models are based on the Walrasian general equilibrium structure. The models explicitly incorporate supply

---

[1] Although fixed-price impact models such as input-output (I-O) and social accounting matrix (SAM) models remain useful for the analysis of some issues, the models lack important microtheoretic foundations by assuming fixed prices and ignoring substitution effects in use of factor inputs and in consumption of final products. Comparisons of fixed-price model with CGE model are found in Koh et al. (1993). Also a comparative analysis of SAM and CGE is found in Seung et al. (1997).

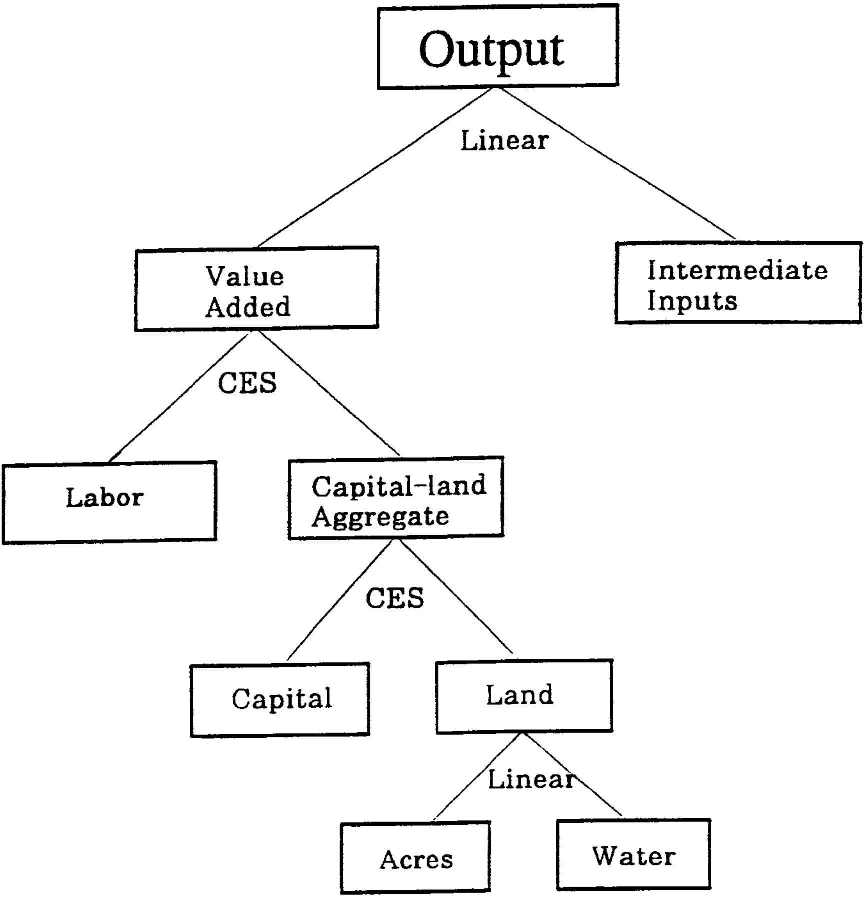
constraint, identify prices and quantities separately, and have smooth, twice differentiable production and preference surfaces. Thus, substitution effects in production and in consumption are allowed in CGE models. Factor and commodity markets attain their equilibrium through the adjustment of prices. There are several regional CGE models in the literature (Seung et al. 1997; Waters et al. 1997; Schreiner et al. 1996; Hoffmann et al. 1996; Kraybill et al. 1992; and Berck et al. 1991). For example, Seung et al. (1997) analyze water reallocation policies in rural Nevada. Schreiner et al. (1996) present a regional CGE framework for analysis of rural development policies. This section describes the major features of the Walker River CGE model.

2.1 Production

There are eight production sectors in the present CGE model. Three are agricultural sectors—(1) livestock, (2) other crops, and (3) hay. These sectors use labor, capital, land, water, and intermediate inputs. In this study, it is assumed that water is removed from the hay sector only. As the water rights to the surface water are transferred from the hay sector to recreational use at waters in the Walker River Basin, land use in the hay sector will be proportionally reduced because water rights are appurtenant to the land and there is no crop substitution. Production technology in an agricultural sector is represented by a quadruple-nested production function (Figure 2). First, acreage and water are combined in fixed ratios to produce land. Second, capital and land are combined via a constant elasticity of substitution (CES) function to produce capital-land aggregate. Third, labor and the capital-land aggregate are combined via another CES function to produce the value added. Finally, value-added and intermediate inputs are combined in fixed ratios to produce output. By nesting the structure of the agricultural production technology this way, the present model allows greater flexibility in specifying the elasticities of input substitution for the primary inputs than a four-input Cobb-Douglas or CES value-added function. In our CGE model, both labor and capital are allowed to change in response to reduction in land use (water use) and are substitutable for land.

