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Europe and Central Asia Region
Environmentally and Socially Sustainable Development

Irrigation in Central Asia
Social, Economic and Environmental Considerations

Julia Bucknall
Irina Klytchnikova
Julian Lampietti
Mark Lundell
Monica Scatasta
Mike Thurman

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Cover photo by: Sapar Ospanov. Dilapidated irrigation canal in Kazakhstan.

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Preface

The team consists of Julia Bucknall, Irina Klytchnikova, Julian Lampietti, Mark Lundell, Monica Scatasta, and Mike Thurman (in alphabetical order). Bekzod Shamsiev and Anatoly Krutov provided valuable input concerning land salinization, aided in the study's formulation, and made a great deal of data available to the team. Field teams of local experts in Uzbekistan, Kyrgyz Republic, and Kazakhstan provided valuable insight concerning the perceptions of stakeholders. The extended team, which has provided significant comments, advice, and consultations, consists of Masood Ahmad, Brian Kropp, Ton Laennarts, Anil Markandya, Stan Peabody, TV Sampath, Orunbek Shamkanov, and Joop Stoutjesdijk. This study has also drawn extensively on the analytical work of and discussions with Shamsiya Ibragimova from the National Statistical Committee of the Kyrgyz Republic. The Bank's sectoral management team for the Europe and Central Asia region, particularly Joseph Goldberg and Laura Tuck, conceived of this study and guided the team.

Acronyms

FSK	Former state and collective farm (kolkhoz and sovkhoz)
GBAO	Gorno-Badakhshan Autonomous Oblast (Tajikistan)
I&D	Irrigation and Drainage
NPV	Net Present Value
O&M	Operation and Maintenance
PPP	Purchasing Power Parity
RESP	Rural Enterprise Support Project, Uzbekistan
RRS	Rayons Under Republican Subordination (Tajikistan)
WUA	Water Users' Association
WEMP	Water and Environmental Management Project

Executive Summary

Why Is This Study Necessary?

The Central Asian countries in the Aral Sea Basin—Kazakhstan, the Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan—have some of the largest irrigation schemes in the world. Some 22 million people depend directly or indirectly on irrigated agriculture in these countries. Twenty to forty percent of the GDP of these countries is derived from agriculture, almost all of which is irrigated. Entire communities of hundreds of thousands of people came into being solely because of irrigation development and settlement schemes. Without irrigation, much of the land would revert to desert scrub.

Since the collapse of the Soviet Union, both government budgets and farm incomes have fallen dramatically, water management institutions have weakened, and infrastructure maintenance has in many places come to a standstill. Irrigation and drainage (I&D) infrastructure is beginning to fall apart. Canals are silted up or damaged, gates broken or non-existent, and pumps held together by improvised repairs and parts cannibalized from other machinery. Across vast areas, water supply has become erratic, and land salinized and waterlogged.

Farmers cannot afford to maintain the schemes and neither governments nor the combined international donors have sufficient resources to rehabilitate anything but a small proportion of the schemes. Yet, the economies of most countries in the region are not creating alternative jobs to absorb people who will be displaced as farming becomes impossible. Therefore, donors and local policy-makers are faced with a series of difficult questions:

- What happens to communities as irrigation infrastructure declines? Do they move and find jobs elsewhere or do they stay? How do they cope?
- What is the relationship between poverty and irrigation in Central Asia? Do the poor suffer disproportionately from a contraction in irrigated area?
- Would irrigated agriculture be economically viable if all farm production and inputs (including electricity for pumping) were at world market prices?
- If we considered the environmental costs of irrigation, how would that affect the economic analysis of rehabilitation projects?
- Should policy-makers try to reduce the hardship that results from the contraction in infrastructure? If so, what options are available to them? In particular, could it be worth rehabilitating irrigation schemes, even when they are not economically viable, to keep people employed for a limited period? How do the financial costs of this use of irrigation as a form of social assistance compare with those of various alternatives such as income support programs?

Many detailed studies exist. Yet they tend to address a single issue or look at a particular geographic area. Few systematic analyses analyze a topic across all of the countries or attempt to weigh the relative importance of the different issues. This makes priority-setting difficult. This study aims to be a first step towards filling that gap. It uses existing household survey and project data, backed up by detailed qualitative work in communities that have already seen significant deterioration in their irrigation systems. The study does not provide definitive answers, nor does it aim to provide a roadmap for governments on which specific schemes to pick for rehabilitation. By making initial estimates of the scale and direction of each issue, it aims to test approaches for the future, to highlight future data needs and to provide some basis on which to make decisions in the period until more detailed information becomes available.

What Do We Find?

Communities are in a vicious cycle of falling income, reduced maintenance, deteriorating service and land degradation.

Irrigation and drainage benefited from massive investment during the Soviet era, but water was not well managed. Water application rates were extremely high, which reduced the quality of farmland through rising water tables and salinization. Construction and maintenance were often shoddy, with the result that I&D systems were in poor condition even before the Central Asian countries became independent in 1991.

Since independence, the situation has worsened considerably. Maintenance has been repeatedly postponed, and many I&D systems have reached the stage of advanced decay. Water supply has become unreliable in many areas. Policy, institutional and governance problems persist in most countries, to different degrees, which means that farmers often have little choice about what to grow and/or little access to information, improved seeds, inputs, agro-processing facilities and markets that might allow them to adapt. In such circumstances, unreliable water supply can have disastrous consequences. Yields per hectare have dropped precipitously, further depressing farm incomes and government revenues from agriculture. As incomes decline, farmers have less money for maintenance, infrastructure degrades, water supply becomes even less reliable, and the cycle continues.

Problems with irrigation infrastructure have compounded such problems by prejudicing soil quality. As drainage systems have deteriorated, vast tracts of land have become either salinized or waterlogged over the last decade, with a corresponding drop in crop yields. Salinization forces farmers to apply ever-greater quantities of water in an attempt to flush the salt out of the soil, making water application even more wasteful than it was before. This raises water tables further, and increases waterlogging, which further reduces yields and in some areas even damages buildings.

Many people tend not to move away when infrastructure degrades, even in the face of great hardship.

Villagers try to adapt to this situation in many ways—for example, switching to drought- or salt-resistant crops, or performing makeshift repairs—but are hampered by several factors. In some countries, government policies may limit their choices of what to grow where, as well as the timing of planting, input application, and harvesting. Farmers often cannot get information to help them diversify or adopt new water and soil management techniques. And in almost all of the countries, the influence of strong local elites and/or corruption reduces the voice of ordinary farmers in collective decisions.

As irrigation fails and production falls, villagers are often forced to abandon cultivation. Some turn to animal husbandry, some migrate within the country or to Russia, and others become day laborers or work in the local bazaar. Few seem to migrate, even in the face of great hardship in the area. Villagers report that this is because of the scarcity of alternative opportunities elsewhere, because of strong cultural and family ties to the area, and because most villagers cannot afford the relocation costs.

Institutions are weak or missing, allowing local elites to dominate.

The central agencies that once controlled the operation and maintenance (O&M) of I&D structures in Central Asia in Soviet times have been severely weakened. Declining budgets mean that salaries in the water management ministries and their local branches have fallen dramatically, and many skilled technical staff have left. Decentralized institutions, such as water users associations, have begun forming to fill that gap, but are not yet operating properly.

Local elites are able to capture the allocation of the water that is delivered to the area. Villagers reported that well-connected and wealthy individuals with land on the upstream portion of canals are often able to take water first, leaving only that which is left over to the less well-off water users downstream. There is also widespread theft of water from irrigation channels, in many cases by better-off farmers.

Inequitable water allocation is creating enormous social tension. Existing enforcement and conflict resolution mechanisms are often unable to handle the disputes, which have led to violent confrontations in some areas. Problems of this nature were reported in all three countries covered by the field assessment conducted for this study (Kazakhstan, the Kyrgyz Republic, and Uzbekistan), in upstream as well as downstream areas.

Irrigation in Central Asia is pro-poor.

Quantitative analysis of household surveys demonstrates that poverty in these countries is overwhelmingly rural. Within rural areas, the poor are more likely to be employed in agriculture than the non-poor. The surveys indicate little relationship between the size of the land holding and poverty. In some cases, this is because land has not yet been distributed from the former state and collective farms; in others, it is because land distribution has recently taken place, with similarly sized plots allocated to each household, and land markets have not yet developed to allow consolidation. The household data does not include information on land quality, but field work using qualitative methods indicates strongly that the better off households have more fertile plots, which are typically located closer to the water source than the land of other villagers.

Irrigation is important to the poor. Poor households have irrigation on a smaller percentage of their land than non-poor households, and irrigated land contributes three times more to per capita expenditure (a proxy for income) than does rainfed land. The household surveys do not allow us to distinguish the quality of service in different areas, but the qualitative work indicates strongly that better off households have more reliable supply.

Contraction of irrigation systems reduces household expenditure considerably. The extent of the impact depends on the share of land that is irrigated, and increases rapidly as the percentage of land irrigated approaches zero. Therefore, households with a large percentage of their land irrigated would not see a major fall in expenditure from a small contraction in irrigation, whereas households with only a small portion of their land irrigated would see a much sharper drop as a result of the same marginal contraction. Since poorer households have irrigation on a lower proportion of their land, we conclude that a contraction of irrigation systems will hurt the poor disproportionately.

A surprising number of schemes seem to be economically viable.

The agricultural economies of Central Asia have historically been distorted by price supports, production quotas, fixed prices of inputs and outputs, and the like. Even in the countries that have liberalized their economies, some distortions, such as subsidized electricity, remain in place. Conventional wisdom outside Central Asia holds that farming in many of the irrigation schemes would not be economically viable if the farms were subject to world economic prices for all inputs and for farm production. Many experts believe that this is particularly true for the schemes that pump water to irrigate elevated plateaux.

We modeled the effects of applying world market prices to irrigated agriculture at the provincial (oblast or viloyat) level for the entire country in Uzbekistan and for a representative group of districts (rayony) in Tajikistan. The results were quite different for the two countries. Even under the most pessimistic assumptions concerning future prices and farmer response to increased prices for inputs (i.e. if we assume they neither switch to more profitable crops nor use inputs more efficiently), only 12% of the irrigated land in Uzbekistan would become unprofitable. Even without the important economic benefits that would result from policy reform, therefore, most of the irrigation schemes in Uzbekistan would make a profit if full economic costs were applied. Moreover, the margins appear to be high. With policy reform, and farmers switching to higher value crops, the profits would be considerably more. Nevertheless, under the scenarios considered here, nearly a million people in Uzbekistan appear to depend at present on agriculture that is inherently unprofitable. The unprofitable land is highly concentrated—two-thirds of the people affected live in one province.

In Tajikistan, introducing full economic prices would be more problematic. Depending upon the assumptions about future prices, between one- and two-thirds of the land in the representative districts appears to be unprofitable. Again, though, if we assume that farmers use inputs more efficiently and switch to more profitable crops, or crops that have higher returns per cubic meter of water, many more schemes would become profitable. The areas that <u>are</u> profitable in Tajikistan, those that currently grow cotton, still have a strong margins.

However, governments make decisions on the basis of financial rather than economic analysis. To address this, we analyzed agriculture at the district level in the Kyrgyz Republic over a period of ten years. We found that the net present value of costs of rehabilitation of the on-farm infrastructure was substantially less than the net present value of farmers' income attributable to irrigation. That means it would cost the government less to rehabilitate the on-farm structures than to compensate people for their lost income. This analysis is disaggregated to the district level, which shows some important regional variations and points to the importance of conducting site-specific analysis.

Incorporating a value for environmental damage does not fundamentally change decisions about whether to rehabilitate one specific scheme.

Irrigation upstream has negative environmental effects downstream. Significant quantities of salt are trapped in the soils of Central Asia. Irrigation dissolves them and brings them to the surface, where they are drained off and discharged either into desert sinks or returned to the river. When they are returned to the river, they increase river salinity and thus the salinity of water used for irrigation downstream. Irrigation upstream also reduces the quantity of water available downstream. Both of these phenomena affect ecosystems, human health and agriculture downstream. Rehabilitation upstream, even if it caused water to be used more efficiently upstream, would continue the environmental effects downstream. We concentrate on the effects of continuing irrigation upstream on agriculture downstream.

We quantify the effects on agriculture downstream of continuing to irrigate upstream (i.e. the foregone benefits of not contracting irrigation upstream). We consider these foregone benefits as the negative environmental externality of a rehabilitation project upstream. Because we do not have reliable information, we do not consider health nor ecosystem damage, so ours is only a partial value of the externality. We estimated these foregone benefits from a project that the World Bank is currently considering financing on the Uzbekistan portion of the Amu Darya River. In the original project economic analysis, which does not consider environmental externalities, the project has a positive net present value under all of the scenarios the project economic analysis uses to test the sensitivity of its results. We changed this project economic analysis by subtracting an estimate of the environmental costs from the net benefits. We found that this does not greatly alter the conclusions, as none of our scenarios cause the NPV to switch sign in the original base case. It does, however, make the case for the project less clear-cut, as the NPV becomes negative in some sensitivity analysis scenarios.

Where schemes are not economically viable, it may be cheaper to subsidize the irrigation scheme, in combination with economic reform, than to use financial incentives to soften the social impact.

Policymakers need to consider their options when rehabilitation cannot be justified on economic grounds. Liberalization of agricultural policies and development of related support services combined with policies to promote economic growth in the off-farm sector would be the best long term solution to the current dependence on unprofitable irrigation schemes. In the short and medium terms, however, given the structural rigidities and institutional weaknesses in some of the economies, we cannot expect the market to create significant employment outside agriculture and thus stimulate large numbers of villagers to move to alternative employment elsewhere. Communities will continue to depend on irrigated agriculture. Governments that choose not to, or cannot afford to rehabilitate infrastructure may therefore consider providing some sort of assistance to the households that will lose their livelihoods as the infrastructure crumbles.

For the same rehabilitation project considered in the previous section, we estimate the budgetary cost of softening the social burden. We find that subsidizing the rehabilitation, even when it is not economically viable, may be cheaper than other courses of action that the Bank is discussing with policy-makers. In present value terms, it would cost more to provide an income transfer equal to the lost income from irrigation to the affected population than it would to subsidize the project to break-even point under every scenario but one.

This result does not mean that any uneconomic rehabilitation should be undertaken for social purposes. It does, however, mean that irrigation rehabilitation may be worth considering as a short term option even under circumstances that render an investment un-profitable. Even in that case, economic liberalization is vital. Price changes and associated adaptations may cause some irrigation schemes to be economically sound and/or lead to creation of jobs in other parts of the economy. Where the schemes are inherently un-profitable, liberalized prices would provide signals and give incentives to farmers to move away from agriculture, which and allow those schemes to contract gradually.

What Additional Work Is Needed?

Clearly, further information and more detailed analysis are needed to refute or confirm and refine the conclusions outlined above. Improved household survey data will be important. More precise questions on rural issues are needed in household surveys, and, if possible, consistent across countries. Household survey data will ideally permit us to analyze the relationship between key rural assets (such as land and access to irrigation) and poverty. In addition, consumption measures need to be constructed in order to ensure proper differentiation between the situation in rural and urban areas.

We need to make further enquiry into the responses of communities to the decay of their irrigation and drainage systems. We particularly need to understand what drives decisions to migrate. In addition, we need more information concerning how farmers respond to changing conditions in production, such as prices and availability of water. This study also shows that the Bank needs to make the assumptions underpinning the economic analyses of investment projects consistent across and even within Central Asian countries.

Qualitative analysis indicated the importance of institutions in managing water distribution and maintaining infrastructure. The viability of institutions will be a key factor in determining the success or failure of future rehabilitation investments. Future work could usefully address how donors and policy makers can identify strong local institutions or those that, with appropriate support, could be strengthened.

Hydrological and water quality modeling is crucial to understanding the interaction between variables that affect water availability and use. The Bank and other donors are involved in financing such models in Central Asia, sometimes at high cost, and usually aimed at answering specific project-related questions. The experience of this study indicates that the models can be difficult for third parties to use. It may be possible to develop less complex models that serve the project needs and also serve broader strategic and policy needs. This will involve striking a careful balance between precision, flexibility, cost, ease of maintenance and use and potential for integration with economic modeling tools.

The Bottom Line

This study finds that the case for the rehabilitation of many irrigation and drainage schemes in Central Asia is strong for several reasons.

- Many schemes appear to be economically viable, even before necessary policy and institutional reform takes place. If government policies allowed farmers more freedom of choice and the enabling institutions and markets were in place, the schemes could generate considerable profit.
- Halting the deterioration of irrigation infrastructure would benefit the poor more than the non-poor.
- The environmental costs to agriculture downstream of irrigation schemes may not be as major as some commentators have thought. Including a partial estimate of environmental costs into the cost benefit analysis of one specific project did not fundamentally change decisions about whether to invest in one specific project.

For these reasons, the study concludes that governments and the Bank should consider increasing investments in rehabilitating those systems that meet sound economic criteria and have reasonably strong institutions, while always continuing vital policy and institutional reforms.

Schemes that are not economically viable pose major problems because, if irrigation were to stop, much of the land could not sustain agriculture more intensive than nomadic herding. Huge numbers of people that depend on the irrigation schemes have few other livelihood options. In the long term, governments need to promote off-farm economic growth and targeted re-training and education efforts on communities which depend on un-profitable irrigation systems. In the short term, however, governments will need to consider ways to reduce the social costs of contraction of these schemes until the benefits of economic reforms are felt in rural areas. This study suggests that, if carefully designed, rehabilitation of irrigation and drainage infrastructure may be worth considering as one mechanism to maintain rural incomes in the short term.

These conclusions do not represent a blanket endorsement of large-scale investment in rehabilitation. Implementing macroeconomic, agricultural sector, water resources management and irrigation institution reforms will be key to success. This study simply suggests that irrigation rehabilitation—if carefully designed—should be considered as one important component in a strategy for social and economic recovery in Central Asia.

Chapter I. Introduction

1.1 Objectives

Around 22 million people in the five Central Asian countries of the Aral Sea basin depend upon irrigated agriculture for their livelihoods.[1] Since the collapse of the Soviet Union, the irrigation and drainage (I&D) infrastructure of Central Asia has seen little maintenance. Both farm and government budgets are insufficient for operations and maintenance (O&M), and institutional structures are generally not strong enough to ensure efficient water management. Thus, much of the infrastructure is fast approaching collapse.

The need for some investment to maintain the most critical I&D infrastructure seems clear. However, there is disagreement concerning the most appropriate scale and nature of investments, their timing (as soon as possible, or only when agricultural policies and institutions improve), and the criteria for selecting investments (should they focus on economic and financial viability, or is there an argument for using the investment as a form of social protection), and whether the investments are environmentally sustainable.

This study aims primarily to help the World Bank and governments in Central Asia weigh these arguments. It aims to improve the advice the World Bank gives its clients concerning the appropriate scale of rehabilitation, what kind of schemes should be rehabilitated first, and what selection criteria would be most suitable for evaluating these investments.

1.2 Data Sources and Methods

This report is the result of several studies conducted during 2001. It also utilizes quantitative analyses of official statistical data, reports from the World Bank and other donors, and household survey data. The environmental analysis draws heavily on a complex hydrological study conducted as part of preparing a World Bank financed investment.[2] Information was taken from a survey conducted in preparation for the World Bank's Uzbekistan Rural Enterprise Support Project (RESP), as well as a quantitative study of trade-offs in land salinization in Uzbekistan.[3] In addition, we use data, estimates, and analyses from various studies, including the National

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[1] The Aral Sea basin encompasses Southern Kazakstan, the Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan. The rural population of these three areas is 28 million. For the purposes of this study, the rural population has been multiplied by the share of land that is irrigated (source: WDI 2001 and IMF staff country reports).

[2] Mott MacDonald Temelsu and Ministry of Agriculture and Natural Resources of the Republic of Uzbekistan, 1998, *Preparation Study of the Uzbekistan Drainage Project. Phase II. Prefeasibility Study. Draft Final Report.* Parts I-III. (Main Report and Annexes), hereafter cited as MMD.

[3] Bekzod Shamsiev and Norboy Ghoyibnazarov, 2001, "A Model of Soil Salinity Management in the Golodnaya Steppe" (Draft); Mike Thurman, 2001, *Agriculture in Uzbekistan: Private, Dehqan and Shirkat Farms in the Pilot Districts of the Rural Enterprise Support Project.* December 2001.

Action Plan of the Republic of Uzbekistan for Combating Desertification and a general study on water management conducted for the International Fund for the Aral Sea.[4]

This work is augmented by a field assessment of the ways in which the degradation of I&D systems affects the livelihoods of rural stakeholders.[5] Multidisciplinary teams of local experts used qualitative methods to assess the situation in 12 sites in Kazakhstan, Kyrgyz Republic, and Uzbekistan, in both upstream and downstream areas. All sites are characterized by major problems with irrigation. The field assessment was financed by the Bank Netherlands Water Partnership Programme and the Government of Switzerland.

1.3 Organization of the Report

This report is organized as follows. Chapter 2 outlines the extent to which the economies of this region depend on irrigated agriculture and then analyses the causes and patterns of the degradation of I&D systems in various areas. The second half of the chapter is concerned with the effects of infrastructure degradation upon the rural population.

In III, we explore the relationship between irrigation and poverty, first describing the rural poor then analyzing the relationship between irrigated land and household consumption. The chapter concludes with an enquiry into the likely effects of the gradual contraction of existing I&D systems upon various income groups. Chapter 4 analyses the inherent economic viability of irrigated agriculture in Tajikistan and Uzbekistan, followed by financial analysis of irrigation in the Kyrgyz Republic.

Chapter 5 deals with environmental externalities. We take a real economic analysis of a World Bank project and estimate a value of the environmental externalities. We then apply this to the cost-benefit analysis and see how it affects investment decisions. The final chapter attempts to draw conclusions from this work and suggests additional research that could be used to refine various components of the analysis. Statistical tables and methodology related to the calculations in Chapters 3-5 are included in separate Annexes, along with a complete bibliography and maps.

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[4] Uzglavgidromet for UNEP, *Natsional'naia programma deistvii po bor'be c opustynivaniem v respublike Uzbekistan,* hereafter cited as *Natsional'naia programma*; Royal Haskoning for GEF Agency of the IFAS, 2001, *Water and Environmental Management Project, Sub-component A1, National and Regional Water and Salt Management Plans, Regional Report No. 2, Phase III Report - Regional Needs and Constraints, Main Report* (Draft), hereafter cited as WEMP.

[5] Mike Thurman, 2002, *Irrigation, Drainage, and Poverty in Central Asia: A Field Assessment*.

Chapter II. The Importance Of Irrigation In Central Asia

2.1 Dependence on Irrigation

Irrigation plays an important role in the economies of Central Asia. Owing to the arid climate of the region, crops must be irrigated in most areas (see Table 2.1 below). In 1999 the agricultural output that irrigation supports accounted for 11% of GDP in Kazakhstan, 19% in Tajikistan, 27% in Turkmenistan, 33% in Uzbekistan, and 38% in the Kyrgyz Republic.[6] In Uzbekistan, Tajikistan, and Turkmenistan, agricultural products, particularly cotton, constitute 20-40% of exports.

While some areas have been irrigated for centuries, many I&D schemes are the creations of central planning in the 1950s-1980s. Huge schemes were constructed to irrigate desert or steppe areas and hundreds of thousands of people moved to the areas to work in agriculture. During 1970-89 irrigated area expanded by factors of 150% and 130% in the Amu Darya and Syr Darya River basins respectively. This required the diversion of ever-increasing quantities of water—Uzbekistan's annual intake of water grew from around 35 km^3 to 60-63km^3. Water was, and continues to be used highly inefficiently. In Uzbekistan, farmers withdraw an average of 14,000m^3 of water per hectare for irrigation, whereas rates in countries such as Pakistan and Egypt—not known for efficient irrigation—average around 9,000-10,000 m^3/ha.[7]

Table 2.1: Cropland, Irrigated Land, And Pasture In Central Asia, 1999

	Total Cultivated Cropland	Irrigated Cropland		Pasture
	('000 ha)	('000 ha)	% of Cropland	('000 ha)
Kazakhstan	30,135	2,313	7	18,233
Kyrgyz Republic	1,435	1,077	75	9,216
Tajikistan	860	719	84	3,600
Turkmenistan	1,744	1,744	100	3,070
Uzbekistan	4,850	4,309	89	2,280
Central Asia	38,975	10,212	26	36,399

Note: Seventy percent of the cropland in Southern Kazakhstan, i.e. the portion that lies within Central Asia, is irrigated, which drives the percent of irrigated cropland in Central Asia substantially above the figure shown in the table.
Source: FAO Aquastat.

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[6] Cotton Committee International, *Cotton USA Global Fax Update - January 2002*; *World Development Indicators 2001*.

[7] World Bank, 2000, *Republic of Uzbekistan Irrigation and Drainage Sector Study*, Vol. 1, pp. 6-7.

2.2 Farm Incomes

Farmers are responsible for paying for O&M of on-farm irrigation structures. Yet farm incomes have declined precipitously across the region. Agricultural production has fallen by over half in Kazakhstan, the Kyrgyz Republic, and Tajikistan since 1991. Where state planning and purchasing remains prevalent (Uzbekistan and Turkmenistan), these distortions depress farm incomes. For example, if farmgate prices in Uzbekistan were adjusted to export parity levels, cotton and wheat producers would receive 22% and 15% more income than at present.[8] Where farming has been "liberalized" (southern Kazakhstan, the Kyrgyz Republic and increasingly Tajikistan) lack of managerial experience, poor access to inputs, markets, and agro-processing, as well as corruption prevent farmers from realizing the full economic potential of their land.

2.3 Institutions for O&M

Significant problems in O&M had already developed before the demise of the USSR in 1991. Operations and maintenance fell to a highly centralized bureaucracy that implemented inflexible plans calculated from standardized norms and often outdated data. Farms had little input into decision-making concerning O&M. Maintenance was commonly neglected, especially within farms, and construction was often shoddy. According to various estimates, the infrastructure supplying approximately half of the irrigated area of Uzbekistan, Kazakhstan, and the Kyrgyz Republic was in need of capital repairs by the early 1990s.[9]

Since 1991, the Governments of the Central Asian countries have scaled down the central agencies that used to control I&D infrastructure. Expenditure on O&M in Kazakhstan dropped by a factor of 21 during the 1990s, and only 31% of the required maintenance in the Kyrgyz Republic actually receives funding. The figure for the much better-preserved and still-powerful Uzbekistan Minsel'vodkhoz is a reported 50%, although even this is an optimistic estimate.[10] At the local level, district irrigation departments (rayvodkhozy) throughout Central Asia now have very low salaries, small operational budgets, and very little equipment. Qualified staff have left the agencies in large numbers.

Recognizing that cost recovery is necessary, Central Asian Governments have increasingly taken steps to introduce a payment for water, establish cost accounting in district irrigation departments, and divest themselves of the responsibility for O&M of secondary I&D networks. They are encouraging farmers to organize themselves into Water Users' Associations (WUAs). However, even in the countries where this is most advanced, "almost all of them are in an

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8 Brian Kropp, Mark Lundell, and Bekzod Shamsiev, *Uzbekistan Living Standards Assessment*, "Rural Welfare" (Draft).

9 Akademiia Nauk Uzbekskoi SSR, Institut po izucheniiu proizvoditel'nykh sil, 1986, *Ekonomicheskie i sotsial'nye problemy razvitiia i rameshchenia proizvoditel'nykh sil Uzbekskoi SSR na sovremennom etape*, p. 35; Ivan Duyunov, 1996, "Measures to Increase the Efficiency of Irrigated Lands in Kyrgyzstan," in *The Interrelationship Between Irrigation, Drainage, and The Environment in the Aral Sea Basin,* edited by M.G. Bos, pp. 125-26; World Bank, 1994, *Kazakhstan Agricultural Sector Review*, *World Bank Report 13334-KZ*, p. 5. The Uzbekistan figures, over half of irrigated area, date from the mid-1980s.