There are five nonagricultural sectors in this study: (1) mining, (2) construction, manufacturing, transportation, communication, and public utilities (CMTCPU), (3) trade, (4) finance, insurance, and real estate (FIRE), and (5) services. The nonagricultural sectors use labor, capital, and intermediate inputs. Production technology in the nonagricultural sectors is described by a double-nested production function. First, labor and capital are combined via a CES

Figure 2. Production technology, agricultural sectors



function to produce the value added. Second, value added and intermediate inputs are combined in fixed ratios to produce output.

2.2 Compensation for water rights

In the Walker River Basin, landowners hold the water rights. When water rights are sold, the landowners are compensated for their water rights. The payment for this compensation comes from the federal government. Total annual payment required to compensate landowners (water right holders) for their lost income due to water removal is calculated. This annual payment is added to the landowners’ income in the hay sector (and, therefore, in household income) and represents positive direct impacts on the regional economy. Therefore, the land owners’ income in the hay sector with sale of their water rights is calculated as:

$$YNH = (RNH)(LNH) + TWC \tag{1}$$

where:

YNH = Landowners’ income in the hay sector;
RNH and LNH = Return to land and land use in the hay sector, respectively;
TWC = Total annual amount required to compensate the land owners in the hay sector for their lost income, which is calculated by multiplying per acre-foot price of water by the amount of water rights sold.

2.3 Consumption

Following IMPLAN (IMpact analysis for PLANing, Alward et al. 1992), households are grouped into three types: (1) high income, (2) medium income, and (3) low income households. The preference of each type of household is represented by a CES utility function. Utility maximization for each type of household subject to its budget constraint yields its demand function for each good:

$$C_{ih} = \frac{\beta_{ih}\,HEXP_h}{PQ_i^{\gamma h}\sum_j \beta_{jh} PQ_j^{(1-\gamma h)}} \tag{2}$$

where:

C_{ih} = Quantity of good i consumed by household type h;
β_{ih} = Share parameter for good i and household h;
$HEXP_h$ = Household h’s total expenditure on goods;
PQ_j = Price of good j, which is a composite of locally produced and imported versions; and
γ_h = Household h’s elasticity of substitution for goods.

2.4 Factor mobility

Cost minimization for each sector's production yields its conditional factor demand function for each factor of production. There are two types of labor in this study–agricultural labor and nonagricultural labor. Agricultural labor works in the agricultural sectors and is mobile among the agricultural sectors. Nonagricultural labor works in the nonagricultural sectors and is mobile among the nonagricultural sectors. Each type of labor is mobile between the study region and the rest of the United States depending on the interregional differential in the average wage rate of the labor type. The net inmigration of labor type k into Walker River region is determined as follows:

$$LMIG_k = LSTK_k \left[\left(\frac{WAVG_k}{WROW_k} \right)^{LME_k} - 1 \right] \tag{3}$$

where:

$LMIG_k$ = The net inmigration of labor type k;
$LSTK_k$ = The aggregate stock of labor type k in the base year;
$WAVG_k$ and $WROW_k$ = The average wage rates of labor type k in the Walker River region and in the rest of the United States, respectively; and
LME_k = The labor migration elasticity for labor type k.

Physical capital is mobile both between all production sectors and between regions. Because it is assumed that water is removed from the hay sector only, land use in the hay sector is reduced due to water removal while land use in the other agricultural sectors is fixed at its base year level.

In the simulation experiments in this study, three different model variants are specified depending on interregional mobility of labor and capital. Below, we specify model 1 (no mobility) and model 3 (perfect mobility) as extreme cases of interregional factor mobility and model 2 (partial mobility) as an intermediate case.

Model 1 (No mobility).[2] Neither labor nor capital is mobile between regions. Therefore, the total stock of each labor type in the economy is fixed at its base year level (or the labor migration elasticity (LME_k) in equation (3) is equal to zero) and total capital stock in the economy is fixed at its base year level. In this model variant, both wage rates and return to capital are endogenously determined.

---

[2] No mobility model (model 1) in this study is similar to model variant 1 in Hoffmann et al. (1996) or neoclassical CGE in Waters et al. (1997) in the sense that both labor and capital stay in the study region.

Model 2 (Partial mobility).[3] Each type of labor is partially mobile between regions. But capital is not interregionally mobile. This means that there will be some in- or outmigration of each labor type as a result of policy change (or that the labor migration elasticity (LME_k) in equation (3) is equal to a positive finite number) and that total capital stock in the economy is fixed at its base year level. Both wage rates and return to capital are endogenously determined.

Model 3 (Perfect mobility).[4] Both labor and capital are perfectly mobile between regions. In this model variant, in- or outmigration of labor and capital occurs such that the average wage rate of each labor type and return to capital are fixed at their base year levels and are equalized between regions. Compared with the regional economy described in model 1, the economy represented by model 3 is a highly open economy because both labor and capital migrate between regions.

2.5 Recreation-related expenditure

With the reallocation of surface water to recreational use in the Walker River Basin, recreation trips and recreation-related expenditures by recreation visitors would increase because the water levels at waters in the basin will increase. Using the random utility model (RUM), Fadali et al. (1998) estimate the changes in recreation trips due to the water reallocation in the Walker River Basin. Using data from an on-site survey, they calculate per trip recreation-related expenditure. Using the information provided by Fadali et al. (1998), the change in total recreation-related expenditure is calculated.

In this study, the recreation-related sectors are the trade sector and the service sector. Expenditures on gasoline, food, and supplies are allocated to the trade sector and those on lodging are allocated to the service sector. The increases in recreation-related expenditures have two sources: first, increases in expenditures by nonlocal visitors, defined as the visitors who live outside of the Walker River Basin, and second, increases in expenditures by local visitors,

---

[3] The partial mobility model (model 2) in this study is slightly different from model variant 2 in Hoffmann et al. (1996) and Keynesian CGE in Waters et al. (1997). Model variant 2 in Hoffmann et al. (1996) and Keynesian CGE in Waters et al. (1997) assume that labor is perfectly mobile between regions. In contrast, the partial mobility model (model 2) in this study assumes that labor is partially mobile between regions.

[4] The perfect mobility model (model 3) in this study is different from model variant 3 in Hoffmann et al. (1996) and fixed-price I-O model in Waters et al. (1997). Their model versions are fixed-price, I-O-type constant multiplier models. In contrast, the perfect mobility model (model 3) in this study is not an I-O version because land use in some of the production sectors (livestock sector and other crops sector) is fixed at its base year level. Therefore, the policy impacts calculated with the perfect mobility model (model 3) in this study will be smaller than those predicted by an I-O model.

defined as the visitors who live within the basin. Expenditures by nonlocal visitors bring new dollars into a local economy and stimulate economic activity as suggested by export base theory; i.e., recreational services are being exported (Alward et al. 1985; Bergstrom et al. 1996; English and Bergstrom 1994; Miller and Blair 1985; Palmer and Siverts 1985). Thus, impacts in an economy attributable to recreation can be traced to spending by these visitors for recreation and related services. We treat the increases in expenditures by nonlocal visitors as exogenous shocks. Increased recreational spending by local visitors is assumed to come at the expense of reduced recreational spending elsewhere in the Walker River Basin (*displacement effect*). In other words, it is assumed that there is no net change in total recreational spending made by local visitors.

3. Empirical implementation

3.1 Data

IMPLAN is used to make a social accounting matrix (SAM) for the Walker River Basin (Tables A.1 and A.2 in the appendix). The 528 sectors in the Walker River Basin SAM are aggregated into the eight sectors in this study (Table A.3 in the appendix). Calculating the effects of policy changes in a CGE model requires specific parameter values for the model equations. Some parameters such as elasticities of substitution and elasticities of transformation are specified on the basis of econometric research. The remaining parameters such as share parameters are determined by solving the model equations with the base year observations for model variables and the exogenous parameters substituted in the model. To calculate base year factor income in each of the agricultural sectors, factor shares developed by Robinson et al. (1990) are used. Table A.4 in the appendix presents values of major parameters and elasticities used in our CGE model.

3.2 Simulations

Reduction in land use in the hay sector. In this study, 15 percent of the total irrigation diversions (319,974 acre feet) is assumed to be reallocated from agriculture to recreational use. This behavior represents a total amount of water reallocation of 47,997 acre feet. Assuming that water is withdrawn from the hay sector only, the corresponding total decline in land use in the hay sector is 12,232 acres or about 35 percent of its before-policy level of land use. Details are found in MacDiarmid et al. (1998).

Compensation for water rights. The total annual payment for 47,997 acre-feet of water is calculated to be $1,588,421. The annual payment per acre-foot of water is calculated to be about \$33.10 (MacDiarmid et al. 1998).[5] This annual payment is the compensation for the lost income of the water rights holders and represents positive direct impacts on the regional economy.