10 Tajikistan also claims 50%, yet, based on the state of the economy and field reports, this is a highly unrealistic estimate. WEMP, p. 21.

embryonic stage with few financial resources to operate."[11] The field assessment confirmed this repeatedly. Their position (or the lack thereof) is indicated in a Venn diagram constructed by the leaders of a former collective farm in Kazakhstan (Tokmaganbetov village, Syr Darya District) to describe decision-making in water allocation—it does not include either the local WUA or family farms among local level planning or management bodies.

2.4 The Deterioration of Infrastructure

2.4.1 Maintenance

Falling levels of maintenance have led the infrastructure to deteriorate and the distribution and delivery of water to become unreliable. In the field assessment, villagers asserted that I&D systems had not been maintained for five years or more. Drainage has been particularly neglected. Farmers in Uzbekistan reported to the RESP survey that in 2000 only 17-26% of farmers had done *any* work on drains in the last three years, compared to 65-74% for canal systems.

Farmers attempt to keep I&D systems in working condition in various ways. They employ traditional collective methods of labor mobilization, such as the *hashar*, in which users of a canal allocate sections among themselves and remove silt and weeds. However, many of the repairs require expensive machinery. Sometimes villagers manage to pool resources and hire equipment. A typical example is that of a FSK in Kazakhstan (Ilyasov village of Syr Darya District) that managed to hire two excavators to clean three kilometers of a main canal and to remove weeds and silt from another kilometer using its own laborers. However, on the remaining 45 km of this and other on-farm canals "cleaning has not been done due to the lack of specialized equipment and funds."

Only the few wealthy family farmers and those inside or connected with the administration of FSKs can afford to adequately maintain infrastructure. For instance, a private farmer in Nishan District of Uzbekistan was able to sell 200 sheep in 2000 in order to install a drainage system on his private farm of 60 ha.

Because water users cannot maintain I&D systems, they have become dilapidated. Typically, canals with earthen beds have fallen into decay most rapidly. Yet in many areas the more modern concrete flumes are in poor shape, as they have fallen out of joint, become structurally unsound, or simply been pierced to (illegally) withdraw water. Canals in downstream areas are in the worst condition, owing to the higher concentration of silt carried there. Locales served by pumps are also vulnerable, as pumps are beginning to break down.

The deterioration of canals has resulted in lower conveyance efficiency. In most of the field assessment sites, around half of the water is lost between the source and the farm intake; even worse than the average for Central Asia of around 30%. In the Kazakhstan field sites, the

[11] Asian Development Bank, 2000, *Institutional Development and Policy Reforms for Improving Water Management, Government of Kazakstan T.A. No 2946-KAZ*, Richard Burger, 1998, "Water Users' Associations in Kazakstan: An Institutional Analysis," report for Harvard Institute for International Development; World Bank, 2000, *Project Appraisal Document: Kyrgyz Republic On-Farm Irrigation Project*, *World Bank Report No. 20353-KG*, p. 5.

conveyance efficiency of the main channels has declined since 1996 by 7-24%. On-farm losses are even higher. The average for Central Asia is 48% in conveyance and operational losses, although some of this is recouped through groundwater irrigation.[12]

Drains are in even worse shape than canals. In most locales studied, villagers complained that large collectors are not of sufficient depth and are choked with weeds, closed drainage is blocked, and vertical drainage pumps have all too often burned up, resulting in systems that "do not work at all" (Otrar District of Kazakhstan). Even in Uzbekistan, where O&M is better funded than elsewhere in the region, the effectiveness of drainage systems "has declined a good deal, a considerable number of vertical drains are out of commission (over 5,000), and a large portion of the horizontal drains, the average length of which is 30-32m/ha, are clogged and silted."[13]

2.4.2 Water Distribution and Delivery

Despite the fact that withdrawals of water per irrigated hectare in Central Asia are excessively high (on the order of 12,000-14,000m^3/ha or more) water for application to crops has become increasingly scarce. For instance, a resident of Kara Bora District of Kyrgyz Republic noted, "Our water comes from the Bolk Canal. Until 1999 I had never seen the Bolk, because it wasn't necessary to go there—there was always enough water. During the last year, lack of water forced me to go to the canal several times." The increasing unreliability of water supply is due in large part to the deterioration of infrastructure and consequent rise in losses of water during conveyance.[14]

However, supply is also disrupted not because canals cannot carry water, but because institutions and governance structures cannot ensure its equitable distribution and successful delivery. Although illegal capture of water occurred during the Soviet period, it has become increasingly common over the past decade. Presently, under-funded and over-burdened local ministries of water management, WUAs, local authorities and farms are often unable to curb rent-seeking by farmers with enough informal connections or money to capture an unfair share of water.

Farmers in the upstream portions of I&D systems account for the majority of illegal water withdrawals. For example, those in the upper reaches of Kadamjan District (Batken Province, Kyrgyz Republic) have knocked holes in 2 km out of 5.5 km of concrete flumes and installed pipes and hoses in order to steal water above the established limits. Now an old earthen canal with a low flow capacity must be used to transfer water downstream, resulting in a 70% loss between the upper and lower portions. Needless to say, farmers in the downstream zone of the district are unhappy with this situation. Elders from the village at the very end of the system remarked: "People live very poorly. Compare us with the upper zone. See, they live better than we do, because they have water. There is no order in water allocation. Those in the upper zone always take the water and tell us, 'The water is ours. First we will irrigate, and if any is left, we will give it to you.' We discussed this in the council of elders, but all the same there was no result. Because there is a lack of irrigation water, people can't cultivate their land."

[12] WEMP, pp. 7-9.
[13] *Natsional'naia programma*, p. 69.
[14] During 2001-01 droughts (2000-01) exacerbated this situation.

In all of the instances of water theft examined during the field assessment, the perpetrators were usually well connected and wealthy farmers, many of which had succeeded in acquiring land near canal inlets. On the Turkmenistan FSK in Nishan District of Uzbekistan, farmers noted: "The rich [private farmers] are those with land...at the intake. These are usually former directors of sovkhozy [state farms], policemen, farm agronomists, brigade leaders, entrepreneurs, and also Tajiks from Surkhandarya [Province] with a lot of money and connections...The wealthy farmers can irrigate their land five times...The hakim decreed that private farmers at the head of the irrigation system were to economize in water use, but none of them listens to anybody."

The inequitable distribution of water has heightened conflict over water supply. Field teams ran into cases of tension and outright violence in several sites. The situation is acute in Uzbekistan District (Uzbekistan), where "conflicts over water distribution constantly occur, which in some cases have ended in fatality". A FSK irrigator in Ellikkala District told interviewers for the RESP survey that there the police are even involved: "Last year our farm director had a tremendous problem with water allocation. Yangiyer [the upstream farm conglomerate] did not give us water, and in the end we didn't have any. Water for garden plots is allocated for three to four days every 15 days. Whoever can get it, gets it. The matter goes as far as fighting. Therefore, the farm director delivers water together with the head of the district police. They also control water on the Ellikkala [the main canal]."

Institutional failure also contributes to the continuation of conflicts: the prevailing (formal) procedures and methods of conflict resolution focus upon punitive measures (largely to the exclusion of information-sharing and consultation). Moreover, official judgments concerning disputes over water are often not enforced.

2.5 The Environmental Effects of Irrigation

2.5.1 Ecosystem and Soil Quality Damage

Irrigation profoundly affects the environment, primarily by bringing large quantities of water to areas where nature does not provide it and allowing human settlement where it otherwise would not be possible. The extent of this impact depends upon the way that I&D is managed. Unsustainable construction and mismanagement of water, which proceeded during the 1960s-80s under the auspices of the former USSR Ministry of Water Management (Minvodkhoz), diverted water from downstream ecosystems.

The most glaring case of ecosystem damage is the Aral Sea. This inland lake, which in 1960 covered an area the size of West Virginia, has diminished to a fourth of its former volume. The local fishing industry is ruined, millions of hectares of cropland, pasture, and ecologically valuable delta areas have undergone intense desertification, and dust storms drive a growing amount of salt to other areas of Central Asia. Dust storms, salinization of drinking water and poverty all contribute to the poor health of the population: infant mortality in some areas reaches 100/1000.[15]

The rapid flow of irrigation water erodes fields with uneven relief, where terracing is absent, and/or where furrows have been cut. Nineteen percent of the irrigated area of Uzbekistan is threatened by water erosion (6% to a moderate or severe extent). In Kazakhstan, around 45% of irrigated land (concentrated mainly in the southern portion of the country) suffers from water erosion, and in the more mountainous countries of the Kyrgyz Republic and Tajikistan, the steep terrain makes anti-erosion measures essential.[16] Erosion takes away the topsoil, which is already scarce on 40-50% of the irrigated land in the region, and increases the maintenance requirements of downstream (or in some areas downwind) I&D systems.

Irrigation can also transfer of toxic agro-chemicals and salts via drainage systems to downstream areas, where they harm ecosystems and mix into aquifers and wells used for drinking water.[17] The application of toxic agro-chemicals in Central Asia has dropped from previously high levels (by a factor of 1.5 in Uzbekistan during 1990-96), largely because most farms cannot afford previous levels of application. Yet some persistent toxic chemicals, such as DDT, have accumulated in the soil since the late 1960s and are still being washed into rivers and I&D systems. The average concentration of DDT in soils in Uzbekistan in the mid-1990s was 0.321 mg/kg, over three times above acceptable limits.[18]

2.5.2 Salinization

The most widespread environmental effects of irrigation in Central Asia, and the ones most closely examined in this study, are salinity and the waterlogging associated with it. Irrigation dissolves salts already in soil and causes them to rise to the surface. When enough salt enters the root zone of the crop, plant growth is retarded and yields fall.

Salinization intensifies downstream, because salts wash down the main rivers in the basin, the Amu Darya, the Syr Darya, and the Zerafshan. This is apparent in Table 2.1 below, which shows the dimensions of land salinization in the Central Asian countries. The upstream countries, Tajikistan and Kyrgyz Republic, have very low rates of salinization, while the downstream countries suffer more. The problem is particularly acute in the areas closest to the Aral Sea—90-94% of the land in Karakalpakstan, Khorezm, and Bukhara Provinces of Uzbekistan is salinized.

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[15] N.F. Glazovskii, *Aral'skii krizis: prichiny voznikoveniia i puty vykhoda*; World Bank, 1998, *Aral Sea Basin Program (Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan and Uzbekistan), Water and Environmental Management. Project Document.*

[16] Minsel'vodlhoz Kyrgyzskoi Respubliki, 2000, *Natsional'nyi plan deistvii po bor'be c opustynivaniem v Kyrgyzskoi respublike*; *Natsional'naia programma*; UNEP, 2000, *State of the Environment of the Republic of Kazakhstan*.

[17] By the late 1980s, the average application of toxic agro-chemicals per hectare in Uzbekistan was 22 kg of herbicides, 16.2 kg of defoliants, and 36 kg of insecticides. The substances used include DDT, Aldrin, and a highly toxic defoliant called *butifos*. These substances were banned in 1983, yet application continued in areas with a low population density until stocks ran out. See: Ziyaviddin Akramov and Abdihakim Qyumov, 1988, "Qishlaq wa tabiat;" Patricia M. Carley, 1989, "The Price of the Plan: Perceptions of Cotton and Health in Uzbekistan and Turkmenistan."

[18] *Natsional'naoa programma*, pp. 72-74; Arzimurad Rahmatullaev, 1995, "Zuryadimiz taqdiri." Concentrations of DDT in Uzbekistan are highest in Ferghana, Andijan, and Kashkadarya Provinces.

Table 2.1 Land Salinization in Central Asia			
	Irrigated Area (Ha)	**Area Affected By Salinization**	
		Ha	**% of Irrigated Area**
Kyrgyz Republic	1,077,100	124,300	11.5%
Tajikistan	719,200	115,000	16.0%
Kazakhstan	2,313,000	>763,290	>33.0%
Turkmenistan	1,744,100	1,672,592	95.9%
Uzbekistan	4,280,600	2,140,550	50.1%
Central Asia	10,134,000	4,815,732	47.5%

Sources: Ministerstvo okhrany prirody Turkmenistana for UNEP, 2000, *Doklad po osushchestvleniiu Natsional'noi programmy deistvii po bor'be s opustynivaniem v Turkmenistane*, p. 24; FAO, 2002, *Aquastat* (figures are for 1993-94); TACIS, 2000, *Kyrgyz Republic National Irrigation Strategy and Action Plan. Supporting Document*, pp. 2-13.
Note: The salinization statistics for Kazakhstan are based upon 1989 land surveys, because the present reported figures are too low to be credible. The present dimension of land salinization is probably greater than that shown above.

Salt reaches the root zone of the soil from both on-site and off-site sources. On-site salinization occurs when salts already in the substrata or groundwater are mobilized within the water table. When drainage is insufficient, that salt stays in the soil or groundwater and damages crops on-site. Off-site salinization takes place when the salts are returned via drainage systems to river water to be abstracted downstream. Both are common in Central Asia, largely because of the huge expansion of irrigation into lands with inherently high salinity in the 1960s-80s.[19]

Most of the off-site transfer of salt in Central Asia occurs when upstream areas discharge saline drainage water, which is re-used downstream. Over 70% of the salts carried by the rivers of Central Asia is derived from drainage systems, which discharge 10-25% of the total volume of water carried by canals back into the river system, while the remainder runs into large "sinks" in the desert.[20] The total amount of salt carried every year by the Syr Darya and Amu Darya Rivers grew between the mid-1960s and the mid-1990s from 55-60 to 135-40 million tons.[21] With the halt of the expansion of irrigated area and diminishing drainage system operation in the 1990s, the mineral content of river water has dropped slightly. Average salinity levels are 0.45-0.60 g/l in the upper reaches of the Amu Darya and Syr Darya. The Amu Darya becomes more intensely salinized between its middle and lower reaches (from .60 g/l in Termiz near the Tajik border, to over 1 g/l near the Aral Sea), while salinity levels remain fairly constant in the middle and lower reaches of the Syr Darya River (1.1 at the outlet of the Ferghana Valley to 1.4 g/l)[22].

[19] *Natsional'naia programma*, p. 67. By the middle of the 1950s irrigation had expanded well beyond the traditionally cultivated areas, and the majority of virgin land that could be developed was already saline. Substantial salt horizons in the soils of Central Asia were either deposited by a sea that inundated Central Asia several times millennia ago or were washed downstream over the centuries, often from traditionally irrigated locales.

[20] Of the water carried by canals, 30-40% makes its way into the drainage system. In Uzbekistan and Kazakstan, 40% of drainage water is discharged into desert sinks, while in Turkmenistan this figure reaches 70%. See: WEMP, App.C.1-2.

[21] *Natsional'naia programma*, pp. 61, 63, 89. The much smaller Zerafshan River presently carries about 5 million tons of salts annually to Bukhara Province. Each hectare of irrigated land in Uzbekistan discharges 18-20 tons of salts per year.

[22] In general, irrigation water containing 0.5-2 g/l of salts poses a slight to moderate risk of salinization of land and crops and thus can be used with appropriate management practices. The application of water containing concentrations above 2 g/l (most drainage water) has a much higher risk of salinization. These two ranges roughly correspond to an electrical conductivity of 0.7-3.0 deciSiemens/m and 3.0 dS/m or above.

Salinization hampers agricultural productivity in several ways. First, it increases water requirements. Farmers try to flush salt out of the soil by applying large volumes to the fields before or after the growing season; a practice called leaching. Water for leaching accounts for one-third of total water use in highly salinized areas, such as Karakalpakstan.

Second, salinity inhibits the growth of plants when the osmotic pressure of the soil-water solution in the root zone inhibits the ability of plants to absorb water. Salts can also hamper growth through ion toxicity, but the osmotic effect is more prevalent.[23] The yield response to salinization varies according to several site-specific factors, including the salt-tolerance of the crop,[24] the stage in the life cycle that the salts are applied (plants are especially sensitive during germination), the moisture content and texture of the soil, and the characteristics of the salts.[25] The Central Asia Scientific-Research Institute for Irrigation's estimate of the loss in cotton yields is 20-30% on slightly salinized land, 40-60% on moderately salinized land, and up to 80% and beyond on severely salinized land.[26]

2.5.3 Waterlogging

When water tables rise, soils become waterlogged. This reduces yields, places a greater load on plowing and traction machinery, and compacts the subsoil.[27] Water tables have risen considerably in the past decade. In the Aral Sea basin, the area of irrigated land with a water table of two meters or less expanded by 35% between 1990 and 1999. The situation in Southern Kazakhstan is particularly acute: land in this category grew by 200% over this period.[28]

The sites covered by the field assessment had seen extreme problems with rising water tables. During the 1990s, the percentage of irrigated area with a water table of three or less meters rose from 76% to 93% on the Pakhtaabad FSK (Nishan District, Uzbekistan), from 36% to 82% on the Turkmenistan FSK (Nishan District, Uzbekistan), while on the Kirkkiz FSK (Ellikkala District, Uzbekistan) the percentage of cropland with a water table of less than 1.5 meters rose from 93% to 100%. By 1995, the *average* level of groundwater at all sites in Kazakhstan was 2 meters or less, and by 2000 it had reached 1.5 meters in Shoymanov village (Otrar District), 1.2 meters in both sites covered in Syr Darya District, and 0.5 meters in Otrar village (Otrar District).

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[23] This is measured by electrical conductivity, EC_e, expressed in DeciSeimens per metre (dS/m). When the salinity of the soil-water solution (saturation extract) reaches a range of 4.5-9 dS/m, it is considered to be slightly saline, moderately saline at 9-18 dS/m, and severely saline at over 18 dS/m. These ranges are roughly equivalent to 3-6, 6-12, and over 12 g/l of Total Dissolved Solids, respectively. DeciSeimens (dS/m) is alternatively expressed as millimhos per centimetre (mmho/cm).

[24] Among the crops grown in Central Asia, the most salt-tolerant are barley and sugar beets. Moderately tolerant crops are alfalfa, rice, cotton, wheat, corn, potatoes, carrots, onion, cucumbers, pomegranates, figs, melons, and grapes. The least salt-tolerant crops are stone fruits, almonds, peas, and beans.

[25] World Bank, 2001, *Aral Sea Basin Program, Subcomponent A1, Report of the National Working Group of the Republic of Uzbekistan: Functional Relationship Between Salinity and Yields in Agriculture*.

[26] A study conducted for the GEF Agency of IFAS examined the methods of measurement and estimation of yield response that Central Asian specialists employ. The authors concluded that there is "reasonable agreement" between the methods of measurement and estimates described above and the FAO method.

[27] WEMP, pp. 13-14.

[28] WEMP, p. 12.

Villagers in these areas observed that groundwater often seeps into the foundations of buildings and rots them. In some areas, corrosion caused by groundwater affects as many as 10% of the homes. Schoolhouses and other public buildings are also affected. People who live or study in these buildings worry about their exposure to damp conditions. Teachers in Aravan District noted that in the winter cold, when temperatures in the rooms dip to around 5^{o}C, pupils often catch cold. The director of the local Government office noted, "I put my daughter in school in the city of Osh and every day I take her to the city, because here [in the local school] she could fall sick with rheumatism, like the others."

Waterlogging also contaminates drinking water sources with bacteria, salts, and agrochemicals. When drainage systems fail, water tables rise, and polluted drainage and irrigation water often mixes with shallow and even deep aquifers that supply household drinking water. Where piped water supply systems are available, they are in poor enough condition to be susceptible to infiltration from groundwater and bacteria from latrines. Many villagers use irrigation or drainage water for drinking. When irrigation water becomes scarce, it becomes more stagnant and salts more concentrated, thus affecting drinking water supplies.[29]

The drinking water in most areas of Central Asia is poor and getting worse. The principal contaminant related to irrigation is salt. The WHO limit is 1 g/l, which was established on the basis of palatability, rather than health. The salinity of groundwater in Central Asia is highest in the lower reaches of river basins, where concentrations are in the range of 1-2g/l, reaching 3g/l in some areas.

Drinking highly saline water may have widespread health effects, but these have not been quantified. There is no specific epidemiology on this issue.[30] However, healthcare workers in fieldwork sites where the salinity of water is high believe it to be linked to poor health, both of humans and livestock. In other areas, water-borne maladies such as viral hepatitis (Talas District of Kyrgyz Republic), and typhoid fever (Aravan District of Kyrgyz Republic) appeared despite the fact that households routinely boil water.[31]

The poor quality and unavailability of drinking water affects woman and children particularly. The fieldwork indicated that children in middle school in both sites in Nishan District (Uzbekistan) spend an average of 1-2 hours per day obtaining drinking water, and 3 hours in Uzbekistan District. The health effects of this are apparent in Ellikkala District, where medical authorities mentioned that women experience a high rate of miscarriages due to the strain of constantly hauling water. Even when the overall quantity of water available is sufficient, it is often not distributed equitably. For example, in the Dostlik village of the Turkmenistan FSK

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[29] For example, the decline of the flow in the Amu Darya during the droughts of 2000 and 2001 "resulted in poorer quality water remaining stagnant in canals for a long period of time." See: WHO, 2001, "Health Aspects of the Drought in Uzbekistan, 2000-2001," *Technical Field Report Series*, p. 5.

[30] See: WEMP, App.B.3, p. 18; Van der Meer, Joost et al, forthcoming, "Safe Water for the Aral Sea Area: Time to Turn the Tide."

[31] Excessive salt intake in animals elevates the extra cellular salt level which induces further increased water intake and expansion of extra cellular fluid (hypervolemia). At a low level this is self correcting, because the levels of the aldosterone hormone drop and the kidneys excrete sodium. However, at higher levels fluids accumulate in body cavities (waterbelly/ascites, pleural effusion, edema etc.).

(Nishan District, Uzbekistan), there are four neighborhoods that drinking water does not reach. People in this village must stand in line for water. In the evening, large crowds of women wait their turn, wondering if the supply will hold up until they have obtained water for their family. Fights are common enough among those in line to fill their buckets that even the children sometimes become enemies and throw rocks at each other.

2.6 Coping with the Degradation of I&D Systems

2.6.1 Land Retirement

Severely salinized and waterlogged land often will not produce a crop and must be retired. Approximately 600,000 ha of irrigated cropland in Central Asia has become derelict over the last decade, although this figure also includes retirement due to water scarcity and lack of inputs.[32] In the Kyrgyz Republic, where natural drainage is better than in other parts of Central Asia, around 80,000 ha of land, over 7% of the total, has been removed from cultivation owing to severe land salinization or waterlogging, presumably during the 1990s.[33] Uzbekistan loses around 20,000 ha per year for this reason. Many farmers consulted during the field assessment stated that they plant less land due to the incursion of salt.[34]

2.6.2 Adaptations in Agricultural Production

Villagers try to adapt agricultural production to the degradation of I&D systems in several creative ways. They try to repair or reconfigure I&D systems, but, owing to lack of resources and poor organization, most fixes are of a stopgap nature. Many resourceful backyard engineers use siphons or portable pumps to draw water where pumps or other infrastructure no longer deliver water. Those that can afford it install small hand pumps to water their garden plots, yet the water obtained is sometimes saline and unfit for irrigation. Drainage is harder to adapt. Makeshift repairs such as the small ditches (*zawurs*) that villagers dredge from their fields (and homes) often cannot lower the water table of even a garden plot, due to the high water table in the surrounding area. Most investments needed for repair are within reach of only the wealthy and well connected.

Another common response is to alter water use and crop selection. Most farmers will plant a smaller area (see below). Traditional water-saving methods are occasionally employed, such as *nawbat* (also called *avandaz*), which involves irrigating fields by turn, rather than all at once, to reduce evaporation and filtration losses. Others irrigate with substitute sources, such as drainage water (which often intensifies land salinization) or drinking water (which reduces the limited community supply for household use). The few that can afford it bring water or have it delivered from elsewhere. In areas where salinity is severe, farmers must quit planting salt-sensitive crops, in particular stone fruits and many vegetables. In these and other areas where water scarcity is acute, the switch is generally to low-value crops that consume less water.

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[32] WEMP, p. 14.

[33] UNEP, 2000, *State of the Environment of the Kyrgyz Republic*.

[34] Three percent of irrigated cropland in Uzbekistan District has been abandoned for this reason, while in the Kirkkiz FSK of Ellikkala District this figure reaches 27%, owing to the greater severity of land salinization there. Salinized and waterlogged land taken out of commission in Tokmaganbetov (Syr Darya District) comprises 10% and 2% of the total command area, respectively. The corresponding figures for Ilyasov (Syr Darya District) are 4% and 14%.

Traditional methods of counteracting land salinization are becoming more common. In Uzbekistan District (Uzbekistan), organic fertilizer is worked into the ground, or else the saline upper layer of the soil is replaced with more fertile soil from another location. On salinized land in Nishan District, farmers increasingly replace furrows in large fields with *joyaks*, quadrant-shaped beds surrounded by small ditches that drain better and help keep soil more permeable.

Relocating one's land to an area with better water or drainage conditions is possible, especially where land legislation permits the transfer of land rights (Kazakhstan and especially the Kyrgyz Republic). Yet, as noted above, the rural elite enjoys a substantial advantage in acquiring the best plots of land. Many ordinary family farmers receive land that is already in need of substantial reclamation. Moreover, most families lack the capital required to begin a farm in another location.

Another way of adapting agricultural production when irrigation becomes problematic is to emphasize livestock production. Attempts to do this are more common in areas where irrigated cropland has gone out of commission or substantial areas of natural pasture are available. However, this land is limited, and in the areas covered by the field assessment the more affluent villagers have access to most of it. In many areas, salinity and water scarcity limits the conversion of irrigated land into pasture. In Shoymanov village (Otrar District, Kazakhstan), "weeds that are more tolerant of salinization and lack of water are displacing the grass. The population is forced to move to raising less delicate livestock, such as goats and camels." In neighboring Otrar, "the fields devoted to hay and fodder have declined, due to the salinization of hay meadows and pastures." Moreover, many livestock "drink water from the drainage system," as a result of which there are "many sick cows; herds decline."[35]

Villagers face numerous constraints in changing agricultural production, chief of which is lack of capital. While farmers are willing to invest in irrigation, they have little with which to do so aside from their labor and resourcefulness. Few farmers, mostly members of the elite, have enough money to invest, and many FSKs are operating at a loss. Low farmgate prices, fickle markets, disorganized input supply, and tight credit depress rural incomes. Where privatization has resulted in an inequitable allocation of farm resources, as claimed by the majority of farm workers consulted in Kazakhstan and the Kyrgyz Republic, it is also to blame. Where state orders for crops remain predominant and farmers have little input into decision-making, they are unable to effectively direct the few resources that are available.

Throughout Central Asia, villagers must also contend with limitations that corrupt officials imposed upon their endeavors. For example, in Kara Bora District of Kyrgyz Republic, the local authorities effectively imposed a monopoly on the purchase of the main crop, beans, through selective granting of licenses to "their" buyers, which resulted in farmgate prices 2-3 times lower than farmers were led to believe would be available when they planted the beans.

[35] Water with a salinity of 3-5 g/l poses a slight danger to livestock (with the exception of poultry), while any concentration above this is to be avoided. Drainage water commonly exceeds this threshold. Drainage water in the midstream and downstream areas of the Aral Sea basin commonly contains 4-8 g/l of salts.

Because farmers cannot successfully adapt agricultural production to the degradation of I&D systems, output falls. For example, farmers of the Turkmenistan FSK in Nishan District claimed, "50% of the [potential] yield is lost because of failure to irrigate." On three out of four FSKs studied in Uzbekistan, cotton yields per hectare have fallen by 25-80% since 1991. Yields per hectare have dropped more precipitously in sites in the Kyrgyz Republic and Kazakhstan, to half or less of what they were during the Soviet period. Downstream areas are especially hard hit. A typical example is Gulbaar village of Aravan District (Kyrgyz Republic) where yields are 40-50% lower than in upstream areas.