Recreation-related expenditure. Fadali et al. (1998) estimate the changes in recreation trips by nonlocal visitors to Topaz Reservoir and Walker Lake for 47,997 acre-feet of water reallocation. They find that the recreation trips by nonlocal visitors to Topaz Lake would increase 60 percent (66,000 trips) and that the trips to Walker Lake would decrease 5 percent (24,000 trips). Using data from an on-site survey, they also calculate per trip recreation-related expenditure for nonlocal visitors. The authors find that per trip expenditure for trade sector (gasoline, food, and supplies) is about \$54.43 and \$66.37 for trips to Topaz and Walker, respectively. The per trip expenditure for the service sector (lodging) is about \$7.30 and \$8.49 for trips to Topaz and Walker, respectively. We margin the trade sector expenditure 25.5 percent (Fletcher et al. 1997). The margined values of the per trip expenditure for trade sector are calculated to be \$13.88 and \$16.92 for trips to Topaz and Walker, respectively.

Using the change in recreation trips and per trip expenditure for the trade sector and the service sector, we calculate the total increases in expenditure by nonlocal visitors for these sectors for the whole Walker River Basin. The increase in trade sector expenditure is calculated to be about \$509,872, and the increase in services sector expenditure is calculated to be about \$278,040. These increased expenditures are treated in our CGE model as exogenous increases in exports of trade and service sectors. The total increase in these expenditures of about \$787,912 is only about 0.05 percent of the base year total output of the Walker River Basin economy. This increase is not expected to produce large effects. Details are found in Fadali et al. (1998).

3.3 Discussion of results

First, a discussion of the results from model 2 (partial mobility), an intermediate case, is presented. We compare the results from the three different model variants. Results from model 2 are presented in Tables 2 and 3. Table 2 presents the impacts of reallocating 47,997 acre-feet of water from hay production to recreational use. The table shows that as water is withdrawn from the hay sector, output in the sector decreases about 32.9 percent.

Output in the other agricultural sectors increases slightly; output in the livestock sector and the other crops sector increases about 3.0 and 3.1 percent, respectively. The increase in output in these two sectors is due to inflow of labor

---

[5] In a San Joaquin Valley CGE study, Berck et al. (1991) calculate the annual payment per acre foot of water to be \$67 for a 50 percent reduction in ag water use. Berck et al. do not consider the increase in landowners' income from water rights compensation for calculating the impacts.

Table 2. Impacts of water reallocation on output, employment, and value added (percentage change), model 2

	Output	Employment	Value added
Livestock	3.00	8.33	2.81
Other crops	3.06	8.47	2.98
Hay	-32.87	-29.17	-32.68
Agricultural total	-5.81	-6.92	-8.02
Mining	0.47	0.38	0.45
CMTCPU[a]	0.19	0.09	0.16
Trade	0.28	0.22	0.30
FIRE[b]	0.18	-0.02	0.03
Services	0.10	0.03	0.11
Nonagricultural total	0.19	0.09	0.16
Regional total	-0.08	-0.19	-0.27

[a] CMTCPU = Construction, manufacturing, transportation, communication, and public utilities
[b] FIRE = Finance, insurance, and real estate

and capital to these sectors, which are released from the hay sector. Total agricultural output decreases about 5.8 percent. Table 2 also shows that employment in the hay sector decreases about 29.2 percent while employment in livestock sector and other crops sector increases 8.3 and 8.5 percent, respectively. Total agricultural employment decreases 6.9 percent. Total agricultural value added decreases some 8.0 percent.

Table 2 also shows that nonagricultural output increases slightly due to (1) compensation for water rights, (2) the increase in recreation-related expenditures, and (3) the inflow of capital from the hay sector to nonagricultural sectors. Total nonagricultural output increases 0.2 percent. Increase in nonagricultural output requires an increase in labor employment; total nonagricultural employment increases 0.1 percent. The increase in total nonagricultural output does not offset the decrease in the total agricultural output; total regional output decreases 0.1 percent. This implies that the combined effect of water rights compensation and the increase in recreation-related expenditures does not offset the reduction in agricultural production. Total regional value added decreases 0.3 percent (Table 2). Because of the decrease in total regional value added, household income decreases; total household income decreases about 0.1 percent (Table 3). Also, total household welfare decreases $0.36 million (Table 3).