Moreover, less area is planted and irrigated than before, due to I&D system degradation, as well as lack of inputs, capital, and access to output markets. The problem is most severe in field sites in Otrar District of Kazakhstan, where by 1995 command areas dipped to 33-45% of 1991 dimensions, and to 23-34% by 2000. In Uzbekistan field sites this has not occurred to the same degree: in two of the FSKs, command areas actually grew by 25%.[36] Although in part this is due to better state support of O&M than elsewhere, as the shirkat workers on the Turkmenistan FSK noted above, the state tells them what and where to plant, all too often on salinized or infertile land.

Given the arid climate of Central Asia, how much of the present population could the land support if infrastructure continues to break down? The present backlog of maintenance is substantial, and the large areas served by pumps are particularly vulnerable (see Chapter 5). In steppe areas like Kashkadarya, which is served mainly by the Karshi Cascade pumping scheme, extensive sheep herding is an option. Yet there is no guarantee that irrigated land can be converted into pasture. In fact, as in much of Arizona, derelict farmland may actually become an environmental liability requiring investment in order to forestall a "dust bowl" effect.[37] A small minority of farmers in the Shahrisabz and other eastern locales would be able to irrigate from the Kashkadarya River. In other areas, particularly where mountain rivers feed alluvial plains, such as the Ferghana Valley, large expanses have been irrigated over the centuries using non-industrial technology and could continue. Rainfed agriculture is impossible, outside of some mountain areas. Rough estimates of the population that the land could support if irrigation disappeared range from 10-20%.[38]

2.6.3 Looking for Other Work

In areas where I&D systems no longer support reliable agricultural production, villagers must turn elsewhere for employment. However, the labor market in rural areas of Central Asia has been saturated since the late 1980s, and few jobs have been created outside agriculture (see Box 1). Available work in villages mostly consists of weeding the fields and harvesting crops on

[36] In Ellikkala District as a whole, irrigated area actually rose by 15%, while in Nishan District it declined by only 2%. This data was kindly furnished by the Mirob-A Directorate of the Uzbekistan MAWR.

[37] Joe Gelt, "Abandoned Farmland Often Is Troubled Land in Need of Restoration," *Arroyo*, Fall 1993.

[38] One Karakul sheep requires at least two hectares of land, and two or three sheep are required to sustain one person for a year, making the requirement at least six hectares per person. Thus, the 500,000 hectares currently irrigated by the Karshi pumping station might support 83,000 people if there were no irrigation. The current rural population of Kashkadarya is 778,000. Therefore, with no irrigation and given available pasture, the land could support around 11% of the current population. V. Tsurikov. Pers com.

prosperous farms, but wages are extremely low. Villagers in the field assessment indicated that "only women will accept such low wages."

Therefore, villagers seek work in other areas. The first option is the district or province center, all of which have a *mardikar* ("day laborer") bazaar, in which men are hired for and perform other physically demanding tasks and women offer their services as housekeepers and midwives. In the main bazaars of Central Asian cities, a growing contingent of people from rural areas, particularly women, sell goods. [39] Villagers in Syr Darya District, Kazakhstan reported in that men also "work as carriers in bazaars and train stations."

Box 1: The Central Asian Economies' Performance in Creating Jobs Outside of Agriculture

All transition economies have experienced recession in the past decade, which resulted in a large contraction of output and large-scale loss of employment in the formerly state-owned sector. Output in Central Asia declined by about 40% between 1991 and 1997 (although in Uzbekistan the decline was reported at only 16%).[40] The contraction of output was greatest in the industrial sector and somewhat less in agriculture. In most of the transition economies, employment creation in the emerging new private sector has been slow and has not compensated for the lost employment.

Uzbekistan and Turkmenistan have yet to feel the full effects of market reforms. As they pursue enterprise restructuring and reduce subsidization of the industrial sector, unemployment can be expected to grow, and industrial jobs will probably be curtailed the most. Thus, the prospect of large-scale job creation in sectors other than agriculture does not appear realistic.

In Tajikistan and the Kyrgyz Republic, the situation is slightly different. These countries have been quicker to implement market reforms. However, the economy of Tajikistan was severely damaged by the civil war, contributing to a 60% contraction of GDP that this country experienced between 1991 and 1997. Kazakhstan is an exception in Central Asia in terms of job creation. It is the most urbanized and industrialized country of all Central Asia, and industry has recently been growing, although mainly in the hydrocarbons sector (development of new oil fields), which is not labor-intensive.

Most villagers have strong ties to the land. Recalling high yields obtained in 1980s, a farmer in Uzbekistan District (Uzbekistan) asserted, "If we had a good, fertile plot of land...I wouldn't take a step from home." Thus, people, particularly older villagers, are unwilling to migrate. Nevertheless, more and more villagers travel to cities in Central Asia or Russia in search of employment. Residents estimated that between one and five members of each extended family had left for work elsewhere: to Russia to labor in construction and factories, to Kazakhstan and other areas of Uzbekistan (such as the Karshi Steppe), where more irrigated land is available and work on the cotton fields of large farm enterprises can be exchanged for access to personal garden plots. A group of women estimated that 80% of their husbands' income came from migrant work.

The field assessment indicates some general patterns in migration for work. In most areas, emigration has accelerated in the last five years, although the causes and dynamic of this phenomenon vary greatly among locales. When ethnic minorities leave, they tend to seek work

[39] Increasingly the wife sells the products of the household instead of the husband, because, in deference to the extreme separation of the genders in rural areas, local police authorities are less prone to extort from women than men.

[40] Paolo Verme, 1998, *Unemployment, Labour Policies and Health in Transition: Evidence from Kazakhstan*.

in the country in which their nationality is the titular majority. Men under 50 years in age, who are less set in their ways and not subject to social restrictions like women their age, are more likely than others to leave the village for work. Work is typically seasonal, peaking in summer and early fall along with the availability of construction and other menial jobs, and ebbing to a low in winter, when many try to be home for the holidays. "If the job proceeds successfully, the working member of the family brings money home once a month, or else takes his wife and children [from the countryside to the city], where they live in temporary housing." (Nishan District, Uzbekistan). Those who can afford it travel home as often as possible, but many must "leave in the spring and return in the fall" (Uzbekistan District, Uzbekistan). Workers find housing with people from the same province or (if possible) district, make do with temporary quarters at construction sites or schools, or sleep on the streets. Villagers visiting the cities commonly try to find jobs for other family members, friends, or residents of their village that want to travel elsewhere.

Migrants face several impediments to successfully working and settling elsewhere. First, there are few jobs (see Box 1 above). Second, they tend not to have sufficient savings: "Many are in the mood to leave [the village], but there is nowhere to go, and, what's more, no money for moving." Expenses are also higher in cities, and the wages are low, meaning that few can permanently settle their families. A resident of Kadamjan District (the Kyrgyz Republic) remarked, "Some people have gone to work in [the capital city of] Bishkek, but no one has returned with any [real] money." Thus, in general, although migration for work elsewhere is somewhat better than staying in rural areas with no livelihood, it is by no means a panacea.

2.7 Conclusions

The near-collapse of O&M in Central Asia has resulted in the dramatic deterioration of I&D systems and caused major problems for affected communities. The poor condition of the infrastructure compounds the problems by reducing soil quality. Farmers attempt to adapt production or migrate for work elsewhere, but they encounter so many impediments that only those with wealth and connections are able to successfully move and work in another place.

Despite the obvious need for rehabilitation, governments will waste any efforts directed at it, unless they complement it with institutional strengthening and (especially where state orders for output remain intact) agricultural policy reform. Farmers must earn enough to be able to finance operation and maintenance of irrigation and drainage structures. They also need to have a stake in decisions that relate to water distribution and infrastructure maintenance. This calls for the establishment of participatory forms of organization for maintenance, such as Water User Associations (WUAs). In Kazakhstan and the Kyrgyz Republic, WUAs are becoming more widespread, yet they need greater capacity. Elsewhere, initial steps for decentralization and reform are urgent.

Chapter III: What Is The Relationship Between Irrigation and Poverty?

This section combines qualitative and quantitative analysis to explore the ways in which irrigation affects poor people. Are irrigated farmers worse or better off than the rest of the population or other farmers? How much difference does irrigation make in a household's welfare? Does a successful investment in I&D infrastructure affect the poor disproportionately? Which income groups will benefit the most? Conversely, if there is no investment, and the irrigation infrastructure deteriorates, which income groups will be most affected? How will such a contraction affect rural poverty rates?

3.1 Where Are the Poor in Central Asia?

Poverty is undeniably a rural issue in Central Asia, with 80-90% of the poor living in rural areas. Yet according to survey data collected in Tajikistan, Kyrgyzstan, Turkmenistan, and the Ferghana Valley area of Uzbekistan, in absolute terms the rural poor are only slightly worse off than the urban poor (as presented below in Table 3.1)[41] The mean expenditure per day of the rural poor is approximately $1.5 per day, compared with $1.6 for the urban poor. The mean distance below a $2.15 per day poverty line is approximately $0.69 for rural and $0.59 for urban poor.[42]

The survey data should be interpreted with caution, because prices in urban areas are substantially higher than in the countryside. The only country for which rural/urban differences in the consumer price index were taken into account in computing the consumption expenditure aggregate is the Kyrgyz Republic, which is also the only country with lower expenditures in urban areas. This suggests that differences in rural and urban expenditures may disappear or be reversed, given appropriate adjustments for the consumer price index. Annex 3 provides the exchange rates used in calculating Purchasing Power Parity (PPP).[43]

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[41]The Living Standards Assessment in the Ferghana valley in Uzbekistan was conducted as a pilot for the national survey. The consumption aggregate for the national levels survey that would allow us to differentiate households on the basis of their welfare was not available when this analysis was conducted. Therefore, we were restricted to the Ferghana data.

[42] Results in this section are difficult to compare with those in other sections, because all monetary figures presented here are in PPP terms, applied to the survey data using the same methodology as in World Bank,. 2000. *Making Transition Work for Everyone: Poverty and Inequality in Europe and Central Asia*. The other sections use regular market exchange rates.

[43] Exchange rates are calculated using the same methodology as World Bank,. 2000. *Making Transition Work for Everyone: Poverty and Inequality in Europe and Central Asia*. Washington D.C.

Table 3.1: Poverty Decomposition (Poverty Line = PPP$2.15 Per Day)						
	Mean $/Day		Mean $/Day|Poor		Mean $/Day Gap|Poor	
	Urban	Rural	Urban	Rural	Urban	Rural
Tajikistan	2.2	1.9	1.4	1.4	0.7	0.8
Kyrgyz Republic	2.3	2.5	1.4	1.5	0.7	0.7
Turkmenistan	9.8	5.7	1.8	1.6	0.3	0.5
Ferghana	6.5	4.1	1.6	1.4	0.5	0.8
Source: World Bank staff calculations.						

Table 3.2 reveals that around 70% of the population lives in rural areas. The percentage of the population below the poverty line varies considerably across countries. For example, 71% of the population is poor in rural Tajikistan, whereas this is true of only 10% of the rural population of Turkmenistan. Differences in the poverty head count are partly a result of the different methods used to generate the welfare measure (per capita consumption expenditure). Even after appropriate adjustments to the welfare measure using the consumer price index and other methods, this will not change substantially.

Table 3.2: Population Decomposition						
	Population Share		Head Count		Poverty Share	
	Urban	Rural	Urban	Rural	Urban	Rural
Tajikistan	22%	78%	0.63	0.71	0.20	0.80
Kyrgyz Republic	17%	83%	0.57	0.54	0.17	0.83
Turkmenistan	43%	57%	0.03	0.10	0.17	0.83
Ferghana	24%	76%	0.11	0.25	0.12	0.88
Source: World Bank staff calculations.						

The field assessment confirms that poverty is rural. Villagers in all of the sites covered estimated that 70%-90% of the population is in poverty, 5-25% live at an "average" standard, and 2-10% are "wealthy." Occasionally a minority of the indigent was categorized as "extremely poor." Moreover, villagers feel that poverty has grown in the countryside. Residents of all of the areas studied noted that their standard of living is much worse than before, especially in the last two to three years.[44]

Because attempts to cope with the degradation of I&D systems are generally unsuccessful, incomes decline, and many households consequently reduce their consumption. This was readily apparent in all areas covered by the field assessment. Villagers most commonly referred to a worsening of their diet, in which cheaper staples such as bread have increasingly replaced meat, fruits, and vegetables. The poorest must obtain wheat on credit (against the next year's harvest). Others mix the much-preferred wheat flour with corn meal in order to make bread, which most Central Asians consider as but a short step from having no food at all. Some villagers in the Kyrgyz Republic must obtain flour on credit in order to have enough to eat between crops.

[44] For example, villagers in Talas District of Kyrgyz Republic estimated that the percentage of residents in poverty has increased by a factor of 8 since 1995. A group of men in Ilyasov village (Syr Darya District) claimed that their poverty had increased by 70% since 1993.

3.2 Who Are the Rural Poor?

The survey data permit the calculation of poverty in rural areas according to employment, household size, and education (see Table 3.3 below). Poor villagers are 10-20% more likely to be employed in agriculture. Their households typically include one more member than those of the non-poor. The rural poor are also 5-10% less likely than rural non-poor households to have a secondary or higher education.

Table 3.3. Characteristics of Poor and Non-Poor Rural Households

	Household Head Primary Occupation In Agriculture		Household Size		Household Head > Than Secondary Education	
	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor
Tajikistan	49%	59%	6.8	7.9	18%	12%
Kyrgyz Republic	-	-	4.6	5.8	15%	5%
Turkmenistan	52%	71%	6.2	7.8	14%	8%
Ferghana	54%	60%	6.4	6.3	13%	8%

Source: World Bank staff calculations.

Due to the nature of the data and the complexity of the situation in rural areas of Central Asia, there are considerable problems in finding a definition of "farmer" that produce reasonable results. Various options are available:

- The amount of land held by a household. One could define any rural household that has access to more than a certain amount of land as a farmer. Using this definition with the same cut-off point for each country indicated that some "non-farmer" households received more income from agriculture than "farmer" households. In addition, this definition made it hard to analyze the relationship between access to land and poverty.
- Agricultural income. We could define as a farmer any household that earns more than 20% of its income from agricultural production. Data problems confounded this measure, because many households reported zero or negative income.
- Self-reported job. We could define any household where the head reports that he or she is employed in agriculture as a farmer. This is the definition that we eventually employed.

This difficulty reflects the complex situation in rural areas. Most households seem to have diverse sources of income, and almost all households derive a substantial portion of their consumption from their household plots. Furthermore, households that work on a FSK often do not consider themselves as having access to land in the normal sense, because they work on land owned by the farm in return for a wage.

How is irrigated land distributed among households of different income groups? The survey data have limited information that helps us answer this question and those specific to irrigation. Although one would expect the rural poor to have significantly less land, no clear pattern emerges in the distribution of these resources (see Table 3.4). In Tajikistan and the Kyrgyz Republic, the poor have less land per capita than the non-poor, whereas in Turkmenistan and Ferghana, the difference is not significant. Almost all the land of the poor and the non-poor is irrigated in Turkmenistan and Ferghana, owing to the intensive nature of agriculture there. In

Tajikistan the poor irrigate a slightly higher percentage of their land than the non-poor, which may reflect the greater availability of rainfed crop or pasture land and thus more diversified farming by the non-poor.

There are several reasons that we do not observe more differentiation of land and irrigation resources between the poor and the non-poor in Uzbekistan and Turkmenistan. First, the state continues to direct the allocation of the majority of land. Furthermore, the survey data capture neither quality nor location of land, which, as farmers who participated in the field assessment indicated, are at least as important as quantity.

There is greater differentiation in irrigated land holdings in Tajikistan, which is just beginning the land privatization process, and in the Kyrgyz Republic, where most land allocation took place in the mid-1990s. According to stakeholders in the field assessment sites in Kyrgyz Republic, privatization was inequitable. Few complained about the *amount* of land appropriated by better off villagers (in contrast to the amount of livestock, equipment, and inputs). Instead, farmers emphasized the better water supply and soil fertility of elite land holdings. Differentiation in the size of land holdings between poor and non-poor rural households might increase, as land sales and leasing lead to consolidation. However, land sales have been established only recently in Kazakhstan and the Kyrgyz Republic. Elsewhere, they are illegal.

Table 3.4. Land and Irrigation Resources of Poor and Non-Poor Rural Households

	Mean Land Per Capita (m^2)		Mean Percent Irrigated	
	Non-Poor	Poor	Non-Poor	Poor
Tajikistan	1081	692	49%	56%
Kyrgyz Republic	3915	2050	82%	57%
Turkmenistan	3059	3228	97%	97%
Ferghana*	267	276	97%	97%

* In this survey households were only asked about their private land plots, thus these numbers are underestimates of total land available to households.
Source: World Bank staff calculations.

3.3 How Is Access to Irrigation Related to Poverty?

3.3.1 Perceptions of I&D and Poverty

Despite the varying geographic, economic, and social conditions of the field assessment sites, stakeholders in the field assessment all linked water management problems with their present predicament. However, when asked what constitutes wealth and poverty, as well as what are the main problems and causes of poverty in their village, stakeholders in Kazakhstan and Kyrgyz Republic stressed factors such as unemployment, wage arrears, and poor access to livestock, inputs, capital, and machinery almost as much as water scarcity, poor condition of drainage system, etc.

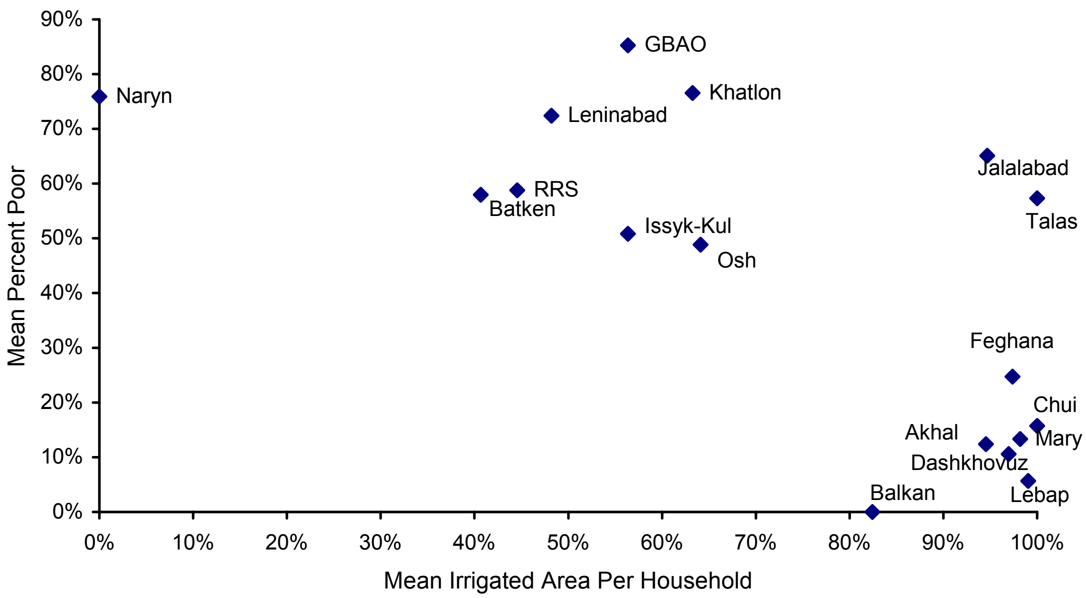
In Uzbekistan, where state support of agriculture is still profound, stakeholders did not emphasize non-irrigation factors to the same extent as their counterparts in Kazakhstan and Kyrgyz Republic. In Uzbekistan, disruption of the supply of irrigation and drinking water, salinization, and waterlogging dominate the stakeholders' perception of the main problems and causes of poverty in their village, and water supply is of paramount importance in their views of wealth. In all three countries, the rich, especially elite private farmers, are identified with those living “near the source.” Residents of the Turkmenistan FSK in Nishan District of Uzbekistan divided their village into three zones: one near the source of the water, in which farmers are wealthy, another where there are “islands of trees” and some live well, and another “resembling a desert” (the downstream area), where everyone is poor.

3.3.2 Quantitative Analysis

An assessment of the quantitative relationship between poverty and access to irrigation must begin with a statistical definition of access to irrigation. Unfortunately, the household surveys consulted contain very little information about quantity and quality of irrigation services available to rural households. Thus, we defined access to irrigation differently, depending on the information available in the surveys. The Tajikistan survey reported the size of irrigated land. This is the only survey that includes both the reported size of total land available to the household and the size of irrigated land. In the Ferghana Valley and Turkmenistan surveys, the source of information about irrigated land is the question “source of irrigation water, including none (or rain).” If the answer was “none” or “rain,” this plot is considered as non-irrigated, while the opposite is true if the answer was “canal,” “river,” “stream,” etc. Each household can have more than one plot, so each plot was analyzed separately to see whether it was irrigated or not. In the 2000 data set for the Kyrgyz Republic, external data on the share of irrigation in each district of every province was obtained from a committee of local experts and joined with the household data from the survey. Then we defined a district as “irrigated” or “non-irrigated” depending on the share of irrigation within it (over 11% was considered “irrigated”).

Using these definitions, we derived Figure 3.1, which suggests a negative relationship between access to irrigation and poverty, i.e. that the incidence of poverty tends to be high where the average household has a low percent irrigated land and low where the average farm has a high percentage of irrigated land. This result may not be entirely attributed to irrigation, because other types of network infrastructure, such as roads and electricity, are also commonly associated with the presence of irrigation.

Figure 3.1: Rural Poverty and Access to Irrigation



Source: World Bank staff calculations.

In order to understand the relationship between poverty and irrigation, one would ideally estimate a profit function with net agricultural income as the dependent variable and irrigated and total land, among others, as explanatory variables. However, the preferred dependent variable is not reliably reported in the surveys. Therefore we use log per capita expenditure (PPP $ per day) as a proxy for net agricultural income.

Using ordinary least squares we regress log income onto log irrigated area, log total area,[45] occupation of household head, household size, education of household head, and region.[46] The parameter estimate on the log of total area should be interpreted as the marginal effect of increasing farm size, holding the mix of irrigated to non-irrigated land constant, while the estimate on the irrigated land variable should be interpreted as the marginal increase in per capita expenditures when unit of land becomes irrigated holding the size of the farm constant. A description of the variables and the regression results is provided in Table 3.5. The model is run only on households with greater than zero irrigated area to ensure that it only includes plots of land upon which farming actually occurs in the data set. The model fits the data reasonably well with an F statistic of 115.85 and an R-square of 0.47. All of the variables of interest have the expected sign and are significant.

[45] We are not concerned about any potential multi-colinearity between the amount of irrigated land and total farm land for two reasons. First, the correlation between the two variables is only 0.4 and the variance inflation factor for both variables is well below two. This implies that there is very little effect on our error terms from any colinearity that exists between the two variables.

[46] A number of alternative functional forms and specifications of the model were tested, including quadratic, linear and log-linear specifications as well as several interaction terms. The variables of interest maintained their directionality and significance.

Table 3.5: Regression Model Results			
Variable	**Mean**	**Coefficient**	**T**
Log per capita expenditure (PPP$/day)	1.03		
Log irrigated land (m2 per household)	8.25	0.026	6.44
Log total land (m2 per household)	9.77	0.033	3.68
Household head primary occupation (1=farmer, 0=other)	0.26	-0.091	-2.92
Missing occupation (1=missing, 0=not missing)	0.52	-0.035	-1.05
Household head education (1=> secondary, 0=<secondary)	0.12	0.240	7.82
Household size (number of household members)	6.39	-0.045	-9.21
Region (1=region, 0=other) GBAO/Tajikistan = omitted region	0.08		
Rayons under Republican Subordination (RRS) – Tajikistan	0.11	0.481	6.48
Leninabad – Tajikistan	0.13	0.300	4.14
Khatlon – Tajikistan	0.07	0.272	3.81
Dashawuz – Turkmenistan	0.11	1.015	13.53
Mary – Turkmenistan	0.09	1.142	15.53
Lebap – Turkmenistan	0.06	1.407	18.33
Akhal – Turkmenistan	0.01	1.360	15.86
Balkan – Turkmenistan	0.04	1.280	11.33
Issyk-kul – Kyrgyz Republic	0.10	0.422	4.87
Jalalabad – Kyrgyz Republic	0.00	0.227	3.12
Naryn – Kyrgyz Republic	0.04	0.331	3.86
Batken – Kyrgyz Republic	0.02	0.463	5.74
Osh – Kyrgyz Republic	0.06	0.501	6.56
Talas – Kyrgyz Republic	0.05	0.342	4.17
Chui – Kyrgyz Republic	0.07	0.765	9.40
Constant		0.143	1.46
Source: World Bank staff calculations.			

The model offers several important insights into the relationship between irrigation and poverty. It indicates, *ceteris paribus*, that a 10% increase/decrease in irrigated land will result in 0.26% increase/decrease in per capita expenditure and that a 10% increase/decrease in the total land area, keeping the mix of irrigated and non-irrigated land constant, will result in 0.33% increase/decrease in per capita expenditure. Thus, irrigated land contributes 75% of the increase in per capita expenditure of a marginal increase in farmland, or roughly three times more to per capita expenditure than does non-irrigated land. This may be underestimating the impact of irrigation, because people who currently do not have it would switch back to irrigated agriculture if it became available again.

The other variables in the model reveal patterns consistent with the summary statistics presented earlier. Farmers appear to be worse off than non-farmers, larger households are worse off than smaller households, those with more education are better off, and location (region) plays a large and significant role in determining per capita expenditure. The significance of the location specific variables should be noticed, especially when one considers the prominent role that the farmers consulted in the field assessment attribute to them. They could be capturing differential infrastructure or land quality effects in the model. Future analysis should include these effects.

3.4 What Happens as Land Ceases To Be Irrigated?

The model can be used to simulate how a contraction in irrigated land will affect the per capita expenditure of villagers. Figure 3.2 depicts the change in per capita expenditure as a representative farm of 1.2 ha. moves from 100% irrigated to 100% non-irrigated.[47] The figure suggests that per capita expenditures will decline at an increasing rate as the percentage of land that is irrigated drops. Reading from right to left, taking the first 20% of land out of irrigation will result in a decrease in per capita expenditure of approximately $0.1 per person per day. Retiring the next 20% of irrigated land diminishes it by an additional $0.2 per person per day. When the irrigated area falls below 20%, per capita expenditure drops precipitously, by an additional $0.68 per person per day as the last unit of land is taken out of irrigation. The model permits an approximation of the amount of net income that will be lost due to a contraction in the irrigation system. If an average sized farm owned by household of six goes from being entirely irrigated to entirely non-irrigated, annual *household* expenditure in PPP terms will drop from $6,213 to $4,314, a loss of $1,898 or about 30%.[48] In reality, the drop in per capita expenditure is likely to be even sharper, because in this model the baseline for non-irrigated land is land that is currently rainfed and relatively profitable. Yet the overwhelming majority of irrigated areas in Central Asia lie in steppe and desert zones, which would be far less productive than mountain areas when the water stops flowing.

This simulation appears sound for several reasons. First, the data are well distributed throughout the forecasting range, which implies that the forecasts are made based on data rather than on extrapolation. Second, the estimates of per capita income generated from the simulation are close to the observed data. For example, mean daily per capita income within the data set was $2.80. The predicted mean from the simulation was 2.81, a difference of less than 1%. The smoothness of the curve should be attributed to the fact that consumption is used as the dependent variable rather than income. Farmers are likely to smooth their consumption through time as the amount of irrigated land changes.[49]

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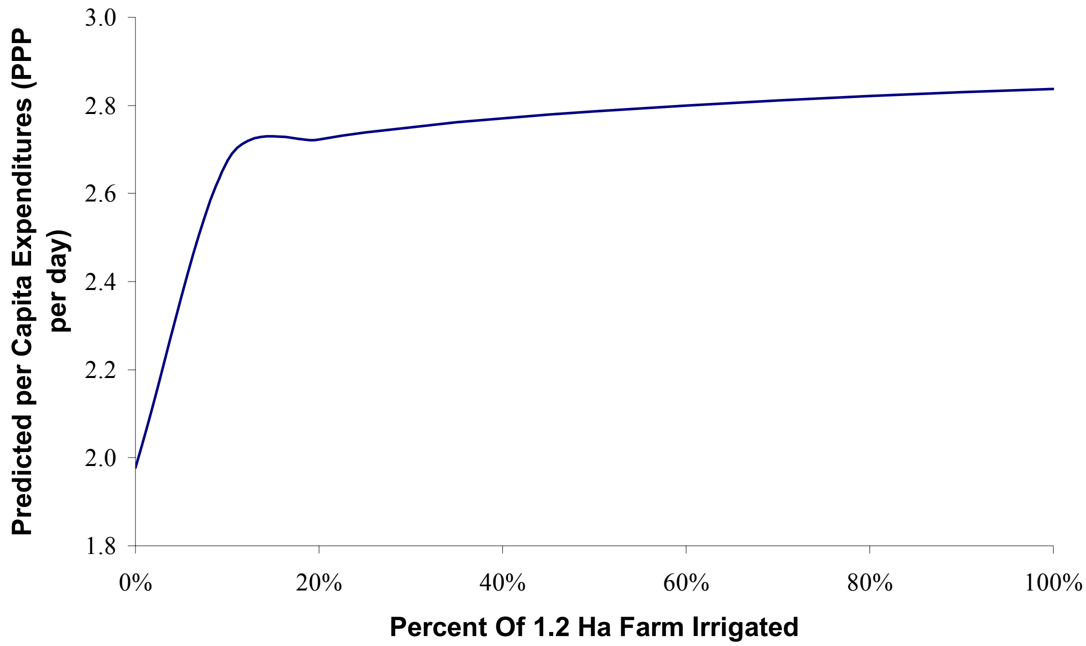
[47] A representative farm is defined as being 12,475 m^2. This is the mean size of land within the data set.

[48] It is important to remember that PPP adjusted per capita expenditure is used as a proxy for income in the model.

[49] Many alternative function forms were tested for the model, and the specification outlined in Table 3.5 proved to be the most robust.

Figure 3.2: Simulated Impact of Change in Irrigated Area on Welfare



Source: World Bank staff calculations.

In the figure above, once households have more than 20% of their cropland irrigated, additional increases in irrigation do not increase per capita expenditure as much as one might expect; i.e. the curve is very flat. There are several possible explanations for this empirical result. First, due to policy distortions farmers are not receiving the full economic value for their crops, and therefore the expected increases in income are not materializing (as noted in Chapter 2). Moreover, farmers may not be receiving water in a manner that allows them to maximize their yields—survey data does not capture the condition of infrastructure, relative amounts of water applied, the timing of water delivery, salinity problems. Finally other factors, such as the provision of inputs and finance, also influence the amount of income generated from irrigated cropland.

The model suggests that for households with a large percentage of irrigated land, an initial decrease in irrigation will not be devastating. For households with a small amount of irrigation, the decrease in irrigation will result in a dramatic drop in per capita expenditure (i.e. the proxy for income). The model also indicates that households with less irrigated land tend to be poorer. Due to the increasing magnitude of the slope in the graph as irrigation decreases, this implies that poorer households are likely to suffer more than richer households as the amount of water available for irrigation declines. The model suggests that poor people may be disproportionately affected, as is apparent in the field assessment (see Chapter 2).

Thus, if the objective of irrigation investments is to maintain the income of entire rural communities, the rehabilitation or new investments would aim to maintain a minimum level of irrigation for as many households as possible. In other words, ensuring that many farmers maintain access to a small amount of irrigation will result in larger welfare gains than maintaining irrigation facilities that supply only a few large farmers fully. Irrigation distributed in this manner reduces vulnerability by increasing food security. This approach is, however, not easily put into practice because the systems are already in place and were for the most part built to serve large farms. Modifying them may be prohibitively expensive.

Chapter IV. Is Irrigation Economically Viable?

4.1 Introduction

Is irrigated agriculture in the Aral Sea basin economically viable? If farmers paid market prices for all inputs, and were paid market prices for their goods, how many schemes would be economically attractive, particularly if the costs of pumping water up to high levels are included? Conventional wisdom outside Central Asia is that much of the agriculture is inherently unprofitable at full market conditions. If that is the case, upgrading infrastructure would clearly be an unattractive proposition.

This chapter addresses the issue of economic viability in two parts. The first is an economic analysis for one year in Uzbekistan and Tajikistan, the countries with the greatest dependency upon pumped irrigation. This is followed by a financial analysis of the flows from irrigated agriculture in the Kyrgyz Republic over the life of a potential investment. This is disaggregated to the district level. We compare the costs of rehabilitation with the expected stream of benefits from irrigation, which provide an estimate of the amount of compensation the government might pay farmers if it does not rehabilitate the infrastructure but rather lets it degrade.

4.2 Economic Analysis for Uzbekistan and Tajikistan

4.2.1 The Importance of Pumped Irrigation

During the 1960s-80s the development of irrigation in some areas was possible only with the installation of pumps. When most pumping schemes in Central Asia were constructed, energy was valued well below economic cost.[50] As was seen in the Pacific Northwest of the US, when energy prices rise to their economic cost, farms may be threatened with producing at a loss. Currently, the estimated economic value of electricity is several times higher than its financial price in the three countries that rely on pumped irrigation, with a particularly large discrepancy in Tajikistan.

Dependence on pumped supply varies dramatically from country to country. Uzbekistan and Tajikistan depend heavily on pumped irrigation, where over 60% of irrigated land receives at least part of its water from pumped supplies. Ten percent of irrigation is pumped in the Kyrgyz Republic, whereas Turkmenistan and Kazakhstan have very little pumping. Furthermore, due to the nature of the terrain, the lifts (or heads) in Tajikistan and Uzbekistan are much higher than in the Kyrgyz Republic. The cascades in Uzbekistan have a greater capacity than elsewhere, even exceeding 150 m^3/sec.

[50] See Norman K. Whittlesey and Jon P. Herrell, 1987, "Impacts of Energy Cost Increases on Irrigated Land Values."

4.2.2 Methodology

This analysis is based on the economic analysis for World Bank financed projects.[51] It covers the whole country for Uzbekistan, disaggregated to the provincial (oblast or viloyat) level. For Tajikistan, it covers eight of the most heavily agricultural districts (rayons) of the country. The analysis proceeds as follows: We calculate 1) the economic gross margins for each crop, adjusted for yields in each province or district, and 2) the costs of pumping for each crop and lift height. The resulting economic margins for each crop are applied to the current cropping patterns in each province or district. This gives the number of hectares that would produce negative gross margins at economic costs ("negative hectares"), which is expressed as a percentage of total irrigated land in Uzbekistan and total agricultural land in Tajikistan. Lastly, we estimate the number of people who depend on these negative hectares by multiplying the resulting percentage by the rural population in each province in Uzbekistan and by the total population in each district in Tajikistan. Details of the prices used and assumptions made are included in Annex 4.

This analysis does not include the cost of drinking water. Many of the pumped irrigation schemes are the source of drinking water (and water for industries and services) to the populations that live on the elevated plateaux. If governments chose to let the irrigation infrastructure degrade, they would have to find alternative means of delivering water used for purposes other than irrigation.

The analysis is based on projected world market prices for key crops, calculated back to border prices. The sensitivity analysis considers three scenarios:

- Scenario 1: 2015 indicator price
- Scenario 2: 2015 indicator price +10%
- Scenario 3: 2015 indicator price –10%

Scenario 3 is conservative and uses prices similar to the indicator prices for 2002, which are unusually low. We also modeled various assumptions concerning farmers' behavior, such as those at higher lifts using water more efficiently or changing to higher value crops. These produced very similar results to those of Scenario 2 (using the projected indicator price for 2015 +10%) and therefore do not merit separate inclusion. For Uzbekistan, a market exchange rate of Som500=$1 is employed instead of the official exchange rate.

4.2.3 Results of the Economic Analysis

Table 4.2 below shows the results. The table shows that, given current price projections, almost all pump-supplied land in Uzbekistan would be profitable. If prices fall to 10% lower than currently projected (close to today's prices) and assume that farmers do not adapt in response to higher prices, an average of only 12% of the land would be unprofitable. In this case, almost a million people would be affected, more than half of them in Kashkadarya. Results for Kashkadarya are highly sensitive to the assumptions used. Its large pumped areas are barely

[51] Rural Enterprise Support Project for Uzbekistan (in preparation) and the Farm Privatization Support Project for Tajikistan.

profitable at the prices currently projected. They become unprofitable if the prices fall, hence dramatic rise in negative hectares between Scenarios 1 and 3. If we assume that farmers adjust by shifting away from wheat to more profitable cotton or fruits and vegetables, or alternatively assume that farmers use water more efficiently, a far lower proportion of land in Kashkadarya would become unprofitable when prices fall. Jizzakh, by contrast, has lower yields owing to its less fertile soil, rendering large expanses unprofitable, even at today's projected prices. Thus, the results for Jizzakh do not change between Scenarios 1 and 3.

Table 4.2: Results Of Sensitivity Analysis For Uzbekistan

				Scenario 1 (base indicator)		Scenario 2 (+10%)		Scenario 3 (-10%)	
	Total Irrigated Area ('000 ha)	Total Pumped Area ('000 ha)	Total Rural Population ('000)	Negative Ha as % of Total Pumped Ha	"Affected" Population ('000)*	Negative Ha as % of Total Pumped Ha	"Affected" Population ('000)*	Negative Ha as % of Total Pumped Ha	"Affected" Population ('000)*
Karakalpakstan	333	217	784	0%	-	0%	-	0%	-
Andijan	227	167	1,540	0%	-	0%	-	10%	112
Bukhara	244	244	987	0%	-	0%	-	0%	-
Jizzakh	244	79	687	21%	46	0%	-	21%	46
Kashkadarya	388	310	1,635	1%	7	1%	7	44%	577
Navoi	107	76	469	0%	-	0%	-	0%	-
Namangan	227	78	1,212	0%	-	0%	-	9%	36
Samarkand	288	77	1,964	0%	-	0%	-	0%	-
Surkhandarya	283	188	1,407	0%	-	0%	-	2%	20
Syrdarya	266	27	439	0%	-	0%	-	0%	-
Tashkent	292	56	1,410	0%	-	0%	-	11%	31
Fergana	301	97	1,903	8%	49	8%	49	14%	85
Khorezm	163	104	1,020	0%	-	0%	-	0%	-
Total	3,363	1,721	15,455	2%	102	1%	56	12%	906

1/ This is a rough estimate that takes the rural population in the rayon and multiplies it by the percentage of pumped area that results in negative margins and the share of irrigation that is pumped.

The situation in Tajikistan is quite different from that in Uzbekistan, as shown in Table 4.3 below. Using the current projections, around one-half of the land, concentrated in three districts, would be unprofitable. These are relatively less populated districts, meaning that the application of full economic prices would affect around 20% of the total population in the districts considered in this analysis. If prices fall by 10%, negative hectares comprise two-thirds of the land, affecting around one-third of the population. These scenarios are also sensitive to assumptions about yields and cropping patterns. For example, if we assume that farmers would respond to increased price of electricity and adjust their production and/or improve the efficiency of their use of inputs, at the current prices (Scenario 1), the amount of unprofitable land would drop from one-half to slightly less than one-third.[52]

[52] This scenario assumes that because of various adjustments made by farmers in response to price changes, the gross margin increases as follows: 20% in areas with lifts of 0-50m, 25% in areas with 50-100m lift and 30% in areas with over 30m lift.

Table 4.3: Negative Gross Margins As A Percentage Of Total Irrigated Cropland In Districts Of Tajikistan					
District	Irrigated Area (ha)	Areas With Negative Margins As % of Total	Average Lift Height in the Project Area (m)	Total Population (1,000 People)	"Affected" Population (1,000 People)
Scenario 1: Current Situation					
Gissar	8,883	0%	-	196	-
Kolkhozabad	5,042	1%	3	80	1
Shahrinov	4,516	5%	31	126	7
Lenin	5,955	0%	-	268	-
Yavan	14,052	20%	35	135	27
Macho	25,899	73%	72	48	35
Ghozimolik	6,976	86%	60	72	61
Zaforobad	24,933	95%	121	85	81
Total	96,256	54%	62	1,010	212
Scenario 2: Projected Cotton And Wheat Indicator Price For 2015 Plus 10%					
Lenin	5,955	0%	-	196	-
Gissar	8,883	0%	3	80	-
Kolkhozabad	5,042	2%	31	126	2
Shahrinov	4,516	0%	-	268	-
Yavan	14,052	19%	35	135	26
Zaforobad	24,933	60%	72	48	29
Macho	25,899	86%	60	72	61
Ghozimolik	6,976	93%	121	85	78
Total	96,256	49%	62	1,010	197
Scenario 3: Projected Cotton And Wheat Indicator Price For 2015 Minus 10%					
Lenin	5,955	0%	-	196	-
Gissar	8,883	1%	3	80	1
Kolkhozabad	5,042	5%	31	126	7
Shahrinov	4,516	0%	-	268	-
Yavan	14,052	61%	35	135	82
Zaforobad	24,933	97%	72	48	47
Macho	25,899	86%	60	72	61
Ghozimolik	6,976	95%	121	85	81
Total	96,256	66%	62	1,010	279

4.2.4 Accounting for the Costs of Rehabilitation of Off-Farm Infrastructure

The calculations above include the annual O&M costs of operating on-farm irrigation infrastructure.[53] They do not, however, include the cost of operating and maintaining major off-farm structures such as dams and trunk canals. This biases upward the estimates of the proportion of land that is profitable. These costs could be included in the above analysis using one of the following approaches:

[53] In Uzbekistan and Tajikistan, we give annual O&M costs of $15/ha/year, and in the Kyrgyz Republic $20/ha/year. These estimates appear reasonable based on the overview of O&M costs in a range of countries reported in the *National Irrigation Strategy for the Kyrgyz Republic* and consultation with World Bank experts.

(1) actual estimates of rehabilitation costs for each particular irrigation system that takes into account the complexity and the degree of deterioration of each scheme;
(2) a blanket approach based on including an average rehabilitation cost per ha in the crop budgets that appears a reasonable and does not vary by scheme;
(3) calculation of "switching values" that show the amount of investment per ha, which results in all the land in Tables 4.2 and 4.3 producing negative gross margins.

While the first approach would be preferable, it amounts to conducting detailed feasibility studies of each scheme—a task which is beyond the scope of this analysis. Therefore, the study takes the second and third approaches. The sensitivity analysis is done using the base case Scenario 1.

We perform sensitivity analysis, using the second approach, by including an additional cost item in crop budgets that can represent rehabilitation costs and additional O&M costs to the $15/ha that are already included. Based on consultations with World Bank experts, we use average rehabilitation costs of $150/ha, and O&M of $30/ha/year. We assume that the rehabilitation costs are spread over a period of 5 years, totaling $30/ha/year, and additional O&M costs are a further cost of $15/ha year. We thus test a scenario in which we take the base case scenario from Table 4.2 and 4.3 and include a further cost of $45/ha/year in the crop budgets. In both Uzbekistan and Tajikistan, this change makes the overall proportion of land that is unprofitable under scenario one roughly the same as that reported in scenario three in tables 4.2 and 4.3. That is 12% of land in Uzbekistan and 68% in Tajikistan is not profitable, assuming no change in cropping patterns or water application rates. The areas where the impact of the change is felt is, however, different in Tajikistan.[54]

To discern how profitable schemes are and further test the robustness of the results presented above, we use the third approach and calculate switching values by estimating a ceiling for the lump sum investment that would allow land to remain profitable. These "switching values", shown in Table 4.4, are the dollars per hectare (as a lump sum spent in one year) that push the negative gross margins negative for all irrigated land in the country. If the switching values were calculated for each rayon, lift height range, and crop type separately, they would just equal the margin for that category as reported in Annex Tables A 4.19 and A4.8 if the margin is positive, and zero if the margin is already negative before the inclusion of rehabilitation costs. This would not be a very meaningful result for the purpose of making general conclusions. Therefore, we calculate the switching values by lift height and by crop type, but aggregate the analysis to the country level. Table 4.4 shows that the switching value for wheat grown below 50 m is $123/ha. This means that if such a hypothetical rehabilitation cost is added to the crop budgets, 100% of the irrigated area in the country total in Table 4.3 (Scenario 1) produces negative gross margins. The switching values can be seen as representing the magnitude of an upper bound for the investments, but can not be viewed as the amount that can actually be invested.

[54]. In Table 4.3, areas with negative margins as percent of the total irrigated area remain unchanged in Gissar, Lenin, Ghozimolik and Zaforobad, and increase to 23% in Kolkhozabad, 6% in Shahrinov, 62% in Yavan, 97% in Macho, and 68% for the total.

Table 4.4: Estimated Maximum Levels Of Investment In Various Crops, Differentiated By Lift Height				
Tajikistan	Pumping Lift			
Crop	0-50 m	50-100 m	100-150 m	150-200 m
Wheat	123	3	0	0
Cotton (Raw)	398	349	229	0
Fruit/Vegetables	903	813	723	383
.				
Uzbekistan	Pumping Lift			
Crop	0-500m	50-100 m	100-150 m	150-200 m
Wheat	97	64	21	0
Cotton	396	320	217	83
Fruit/Vegetables	666	603	520	388
Notes: Excludes lift over 200m. Based on Scenario 1 with 2015 indicator prices.				

These results of the sensitivity analysis using the two approaches described above demonstrate that the conclusions reached above concerning the economic viability of pumped irrigation in Uzbekistan and Tajikistan are reasonably robust. Where land is profitable, it produces sufficiently large margins that it appears worthwhile investing in infrastructure rehabilitation without incurring economic losses.

Governments, however, make choices on the basis of financial rather than economic returns. They also face choices, of where it is best to make investments, rather than simply whether it is profitable to do so. In addition, in areas that are not profitable, governments would ideally weigh their options for avoiding the large-scale social disruptions typically associated with the collapse of irrigation schemes in arid lands. To address this consideration, the next section employs a financial analysis to compare the benefits of rehabilitation of irrigation investments with those of allowing the infrastructure to degrade and providing income transfers to households that lose their livelihoods.

4.3 Financial Analysis for the Kyrgyz Republic

Neither governments nor combined donors have sufficient funds to rehabilitate all of the infrastructure on profitable land. Furthermore, agriculture in many areas appears to be unprofitable. Given that entire communities are totally dependent on irrigation, with little option for rain-fed agriculture, letting infrastructure degrade will cause tremendous hardship. If governments do not invest in irrigation they may wish to find some way to relieve the social upheaval that the deterioration of agriculture will cause. There are a number of options, including encouraging the market to create private sector jobs, investing in education or training, paying people to relocate to areas of higher employment, or offering direct income transfers of some kind.

Governments may be tempted to rehabilitate irrigation in order to postpone social upheaval and hardship until the economy becomes more buoyant. To evaluate the costs to the budget of rehabilitating irrigation, one must compare the cost of investment with those of alternatives. The ensuing analysis weighs investment in rehabilitating I&D systems against the simplest alternative—to provide an income transfer to compensate farmers for the lost income associated with the irrigation.

4.3.1 Methodology

The calculation begins with measuring the costs of the rehabilitation against the present value of the net agricultural income associated with irrigation (the stream of benefits that the irrigation would generate) in each district of the Kyrgyz Republic.[55] The costs are based on those of ongoing World Bank financed irrigation rehabilitation projects. We take the benefits attributable to irrigation as the compensation that the government would give farmers for their income loss if the infrastructure is left to decay. We then estimated what happens to the total agricultural income in each district when land gradually shifts from irrigated to non-irrigated over the course of ten years. We assume that the contraction is gradual and linear over a period of ten years. It also assumes a natural migration from rural to urban areas of 1% per year and that 15% of the rural population does not earn a living from agriculture and thus would not require compensation. Annex 4 of this report gives details.

We use three scenarios to estimate the amount of income that irrigated land can still provide after it becomes non-irrigated:

- In Scenario 1, irrigated land that turns to non-irrigated provides **20%** of the income from current irrigated. This fits the estimates offered by local experts and matches the results of the household survey analysis in Chapter 3 of this report.
- In Scenario 2, land that ceases to be irrigated provides **35%** of the current level of income derived from it.
- In Scenario 3, land that ceases to be irrigated provides the same income as land that is currently not irrigated. This is an extremely optimistic scenario, as irrigated land tends to be in far drier areas than currently non-irrigated land, which is rain-fed and reasonably profitable.

4.3.2 Results

The analysis shows that investing in I&D is less expensive than providing a simple income transfer to people to compensate for lost income. In Table 4.5 (below), the present value of the incremental income from irrigation is twice the present value of the costs to the budget of rehabilitation. Therefore, it might make more sense from a budgetary point of view for the government to invest in rehabilitating these systems than to compensate the current beneficiaries for losing access to irrigation water.

[55] We chose the KR as example, because it is the only country for which data was available that allowed us to project a stream of benefits over time, disaggregated to the lowest administrative level. The analysis tells us how much income irrigated and non-irrigated land generates, taking into account the climatic and land quality variation in each district.

Table 4.5: Costs of Rehabilitation of I&D Infrastructure and Incremental Income from Irrigated Land in The Kyrgyz Republic	
Present Value Costs of Rehabilitation of Infrastructure and O&M for 10 Yrs	$217 million
Present Value of Incremental Income From Irrigated Land (Scenario 1)	$438 million
Source: World Bank staff calculations.	

Social considerations reinforce this idea. Experience in Western Europe and elsewhere indicates that rendering large numbers of people dependent entirely on government handouts leads to widespread social problems. And the economies cannot be expected to create sufficient jobs to absorb such large numbers of people in the medium term.

These national averages mask important regional differentiation. The costs of rehabilitation vary from scheme to scheme, and the incremental incomes from irrigation depend on crop patterns, soil fertility, population density and other factors. Therefore, the next step is to capture the regional variation through disaggregating the foregoing analysis down to the district level.

When the results of the calculation presented above are disaggregated for each of the 44 districts (rayons) of the Kyrgyz Republic that have agricultural land, the ratio of costs and incremental incomes varies considerably. This is because of the diverse climatic and agricultural conditions in different parts of the country, as well as the specific qualities and O&M requirements of I&D systems. For the sake of simplicity, Table 4.6 presents the results by province (oblast); the district level analysis is presented in Annex 4. The table indicates that the value of the lost income is greater than the cost of rehabilitating irrigation infrastructure under the least optimistic and most realistic scenario. If we assume that non-irrigated land provides more income relative to irrigated land (Scenarios 2 and 3), the value of the lost income falls, and the rehabilitation costs begin to outweigh the compensation costs. The switch takes place first in the most remote, least densely populated areas in the country, which also have poorer soil quality, indicating that the model is reasonably realistic.

The analysis shows that, under the most likely scenario for productivity of land without irrigation, it makes financial sense for governments to invest in irrigation infrastructure, because the costs of the investment are less than the value of the output. But in some districts, mostly those in remote areas and/or those with less fertile soils, this is not the case. There, it would be more efficient to provide households with income transfers.

The results underline the importance of determining the objectives of an intervention. If the Kyrgyz Government aims to increase agricultural productivity, it would invest in Jalalabad, Osh, and Batken Provinces in the Ferghana Valley. The investment would help beneficiaries derive the most profit from agriculture and focus on using inputs (including water) efficiently, as well as improving the way that markets and prices work. On the other hand, an investment that aimed for social protection would probably concentrate on Naryn Province. A social protection investment would have completely different technical assistance and institutional components from one with the goal of enhancing agricultural productivity.

Table 4.6: Costs of Rehabilitation, Population Density, and Poverty Rate of Provinces of the Kyrgyz Republic						
Province	Rehabilitation Costs Per Person ($/Person)	Population Density (Rural Population/ Irrigated Ha)	Poverty Rate (Headcount Below $2.15 PPP/Day, In %)	Ratio Of Costs To Benefits		
				Scenario 1	Scenario 2	Scenario 3
Batken	31	5.5	47%	0.7	0.9	1.0
Osh	27	6.3	46%	0.8	0.9	1.0
Jalalabad	32	5.3	70%	0.6	0.7	0.6
Issyk Kul	96	1.8	35%	0.7	0.9	1.4
Naryn	106	1.6	64%	2.3	2.9	3.7
Chu	156	1.1	10%	0.9	1.0	1.3
Talas	109	1.6	39%	1.4	1.7	2.0
Total	69	2.5	47%	0.8	1.0	1.3
Source: World Bank staff calculations.						

4.4 Conclusions

The first section of this chapter demonstrates that the majority of irrigated agriculture appears to be inherently economically viable. This analysis indicates only the inherent economic *potential* of irrigation in Central Asia. Many areas are not realizing that potential for reasons discussed in Chapter 2. Lack of choice about what and how to farm, corruption, irregular supply of water and other inputs, lack of profitable output markets, and underdeveloped agro-processing facilities all combine in practice to reduce the benefits that farmers could theoretically obtain from irrigated agriculture.

This indicates that one key criterion for deciding where to invest is to choose those schemes with the highest economic rates of return. However, bearing in mind the findings of the qualitative analysis in Chapter 2, governments should also select first those schemes that have reasonably good governance and functional I&D institutions.

Many areas, however, appear not to be inherently profitable, and millions of people rely on irrigated agriculture in these areas. If they let the infrastructure in those areas degrade, governments may face large scale social upheaval and possibly conflict. There are many options for reducing the social tensions, none of them easy. These include inducing the economy to create additional non-farming jobs, training, and relocating people to more prosperous areas, or providing cash transfers to people to compensate them for the income they have lost. This initial analysis indicates that in the Kyrgyz Republic, rehabilitation would be cheaper than the simplest option for reducing the social tension—providing cash transfers. Both options—rehabilitation and cash transfers—have many potential problems and would need to be designed carefully and based on the specific circumstances of each case. This study does not advocate rehabilitating irrigation for social reasons but suggests simply that it is worth considering as one option.

Even if funds were available, rehabilitating irrigation infrastructure for social reasons is no panacea. Because neither governments nor farmers currently maintain their infrastructure properly, there is a good chance that once the first round of rehabilitation reaches the end of its natural life, governments would be faced with the same quandary. It may be possible to design a rehabilitation investment to take account of such factors. The government could publicly announce a defined end-point, after which there would be no more rehabilitation and the infrastructure would be allowed to deteriorate. The project could also include specific activities to reduce the dependence of the population upon irrigation during the lifetime of the rehabilitated system, such as training in alternative skills, and/or give people incentives to move to other parts of the country.

This chapter has assessed the economic viability of irrigation schemes, but did not consider the externalities. As emphasized in Chapter 2, externalities are significant, owing to the considerable environmental impact of irrigation and drainage. The next chapter examines the extent to which incorporating environmental externalities affects the cost-benefit analysis of a real investment considered for World Bank financing.

Chapter V. Including Environmental Externalities

The previous chapter demonstrated that a large proportion of schemes appear to be economically viable. But, we also saw in Chapter Two that continuing to irrigate areas upstream can have important environmental effects downstream.[56] How much does that environmental damage affect the economic viability of a project? Answering this question comprehensively would require enormous quantities of site-specific data and complex models, which is beyond the scope of this and probably any region-wide study. Instead, we develop a relatively simple way of valuing part of the environmental externality building upon existing models and data, in order to understand the approximate scale of the environmental problem.