As output is reduced in the hay sector, some labor is released from the sector. Some of this released labor is either employed in the other agricultural sectors or outmigrates to the rest of the United States. Net outmigration of agricultural labor is estimated to be 6.9 percent (58 full-time jobs) compared to base year total agricultural employment (the third column in Table 5). In contrast,

Table 3. Impacts of water reallocation on household income and welfare, model 2

	Income (% change)	Welfare ($ million)[a]
Low income household	-0.09	-0.01
Medium income household	-0.12	-0.22
High income household	-0.09	-0.13
Total	-0.10	-0.36

[a] Welfare change is measured in Hicksian compensating variations (CV) in millions of 1994 dollars The welfare change in this table must be interpreted with care. Because model 2 allows interregional labor migration, the residents of the Walker River Basin before a policy change differ from the residents in the basin after the policy change. The welfare change reported in this table refers only to the initial residents who are in the basin prior to the water reallocation policy

there will be net inmigration of nonagricultural labor; net inmigration of nonagricultural labor is found to be about 0.1 percent (about 18 full-time jobs) compared to the base year total nonagricultural employment (third column in Table 5). The total net outmigration of regional labor is about 0.2 percent (or about 40 full-time jobs) compared to the base year total regional employment (third column in Table 5).

Table 4 compares the results for sectoral output from three different model variants. The table shows that model results for sectoral output are sensitive to alternative assumptions about the interregional factor mobility. If factors of production are not interregionally mobile (model 1), output in the livestock sector and the other crops sector increases 5.7 percent. This is because in model 1 all the labor and some of the capital released from the hay sector are absorbed in the other agricultural sectors within the region. Total agricultural output decreases 3.3 percent in model 1. In contrast, if the factors are perfectly mobile (model 3), output in all agricultural sectors decreases because labor and capital released from the hay sector leave the region immediately after the policy shock such that factor prices are equalized between regions. Total agricultural output in model 3 decreases 8.7 percent. Model results show that the policy impacts on total agricultural output are greater if factors of production are more mobile between regions.

Table 4 shows that output in all nonagricultural sectors increases slightly in models 1 and 2. This is due to (1) increase in recreation-related expenditures and (2) inflow of capital from the hay sector to the nonagricultural sectors. Total nonagricultural output in models 1 and 2 increases 0.1 and 0.2 percent, respectively. If the factors are perfectly mobile (model 3), however, output in all nonagricultural sectors decreases slightly. This is because all the capital from the hay sector leaves the study region immediately after the policy shock without being absorbed in nonagricultural sectors within the region. Total nonagri-

Table 4. Impacts of water reallocation on sectoral output (percentage change), three model variants

	Model 1	Model 2	Model 3
Livestock	5.72	3.00	-0.13
Other crops	5.74	3.06	-0.02
Hay	-31.11	-32.87	-34.89
Agricultural total	-3.34	-5.81	-8.65
Mining	0.00	0.47	-0.14
CMTCPU[a]	0.07	0.19	-0.26
Trade	0.28	0.28	-0.14
FIRE[b]	0.24	0.18	-0.53
Services	0.05	0.10	-0.30
Nonagricultural total	0.10	0.19	-0.29
Regional total	-0.06	-0.08	-0.67

[a] CMTCPU = Construction, manufacturing, transportation, communication, and public utilities

[b] FIRE = Finance, insurance, and real estate

cultural output decreases 0.3 percent in model 3. Table 4 also shows that the total regional output decreases in all model variants. This implies that in all model variants the combined effect of water rights compensation and the increase in recreation-related expenditures does not offset the reduction in agricultural production, resulting in net decrease in the total regional output.

Table 5 summarizes the results from three different model variants. The table shows that results for employment are significantly different depending on the assumptions about the factor mobility. Under the perfect mobility assumption (model 3), total agricultural employment decreases as much as 14.3 percent while it does not change under no mobility assumption (model 1). Net outmigration of agricultural labor is 0.0, 6.9, and 14.3 percent in models 1, 2, and 3, respectively, compared to base year level of total agricultural employment. Net outmigration of nonagricultural labor is about 0.3 percent in model 3. Model 2 reports a net inmigration of nonagricultural labor. Table 5 also shows that the impacts on other variables are also sensitive to different assumptions about interregional factor mobility.