In this chapter, we analyze a specific irrigation scheme and estimate how a partial assessment of the environmental effects might change its economic rates of return. The starting point is a cost-benefit analysis conducted for an actual World Bank project in preparation. This project is generally considered to be the scheme with the most severe environmental externalities in the region, owing to high salinity levels and the large area affected downstream. If the project does not take place, upstream land will cease to be irrigated and levels of salinity downstream will fall. We would expect yields downstream to improve, albeit marginally, over the current extremely low levels. Carrying out the project would therefore impose a cost (expressed as forgone yield increases) downstream, which are defined here as the environmental costs.[57] We place a value on those foregone yield increases and use them to address two issues:

- How does including environmental costs alter the project's net present value?
- Under scenarios where the project would not be economically viable, what are the costs of alternative options for softening the social impact of allowing upstream infrastructure to degrade?

5.1 The Project Economic Analysis

The starting point of the analysis is the economic analysis for the Karshi Pumping Cascade Rehabilitation Phase I Project. This project rehabilitates the pumps that irrigate some 400,000 ha of land, 322,000 ha of which is in Kashkadarya Province in Uzbekistan. Some two million people depend directly or indirectly on the cascade for their livelihoods. Most communities in this region only came into existence in the 1970s to work on the land once the irrigation scheme was built. The land is naturally desert scrub, and without irrigation only extensive sheep farming would be possible.

[56]Rehabilitating irrigation upstream, if accompanied by appropriate technical assistance and investment in drainage structures, could make the water use upstream more efficient and create less salt in the river per unit of upstream agricultural output. Ceasing to irrigate large areas upstream, however, would reduce salt levels even more.

[57] We were not able to quantify ecosystem losses associated with continuing to operate existing schemes but they are not likely to be high. Health damage downstream are important, but we were not able to calculate them here. This is because we lacked epidemiological evidence and because it was not possible to separate the contribution to drinking water salinity of salt coming from upstream irrigation from that mobilized on-site.

The project economic analysis compares a with-project scenario to one without a project, where the equipment gradually wears out and part of the land ceases to be irrigated. Without project, the project analysis assumes that 20% of the original 322,000 ha in the project area will be retired according to a linear schedule between years 2 and 15 (i.e. a contraction of 7% per year of a total of 64,400 ha). For the following exercise, all major assumptions underlying the project's economic analysis are left unchanged.[58] The project analysis calculates the difference between the with- and without-project net benefits over the project's expected 25-year life. This has a net present value (NPV) of $71 million. The analysis sets up several alternative scenarios to test the sensitivity of the results, all of which are positive before the environmental costs are included.[59]

5.2 Estimating the Environmental Externalities

The environmental effects of rehabilitating existing schemes are different from those of constructing them in the first place. Rehabilitation has both positive and negative effects. The negative ones relate to the continued reduction in water quantity available and impairment of water quality downstream. Most of the biodiversity damage has already taken place, though continuing irrigation upstream is likely to have some biodiversity impacts. The positive effects relate to taking land out of production upstream. It is far from certain that irrigated land, in which the soils and water table have been substantially altered, will revert back to its natural state if decommissioned, especially if salinity is the cause.

It is beyond the scope of this study to evaluate the full range of environmental effects. This study concentrates on the partial valuation of a portion of downstream environmental impacts, i.e., the potential positive effects on downstream agricultural yields of reduced irrigation water salinity due to upstream land retirement. Our analysis draws from the extensive research conducted for the Aral Sea Program in preparation for a World Bank financed loan.[60] The calculation, which is presented in detail in Annex 5, assumes that yields downstream would increase if irrigation upstream were halted. It therefore calculates the value of benefits foregone if rehabilitation allows irrigation upstream to continue.

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[58] This choice resulted in a number of discrepancies with the economic analysis in chapter 4. Previous analysis applies to the whole country and is constructed to allow comparisons with the analysis for Tajikistan. The primary differences relate to the costs of production used to calculate farm gate values. Costs of handling and insurance are assumed to be higher in this analysis than we used in chapter 4. In addition, the original project analysis uses a 10% discount rate whereas a 12% rate was used in previous chapters. In previous chapters we chose to use a higher 12% discount rate to ensure that our conclusion on scheme viability did not depend on assuming an optimistic discount rate. However, for this chapter we chose not to alter the 10% discount rate used in the original project analysis, because the objective of this chapter is to see how environmental cost estimates may alter the original results, not a revised version of them. However, later in the text we indicate the consequences of applying a 12% discount rate.

[59] Five of these scenarios are more conservative than the base: (i) with project investment cost up 50%; (ii) both with and without project investment up 50%; (iii) irrigation O&M cost up 20%; (iv) net crop income down 20%; (v) power prices up 25%. On the other hand, five scenarios tilt the analysis further in favor of the project: (i) with project investment cost down 25%; (ii) without project investment cost up 50%; (iii) irrigation O&M cost down 20%; (iv) net crop income up 20%; (v) power prices down 25%. Two additional scenarios are not classifiable *a priori*, but end up dampening the net gains of the project over the without project alternative. These are: (i) future area irrigated down 20%; (ii) future water use down 20%.

[60] Mott MacDonald Temelsu and Ministry of Agriculture and Natural Resources of the Republic of Uzbekistan, 1998, *Preparation Study of the Uzbekistan Drainage Project. Phase II. Prefeasibility Study. Draft Final Report.* Parts I-III. (Main Report and Annexes).

The calculation proceeds as follows. First, we estimate the amount that salinity in the river downstream would fall for each hectare of land retired upstream.[61] Then we estimate how that reduced salt in the water would affect salinity of the soil. This allows us to calculate how the reduced salt would increase yields downstream. We apply those increased yields to the entire downstream area (1,350,000 ha) under its current cropping patterns and current low yields. This produces a net present value for the increase in yields downstream of $2.4 million under our baseline scenario. Dividing that by the number of hectares that would be retired if the project does not take place gives a value of $69/ha of land retired upstream. Therefore, rehabilitation causes benefits of $69/ha to be foregone.

Results for the Environmental baseline. When we include our limited definition of environmental externalities into project costs, the NPV of the project falls by 27% to $52 million. Thus, under the base case of the original economic analysis, the project remains economically viable even when partial environmental externalities are considered. Including the environmental costs makes the NPV negative under two scenarios—net crop income falling by 20% and project investment costs increasing by 50%. The following sections discuss alternative assumptions for measuring environmental externalities.

5.3 Environmental Scenarios

A. What If Soil Salinity Downstream is More Reactive to Water Salinity?

The environmental baseline assumed that one unit of salt in the water translates into 1.5 units of salt in the soil (i.e. $EC_e = 1.5\ EC_W$).[62] However, this relationship implies reasonably good drainage conditions, which we know not to be the case in the lower reaches of the Amu Darya basin. Therefore, we calculate both the with- and without-project yields (see Table 6.1 above) assuming worsening drainage conditions downstream ($EC_e = 3\ EC_W$.)

Results of first environmental scenario. Increased soil salinity responses to water salinity downstream intensifies the yield response to salinity of water received from upstream. This reduces the NPV of the project, but does not turn it negative. Three of the sensitivity analysis scenarios switch sign.

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[61] Following MMD, we estimate the effects of retiring 35,000 ha of particularly saline land, because it is the only hydrological data available. We then apply that value to the 64,000 ha that would be retired in the "without project" scenario. Thus we may be overstating the salinity impacts.

[62] This relationship implies a leaching ratio of 0.3. The leaching ratio (LR) is the ratio between deep percolation flows and irrigation flows from all sources plus rainfall. Its link with ECe and ECw is approximately as follows: LR = ECw / (2*ECe). In the lower Amu Darya reaches, the poor drainage conditions suggest lower leaching ratios. Following recommendations in the MMD study, we considered three options: 0.25, 0.16667 and 0.10 (i.e., ECe=2*, 3* and 5*ECw). We present the case for Ece=3Ecw as experts consider this to be the most realistic. Lower downstream leaching ratios influence 1) the threshold above which soil salinity-sensitive crops react to water salinity, lowering it; 2) yield responses above such threshold, increasing them; and therefore 3) the increase in expected yields due to lower water salinity levels from upstream land abandonment in the absence of rehabilitation. As reported in the Annex, rice yield impacts do not change, however, since this crop reacts directly to irrigation water salinity and the peculiar planting conditions of rice generate deep percolation dynamics that are different from those of aerated root zone crops. As the impact of water salinity on soil salinity increases, the benefits of ceasing irrigation upstream increase and therefore the environmental externality increases.

B. What If We Consider That Ceasing Irrigation Upstream Makes More Water Available Downstream?

The second scenario considers the impacts of increased water availability due to upstream land retirement on downstream agricultural output. Salinity-induced reduction of yields in the lower Amu Darya basin is derived mainly from on-site drainage and groundwater problems[63] The primary cause of the latter is insufficient availability of relatively clean surface water, which encourages the use of highly saline ground and drainage water. This further increases soil salinity, causing farmers to use increasing quantities of (saline) water for leaching, thus raising groundwater further and exacerbating the problem. Retiring upstream land would make more water available downstream, and of slightly better quality, which would slow down if not stop this vicious cycle. Using water upstream more efficiently would have more or less the same effect.

Ideally, to assess this impact, one would want to know 1) how much "freed" water from Karshi actually reaches downstream areas, 2) whether and to what extent increased water availability displaces the use of saline drainage water, 3) how this influences soil salinity and yields, and 4) what level of water application will improve leaching without increasing water tables. The provision of adequate drainage is also paramount in determining the final outcome, so that a thorough analysis should carefully consider assumptions regarding downstream drainage conditions. In view of the complexity and site-specific nature of these factors, a calculation of this nature is impossible, based on the scarce data available to this study. However, future analyses should try to answer these questions when including this additional component to an extended cost-benefit analysis.

Given the difficulties mentioned above, we chose an alternative path. The key is a simplifying assumption about the value added of an additional cubic meter of water reaching the downstream region. Since the field assessment noted that a great deal of formerly irrigated land is out of production downstream, we assume that any additional water will be used to irrigate a field that currently receives no irrigation water. Thus, the value of increased water availability is the value of output that would be produced on the additional land that can be irrigated downstream, at the current low yields. This enables us to avoid making unfounded hypotheses regarding the degree of substitutions of saline drainage water with less saline river water on already irrigated plots. The results, however, should be handled with care, as they only provide a gross approximation of potential benefits.

In this scenario, we assume that downstream farmers use 50% more water than those upstream, following their current practices. Improved water management downstream would allow significantly lower water use. For this analysis, we consider only Karakalpakstan as the downstream area affected. We assume that 30% of the water no longer pumped by the Karshi station reaches Karakalpakstan and that current cropping patterns and gross margins downstream remain the same.

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[63] WEMP, p. 17.

Results of the second environmental scenario: The new assumption also increases the value of the environmental externality, but again the NPV remains positive under the base case of the original CBA. As with the previous environmental scenario, the NPVs in three of the sensitivity analysis scenarios become negative.

C. What If We Consider Both Increased Soil Salinity Responses And Increased Water Availability?

Combining the effects of worsening drainage (ECe=3*ECw) and increased water availability downstream increases the environmental externality. It brings the NPV down to $24 million—a 66% reduction from that calculated in the original project analysis. This still does not impair the project's viability, but does cause four of the sensitivity analysis scenarios to become negative.

It is important to note that these mildly reassuring results would be considerably altered if one were to re-compute both the original analysis and our modified version, using the more conservative 12% discount rate used in our previous chapter. First of all, the original project NPV–excluding environmental costs–would fall to US$ 47 million. Once environmental costs are considered, the base case NPV falls to US$25 million (a 52% drop with respect to the new base case NPV), and four out of the seven conservative scenarios considered in the original sensitivity analysis present negative NPVs. More importantly, the base case NPV turns slightly negative under our last salinity-plus-availability scenario.

While our calculation was meant to simply amend the original project analysis (thus prompting the decision to maintain its 10% discount rate), these results indicate that including environmental costs may well alter the conclusions about viability of this project, particularly once their partial estimate is substituted with values based on a more thorough assessment of the full range of downstream impacts. Thus, the results should be read as a first approximation of the order of magnitude of some of the relevant variables.

5.4 What Should be Done When the NPV is Negative?

We have seen that including environmental costs under some scenarios of the original sensitivity analysis results in a negative NPV for the proposed investment. Economic reasoning would suggest that the government should not undertake this project if these scenarios were considered to more likely than the base case. Yet two million people depend on the Karshi cascades for their livelihoods and without irrigation regular crop production is impossible. As shown in Chapter 2, when the irrigation infrastructure deteriorates, most households remain in the village, even despite the great difficulties they encounter. Significant structural rigidities and policy distortions prevent the structure of the economy from responding to market signals. In addition, even if alternative means of livelihoods were available for displaced farmers, information and other transition costs are likely to be too high.

The government may therefore wish to soften the blow to the community in the face of a collapse in irrigation infrastructure. Could it be worthwhile to rehabilitate irrigation infrastructure, even when this course of action is not viable from a purely economic standpoint? Do the costs of the subsidy the government would have to provide to make the scheme break even outweigh the costs of alternative means of reducing the social impact? Note that these social costs are not considered externalities of a without project scenario. In this section we merely compare the fiscal impact of the options the government may consider.

Even if infrastructure is rehabilitated, a natural migration out of agriculture is to be expected. We therefore assume that non-agricultural employment grows at 5% per year and absorbs an outflow of 2% of former farm workers (with other urban people taking the rest of the jobs). In Uzbekistan, this represents around 70,000 farmers per year moving to the urban sector (about 50% more than actually occurred between 1994-98). The calculation in the following section assumes that displacement from the Karshi system would occur over and above this natural shift away from agriculture, and that the government would be willing and able to fund some form of support measures for these families.

The first step is to model a scenario in which the government provides a cash transfer to the entire population affected by a without-project scenario. We surmise that the cash transfer should be equal to the lost income from irrigation, which is estimated as the difference between gross margins with and without project computed in the economic analysis of the Karshi project.

We assume an average of one job lost per ha retired, and follow the land retirement schedule of the Karshi project analysis. Finally, we assume that once a farmer starts receiving income support, it will continue receiving it at least until the end of the project's time horizon (25 years). When discounted at 10%, the net present value of providing the compensation is $38 million. This is less than the cost to the government of subsidizing the rehabilitation project so that it breaks even ($46 million) under the most pessimistic scenario.[64] However, the income support alternative is more expensive than subsidizing the project under all other scenarios.

The social implications of large communities that depend entirely on government paychecks, may discourage the use of long-term income support programs. An alternative course of action may be to encourage job creation in sectors other than agriculture, coupled with funds to encourage people to move away from the area where irrigation is contracting. As was mentioned above, a better course of action would be to eliminate some of the policy distortions that prevent the economy from reacting to market signals, but these distortions and other structural rigidities in the economy are expected to remain in place at least for the medium term.

Therefore, we developed a job creation scenario that includes two main assumptions. First, we assume that displaced farmers would emigrate at a constant rate of 5% requiring no help from the government. Second, the ratio of people who migrate within Uzbekistan and who stay in the upstream region would change over time. Over the first five years, 90% of the unemployed workers would remain in the formerly-irrigated region and require income support, while 5% would move elsewhere in the country and get a new government-subsidized job, with the government further covering their housing and relocation costs. As people realize that the land retirement will continue, a progressively larger share of them will leave the region. In the scenario, the share of those who remain *in situ* falls to 85% in years 6-10, to 80% in years 11-15 and to 75% in years 16-20.

[64] This is the original sensitivity analysis scenario with a 50% increase in project costs, coupled with the scenario for computing environmental costs where both higher downstream soil salinity reactions and increased water availability are considered.

What is the cost to the public sector of subsidizing the creation of a new job and helping people relocate? We estimate the cost of creating an additional job in the service sector in Uzbekistan at $8,000.[65] Local experts estimate that it would cost around $500 for a family of six to move family members plus a limited number of possessions to the nearest city. This includes the amount necessary to allow minimum consumption for three months while the household searches for a new job. We estimate the cost of a 50 square meter apartment to be around $9,000 in total. We scaled this amount back by 30%, on the assumption that around 30% of migrants will find pre-existing housing elsewhere, given the available supply of housing in many of these cities. Thus, the estimated relocation cost is around $6,800 per family of six.

Results: Under these assumptions, and using a 10% discount rate, the NPV of the amount the government would have to spend on the social costs if it decides not to go ahead with the project is US$64 million. This compares unfavorably to the US$46 million costs for the government of subsidizing the Karshi project under the most pessimistic scenario.

From this analysis, it descends that irrigation rehabilitation may be worth considering as one option for providing temporary social assistance to communities that depend on irrigation schemes that are not economically viable. Here, too, however, the choice of discount rate also matters. If we use a 12% discount rate to compute NPVs both for the project and for the social assistance programs, subsidizing the project still compares favorably with the job-creation alternative under all but three scenarios. On the other hand, the comparison with the provision of income support becomes inconclusive, as the latter is a less expensive alternative for the government in about half of the scenarios for which the project is not viable.

These results need to be carefully interpreted. In particular, they should not be read as supporting large-scale investment in irrigation rehabilitation schemes, regardless of their economic viability. Irrigation rehabilitation should not be viewed as a cause for postponing much-needed reforms in irrigation, agriculture, and other sectors of the economy. The results simply underline the fact that rehabilitation may compare favorably *purely in cost terms* as a measure to reduce impacts on rural population during the transition period, when distortions still prevail and prevent the non-agriculture sector from expanding sufficiently or farmers from taking advantage of existing opportunities.

Thus, the available options that governments should actually select depend on considerations beyond their cost. In particular, one should consider the way in which each option interacts with the expected reform path. If the elimination of distortions is expected (as is the case in Uzbekistan) a winning strategy may be to remove the current net taxation of agriculture and to allow farmers to more freely respond to market signals regarding cropping patterns and input use, rehabilitating even currently uneconomic schemes, particularly if their collapse led to irreversible land abandonment. On the other hand, if reforms are expected to produce a shift away from agricultural production, subsidizing rehabilitation may send the wrong signal to rural populations, so that alternative transition support programs may be preferable.

[65] This comes from IFC and IMF data and is at the low end of the range because most displaced workers will earn money in the informal sector.

5.5 Conclusions

In this chapter, we calculated partial estimates of the environmental externality of a scheme with some of the largest environmental effects in the Aral Sea basin. This includes neither the health damage from drinking saline water nor the ecosystem damage, which to date cannot be quantified.

This admittedly partial estimate did not greatly alter the conclusions of the original cost-benefit analysis regarding the viability of the project, at least when using its 10% discount rate. None of the estimates for environmental damage caused the net present value of the project to become negative under the original base case. Yet the results became less clear-cut than in the original analysis, because including the environmental costs caused NPV to turn negative under several of the original sensitivity analysis scenarios. However, the use of a more conservative 12% discount rate returns a negative NPV under the base case scenario when the highest estimate of environmental externalities is considered. A full valuation of environmental damages might produce negative NPVs under an even broader range of scenarios. Further research in this direction is therefore highly recommended.

We then expanded our perspective to consider the social implications of letting irrigation collapse in an economy with policy distortions and structural rigidities, conditions that are expected to prevail in the transition period even if the government were to undertake reforms. In this context it appears that, even under the circumstances that most negatively affect project outcomes, subsidizing irrigation rehabilitation might be less expensive for the government than alternative for softening the social impact of the collapse of I&D in the region. Again, the choice of discount rate influences, yet does not reverse the results.

Given the policy and structural distortions currently in place in Uzbekistan, if the infrastructure is allowed to degrade, one cannot assume that market signals would work and that people would move and find jobs elsewhere, at least in the medium term. After estimating the budgetary costs of softening that social burden, we found that subsidizing rehabilitation project when it is not economically viable may be a cheaper option for the government than other likely courses of action. We estimated that the present value of providing an income transfer equal to the lost income from irrigation is less than the economic costs of the project only under the most negative assumptions affecting project outcomes. The provision of subsidies for the project to break even becomes a more attractive alternative, when it is compared to a combination of income transfers and job creation plus moving subsidies. These results simply state that rehabilitation compares favorably *in cost terms* as a measure to reduce impacts on rural population either in the absence of reforms or during the transition period, when distortions still prevail.

Yet if the government chose to rehabilitate an uneconomic project for social reasons, the nature of rehabilitation interventions would have to be different from those that are justified when rehabilitation is economically viable. The physical investment would probably have a "band-aid" rather than fundamental nature, designed to keep the system going for one or two decades rather than to rehabilitate it totally. Such a socially-motivated rehabilitation would also have to be accompanied by a clear and strong public information campaign to overcome the potentially perverse economic signals the government would be sending by maintaining uneconomic schemes. And before advocating rehabilitation for social reasons, one has to bear in mind the difficulties in managing the phase-out of such interventions for a government that has so far had great difficulties in undertaking policy reforms and other fundamental actions to remove rigidities in its economy.

Irrigation rehabilitation should not be seen as an alternative to reform. If the elimination of distortions were to remove the current net taxation of agriculture and to allow farmers to more freely respond to market signals regarding cropping patterns and input use, rehabilitating would be even more attractive. Broad-based economic growth will help create jobs in sectors other than agriculture and thus provide incentives for farmers to move off the land. Location-specific retraining programs could speed that process in areas that are not profitable for irrigated agriculture and thus reduce the dependence on irrigation in the long term.

This section of the report is based simplifying assumptions and addresses only part of the issues involved. In order to arrive at a more definitive answer, future work (often neither conducted nor funded by the World Bank) would need to cover three issues:

- Site-specific research on the costs of human and animal consumption of saline water, and the dynamics of drainage vs. surface water response to increased water availability.
- Making modeling tools more useful for policy work. Hybrid engineering/ economic models would be more useful than complex engineering models. They can be reasonably easily calibrated and maintained by the government users. Terms of reference for such work should specify that information and models and techniques for using them must be shared with local officials and with the client organization.
- Probabilistic risk analysis rather than sensitivity analysis.

Before attempting to reach more definitive answers through additional research, we should consider the costs involved. Merely to calculate the partial estimates in this chapter, we drew upon a two-year, $750,000 hydrological study undertaken as part of project planning and made possible only because the project was part of the Aral Sea Basin Program. Yet even this body of work did not permit us to arrive at conclusive results. It is unlikely that such detailed hydrological information is available for all areas of Central Asia. This indicates that in many cases it will not be possible to extend traditional cost-benefit analysis to include even partial estimates of environmental externalities.

Chapter VI. Conclusions of the Report

There is a need to develop an approach to planning investments in Central Asia, because the investment needs far outstrip the available resources. This report aims to help policy makers arrive at the best possible decisions concerning resource allocation, given the current realities. The report aims to help decision-makers balance between the extensive irrigation infrastructure left from the Soviet era, the few alternative income opportunities for farmers, current policy distortions, structural rigidities and institutional failures that prevent farmers from deriving the full economic value from their land, and major environmental damage resulting from poorly designed infrastructure and inappropriate water management practices.

At present, one can characterize three schools of thought among donors and policy-makers concerning the rehabilitation of I&D systems in Central Asia. The first school holds that villagers have no alternative but irrigation in the medium term. Governments should invest as much as possible, as soon as possible before irrigation collapses altogether and causes more human suffering. According to the second school, most of the I&D schemes are not economically viable, and it makes no sense investing in unprofitable infrastructure. Even where schemes are viable, any money invested in infrastructure will be wasted until policies and institutions are improved, because farmers will not have the funds to carry out proper O&M. The third and final school of thought asserts that international organizations should be helping governments phase out irrigation in many areas, because they are not and can never be environmentally sustainable in these locales.

This paper aims to provide some initial quantification of the situation and to begin reconciling these three lines of thinking. It employs the existing, often inadequate body of data available and proposes approaches that could be used in the future for more detailed, case-specific analyses. This study does not strive to provide definitive answers, but rather a basis on which to make decisions until more detailed information becomes available.

Fieldwork using qualitative methods underlines the importance of irrigation to entire communities. Infrastructure has degraded significantly in the past ten years. Maintenance has almost collapsed, due to declining state budgets, a precipitous drop in farmers' income, and a growing institutional vacuum. Most sites visited have unreliable or scarce water supplies, which is indicative not only of the decay of I&D systems, but also of the poor management practices and corruption in rural areas. Salinization and waterlogging have intensified because of inadequate drainage, to the degree that crop yields are significantly lower than the potential, drinking water quality is reduced, and much infrastructure has been damaged. A small number of powerful individuals often control water allocation and thus increase inequality in the villages. Although villagers try to cope with the new conditions through adapting agricultural production or finding a new line of work in other areas, they are generally unsuccessful. Thus, villagers report that poverty and suffering are becoming more widespread.

Analysis of household income and consumptions surveys indicates that poverty is clearly a rural phenomenon in Central Asia. Although the relationship between the amount of irrigated land and poverty is not clear from the quantitative analysis, the field assessment shows that the location (upstream/downstream) and quality of land are critical factors. Both the quantitative analysis and the field assessment demonstrate that the poor suffer more when irrigated area contracts. In order to understand the relationship between irrigation and poverty in greater depth, future income and consumption surveys need to include better information concerning land quality, the proportion of command area of the I&D system that is actually irrigated, the quality of the irrigation, and outlays (time and money) for maintenance. Ideally, these data sets would be consistent across countries to allow international comparison.

A surprising number of pump-supplied schemes seem to be economically viable. In Uzbekistan, they appear to be viable at full economic prices, including electricity for pumping. Even under the most pessimistic assumptions, only 12% of the land would produce at a loss. In Tajikistan, the situation is less positive, as somewhere between one-half and two-thirds of the land in our representative sample of agricultural districts (rayons) would be unprofitable. Detailed district level analysis in the Kyrgyz Republic demonstrates the importance of disaggregating to as low a level as possible. Even where aggregate numbers are highly positive, certain districts are unviable, due to soil conditions, etc. It must be emphasized that many farmers are not achieving the full economic potential from their land, owing to the institutional weaknesses and policy conditions discussed above. This initial analysis indicates that rehabilitating I&D systems is less expensive to the government than providing cash transfers equivalent to the value of the income lost from irrigation. Future enquiries into this issue would benefit from more accurate and detailed data on soil conditions, local cropping patterns, and farm budgets, as well as better estimates of the cost of rehabilitating off-farm structures.

Many opponents of rehabilitation of irrigation in Central Asia base their opposition on environmental considerations. Including a partial assessment of the environmental externalities associated with a specific rehabilitation investment, chosen for its expected considerable environmental impacts, does not fundamentally affect the conclusions of its original economic analysis. In some of the scenarios of the original sensitivity analysis, the net present value switches sign and become negative, but the NPV in the base case always remains positive. These results are based only on a partial valuation of environmental benefits, because it was not possible to calculate the value of ecosystem and health damage. In the short run, the cost/benefit ratio of trying to include the environmental externalities in the analyses of other irrigation rehabilitation projects in the region may not be positive, given the large data requirements and complex natural systems involved. However, this does not mean we should stop funding research aimed at improving our understanding of these and other issues that are characterized by a high degree of uncertainty. This experience indicates that studies conducted for engineering design could be modified to make them more useful for these and other purposes, while future modeling initiatives should be planned with an eye to questions that cover more than single investments.

Some advocates of rehabilitation state that these projects, even when not viable economically, should be undertaken as social programs to ease the burden of transition. The question is not whether or not reforms should be undertaken, but rather whether their transition impacts on affected populations should be eased, and what options are more appropriate in the region’s context. A group of opponents to rehabilitation for social purposes bases its argument on its alleged excessive cost. We therefore compared the cost that the government would face if it decided to subsidize the rehabilitation project under the most pessimistic scenarios of its economic analysis with the cost to the government of alternative forms of assistance to the workers affected if irrigation infrastructures degrade. If the form of assistance is a cash transfer equal to the value of income from irrigation alone, paid to all affected workers over the life of the project, the net present value of the transfers would be less than the subsidy required for the scheme only under the most pessimistic project scenario. Given the social implications of creating a large community that lives entirely on handouts, the government may consider a second alternative, entailing subsidized job creation and relocation. Under conservative assumptions concerning the number of people who stay on the formerly irrigated site and who migrate to other parts of the country, it would be cheaper for the government to subsidize the unprofitable rehabilitation scheme under all scenarios.