It seems unreasonable to assume that factors of production are either perfectly immobile (model 1) or that they are perfectly mobile (model 3). As observed by Hoffmann et al. (1996), mobility of factors is dependent on expectations of workers and capital owners about future economic conditions within the study region and in the rest of the United States. If it is perceived that there will be alternative employment and investment opportunities within the study region or that conditions in the rest of the U.S. will not be better than those within the study region, then it is likely that workers and capital will remain

Table 5. Impacts of water reallocation (percentage change), three model variants

	Model 1	Model 2	Model 3
Output			
Agriculture	-3.34	-5.81	-8.65
Nonagriculture	0.10	0.19	-0.29
Total	-0.06	-0.08	-0.67
Employment			
Agriculture	0.00	-6.92	-14.27
Nonagriculture	0.00	0.09	-0.26
Total	0.00	-0.19	-0.83
Value added			
Agriculture	-5.62	-8.02	-10.78
Nonagriculture	0.09	0.16	-0.29
Total	-0.20	-0.27	-0.84
Household income			
Low income household	0.00	-0.09	-0.61
Medium income household	-0.06	-0.12	-0.60
High income household	0.01	-0.09	-0.61
Total	-0.02	-0.10	-0.61
Labor migration [a]			
Agricultural labor	0.00	-6.92 (-58 full-time jobs)	-14.27 (-119 full-time jobs)
Nonagricultural labor	0.00	0.09 (18 full-time jobs)	-0.26 (-52 full-time jobs)
Total	0.00	-0.19 (-40 full-time jobs)	-0.83 (-171 full-time jobs)

[a] The percentage change in labor migration is calculated as labor migration divided by the base year level of total agricultural, nonagricultural, or regional employment in the basin

within the study region. In this case, the impacts of water reallocation in the Walker River Basin will be close to those predicted by model 1. On the other hand, if the perception is that conditions will be better in the rest of the United States than those within the region, then workers and capital will flee the region. In this case, results from model 3 are appropriate. Without any empirical evidence about how labor and capital would behave in response to water reallocation in the Walker River Basin, we have considered three different cases.

4. Summary and conclusions

This study uses a regional CGE model to analyze the impacts of water reallocation in the Walker River Basin. To calculate the impacts of the water reallocation, the following three effects are considered: (1) the reduction in agricultural production, (2) water rights compensation, and (3) the increase in recreation-related expenditures. Also, three alternative model variants are specified to examine how sensitive the model results are to different assumptions about interregional factor mobility.

We find that the combined effect of water rights compensation and the increase in recreation-related expenditures does not offset the reduction in agricultural production, resulting in a net decrease in the total regional output. Second, the sectoral effects of the policy are sensitive to alternative assumptions about the interregional factor mobility. A caveat, however, is in order. The impacts that this study examines should be considered as the impacts on market activity or as costs of water reallocation rather than the full economic impacts. It is impossible to assess the full economic impacts without a measure of benefits to the users of recreation activity.

Several research directions are in order. First, this study focuses on the impacts of water reallocation on market activity, ignoring the change in recreation activities. For a more complete benefit-cost analysis, it is necessary to develop a CGE model, in which the values of both market goods and nonmarket goods are calculated in a consistent manner. Also, the CGE model should be a multiregional model, in which the recreators' welfare for both local and nonlocal visitors can be measured. Second, this study assumes that all the farmers with water rights compensation stay within the region. In reality, some of the farmers with compensation may leave the study region. The positive effects of the increase in farmers' (households') expenditure from water rights compensation are overestimated to some extent. If the information about what farmers would do with their water rights compensation were available, then it would be useful to incorporate the farmers' behavior in our study.

References

Acton, R., T. MacDiarmid, E. Miller, and R. Narayanan, *A Preliminary Study of the Potential for Water Banking within the Walker River Basin of Nevada and California, Executive Summary* (Department of Applied Economics, University of Nevada, Reno, 1998).

Alward, G.S., H.G. Davis, K.A. Despotakis, and E.M. Lofting, "Regional Non-Survey Input-Output Analysis with IMPLAN," paper presented at the annual meeting of the Southern Regional Science Association, Washington, D.C., 1985.

Alward, G., E. Siverts, C. Taylor, and S. Winter, *Micro IMPLAN, User' Guide, Version 91-F.* (Fort Collins, CO: USDA Forest Service. Land Management Planning Systems Group, 1992).

Berck, P., S. Robinson, and G. Goldman, "The Use of Computable General Equilibrium Models to Assess Water Policies," in A. Dinar and D. Zilberman (eds.), *The Economics and Management of Water and Drainage in Agriculture* (Norwell, MA: Kluwer Academic Publishing, 1991).

Bergstrom, J.C., R.J. Teasley, H.K. Cordell, R. Souter, and D.B.K. English, "Effects of Reservoir Aquatic Plant Management on Recreational Expenditures and Regional Economic Activity," *Journal of Agricultural and Applied Economics* 28 (1996), pp. 409-422.

Boyd, R., and D. Newman, "Tax Reform and Land-Using Sectors in the U.S. Economy: A General Equilibrium Analysis," *American Journal of Agricultural Economics,* 73 (May 1991), pp. 398-409.

de Melo, J., and D. Tarr, *A General Equilibrium Analysis of U.S. Foreign Trade Policy* (Cambridge, Massachusetts: MIT Press, 1992).

Dinar, A., and D. Zilberman (eds.), *The Economics and Management of Water and Drainage in Agriculture* (Norwell, MA: Kluwer Academic Publishing, 1991).

English, D.B.K., and J.C. Bergstrom, "The Conceptual Links Between Recreation Site Development and Regional Economic Impacts," *Journal of Regional Science* 34 (1994), pp. 599-611.

Fadali, E., D. Shaw, and J. Espey, "Recreational Economic Analysis of Walker River Basin," in Volume IV, *A Preliminary Study of the Potential for Water Banking within the Walker River Basin of Nevada and California* (Department of Applied Economics, University of Nevada, Reno, 1998).

Fletcher, R., G. Borden, T. Harris, D. Taylor, and B. Moline, "Economic Impacts and Trade-Offs from Public Land Grazing on Local Communities," 1997 Society of Range Management Annual Meetings, Rapid City, South Dakota, February 18, 1997.

Hamilton, J., and C. Pongtanakorn, "The Economic Impact of Irrigation Development in Idaho: An Application of Marginal Input-Output Models," *Annals of Regional Science,* 17 (1983), pp. 60-69.

Hoffmann, S., S. Robinson, and S. Subramanian, "The Role of Defense Cuts in the California Recession: Computable General Equilibrium Models and Interstate Factor Mobility," *Journal of Regional Science,* 36 (1996), pp. 571-595

Koh, Y-K, D. Schreiner, and H. Shin, "Comparisons of Regional Fixed Price and General Equilibrium Models," *Regional Science Perspectives,* 23, no. 1 (1993), pp. 18-32.

Kraybill, D., T. Johnson, and D. Orden, "Macroeconomic Imbalances: A Multiregional General Equilibrium Model," *American Journal of Agricultural Economics,* 74 (August 1992), pp. 726-736.

Leones, J., B. Colby, D. Cory, and L. Ryan, "Measuring Regional Economic Impacts of Streamflow Depletions," *Water Resources Research,* 33 (1997), pp. 831-838.

MacDiarmid, T., E. Miller, S. Stoddard, T. Darden, and R. Narayanan, "Agricultural Sector Analysis of Water Banking," Volume II, *A Preliminary Study of the Potential for Water Banking within the Walker River Basin of Nevada and California* (Reno: Department of Applied Economics, University of Nevada, 1998).

Miller, R.E., and P.D. Blair, *Input-Output Analysis: Foundations and Extensions* (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1985).

Minnesota IMPLAN Group, Inc., *IMPLAN Professional: Social Accounting and Impact Analysis Software*, 1997.

Nevada Agricultural Statistical Service, *Nevada Agricultural Statistics 1994-1995*, 1995.

Palmer, C., and E. Siverts, *IMPLAN Analysis Guide* (Ft Collins, Colorado: Land Management Planning Systems Section, USDA/Forest Service, 1985).

Plaut, T., "An Econometric Model for Forecasting Regional Population Growth," *International Regional Science Review,* 6 (1981), pp. 53-70.

Robinson, S., M. Kilkenny, and K. Hanson, "The USDA/ERS Computable General Equilibrium (CGE) Model of the United States," *USDA/ERS Staff Report No. AGES 9049* (1990).

Schreiner, D., H. Lee, Y. Koh, and R. Budiyanti, "Rural Development toward an Integrative Policy Framework," *Journal of Regional Analysis and Policy,* 26, no. 2 (1996), pp. 53-72

Seckler, D. (ed.), *California Water: A Study in Resource Management* (Berkeley, CA: University of California Press, 1971).

Seung, C., T. Harris, and T. MacDiarmid, "Economic Impacts of Surface Water Reallocation Policies: A Comparison of Supply-determined SAM and CGE Models," *Journal of Regional Analysis and Policy,* 27, no. 2 (1997), pp. 55-76.

Shoven, J., and J. Whalley, "Applied General-Equilibrium Models of Taxation and International Trade: An Introduction and Survey," *Journal of Economic Literature,* 22 (1984), pp. 1007-1051.

U.S. Department of Commerce, Bureau of Economic Analysis, *Regional Economic Information System: 1969-1996.*

Waters, E., D. Holland, and B. Weber, "Economic Impacts of a Property Tax Limitation: A Computable General Equilibrium Analysis of Oregon's Measure 5," *Land Economics,* 73, no. 1 (1997), pp. 72-89.