These results should not be read as saying that any uneconomic rehabilitation project should be undertaken for social purposes. They simply indicate that, if the decision were made to provide social assistance for the transition period, rehabilitating irrigation could not be excluded as an option simply based on cost considerations. Other considerations may come into play. One is whether it is easier for the government to phase out income support programs or subsidies for irrigation schemes. Another is whether a currently uneconomic scheme is expected to become economically viable once the reform process gets under way, so that short-term assistance goals may be coupled with a longer-term expectation of sustainability. On the other hand, if the shift away from agriculture is expected to continue once reforms are completed, the key consideration would be one of signaling, with income support schemes and job creation in non-agriculture sectors.

What should the government do to soften the social impact of reform transition? This area clearly requires further work and more data, but our simplified analysis indicates that it may be cheaper for the government to consider subsidizing a few, carefully selected uneconomic rehabilitation schemes than to try to create jobs for some of the affected people and to provide income transfers to those who remain on-site.

So which schemes should the governments rehabilitate first? This study, again based on preliminary methodologies with incomplete data, indicates that they should look first at those schemes that are economically the strongest. But economic performance alone will not be enough. Within those schemes that meet sound economic criteria, governments and donors need to look for areas where the national and local level institutions are strong and/or where there is a realistic hope of reforming them. Finding clear indicators of what makes a good institution or one that is likely to reform is not easy, and could be a productive topic for future research.

To conclude, this study should not be interpreted as providing a blanket justification for large scale investment in irrigation projects that are not economically viable, nor as a statement of a "construct first, reform later" doctrine. On the contrary, the study concurs that long-run success in reviving the economies of the region can only be based upon broad macroeconomic reforms, accompanied by microeconomic interventions in the agriculture sector, as well as specific reforms regarding water resource management and irrigation water use in particular. The study simply points out that the transition period between beginning a policy reform process and the effects being felt in rural areas can be long. It requires a specific strategy to deal with two sets of issues. The first set regards sequencing of reforms and investments under second-best conditions in the period during which distortions still prevail. The second set regards the impacts of reforms on the countries' population, and the assistance that may be needed in order to prevent hardship from derailing reforms.

Which of the three schools of thought characterized above should predominate? On the basis of the preliminary calculations conducted here, we declare a modest victory for the first, with the second is a strong runner-up. Huge communities do indeed depend on the irrigation systems for their livelihood and have few alternative options in the short and medium term. Preventing or slowing the contraction of I&D schemes is pro-poor, albeit modestly. Many of the schemes appear to be economically viable, although policy and market distortions prevent farmers from achieving all of the potential benefits. Policies and institutions clearly affect the sustainability of investment enormously and both appear to take longer to develop and require more assistance than policy-makers thought at the beginning of the 1990s. Our findings are not conclusive regarding the environmental school of thought, because we were not able to measure all of the environmental impact, and conditions vary so much from case to case. Our initial, relatively simple, analysis indicates that factoring environmental damage into the economic analysis of a project that is considered to have significant environmental impacts would not fundamentally alter investment decisions.

ANNEXES

Annex 1
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Annex 2:
Map

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Annex 3

Poverty and Irrigation:

Data Tables and Recommendations for Future Data Collection

Table A3.1: Purchasing Power Parity Exchange Rates Used To Convert Survey Data Into USD		
	1996 PPP 1/	Survey Period PPP Exchange Rate 2/
Kyrgyz Republic (January-December 2000)	3.47	**8.07**
Tajikistan (May 1999)	56.94	**234.29**
Turkmenistan (May 1998)	392.32	**890.98**
Uzbekistan (February 1999)	12.68	**28.62**

1/ The PPP rate for 1996 that was used in the ECA Poverty Report, 2000.
2/ The 1996 PPP rate was adjusted to the survey period taking into account the inflation differential of national currency and USD.
The calculation did not take into account the fact that the exchange rate may have moved closer to parity with USD.
(This would happen if the domestic price level moved closer to the level of world prices).

Recommendations for Future Data Collection

Data limitations made it difficult to analyze the relationship between poverty and irrigation. The most important of these limitations are:

- Different methods were used to create the consumption/expenditure aggregates in the data sets. This confounds rural and urban comparisons, as well as cross-country comparisons. In the future, when constructing the consumption aggregates, researchers should use consistent methods that address issues such as seasonality, the consumer price index and rationing.
- Land use data was collected in various ways in the surveys, which makes it difficult to ensure that summary statistics accounted for all household land use. Future surveys should collect data on total amount of land available to the household, what it is used for, and a specific measure of land quality.
- Irrigation data was collected differently in the surveys. Surveys sometimes asked whether or not a plot was irrigated (not all of them did), but never asked about the quality (reliability) of irrigation. Future surveys should include questions about the availability of water, the proportion of land that it serves, the water source, the regularity and reliability of the service.
- We had little information about agricultural profits. While some data was collected on agricultural production, this data was missing for a very large number of households. We were therefore forced to use per capita expenditure as a proxy for agricultural income. Future surveys designed to answer questions about irrigation should collect enough

detailed information on inputs and outputs to construct a proper net agricultural income variable.

- Finally, it is difficult to separate farmers from individuals who are engaged in farming, but have other important occupations. In the future data should be collected in a manner that makes it easier to separate farmers from non-farmers and the role that irrigation plays in their expenditures.

Annex 4
Economic and Financial Analysis of Irrigation Schemes: Methodology and Data Tables

Methodology for Calculating the Economic Viability of Pumping

The methodology used in Chapter 4 to estimate the effect of economic energy prices upon gross margins from irrigated agriculture is presented in the chart below. The first step in this equation is to calculate the average economic gross margin for each crop, disaggregated by province (or district) and adjusted for yield differentials. Pumping costs are not subtracted from current economic margins before they are adjusted. We derived gross margins from world prices, adjusted for local conditions as shown in Table A4.1. This is based on World Bank project analysis, adjusted to allow comparison across countries. Table A4.23 shows the range of prices and assumptions used in recent World Bank project analysis. [1]

The second step is to calculate the costs of pumping for each crop type, using 1) the economic price of energy; 2) the cost of pumping 1 m^3/ha to a range of lift heights, assuming that energy costs increase in height in linear fashion; and 3) the crop water requirement (in m^3/ha/year). The annual pumping costs are then computed for each crop type, broken down by the height of the lift.[2] The third step is to derive economic gross margins for each crop, netting out pumping costs from the average gross margin for each crop for each lift. Then the cropping patterns for each province or district are divided into categories by lift and by crop, and the gross margin is adjusted according to the latter two parameters. This indicates how many hectares would produce negative gross margins, which we express as a percentage of irrigated land in Uzbekistan and as a percentage of total agricultural land in Tajikistan. Finally, we estimate approximately how many people depend on land that would produce losses at economic costs. We calculated this by multiplying the rural population of provinces of Uzbekistan and the total population of relevant regions of Tajikistan by the percentage of the hectares with negative gross margins. Table A4.2 shows the assumptions used in this analysis for each country and Table A4.3 shows the world market prices and thus the gross margin calculations. The data upon which these tables are based is presented in Tables A4.4 through A4.23.[3]

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[1] Data for Tajikistan relies only on the area covered by the World Bank's Rural Infrastructure Rehabilitation Project, while that for Uzbekistan is for the country as a whole.

[2] We aggregate continuous lifts into six discrete lift heights, in order to match the lifts of agricultural land covered in the data. Costs of pumping more than 200 m are higher, and this is not reflected in our calculation. However, this does not have a significant effect on the conclusions of the analysis. Our results show that between 70 and 60% of irrigated land at lift heights of 200m and above 200 m, respectively, produce negative margins even when we underestimate the cost of pumping to lifts much beyond 200m.

[3] The starting point of economic analysis of projects is the calculation of the farm gate value of outputs, based on assumptions about the world market prices, yields and adjustments for deriving farm gate value. In the course of this analysis, we found many variations in the assumptions used in different project appraisal documents, which obviously affects the estimates of gross economic margins. Table A4.24 compares the indictor prices, farm gate values and economic gross margins used in various projects. In this analysis, we adjusted the methodologies used in project analysis to calculate gross margins to enable our methodologies to be comparable.

The foregoing methodology assumes that cropping patterns and water application rates are stable (shown in Table A4.2), a conservative assumption. It also derives gross margins from a single world market price. In practice, commodity prices fluctuate and energy prices are likely to change. Farmers would probably react to these changes by shifting to more profitable crops and using water more efficiently, especially in areas with higher energy costs associated with pumping. To give an indication of likely impacts of changing prices, we developed three scenarios.

- Scenario 1: 2015 indicator price
- Scenario 2: 2015 indicator price +10%
- Scenario 3: 2015 indicator price –10%

Scenario 3 is conservative, and uses prices similar to the indicator prices for 2002, which are unusually low. We also modeled various assumptions about farmers' behavior, such as those at higher lifts using water more efficiently or changing to higher value crops. These produced very similar results to those of Scenario 2 (using the projected indicator price for 2015 +10%) and therefore do not merit separate inclusion.

Methodology Of The Analysis Of Viability Of Pumped Irrigation In Each Region (Province in Uzbekistan And District In Tajikistan)

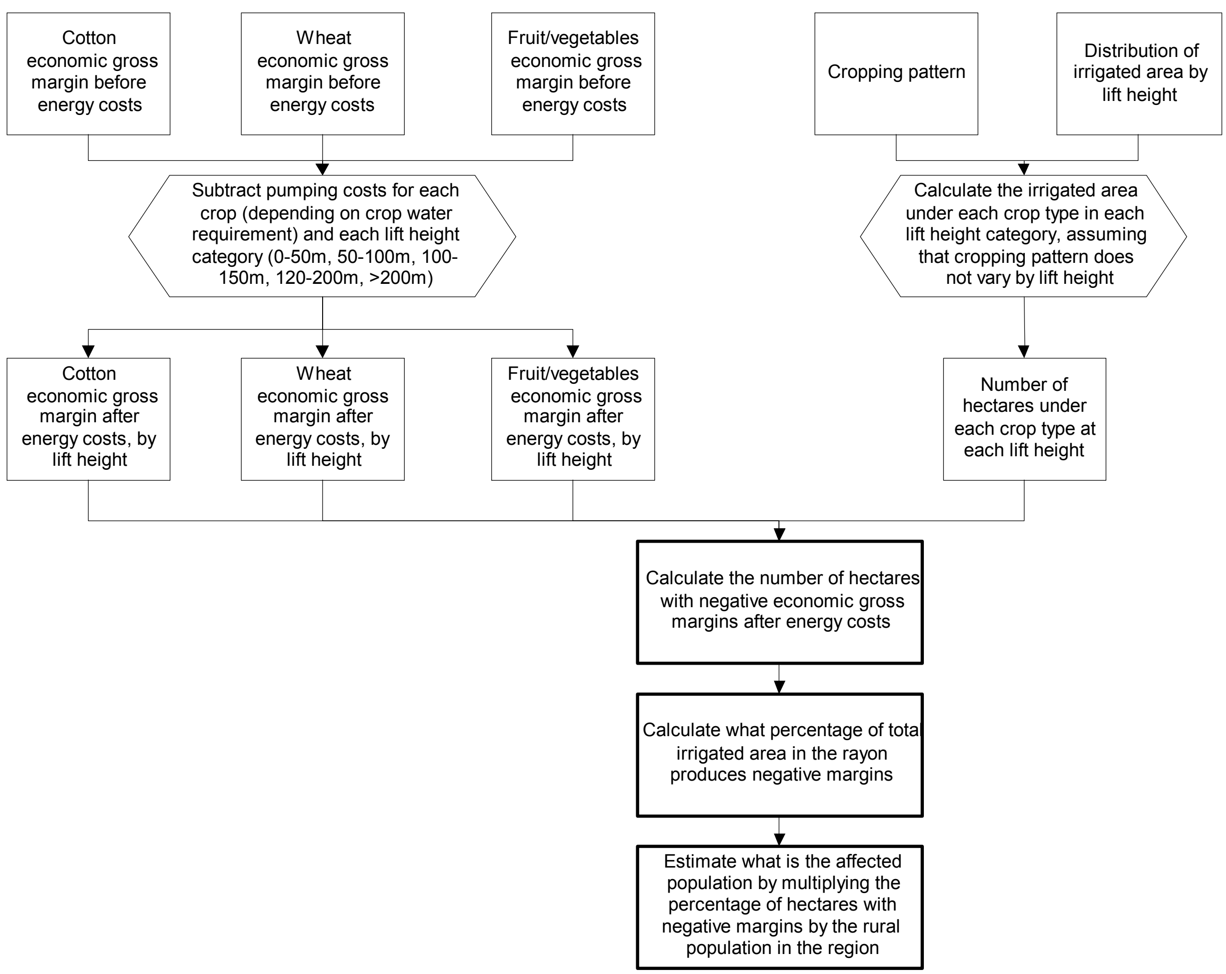

Table A4.1: Comparison Of Economic Gross Margins Before Subtracting The Energy Cost Of Pumping (Scenario 1 With The Projected 2015 World Prices For Cotton And Wheat)						
	Cotton		**Wheat (Irrigated)**		**Vegetables 1/**	
	Tajikistan	**Uzbekistan**	**Tajikistan**	**Uzbekistan**	**Tajikistan**	**Uzbekistan**
World Price Projected For 2015 ($/ton)	1,265	1,305	130	130		
Output Farm Gate Price ($/ton)	346	382	147	160	60	125
Yield (t/ha)	1.8	2.2	1.5	2.5	12.0	11.0
Revenues ($/ha)	622	825	221	400	720	1,369
Costs ($/ha), of which...	444	392	168	283	503	702
Machinery 4/	104	147	59	119	93	233
Labor 3/	105	58	15	14	132	306
Seed	18	34	29	50	180	8
Fertiliser	97	85	27	59	45	70
Pesticide	90	53	15	26	23	70
Transport 4/	15		8		15	
Water Delivery 2/	15	15	15	15	15	15
Gross Margin (Before Energy Costs)	178	433	53	117	217	667

Notes:
1/ "Vegetables" are a mix of fruit, potatoes and safflower (33% each) in KR, eggplants and apples (50-50%) in Tajikistan, and a mix of fruits and vegetables in Uzb. (from RESP budget data).
2/ This includes costs of operating and maintaining on-farm irrigation structures, but does not include the costs to the economy of maintaining the major off-farm canals and pumps. Those are estimated separately. It also excludes the energy costs related to pumping because that is calculated later.
3/ Economic cost of labor: $0.20/hour in Kyrgyz Republic, $0.25/day in Tajikistan, and $0.72/day in Uzbekistan.
4/ In the RESP budget for Uzbekistan, this category is called "mechanized work" and includes costs of transportation among others. Therefore costs in this category are higher in Uzbekistan than in KR and Tajikistan.

Table A4.2. Calculation of Farmgate Values for Cotton

		COTTON 1/ Kyrgyz Republic		Tajikistan		Uzbekistan
Indicator price						
$/ton		1,265		1,265		1,305
reference date		proj 2015		proj 2015		proj 2015
international transport		(150)		(150)		(150)
border price		1,115		1,115		1,155
transport from mill		(15)		(15)		(5)
value of lint at mill		1,100		1,100		1,150
convert to seed cotton	32%	352	33%	363	32%	368
moisture and gin loss	6%	(21)	4%	(44)	6%	(22)
cotton at mill		331		319		346
volume of seed produced		520		520		620
value of by-products (seed, cake)	$0.15/kg	78		78		93
ginning cost	2/	(50)		(48)		(52)
value of cotton at mill		359		349		387
assembly trasnsport from farm	1%	(4)		(3)		(5)
farmgate value		**356**		**346**		**382**

1/ Marketing year average cotton fiber prices C.I.F. North Europe (US$/ton)
2/ Ginning costs have been assumed to be 15% of the value of cotton at mill.

Table A4.3: Assumptions Of The Model				
	Tajikistan 1/		Uzbekistan 2/	
Economic Cost Of Electricity, $/kWh		0.022		0.04
Pump Motor Efficiency		80%		80%
Energy costs Of Pumping ($/m3) 3/	*Gravity*	2.05	*0-50 m*	5.45
	50 m	4.09	*50-100 m*	10.91
	100 m	8.16	*100-150 m*	18.18
	150 m	12.25	*150-200 m*	25.45
	200 m	16.35		
	>200 m	20.42		
Water Requirements (m3/ha Per Year)				
Cotton	12		*Cotton*	14
Wheat	8		*Wheat*	6
Eggplant	12		*Fruits/Vegetables*	11
Apple	10			
Crop Yields, National Average (Tons/Ha) 4/				
Cotton	1.5		*Cotton*	2.2
Wheat	1.8		*Wheat*	2.5
Eggplant	14		*Fruits/Vegetables*	11
Apple	14			
Cropping Pattern				
Cotton	28%		*Cotton*	35%
Wheat	42%		*Wheat*	38%
Eggplant	3%		*Fruits/Vegetables*	6%
Apple	2%		*Other*	21%
Other	25%			

Notes:
1/ Data for Tajikistan are from World Bank, 2000, *Project Appraisal Document: Tajikistan Rural Infrastructure Rehabilitation Project*.
2/ Data for Uzbekistan are from MMD.
3/ We assume the same energy requirement for pumping 1 m3 of water for Tajikistan and Uzbekistan. The difference in energy costs comes from the difference in energy prices. Pumping costs in Tajikistan are calculated for the reported lift. In Uzbekistan, cost is calculated for the midpoint in the lift range.
4/ These are national averages. In the analysis, we use district (province) specific estimates of yields. For Uzbekistan, we adjust the national average by multiplying them by an index for province-level soil quality, derived from the soil quality index (bonitet grade).

Table A4.4: Cotton And Wheat Price Projections For 2015, (In USD 1/)				
	In Current USD/Ton	Indicator Price In Constant 2000 USD/ton 4/		
		Projected For 2015	-10%	+10%
Cotton Outlook A (Tajikistan) 2/	1,600	1,265	1,139	1,392
Cotton Outlook A (KR) 2/	1,600	1,265	1,139	1,392
Uzbek Cotton 2/	1,650	1,305	1,174	1,435
Wheat 3/	165	130	117	144
		Farm Gate Value, Dependent Upon The Indicator Price		
		Indicator Price Projected For 2015	-10%	+10%
Cotton Outlook A (Tajikistan) 2/		356	324	388
Cotton Outlook A (KR) 2/		346	315	377
Uzbek Cotton 2/		382	349	415
Wheat 3/				
Tajikistan		147	135	160
Uzbekistan		160	147	174

1/ World Bank (Global Commodity Markets) February 2002 mid-term projections for 2015, in constant 2000 USD (deflated using the MUV index).
2/ Cotton outlook "A" index, middling 1-3/32 inch, average of the cheapest 5 of 15 styles traded in Northern Europe, c.i.f. Uzbek cotton has historically traded at an average of $50 above the cotton outlook A index due to higher cotton quality.
3/ Wheat (US), no. 1, hard red winter, export price at the Gulf port.
4/ MUV index (ratio of 2015 to 2000 levels): 1.2644

Pumping Analysis: Tajikistan

Table A4.5: Present Cropping Pattern In The Project Area, 1999 *% Of Total Area									
	Project Area	**Wheat**	**Cotton**	**Corn**	**Pulses**	**Potatoes**	**Onions**	**Eggplant**	**Apple**
Lenin	5,625	33	58	-	0.1	5.0	0.2	11.9	2.7
Gissar	11,020	33	46	4	0.1	0.0	0.1	1.8	0.1
Shahrinov	7,207	18	33	2	-	0.1	0.2	5.1	6.9
Kalkhozabad	8,647	13	42	0	0.1	0.1	0.0	0.8	2.1
Yavan	21,637	27	33	-	-	1.3	0.2	1.8	2.5
Ghozimolik	9,685	23	38	1	-	0.2	0.2	5.4	5.7
Macho	30,210	39	44	2	0.0	0.1	0.0	1.1	2.0
Zaforobod	34,401	24	45	8	0.0	-	0.0	2.5	0.8
All	128,432	28	42	3	0.0	0.5	0.1	2.7	2.2
*data are from Table 4.12, p. 69 of the Tajikistan Rural Infrastructure Rehabilitation Project Project Appraisal Document (PAD)									

Table A4.6: Gross Margin With Costs Of Water Delivery (O&M), But Without Energy Costs									
	Cotton (Raw)	**Wheat (Irrigated)**	**Corn**	**Pulses**	**Potato**	**Onion**	**Eggplant**	**Apple**	**Other (average)**
Lenin	486	106	51	(22)	59	207	222	190	162
Gissar	445	149	53	3	29	287	302	628	237
Shahrinov	486	91	66	(2)	(121)	287	322	670	225
Kalkhozabad	567	48	53	28	(141)	287	47	220	139
Yavan	122	63	51	(2)	(71)	207	147	562	135
Ghozimolik	1	(38)	53	(2)	54	287	147	208	89
Macho	122	5	53	3	154	127	-98	460	103
Zaforobod	82	5	26	(22)	(46)	127	72	670	114
*based on Tables 4.3-4.9 of the Tajikistan Rural Infrastructure Rehabilitation Project PAD. Yields are taken as different for each district (from Table 4.13), and gross margins are district-specific.									

Table A4.7: Energy Costs Of Delivering Water ($/Ha/Yr)						
	Gravity Fed	**50 M Lift**	**100 M Lift**	**150 M Lift**	**200 M Lift**	**250 M Lift**
Cost per 1000 m3	2	4	8	12	16	20
Cotton (Raw)	25	49	98	147	196	245
Wheat (Avg Irr & Rainfed)	16	33	65	98	131	163
Corn	21	41	82	123	164	204
Pulses	12	25	49	74	98	123
Potato	21	41	82	123	164	204
Onion	31	61	122	184	245	306
Eggplant	25	49	98	147	196	245
Apple	21	41	82	123	164	204
Other (Cotton/Wheat Avg)	21	41	82	123	164	204
*based on water requirements reported in Table A4.2.						

Table A4.8: Gross Margins Net Of Energy (Pumping) Costs, Depending On Lift ($/Ha/Yr)							
	Gravity Fed	**50 M Lift**	**100 M Lift**	**150 M Lift**	**200 M Lift**	250 M Lift	**Crop Share**
Cotton (Raw)							
Lenin	461	437	388	339	290	241	58%
Gissar	421	396	347	298	249	200	46%
Shahrinov	461	437	388	339	290	241	33%
Kalkhozabad	542	518	469	420	370	322	42%
Yavan	98	73	24	(25)	(74)	(123)	33%
Ghozimolik	(24)	(48)	(97)	(146)	(195)	(244)	38%
Macho	98	73	24	(25)	(74)	(123)	44%
Zaforobod	57	33	(16)	(65)	(114)	(163)	45%
Wheat (Avg Irr & Rainfed)							
Lenin	89	73	40	8	(25)	(58)	33%
Gissar	133	116	84	51	18	(14)	33%
Shahrinov	75	59	26	(7)	(40)	(72)	18%
Kalkhozabad	32	15	(17)	(50)	(83)	(115)	13%
Yavan	46	30	(3)	(36)	(68)	(101)	27%
Ghozimolik	(55)	(71)	(104)	(136)	(169)	(202)	23%
Macho	(12)	(28)	(60)	(93)	(126)	(158)	39%
Zaforobod	(12)	(28)	(60)	(93)	(126)	(158)	24%
gross margin net of energy costs	37	21	-12	-45	-77	-110	
energy costs	16	33	65	98	131	163	
baseline gross margin	54	54	54	54	54	54	
Fruit and Vegetables (Average Of Eggplants & Apples)							
Lenin	367	322	232	143	52	(37)	15%
Gissar	885	840	750	661	570	481	2%
Shahrinov	947	902	812	723	632	543	12%
Kalkhozabad	222	177	87	(3)	(93)	(182)	3%
Yavan	664	619	529	440	349	260	4%
Ghozimolik	310	265	175	86	(5)	(94)	11%
Macho	317	272	182	93	2	(87)	3%
Zaforobod	697	652	562	473	382	293	3%
Eggplant							
Lenin	197	173	124	75	26	(23)	12%
Gissar	277	253	204	155	106	57	2%
Shahrinov	297	273	224	175	126	77	5%
Kalkhozabad	22	(2)	(51)	(100)	(149)	(198)	1%
Yavan	122	98	49	-	(49)	(98)	2%
Ghozimolik	122	98	49	-	(49)	(98)	5%
Macho	(123)	(147)	(196)	(245)	(294)	(343)	1%
Zaforobod	47	23	(26)	(75)	(124)	(173)	3%
Apple							
Lenin	170	149	108	68	27	(14)	3%
Gissar	608	587	546	506	465	424	0%
Shahrinov	650	629	588	548	507	466	7%
Kalkhozabad	200	179	138	98	57	16	2%
Yavan	542	521	480	440	399	358	2%
Ghozimolik	188	167	126	86	45	4	6%
Macho	440	419	378	338	297	256	2%
Zaforobod	650	629	588	548	507	466	1%

*Following the same methodology as the PAD, for each height category we use the energy cost for the upper bound lift height (ex, 100 m for category 50-100m). **These gross margins correspond to gross margins in the PAD, p.58. We used slightly more precise yields than the PAD. The difference is only +$3.

Table A4.9: Project Area By Lift (Ha)							
	Project Area (Ha)	**Gravity Fed**	**50 M Lift**	**100 M Lift**	**150 M Lift**	**200 M Lift**	> 200 M Lift
Lenin	5,625	5,625	0	0	0	0	0
Gissar	11,020	9,280	1,740	0	0	0	0
Shahrinov	7,207	4,665	1,104	68	890	0	480
Kalkhozabad	8,647	4,837	3,477	333	0	0	0
Yavan	21,637	15,932	781	532	2,779	45	1,568
Ghozimolik	9,685	5,605	0	0	3,338	0	742
Macho	30,210	2,296	11,434	5,550	4,377	5,015	1,538
Zaforobod	34,401	0	1,521	15,880	0	17,000	0
Total	128,432	48,240	20,701	22,363	11,384	22,060	4,328

Table A4.10: Hectares Under Each Crop, By District And Lift (Using Average Cropping Patterns For Each District)							
	Project Area (Ha)	**Gravity Fed**	**50 M Lift**	**100 M Lift**	**150 M Lift**	**200 M Lift**	> 200 M Lift
Cotton (Raw)							
Lenin	3,290	3,290	-	-	-	-	-
Gissar	5,055	4,257	798	-	-	-	-
Shahrinov	2,372	1,535	363	22	293	-	158
Kalkhozabad	3,625	2,028	1,458	140	-	-	-
Yavan	7,226	5,321	261	178	928	15	524
Ghozimolik	3,650	2,112	-	-	1,258	-	280
Macho	13,306	1,011	5,036	2,444	1,928	2,209	677
Zaforobod	15,570	-	688	7,187	-	7,694	-
Wheat (Avg Irr & Rainfed)							
Lenin	1,841	1,841	-	-	-	-	-
Gissar	3,614	3,043	571	-	-	-	-
Shahrinov	1,280	829	196	12	158	-	85
Kalkhozabad	1,167	653	469	45	-	-	-
Yavan	5,897	4,342	213	145	757	12	427
Ghozimolik	2,250	1,302	-	-	775	-	172
Macho	11,680	888	4,421	2,146	1,692	1,939	595
Zaforobod	8,212	-	363	3,791	-	4,058	-
Fruit And Vegetables (Sum Of Area Under Eggplants And Apples)							
Lenin	824	824	-	-	-	-	-
Gissar	214	180	34	-	-	-	-
Shahrinov	864	559	132	8	107	-	58
Kalkhozabad	250	140	101	10	-	-	-
Yavan	929	684	34	23	119	2	67
Ghozimolik	1,076	623	-	-	371	-	82
Macho	913	69	346	168	132	152	46
Zaforobod	1,151	-	51	531	-	569	-

Table A4.11: Number Of Hectares That Produce Negative Gross Margins For Three Main Crop Categories									
	Crop Area (Ha)	Gravity Fed	50 M Lift	100 M Lift	150 M Lift	200 M Lift	> 200 M Lift	Area With Negative Margins	
								Total Ha	As % Of Total Ha In The District
Cotton (Raw)									
Lenin	3,290	0	0	0	0	999	0	999	30%
Gissar	5,055	0	0	0	0	0	0	0	0%
Shahrinov	2,372	0	0	0	0	0	0	0	0%
Kalkhozabad	3,625	0	0	0	0	0	0	0	0%
Yavan	7,226	0	0	0	928	15	524	1467	20%
Ghozimolik	3,650	2112	0	0	1258	0	280	3650	100%
Macho	13,306	0	0	0	1928	2209	677	4814	36%
Zaforobod	15,570	0	0	7187	0	7694	0	14882	96%
Wheat (Avg Irr & Rainfed)									
Lenin	1,841	0	0	0	0	0	0	0	0%
Gissar	3,614	0	0	0	0	0	0	0	0%
Shahrinov	1,280	0	0	0	158	0	85	243	19%
Kalkhozabad	1,167	0	0	45	0	0	0	45	4%
Yavan	5,897	0	0	145	757	12	427	1342	23%
Ghozimolik	2,250	1302	0	0	775	0	172	2250	100%
Macho	11,680	888	4421	2146	1692	1939	595	11680	100%
Zaforobod	8,212	0	363	3791	0	4058	0	8212	100%
Fruit and Vegetables (Apples And Eggplants)									
Lenin	824	0	0	0	0	0	0	0	0%
Gissar	214	0	0	0	0	0	0	0	0%
Shahrinov	864	0	0	0	0	0	0	0	0%
Kalkhozabad	250	0	0	0	0	0	0	0	0%
Yavan	929	0	0	0	0	0	0	0	0%
Ghozimolik	1,076	0	0	0	0	0	82	82	8%
Macho	913	0	0	0	0	0	46	46	5%
Zaforobod	1,151	0	0	0	0	0	0	0	0%
Total*	96,256	4,302	4,784	13,314	7,497	16,926	2,889	49,713	52%

*Total area of 96,256 ha in this table is less than the total of 128,432 ha in Table A4.8, because a portion of land that was under an undetermined crop (category "other") is not used in the present table.