Appendix

Table A.1 Social accounting matrix for the Walker River CGE

	Activity	Commodity	Value added	Enterprise	Household	Local govt	State govt	Federal govt	S-I	World
Activity		Gross output								
Commodity	Intermediate inputs				Household purchase	L. govt purchase	S. govt purchase	F. govt purchase	Investment demand	Exports
Value added	Value added									
Enterprise			Enterprise income							
Household				Household income		Govt transfer to households	Govt transfer to households	Govt transfer to households		
Local govt							State govt transfer	Federal govt transfer		
State govt	Indirect business tax					Local govt transfer		Federal govt transfer		
Federal govt	Indirect business tax		Social Security tax	Capital tax	Personal income tax					
S-I				Business savings	Household savings	Local govt savings	State govt savings			
World		Imports	Income leakage					Fed. govt savings	-(External savings)	

Table A.2 Social accounting matrix for the Walker River CGE, 1994 (in millions of 1994 $ U.S.)

	Activity	Commodity	Value added	Enterprise	Household	Local govt	State govt	Federal govt	S-I	World
Activity		1525.395								
Commodity	644.727				678.883	36.436	85.017	113.104	133.708	732.554
Value added	799.010									
Enterprise			712.804							
Household				654.622		20.619	48.112	102.094		
Local govt				0.954	0.655		21.254	5.255		
State govt	69.628			2.226	12.112	0.364		12.262		
Federal govt	12.030		46.255	21.804	66.651					
S-I				33.198	67.147	-29.302	-57.791			
World		899.034	39.950					-85.975	-120.456	

Table A.3 Sector aggregation scheme for the Walker River Basin CGE model

IMPLAN sectors	Sectors in the Walker River Basin CGE model
Sectors 1-9	Livestock
Sectors 10-12 and 14-27	Other crops
Sector 13	Hay
Sectors 28-47	Mining
Sectors 48-446	Construction, manufacturing, transportation, communication, and public utilities
Sectors 447-455	Trade
Sectors 456-462	Finance, insurance, and real estate
Sectors 463-528	Services

Table A.4 Parameter values used in the Walker River Basin CGE model

Elasticities/parameters	Values
Elasticity of substitution in production [a]	
Agricultural sectors	σ_{LJ}[1] = 0.70 σ_{KN}[2] = 0.30
Nonagricultural sectors	0.8
Elasticity of substitution in consumption [b]	
Low income households	0.750
Medium income households	1.125
High income households	1.500
Elasticity of substitution between imports and local goods [c]	
Agricultural goods	3.500
Mining	0.500
CMTCPU [3]	2.868
Trade, FIRE,[4] and services	2.000
Elasticity of transformation in production: domestic goods and exports[d]	
Agricultural goods	3.9
Mining and CMTCPU [3]	2.9
Trade, FIRE,[4] and services	0.7
Factor shares in agricultural sectors [e]	
Labor	0.323
Capital	0.251
Land	0.426
Labor migration elasticity [f]	
Model 1	0.00
Model 2	0.92
Model 3	∞

[a] The values of the elasticities of substitution, 0.7 for labor and capital and 0.3 for capital and land are from Boyd and Newman (1991). The value of the elasticity of substitution between labor and capital, 0.7, is larger than the central estimate for agriculture of 0.61 in de Melo and Tarr (1992, p. 232). The elasticity of substitution between labor and capital used in nonagricultural sectors, 0.8, is based on de Melo and Tarr (1992, p.232)

[b] The elasticities of substitution for low and high income households are from Shoven and Whalley (1984, p. 1011). We set the elasticity of substitution for medium income households at the average value of the elasticities for low and high income households

[c] Because locally produced agricultural good and its imported version are highly substitutable, we set the elasticity of substitution for imports and local goods at a high value of 3.5 for agricultural goods. The elasticities of substitution for the other sectors are based on de Melo and Tarr (1992, p. 231)

[d] The elasticities of transformation are based on de Melo and Tarr (1992, p. 233)

[e] The factor shares for agriculture are from Robinson, Kilkenny, and Hanson (1990). These shares are compared with those used in Boyd and Newman (1991), that used about 0.27, 0.36, and 0.37 for labor, capital, and land shares, respectively, for the livestock sector. Boyd and Newman (1991) use similar factor shares for the other agricultural sectors

[f] The labor migration elasticity of 0.92 used in model 2 is from Plaut (1981)

[1] σ_{LJ} = The elasticity of substitution in ag production between labor and capital-land aggregate

[2] σ_{KN} = The elasticity of substitution in ag production between capital and land

[3] CMTCPU = Construction, manufacturing, transportation, communication, and public utilities

[4] FIRE = Finance, insurance, and real estate