Table A4.12: Number Of Hectares That Produce Negative Gross Margins For Three Main Crop Categories (Adjustment Case Scenario)									
	Crop Area (Ha)	Gravity Fed	50 M Lift	100 M Lift	150 M Lift	200 M Lift	> 200 M Lift	Area With Negative Margins	
								Total Ha	As % Of Total Ha In The District
Cotton (Raw)									
Lenin	3,290	0	0	0	0	0	0	0	0%
Gissar	5,055	0	0	0	0	0	0	0	0%
Shahrinov	2,372	0	0	0	0	0	0	0	0%
Kalkhozabad	3,625	0	0	0	0	0	0	0	0%
Yavan	7,226	0	0	0	928	0	0	928	13%
Ghozimolik	3,650	0	0	0	1258	0	280	1538	42%
Macho	13,306	0	0	0	0	0	677	677	5%
Zaforobod	15,570	0	0	0	0	0	0	0	0%
Wheat (Avg Irr & Rainfed)									
Lenin	1,841	0	0	0	0	0	0	0	0%
Gissar	3,614	0	0	0	0	0	0	0	0%
Shahrinov	1,280	0	0	0	158	0	85	243	19%
Kalkhozabad	1,167	0	0	45	0	0	0	45	4%
Yavan	5,897	0	0	0	757	12	427	1197	20%
Ghozimolik	2,250	1302	0	0	775	0	172	2250	100%
Macho	11,680	888	4421	2146	1692	1939	595	11680	100%
Zaforobod	8,212	0	363	3791	0	4058	0	8212	100%
Fruit and Vegetables (Apples And Eggplants)									
Lenin	824	0	0	0	0	0	0	0	0%
Gissar	214	0	0	0	0	0	0	0	0%
Shahrinov	864	0	0	0	0	0	0	0	0%
Kalkhozabad	250	0	0	0	0	0	0	0	0%
Yavan	929	0	0	0	0	0	0	0	0%
Ghozimolik	1,076	0	0	0	0	0	82	82	8%
Macho	913	0	0	0	0	0	46	46	5%
Zaforobod	1,151	0	0	0	0	0	0	0	0%
Total*	96,256	2,190	4,784	5,981	5,569	6,009	2,366	26,899	28%

*Assumed that gross margins are higher than in the current conditions scenario by the following percentage: 10% in areas with 0-50 m lift , 15% in areas with 50-100 m lift , and 20% in areas with over 100 m lift.

Pumping Analysis: Uzbekistan

Table A4.13: Uzbekistan. Cropping Patterns And Soil Quality Index By Province							
Province	Irrigated Cropland (x 1000 Ha)	Soil Quality (Avg Bonitet Grade)	Soil Quality Index (Derived From Bonitet)	Cropping Pattern (% Of Total Arable Area)			
				Cotton	Grain	Orchard and Vineyards	Other
Karakalpakistan	501	41	0.75	0.38	0.27	0.01	0.34
Andijan	272	60	1.09	0.42	0.33	0.09	0.16
Bukhara	274	53	0.96	0.51	0.32	0.06	0.11
Jizzakh	301	50	0.91	0.27	0.52	0.03	0.19
Kashkadarya	505	51	0.93	0.31	0.42	0.04	0.23
Navoi	125	52	0.95	0.37	0.40	0.08	0.14
Namangan	278	59	1.07	0.38	0.34	0.10	0.18
Samarkand	373	57	1.04	0.21	0.46	0.10	0.23
Surkhandarya	328	60	1.09	0.39	0.40	0.07	0.14
Syr Darya	294	49	0.89	0.51	0.37	0.02	0.10
Tashkent	391	59	1.07	0.29	0.37	0.08	0.25
Ferghana	357	56	1.02	0.37	0.39	0.08	0.16
Khorezm	275	54	0.98	0.38	0.18	0.03	0.41
Total	4,274	**55**	**1.00**	0.35	0.38	0.06	0.21

Notes:
1/ Calculated from statistics provided by the WB Country Office in Tashkent. Excludes household plots.

Table A4.14: Pumped Areas By Province						
Province	Total Area Irrigated By Pumps, (x 1000 Ha)	Pumped Area As % Of Total Irrigated Land	Distribution Of Land By Lift (M Of Pumping Head)			
			0-50	50-100	100-150	150-200
Karakalpakistan	327	65%	327	0	0	0
Andijan	200	74%	100	50	50	0
Bukhara	274	100%	274	0	0	0
Jizzakh	97	32%	25	40	32	0
Kashkadarya	404	80%	80	0	320	4
Navoi	89	71%	53	36	0	0
Namangan	95	34%	45	30	20	0
Samarkand	100	27%	100	0	0	0
Surkhandarya	218	66%	173	35	10	0
Syr Darya	30	10%	30	0	0	0
Tashkent	75	19%	0	58	17	0
Ferghana	115	32%	60	20	15	20
Khorezm	176	64%	176	0	0	0
Total	2,200		1,443	269	464	24

Table A4.15: Energy Costs Of Pumping Water (Using The Economic Price Of $0.05/kWh For Electricity)						
	Gravity Fed	**50 M Lift**	**100 M Lift**	**150 M Lift**	**200 M Lift**	250 M Lift
Tajikistan: Cost Per kWh: $0.022						
Uzbekistan: Cost Per kWh: $0.05						
Tajikistan: Cost Per 1000 m3	2	4	8	12	16	20
Uzbekistan: Cost Per 1000 m3	**4**	**7**	**15**	**22**	**29**	**36**
Pumping Costs in $/Ha/Yr**						
Wheat						
Water Use (x1000 m3/ha)	6	6	6	6	6	6
Energy Costs ($/ha)	22	44	87	131	174	218
Cotton						
Water Use (x1000 m3/ha)	14	14	14	14	14	14
Energy Costs ($/ha)	51	102	205	307	409	512
Vegetables & Fruit						
Water Use (x1000 m3/ha)	11	11	11	11	11	11
Energy Costs ($/ha)	42	83	167	250	333	417

*Source of crop water requirement data is MMD, 1998. Source of energy requirements: Tajikistan PAD and WB expert opinion.
** We use same assumptions of cost of pumping one m3 as Tajikistan, but use Uzbekistan-specific water requirements

Table A4.16: Pumping Costs Adjusted For Height Categories				
	0-50 m	**50-100 m**	**100-150 m**	**150-200 m**
Tajikistan: Cost Per kWh: $0.022				
Uzbekistan: Cost Per kWh: $0.05				
Tajikistan: Cost Per 1000 m3	3	6	10	14
Uzbekistan: Cost Per 1000 m3	**5**	**11**	**18**	**25**
Pumping Costs In $/Ha/Yr				
Wheat	33	65	109	153
Cotton	77	153	256	358
Vegetables	63	125	208	292

Table A4.17: Yields by Province (T/Ha/Yr, Taking National Average And Multiplying By Soil Quality Index)			
	Wheat	Cotton	Vegetables & Fruits
Karakalpakistan	1.9	1.6	8.2
Andijan	2.7	2.4	12.0
Bukhara	2.4	2.1	10.6
Jizzakh	2.3	2.0	10.0
Kashkadarya	2.3	2.0	10.2
Navoi	2.4	2.1	10.4
Namangan	2.7	2.4	11.8
Samarkand	2.6	2.3	11.4
Surkhandarya	2.7	2.4	12.0
Syr Darya	2.2	2.0	9.8
Tashkent	2.7	2.4	11.8
Ferghana	2.5	2.2	11.2
Khorezm	2.5	2.2	10.8
Average	2.5	2.2	11.0

*Average yields are from RESP, and soil quality index from Table A3.1. RESP Yields: 2.5 t/ha for wheat, 2.2. t/ha for cotton, and 11.0 t/ha for fruits.
**Wheat yield is high here compared to data from the RESP survey. The yields are from RESP economic analysis.

Table A4.18: Gross Margins Without Energy Costs, But Subtracting Out O&M Costs Of Water Delivery ($15/ha/yr)			
	Wheat	Cotton	Vegetables & Fruits
Karakalpakistan	83	382	497
Andijan	122	558	728
Bukhara	108	493	643
Jizzakh	102	465	607
Kashkadarya	104	475	619
Navoi	106	484	631
Namangan	120	549	716
Samarkand	116	531	692
Surkhandarya	122	558	728
Syr Darya	100	456	594
Tashkent	120	549	716
Ferghana	114	521	679
Khorezm	110	503	655
Average	112	512	667

*Average gross margins for Uzbekistan are from RESP. Re-calculated using yields in Table A4.16 for each Province.

Table A4.19: Gross Margin For Various Lift Heights ($/Ha/Yr), After Subtracting Energy And Other O&M Costs Of Water Delivery (At $15/Ha/Yr)				
	Up To 50 M	**50-100 M**	**100-150 M**	**150-200 M**
Wheat				
Karakalpakistan	51	18	(26)	(69)
Andijan	89	57	13	(31)
Bukhara	75	42	(1)	(45)
Jizzakh	69	36	(7)	(51)
Kashkadarya	71	38	(5)	(49)
Navoi	73	40	(3)	(47)
Namangan	87	55	11	(33)
Samarkand	83	51	7	(37)
Surkhandarya	89	57	13	(31)
Syr Darya	67	34	(9)	(53)
Tashkent	87	55	11	(33)
Ferghana	81	49	5	(39)
Khorezm	77	44	1	(43)
Average	77	44	1	(43)
Cotton				
Karakalpakistan	305	228	126	23
Andijan	482	405	303	200
Bukhara	417	340	237	135
Jizzakh	389	312	210	107
Kashkadarya	398	321	219	117
Navoi	407	330	228	126
Namangan	472	396	293	191
Samarkand	454	377	275	172
Surkhandarya	482	405	303	200
Syr Darya	379	303	200	98
Tashkent	472	396	293	191
Ferghana	444	368	265	163
Khorezm	426	349	247	144
Average	425	348	246	144
Vegetables & Fruit				
Karakalpakistan	435	372	289	206
Andijan	665	603	519	436
Bukhara	580	518	435	351
Jizzakh	544	482	398	315
Kashkadarya	556	494	410	327
Navoi	568	506	422	339
Namangan	653	591	507	424
Samarkand	629	566	483	400
Surkhandarya	665	603	519	436
Syr Darya	532	469	386	303
Tashkent	653	591	507	424
Ferghana	617	554	471	388
Khorezm	593	530	447	363
Average	592	529	446	362

Table A4.20: Population by Province		
Province	Total Population (x1000)	Rural Population (x1000)
Karakalpakistan	1,515	784
Andijan	2,201	1,540
Bukhara	1,429	987
Jizzakh	983	687
Kashkadarya	2,190	1,635
Navoi	787	469
Namangan	1,939	1,212
Samarkand	2,690	1,964
Surkhandarya	1,754	1,407
Syr Darya	646	439
Tashkent	2,360	1,410
Ferghana	2,681	1,903
Khorezm	1,336	1,020
Tashkent (City)	2,140	
Total	24,650	15,455

Table A4.21: Crop Areas (x1000 Ha) (Using Average Cropping Patterns For Each Province)						
	Total Area	**Gravity**	**Up To 50 M**	**50-100 M**	**100-150 M**	**150-200 M**
Cotton						
Karakalpakistan	191	66	125	-	-	-
Andijan	114	30	42	21	21	-
Bukhara	139	-	139	-	-	-
Jizzakh	80	54	7	11	9	-
Kashkadarya	158	32	25	-	100	1
Navoi	46	13	20	13	-	-
Namangan	106	70	17	11	8	-
Samarkand	78	57	21	-	-	-
Surkhandarya	130	43	68	14	4	-
Syr Darya	150	134	15	-	-	-
Tashkent	114	92	-	17	5	-
Ferghana	133	90	22	7	6	7
Khorezm	105	38	67	-	-	-
Wheat						
Karakalpakistan	137	48	90	-	-	-
Andijan	90	24	33	16	16	-
Bukhara	88	-	88	-	-	-
Jizzakh	155	105	13	21	16	-
Kashkadarya	211	42	33	-	134	2
Navoi	50	14	21	14	-	-
Namangan	93	61	15	10	7	-
Samarkand	172	126	46	-	-	-
Surkhandarya	130	44	69	14	4	-
Syr Darya	110	99	11	-	-	-
Tashkent	147	118	-	22	6	-
Ferghana	138	93	23	8	6	8
Khorezm	50	18	32	-	-	-
Fruits And Vegetables						
Karakalpakistan	5	2	3	-	-	-
Andijan	24	6	9	4	4	-
Bukhara	17	-	17	-	-	-
Jizzakh	9	6	1	1	1	-
Kashkadarya	18	4	3	-	12	0
Navoi	11	3	4	3	-	-
Namangan	28	19	5	3	2	-
Samarkand	38	28	10	-	-	-
Surkhandarya	23	8	12	2	1	-
Syr Darya	6	5	1	-	-	-
Tashkent	31	25	-	5	1	-
Ferghana	30	20	5	2	1	2
Khorezm	8	3	5	-	-	-
Total	3,363					
Other land*	911					
Actual total	4,274					
*Land that could not be allocated to a particular crop (see category “other” in Table A4.12) is not included in the Total.						

Table A4.22: Areas (x1000 Ha) That Produce Negative Gross Margins For Three Main Crop Categories								
	Total Area	**Gravity**	**Up To 50 M**	**50-100 M**	**100-150 M**	**150-200 M**	Negative Ha As % Of Total	"Affected" Population
Cotton								
Karakalpakistan	191		-	-	-	-	0%	-
Andijan	114		-	-	-	-	0%	-
Bukhara	139		-	-	-	-	0%	-
Jizzakh	80		-	-	-	-	0%	-
Kashkadarya	158		-	-	-	-	0%	-
Navoi	46		-	-	-	-	0%	-
Namangan	106		-	-	-	-	0%	-
Samarkand	78		-	-	-	-	0%	-
Surkhandarya	130		-	-	-	-	0%	-
Syr Darya	150		-	-	-	-	0%	-
Tashkent	114		-	-	-	-	0%	-
Ferghana	133		-	-	-	-	0%	-
Khorezm	105		-	-	-	-	0%	-
Wheat								
Karakalpakistan	137		-	-	-	-	0%	-
Andijan	90		-	-	-	-	0%	-
Bukhara	88		-	-	-	-	0%	-
Jizzakh	155		-	-	16	-	11%	73
Kashkadarya	211		-	-	134	2	64%	1,049
Navoi	50		-	-	-	-	0%	-
Namangan	93		-	-	-	-	0%	-
Samarkand	172		-	-	-	-	0%	-
Surkhandarya	130		-	-	-	-	0%	-
Syr Darya	110		-	-	-	-	0%	-
Tashkent	147		-	-	-	-	0%	-
Ferghana	138		-	-	-	8	6%	107
Khorezm	50		-	-	-	-	0%	-
Fruits And Vegetables								
Karakalpakistan	5		-	-	-	-	0%	-
Andijan	24		-	-	-	-	0%	-
Bukhara	17		-	-	-	-	0%	-
Jizzakh	9		-	-	-	-	0%	-
Kashkadarya	18		-	-	-	-	0%	-
Navoi	11		-	-	-	-	0%	-
Namangan	28		-	-	-	-	0%	-
Samarkand	38		-	-	-	-	0%	-
Surkhandarya	23		-	-	-	-	0%	-
Syr Darya	6		-	-	-	-	0%	-
Tashkent	31		-	-	-	-	0%	-
Ferghana	30		-	-	-	-	0%	-
Khorezm	8		-	-	-	-	0%	-

*"Affected" population is calculated as rural population in the rayon multiplied by the percentage of 'negative hectares'

Table A4.23: Total Area That Produces Negative Gross Margins								
	Total Area	**Gravity**	**Up To 50 M**	**50-100 M**	**100-150 M**	**150-200 M**	Negative Ha As % Of Total	"Affected" Population
Karakalpakistan	333	-	-	-	-	-	0%	-
Andijan	227	-	-	-	-	-	0%	-
Bukhara	244	-	-	-	-	-	0%	-
Jizzakh	244	-	-	-	16	-	11%	73
Kashkadarya	388	-	-	-	134	2	64%	1,049
Navoi	107	-	-	-	-	-	0%	-
Namangan	227	-	-	-	-	-	0%	-
Samarkand	288	-	-	-	-	-	0%	-
Surkhandarya	283	-	-	-	-	-	0%	-
Syr Darya	266	-	-	-	-	-	0%	-
Tashkent	292	-	-	-	-	-	0%	-
Ferghana	301	-	-	-	-	8	6%	107
Khorezm	163	-	-	-	-	-	0%	-
Total	3,363	-	-	-	150	9	5%	1,228

*A very rough estimate of the "affected" population is calculated as the rural population in the province multiplied by the percentage of total area that results in negative margins.

Table A4.24: Comparison Of Economic Gross Margins In Project Appraisals 1/						
	Cotton			**Wheat (Irrigated)**		
	Tajikistan RIRP	**Uzbekistan RESP**	**Uzbekistan MMD**	**Tajikistan RIRP**	**Uzbekistan RESP**	**Uzbekistan MMD**
Indicator Price ($/Ton)	1,180	na	1,577	122	na	133
Reference Date	Projected 2000	na	Projected 2010	Projected 2000	na	Projected 2010
Output Farmgate Price ($/Ton)	261	302	393	155	165	263
Yield (t/ha)	1.8	2.1	2.8	1.5	2.5	2.7
Revenues ($/ha)	470	634	1,100	232	413	710
Revenues From By-Product ($/Ha)			42			15
Costs ($/ha)	429	370	325	153	268	390
Machinery	104	147	149	59	119	108
Labor	105	58	56	15	14	3
Seed	18	27	38	29	50	239
Fertilizer	97	85	69	27	59	40
Pesticide	90	53	13	15	26	-
Transport	15	-	-	8	-	-
Water Delivery 3/	-	-	-	-	-	-
Gross Margin (Before Energy Costs)	41	264	817	79	145	335

Notes:
1/ Source of data for Tajikistan: Rural Infrastructure Rehabilitation Project PAD, 2000.
Source of data for Uzbekistan: Rural Enterprise Support Project (RESP) (2000).
Source of data for Uzbekistan (MMD): Mott Mac Donald, Preparation Study of the Uzbekistan Drainage Project Phase II Prefeasibility Study. Draft Final Report. Part III. Annexes F to L. September 1998.
2/ Output farm gate price for cotton includes $393/ton for the main product and $10/ton for by-products; for wheat it is $263/ton for the main product and $15/ha for by-products. (For detailed crop budget calculation, see MMD report, Appendix L-II Crop Budgets (baseline scenario)).
3/ Water delivery costs are zero in all three cases.

Methodology for Calculating a Proxy for Income Lost When Irrigated Land Becomes Non-Irrigated

The calculation of a proxy for income lost when irrigated land becomes non-irrigated is based upon data from household surveys and the judgment of local experts. It utilizes conservative assumptions. We aim to indicate the order of magnitude of different types of expenses involved, as well as to discern variation among different parts of the country. The goal is to help policymakers decide what kind of investments to make and where, rather than to provide site-specific analysis of individual projects.

The calculation proceeds as follows:

- First, the costs of maintaining the I&D infrastructure are calculated for each district. We assume that the rehabilitation of on- and off-farm structures costs $150/ha over five years, plus an additional $15/ha/year for the annual O&M costs. We do not estimate the cost of rehabilitating the largest off-farm structures, i.e. trunk canals, major dams and weirs, pump aggregates, and the like.
- Second, we calculate the amount that the government would have to compensate people for lost income. To do this, we estimated the cost of letting the I&D infrastructure degrade, i.e. the lost incremental income as irrigated land becomes non-irrigated. It is equal to the difference between the income per irrigated ha times the total irrigated area in each district in every period, minus the income per non-irrigated ha times the irrigated area in the same period.[4] We assume that, without rehabilitation, irrigated area gradually contracts at the rate of 10% per year over a period of ten years, and in ten years all the current irrigated area becomes non-irrigated. The figures used here are conservative estimates of agricultural income, based upon the 2000 household survey data. Because most farmers in rural Kyrgyzstan are at or below the basic subsistence level, we consider this incremental income as the amount of compensation that the Government would need to provide to farmers as an income transfer in case the irrigation system collapses.[5] The calculation does not include the

[4] For this, the average farm income norm for each province is adjusted by land quality in each district, and the income norms for irrigated and non-irrigated land in each district are derived. The norms were provided by the National Statistical Committee.

[5] Note that we take the incremental income from irrigated land (as 20%, 35%, or same as current non-irrigated, depending upon the scenario) and divide it by the total rural population in the district for which this income is calculated. In reality, not all of the rural population is dependent upon irrigation. Making an adjustment to the rural population to reflect this would increase the amount of lost income per person, but would reduce the total number of people that incur this loss. In our calculation the total cost to the budget of compensating this lost incremental

administrative cost of providing people with income transfers to compensate them for lost income, because they are currently negligible.[6]

- All costs streams of cash flows are expressed in PV terms, discounted at 12%.

Using these assumptions, we estimate the value of the lost agricultural income. The results of the calculation, disaggregated by district, are presented Tables A4.24, A4.25, and A4.26 in the following pages.

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income would not be affected by such an adjustment. Therefore, we assume that all rural population is dependent on irrigated land.

[6] In the Kyrgyz Republic, the current social assistance costs $0.22 per month per person to administer.

Table A4.24: Comparison Of The Costs Of Rehabilitation Of I&D Infrastructure With Social Assistance Payments And No Rehabilitation

SCENARIO 1 *(land in hectares, population in number of persons, and monetary values in US$, converted from soms at the prevailing year average exchange rate)*

District (Rayon)	Rural Population	Irrigated Land (ha)	Income From irrigated Land, $/ha/yr 3/	Income From Non-Irrigated Land, $/ha/yr 3/	(A) PV Of 10 Yrs Of Incremental Income, $ (discounted at 12%)	(B) Costs Of Keeping Infrastructure In Operation For 10 Years 1/ current $	(C) NPV Of 10 Yrs Of Costs Of Delivering Social Assistance, $ $0.22/month per person, (discounted at 12%)	(D)=(A)+(C) Required Funding/Welfare (Admin Costs + Compensation Of Lost Income)	(E)=(B)/(A) Ratio Of Rehab Costs To Lost Income
Assumptions							0.22		
Batken Province									
Batken	77,374	14,768	302	60	9,243,908	2,514,927	72,135	9,316,043	27%
Kamajay	119,484	25,712	310	62	16,506,887	4,378,644	111,393	16,618,280	27%
Leylek	100,285	13,835	302	60	8,659,904	2,356,042	93,494	8,753,399	27%
T-k Kysyl-Kyya	11,217	2,136	364	73	1,611,270	363,752	10,457	1,621,728	23%
T-k Suluktu	729		364	73	-	-	-	-	
Subtotal	309,089	56,451			36,021,969	9,613,365	287,480	36,309,449	27%
Osh Province									
Alay	64,320	11,271	92	18	2,155,241	1,919,403	59,965	2,215,206	89%
Ararvan	91,438	22,225	426	85	19,618,860	3,784,823	85,246	19,704,107	19%
Kara-Suu	274,900	6,440	472	94	6,304,999	1,096,705	256,286	6,561,285	17%
Kara-Kulja	80,252	38,909	82	16	6,644,904	6,626,037	74,818	6,719,722	100%
Nookat	194,658	24,165	465	93	23,270,589	4,115,197	181,477	23,452,066	18%
Ozgon	152,269	20,605	465	93	19,842,354	3,508,944	141,958	19,984,312	18%
Chon-Alay	21,759	15,645	72	14	2,350,573	2,664,277	20,286	2,370,858	113%
T-k Osh	23,912	3,338	364	73	2,517,987	568,447	22,293	2,540,280	23%
Subtotal	903,508	142,598			82,705,507	24,283,832	842,329	83,547,835	29%
Jalalabad Province									
Ala-Buka	72,589	16,799	438	88	15,239,904	2,860,798	67,674	15,307,578	19%
Aksy	94,631	11,867	454	91	11,171,888	2,020,900	88,223	11,260,111	18%
Bazar-Korgon	119,007	16,167	438	88	14,666,559	2,753,171	110,949	14,777,508	19%
Nooken	85,415	21,744	479	96	21,586,904	3,702,911	79,631	21,666,535	17%
Suzak	190,209	31,845	479	96	31,614,926	5,423,068	177,329	31,792,255	17%
Toktogul	62,573	3,637	94	19	712,026	619,366	58,336	770,362	87%
Toguz-Toro	21,968	13,756	88	18	2,505,165	2,342,588	20,480	2,525,645	94%
Chatkal	11,784	7,061	99	20	1,446,648	1,202,458	10,986	1,457,634	83%
T-k Jalalabad	7,010	1,864	77	15	297,028	317,431	6,535	303,564	107%
T-k Tash-Komur	3,321	1,119	405	81	938,532	190,561	3,096	941,628	20%
Subtotal	668,507	125,859			100,179,580	21,433,251	623,240	100,802,820	21%

District (Rayon)	Rural Population	Irrigated Land (ha)	Income From irrigated Land, $/ha/yr 3/	Income From Non-Irrigated Land, $/ha/yr 3/	PV Of 10 Yrs Of Incremental Income, $	Costs Of Keeping Infrastructure In Operation For 10 Years 1/	NPV Of 10 Yrs Of Costs Of Delivering Social Assistance, $	Required Funding/Welfare (Admin Costs + Compensation Of Lost Income)	Ratio Of Rehab Costs To Lost Income
Issyk-Kul Province									
Ak-Suu	55,764	40,309	380	76	31,770,902	6,864,451	51,988	31,822,890	22%
Jeti-Oguz	74,414	42,136	311	62	27,122,247	7,175,581	69,375	27,191,622	26%
Ysyk-Kul	61,826	31,731	285	57	18,757,396	5,403,654	57,640	18,815,036	29%
Tong	42,265	24,752	83	17	4,282,310	4,215,160	39,403	4,321,713	98%
Tup	53,420	23,528	387	77	18,853,463	4,006,718	49,803	18,903,265	21%
Subtotal	287,689	162,456			100,786,317	27,665,565	268,209	101,054,526	27%
Naryn Province									
Ak-Tala	29,227	15,479	86	17	2,748,474	2,636,008	27,248	2,775,722	96%
At-Bashy	45,219	32,086	81	16	5,405,072	5,464,109	42,157	5,447,229	101%
Jumgal	36,142	18,290	88	18	3,330,871	3,114,709	33,695	3,364,566	94%
Kochkor	53,089	34,362	97	19	6,883,594	5,851,702	49,494	6,933,089	85%
Naryn	39,811	26,440	103	21	5,657,746	4,502,619	37,115	5,694,862	80%
Subtotal	203,488	126,657			24,025,758	21,569,147	189,709	24,215,467	90%
Chui Province									
Kemin	30,772	54,730	226	45	25,652,700	9,320,286	28,688	25,681,388	36%
Ysyk-Ata	102,908	41,435	250	50	21,487,231	7,056,204	95,940	21,583,171	33%
Alamudun	122,559	315,085	255	51	166,538,008	53,657,633	114,260	166,652,268	32%
Sokuluk	126,991	55,178	260	52	29,714,572	9,396,578	118,392	29,832,964	32%
Moskva	83,608	27,663	250	50	14,345,391	4,710,891	77,947	14,423,338	33%
Jayyl	53,148	29,121	97	19	16,717,529	4,959,182	49,549	16,767,079	30%
Panfilov	36,521	31,237	231	46	14,952,724	5,319,528	34,048	14,986,772	36%
T-k Chui-Tokmok	45,071		241	48	-	-	-	-	
T-k Bishkek	4,104	1,718	241	48	856,649	292,568	3,826	860,475	34%
Subtotal	605,682	556,167			290,264,805	94,712,870	522,650	290,787,455	33%
Talas Province									
Talas	50,068	33,844	140	28	9,803,181	5,763,489	46,678	9,849,859	59%
Bakai-Ata	38,898	26,362	149	30	8,156,595	4,489,336	36,264	8,192,859	55%
Kara-Buura	48,997	29,181	165	33	9,989,326	4,969,400	45,679	10,035,005	50%
Manas	28,389	17,087	156	31	5,511,814	2,909,843	26,467	5,538,281	53%
Subtotal	166,352	106,474			33,460,916	18,132,069	155,088	33,616,004	54%
Total	3,144,315	1,276,662			**667,444,852**	**217,410,099**	2,888,705	670,333,557	33%

Table A4.25: Comparison Of The Costs Of Rehabilitation Of I&D Infrastructure With Social Assistance Payments And No Rehabilitation

SCENARIO 2 *(land in hectares, population in number of persons, and monetary values in US$, converted from soms at the prevailing year average exchange rate)*

District (Rayon)	Rural Population	Irrigated Land (ha)	Income From irrigated Land, $/ha/yr 3/	Income From Non-Irrigated Land, $/ha/yr 3/	(A) PV Of 10 Yrs Of Incremental Income, $ (discounted at 12%)	(B) Costs Of Keeping Infrastructure In Operation For 10 Years 1/ current $	(C) NPV Of 10 Yrs Of Costs Of Delivering Social Assistance, $ $0.22/month per person, (discounted at 12%)	(D)=(A)+(C) Required Funding/Welfare (Admin Costs + Compensation Of Lost Income)	(E)=(B)/(A) Ratio Of Rehab Costs To Lost Income
Assumptions							0.22		
Batken Province									
Batken	77,374	14,768	302	106	7,510,675	2,514,927	72,135	7,582,810	33%
Kamajay	119,484	25,712	310	108	13,411,845	4,378,644	111,393	13,523,239	33%
Leylek	100,285	13,835	302	106	7,036,172	2,356,042	93,494	7,129,667	33%
T-k Kysyl-Kyya	11,217	2,136	364	127	1,309,157	363,752	10,457	1,319,615	28%
T-k Suluktu	729		364	127	-	-	-	-	
Subtotal	309,089	56,451			29,267,850	9,613,365	287,480	29,555,330	33%
Osh Province									
Alay	64,320	11,271	92	32	1,751,134	1,919,403	59,965	1,811,098	110%
Ararvan	91,438	22,225	426	149	15,940,324	3,784,823	85,246	16,025,571	24%
Kara-Suu	274,900	6,440	472	165	5,122,812	1,096,705	256,286	5,379,097	21%
Kara-Kulja	80,252	38,909	82	29	5,398,984	6,626,037	74,818	5,473,802	123%
Nookat	194,658	24,165	465	163	18,907,353	4,115,197	181,477	19,088,830	22%
Ozgon	152,269	20,605	465	163	16,121,912	3,508,944	141,958	16,263,871	22%
Chon-Alay	21,759	15,645	72	25	1,909,840	2,664,277	20,286	1,930,126	140%
T-k Osh	23,912	3,338	364	127	2,045,865	568,447	22,293	2,068,157	28%
Subtotal	903,508	142,598			67,198,224	24,283,832	842,329	83,547,835	36%
Jalalabad Province									
Ala-Buka	72,589	16,799	438	153	12,382,422	2,860,798	67,674	12,450,096	23%
Aksy	94,631	11,867	454	159	9,077,159	2,020,900	88,223	9,165,382	22%
Bazar-Korgon	119,007	16,167	438	153	11,916,579	2,753,171	110,949	12,027,528	23%
Nooken	85,415	21,744	479	168	17,539,359	3,702,911	79,631	17,618,991	21%
Suzak	190,209	31,845	479	168	25,687,127	5,423,068	177,329	25,864,457	21%
Toktogul	62,573	3,637	94	33	578,521	619,366	58,336	636,857	107%
Toguz-Toro	21,968	13,756	88	31	2,035,447	2,342,588	20,480	2,055,927	115%
Chatkal	11,784	7,061	99	35	1,175,402	1,202,458	10,986	1,186,388	102%
T-k Jalalabad	7,010	1,864	77	27	241,336	317,431	6,535	247,871	132%
T-k Tash-Komur	3,321	1,119	405	142	762,557	190,561	3,096	765,653	25%
Subtotal	668,507	125,859			81,395,909	21,433,251	623,240	82,019,149	26%

District (Rayon)	Rural Population	Irrigated Land (ha)	Income From irrigated Land, $/ha/yr 3/	Income From Non-Irrigated Land, $/ha/yr 3/	PV Of 10 Yrs Of Incremental Income, $	Costs Of Keeping Infrastructure In Operation For 10 Years 1/	NPV Of 10 Yrs Of Costs Of Delivering Social Assistance, $	Required Funding/Welfare (Admin Costs + Compensation Of Lost Income)	Ratio Of Rehab Costs To Lost Income
Issyk-Kul Province									
Ak-Suu	55,764	40,309	380	133	25,813,858	6,864,451	51,988	25,865,846	27%
Jeti-Oguz	74,414	42,136	311	109	22,036,825	7,175,581	69,375	22,106,201	33%
Ysyk-Kul	61,826	31,731	285	100	15,240,384	5,403,654	57,640	15,298,024	35%
Tong	42,265	24,752	83	29	3,479,377	4,215,160	39,403	3,518,780	121%
Tup	53,420	23,528	387	135	15,318,438	4,006,718	49,803	15,368,241	26%
Subtotal	287,689	162,456			81,888,883	27,665,565	268,209	82,157,091	34%
Naryn Province									
Ak-Tala	29,227	15,479	86	30	2,233,135	2,636,008	27,248	2,260,383	118%
At-Bashy	45,219	32,086	81	28	4,391,621	5,464,109	42,157	4,433,778	124%
Jumgal	36,142	18,290	88	31	2,706,333	3,114,709	33,695	2,740,028	115%
Kochkor	53,089	34,362	97	34	5,592,920	5,851,702	49,494	5,642,415	105%
Naryn	39,811	26,440	103	36	4,596,919	4,502,619	37,115	4,634,034	98%
Subtotal	203,488	126,657			19,520,929	21,569,147	189,709	19,710,638	110%
Chui Province									
Kemin	30,772	54,730	226	79	20,842,818	9,320,286	28,688	20,871,507	45%
Ysyk-Ata	102,908	41,435	250	88	17,458,375	7,056,204	95,940	17,554,315	40%
Alamudun	122,559	315,085	255	89	135,312,132	53,657,633	114,260	135,426,392	40%
Sokuluk	126,991	55,178	260	91	24,143,090	9,396,578	118,392	24,261,482	39%
Moskva	83,608	27,663	250	88	11,655,630	4,710,891	77,947	11,733,577	40%
Jayyl	53,148	29,121	241	84	11,798,028	4,959,182	49,549	11,847,577	42%
Panfilov	36,521	31,237	231	81	12,149,088	5,319,528	34,048	12,183,136	44%
T-k Chui-Tokmok	45,071		241	84	-	-	-	-	
T-k Bishkek	4,104	1,718	241	84	696,027	292,568	3,826	699,853	42%
Subtotal	605,682	556,167			234,055,189	94,712,870	522,650	234,577,839	40%
Talas Province									
Talas	50,068	33,844	140	49	7,965,085	5,763,489	46,678	8,011,763	72%
Bakai-Ata	38,898	26,362	149	52	6,627,233	4,489,336	36,264	6,663,497	68%
Kara-Buura	48,997	29,181	165	58	8,116,327	4,969,400	45,679	8,162,007	61%
Manas	28,389	17,087	156	54	4,478,349	2,909,843	26,467	4,504,816	65%
Subtotal	166,352	106,474			27,186,995	18,132,069	155,088	27,342,082	67%
Total	3,144,315	1,276,662			**540,513,978**	**217,410,099**	2,888,705	543,402,682	40%

Table A4.26: Comparison Of The Costs Of Rehabilitation Of I&D Infrastructure With Social Assistance Payments And No Rehabilitation

SCENARIO 3 *(land in hectares, population in number of persons, and monetary values in US$, converted from soms at the prevailing year average exchange rate)*

District (Rayon)	Rural Population	Irrigated Land (ha)	Income From irrigated Land, $/ha/yr 3/	Income From Non-Irrigated Land, $/ha/yr 3/	(A) PV Of 10 Yrs Of Incremental Income, $	(B) Costs Of Keeping Infrastructure In Operation For 10 Years 1/	(C) NPV Of 10 Yrs Of Costs Of Delivering Social Assistance, $	(D)=(A)+(C) Required Funding/Welfare (Admin Costs + Compensation Of Lost Income)	(E)=(B)/(A) Ratio Of Rehab Costs To Lost Income
					(discounted at 12%)	current $	$0.22/month per person, (discounted at 12%)		
Assumptions							0.22		
Batken Province									
Batken	77,374	14,768	302	132	6,518,140	2,514,927	72,135	6,590,275	39%
Kamajay	119,484	25,712	310	132	11,864,325	4,378,644	111,393	11,975,718	37%
Leylek	100,285	13,835	302	132	6,106,343	2,356,042	93,494	6,199,837	39%
T-k Kysyl-Kyya	11,217	2,136	302	132	942,765	363,752	10,457	953,222	39%
T-k Suluktu	729		302	132	-	-	-	-	
Subtotal	309,089	56,451			25,431,572	9,613,365	287,480	25,719,052	38%
Osh Province									
Alay	64,320	11,271	92	48	1,295,165	1,919,403	59,965	1,355,129	148%
Ararvan	91,438	22,225	426	132	16,943,561	3,784,823	85,246	17,028,808	22%
Kara-Suu	274,900	6,440	472	132	5,684,835	1,096,705	256,286	5,941,121	19%
Kara-Kulja	80,252	38,909	82	48	3,476,984	6,626,037	74,818	3,551,802	191%
Nookat	194,658	24,165	465	194	16,968,138	4,115,197	181,477	17,149,615	24%
Ozgon	152,269	20,605	465	194	14,468,383	3,508,944	141,958	14,610,341	24%
Chon-Alay	21,759	15,645	72	-	2,938,216	2,664,277	20,286	2,958,501	91%
T-k Osh	23,912	3,338	364	155	1,808,129	568,447	22,293	1,830,422	31%
Subtotal	903,508	142,598			63,583,411	24,283,832	842,329	64,425,739	38%
Jalalabad Province									
Ala-Buka	72,589	16,799	438	140	12,939,541	2,860,798	67,674	13,007,215	22%
Aksy	94,631	11,867	454	190	8,125,009	2,020,900	88,223	8,213,232	25%
Bazar-Korgon	119,007	16,167	438	140	12,452,739	2,753,171	110,949	12,563,687	22%
Nooken	85,415	21,744	479	140	19,074,635	3,702,911	79,631	19,154,266	19%
Suzak	190,209	31,845	479	140	27,935,603	5,423,068	177,329	28,112,932	19%
Toktogul	62,573	3,637	94	46	457,055	619,366	58,336	515,391	136%
Toguz-Toro	21,968	13,756	88	46	1,493,832	2,342,588	20,480	1,514,313	157%
Chatkal	11,784	7,061	77	-	1,406,463	1,202,458	10,986	1,417,449	85%
T-k Jalalabad	7,010	1,864	405	173	1,116,701	317,431	6,535	1,123,236	28%
T-k Tash-Komur	3,321	1,119	405	173	670,380	190,561	3,096	673,476	28%
Subtotal	668,507	125,859			85,671,958	21,433,251	623,240	86,295,199	25%

District (Rayon)	Rural Population	Irrigated Land (ha)	Income From irrigated Land, $/ha/yr 3/	Income From Non-Irrigated Land, $/ha/yr 3/	PV Of 10 Yrs Of Incremental Income, $	Costs Of Keeping Infrastructure In Operation For 10 Years 1/	NPV Of 10 Yrs Of Costs Of Delivering Social Assistance, $	Required Funding/Welfare (Admin Costs + Compensation Of Lost Income)	Ratio Of Rehab Costs To Lost Income
Issyk-Kul Province									
Ak-Suu	55,764	40,309	380	222	16,547,345	6,864,451	51,988	16,599,333	41%
Jeti-Oguz	74,414	42,136	311	190	13,145,987	7,175,581	69,375	13,215,362	55%
Ysyk-Kul	61,826	31,731	285	171	9,378,698	5,403,654	57,640	9,436,338	58%
Tong	42,265	24,752	83	26	3,654,215	4,215,160	39,403	3,693,618	115%
Tup	53,420	23,528	387	247	8,499,512	4,006,718	49,803	8,549,315	47%
Subtotal	287,689	162,456			51,225,757	27,665,565	268,209	51,493,966	54%
Naryn Province									
Ak-Tala	29,227	15,479	86	37	1,938,027	2,636,008	27,248	1,965,275	136%
At-Bashy	45,219	32,086	81	55	2,191,245	5,464,109	42,157	2,233,402	249%
Jumgal	36,142	18,290	88	37	2,394,064	3,114,709	33,695	2,427,759	130%
Kochkor	53,089	34,362	97	37	5,280,030	5,851,702	49,494	5,329,524	111%
Naryn	39,811	26,440	103	55	3,310,384	4,502,619	37,115	3,347,499	136%
Subtotal	203,488	126,657			15,113,749	21,569,147	189,709	15,303,458	143%
Chui Province									
Kemin	30,772	54,730	226	144	11,598,295	9,320,286	28,688	11,626,983	80%
Ysyk-Ata	102,908	41,435	250	135	12,396,479	7,056,204	95,940	12,492,419	57%
Alamudun	122,559	315,085	255	120	109,977,930	53,657,633	114,260	10,092,190	49%
Sokuluk	126,991	55,178	260	120	19,947,282	9,396,578	118,392	20,065,674	47%
Moskva	83,608	27,663	250	120	9,310,710	4,710,891	77,947	9,388,657	51%
Jayyl	53,148	29,121	97	120	na	4,959,182	49,549	na	na
Panfilov	36,521	31,237	231	120	8,956,059	5,319,528	34,048	8,990,107	59%
T-k Chui-Tokmok	45,071		255	135	-	-	-	-	
T-k Bishkek	4,104	1,718	255	135	535,406	292,568	3,826	539,232	55%
Subtotal	605,682	556,167			172,722,162	94,712,870	522,650	171,486,692	55%
Talas Province									
Talas	50,068	33,844	149	79	6,126,988	5,763,489	46,678	6,173,666	94%
Bakai-Ata	38,898	26,362	165	54	7,592,575	4,489,336	36,264	7,628,839	59%
Kara-Buura	48,997	29,181	156	54	7,684,097	4,969,400	45,679	7,729,776	65%
Manas	28,389	17,087	140	79	2,671,543	2,909,843	26,467	2,698,009	109%
Subtotal	166,352	106,474			24,075,203	18,132,069	155,088	24,230,291	75%
Total	3,144,315	1,276,662			**437,823,812**	**217,410,099**	2,888,705	438,954,398	50%

Assumptions and notes:

1/ This is the sum of two costs: investment of $150/ha (over 5 yrs) to conduct minimal rehabilitation works (excludes headworks), and present value of O&M costs that are assumed to be covered by budgetary resources (excludes the share provided through user fees). This calculations uses the following norms that the KR National Irrigation Strategy (2000) recommends for estimating rehabilitation costs (p. 4-10): US$50/ha for off-farm rehabilitation and US$100/ha for on-farm rehabilitation. O&M costs at $20/ha (includes administration, operation and maintenance, the latter about 40% of the total). The PV calculation in the table assumes that O&M costs recur over 10 years, and that the rehabilitation costs of $150/ha are spread over 5 years.

2/ Number of recipients of the United Monthly Benefit in a Province, as % of total rural population in 1999 is shown in italics below the average total amount of benefits. On average, 16% of the total rural population received UMB in 1999. This is an over-estimate, because the number of recipients includes towns, and population is only rural. UMD recipients for Bishkek are excluded.

3/ Income per ha from irrigated land and non-irrigated is adjusted to reflect soil and climatic conditions in each district. Based on data provided by the National Statistics Committee of the Kyrgyz Republic.

Annex 5

Considering the Environmental Externalities: Methodology and Data Tables

Chapter 5 discusses the effects of changes in surface water salinity on agriculture downstream of the Karshi cascades when the system is not rehabilitated. The downstream area comprises 1,350,000 ha in Karakalpakistan, Khorezm, and Dashawuz (Turkmenistan), sown mainly in cotton, rice, and grains. Data on current salinity levels, their potential reduction, and their impacts on downstream yields are based on the Mott MacDonald (MMD) study quoted in Chapter 5. MMD estimated current salinity levels of the lower Amu Darya at between 1.1 and 1.7 g/l, although in some years they can exceed 2g/l. In this initial calculation, salinity levels are set at 1.5 g/l. On-site salt mobilization downstream is considered the main cause of depressed yields in the region.[7] The analysis takes current low yields as the starting point, and assumes that current downstream salt management practices are maintained.

We assume that rehabilitating upstream irrigation would not worsen surface water salinity levels downstream, but simply maintain them at current levels, which appear to have stabilized over the last 20 years.[8] On the other hand, according to MMD, retiring saline land in the upstream project area is expected to reduce downstream surface water salinity. The estimation of the project's externalities thus focuses on the small potential yield increases that may be expected when surface water salinity is reduced as upstream irrigation ceases. Environmental externalities are thus the foregone downstream benefits for each hectare that continues to be irrigated upstream. In subsequent scenarios, we expand the analysis to consider the potential impacts of rehabilitation on downstream water availability. Because we do not value the other environmental damage (e.g. ecosystem and health damage), these estimates of negative environmental externalities are probably low.[9]

The estimation of environmental damage proceeds in stages to arrive at an estimate of downstream foregone benefits, in dollars per hectare of upstream land that is retired. The first step is to estimate the yield impact from reduced salinity. The only model available for calculating this reduced salinity is the MMD study, which refers to a particularly saline

[7] WEMP, p. 17.

[8] Water mineralization in the lower reaches of the Amu Darya doubled during the 1960s and 1970s. Since around 1980 the mean annual concentrations have remained fairly constant, but with appreciable fluctuations between and within years. The highest mineralization reported for the Uzbekistan portion of the Amu Darya River was in March 1983, when 3.85 g/l was measured at Kyzyl Djar in the extreme north of the delta near the Aral Sea. In the portion of the Amu Darya within the borders of Turkmenistan, mineralization in selected points increased from 0.33 g/l in 1962 to 4.0 g/l in 1997. See: MMD; Natsional'naia programma, p. 70; World Bank, 2000, Turkmenistan Water Sector Review; WEMP, p. 17, App.B.3.

[9] I&D rehabilitation upstream, well done, could actually reduce the water use per hectare, thus at least offsetting the reduction in water available downstream caused by the abstraction itself and the drainage sinks. Increased irrigation efficiency, however, is not included in the Karshi Project nor in the original econmic analysis and thus is not included here.

area of 35,000 ha of land in Kashkadarya, which is part of the project area. MMD estimates that removing these specific areas from production would reduce levels of salt downstream by approximately 0.04 g/l. The Karshi project analysis estimates that a total of 64,400 ha would be retired without rehabilitation. There is no estimate of the effects of retiring the whole 64,400 hectares, so the initial calculations refer to only the 35,000 hectares covered by the MMD study and extend the resulting estimate for foregone benefits to the whole 64,400 ha.

The second step is to assess what would be the improvement in yields downstream from reduced surface water salinity if land upstream is retired. This is a complex issue, with a non-linear form that depends on the crop irrigated, type of soil, and other conditions (see Section 2.6). Table A5.1 shows crop-specific threshold levels of soil or water salinity, and the impacts of an increase by 1 ECe or 1 g/l above the threshold for different crops. We used the thresholds and yield responses to compute the effects on downstream yields of current salinity levels and of a decline in water salinity of 0.04 g/l (the MMD estimate of the impact of retiring the most saline 35,000 ha of upstream land), as shown in Table A5.2. Considering current cropping patterns in the downstream area, a weighted average 0.56% gain in yields above current depressed levels could result from lower water salinity. These potential benefits would be lost if infrastructure upstream is rehabilitated.[10]

Table A5.1: The Effects Of Additional Salinity Upon Crop Yields

Crop	Threshold	Yield Decline (%) Due To Increased Salt Content		Threshold	Yield Decline (%) Due To Increased Salt Content	
	Ece /1	1 dS/m Of ECw /1	1 dS/m Of ECe /1	g/l /4	1 g/l In Irrigation Water /4	1 g/l In Saturated Soil Extract /4
Rice /2	2.0	18		1.3	28.1	
Vegetables	1.6		18	1.0		28.1
Orchard	1.6		18	1.0		28.1
Fodder	2.0		10	1.3		15.6
Wheat /3	6.0		7	3.8		10.9
Cotton /3	7.7		7	4.9		10.9

Notes:
/1 See MMD Table A.6.1 and A.6.8. Ecw= electro-conductivity of water, and ECe= electro-conductivity of soil.
/2 For rice, the quality of irrigation water is the determining factor relating the reduction in yield to salinity. Thus, Ecw measures and g/l of salt in irrigation water are the relevant measures of salinity for rice.
/3 For cotton and wheat, MMD used a combination of the FAO standard and calculations by Uzgipromeliovodkhoz, which showed higher yield reductions relative to the FAO standard. MMD field trials showed that cotton and wheat were in reality more affected by salinity than the FAO relationship suggests. Therefore, MMD calculated the impact on wheat and cotton slightly higher than the FAO standard.
/4 1 Ecw = 0.64 g/l in irrigation water. Therefore, thresholds in g/l are lower and yield impacts of 1 g/l above the threshold larger than their electro-conductivity unit counterparts. In the baseline, it was further assumed that 1 ECw in irrigation water increases soil salinity by 1.5 ECe In regions characterized by poor leaching, MMD states that this factor may in fact be higher (up to 3 or even 5). This is explored in the scenario analysis.

Table A5.2: Computing The Value Of Downstream Externalities (Crop Yield Impacts Only)

[10] While it may be confusing to think of downstream externalities as "reduced yield declines," this is necessary, because rehabilitation is not expected to increase current salinity levels, but simply to prevent their decline. Allowing foregone benefits from reduced water salinity to enter the NPV calculations requires a crucial implicit assumption regarding symmetry in the impact of water salinity on soil salinity. We assume identical impacts when water salinity increases or decreases, and ignore lags in such impacts.

	Rice	Vegetables	Orchards	Fodder	Wheat	Cotton	Weighted Average
Downstream Area Cropping Patterns	25%	2%	2%	23%	10%	38%	—
YIELD RESPONSES							
% Yield Reduction At Current Salinity Levels (1.5g/l) 1/	6.2%	34.9%	34.9%	15.5%	0.0%	0.0%	6.5%
% Yield Reduction If Reduce Water Salinity Downstream By 0.04 g/l 1/	5.1%	33.2%	33.2%	14.5%	0.0%	0.0%	5.94%
Yield "Gain" (Lower Decline) If Retire 35,000 Ha Upstream	1.1%	1.7%	1.7%	0.9%	0.0%	0.0%	**0.56%**

ECONOMIC VALUE OF RETIRING 35,000 HA UPSTREAM (US)

Yield Impact (%)	**Affected Downstream Area** (ha[ds])	**Annual Downstream Benefits** (%)* (ha[DS])*($/ha) 2/	**Benefits Per Upstream Ha Retired** ($/ha[us])
0.56%	1,350,000	$2,414,471	**$69**

NOTES:
1/ Yield impacts = MAX(0; yield % change * (Actual current salinity – threshold salinity level))
If upstream land is retired, yield impact = MAX(0; yield%change * (actual current salinity – salinity reduction – threshold salinity level))
2/ We computed the downstream gross margins ($/ha) = $ 317. This is the current gross margins for rice, cotton, wheat, vegetables/fruits, and fodder of Kashkadarya used in the project economic analysis, adjusted for the soil quality in the downstream areas and then weighted by cropping patterns downstream. We assume that the gross margins in downstream affected areas outside of Karakalpakistan are at least as high as those inside it.

The third step in calculating the environmental externalities is to estimate the value of the foregone yield improvements. We compute gross margins per hectare of land downstream attributable to irrigation as **$317** per year (see note /2 in Table A5.2). If all of the highly saline 35,000 hectares upstream were retired, this would result in a potential annual gross margin increase downstream of about **$2.4 million** (0.56%*$317/ha*1,350,000 ha). Dividing this by the 35,000 hectares to be retired upstream, the crop-related externality can be valued at **$69** of foregone benefits per year for each irrigated hectare upstream maintained in production.[11] To calculate the effects of not undertaking the project – retiring the 64,400 ha in the project analysis – we assume that the benefits of retiring any of the 64,400 ha are the same as those from the 35,000 ha modeled by MMD. While this may be seen as a way to inflate environmental costs, two factors need to be considered. First, the remaining 30,000 ha that are expected to be retired would probably contribute to reducing salinity downstream, so that assuming linearity in their impact is as good a guess as any. Also, even if we were overestimating agriculture-related downstream impacts, this would still probably grossly underestimate overall externalities, given our incapacity to account for human, animal, and ecosystem health impacts.

[11] One reason the value of the externality is so high is that the damage per hectare of upstream land irrigated is assumed to affect a very large area downstream (1.35 million ha). We tested the calculations' sensitivity to this by changing this assumption to 1 million. It did not change the sign of any of the results.

Results

Table A5.3 summarizes the results. It compares the NPV of the Karshi rehabilitations project in the base case and in three scenarios of the original sensitivity analysis, with and without the inclusion of environmental costs. For the latter, the Table below presents the values estimated under the scenario that combines the effects of worsening drainage downstream (for which soil and water salinity are linked by ECe=3Ecw) and those of reduced water availability downstream.

Table A5.3: Net Present Value of Karshi Rehabilitation Project With and Without Environmental Costs US$ million

	Without Env. Costs	With Env. Costs (combined scenarios)
Project Base Case	71	24
Investment costs up 50%	2	-46
With and without project investment up 20%	20	-27
Crop income down 20%	15	-32