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Full Length Research Paper

Impact of Rogun dam on downstream Uzbekistan agriculture

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Strains among the states of Central Asia over using the region's scarce water resources are increasing. A major controversy is Rogun dam (RD) on the Vakhsh River, a tributary of the Amudarya River. The intent of RD is to supply energy revenue for Tajikistan, but a side effect may be the agricultural sector of Uzbekistan. Future water shortage may cost Uzbekistan over US $600 million annually in losses from agriculture, reduce the country's gross domestic product (GDP) by 2%, and may result in 300,000 people unemployed. If Uzbekistan changes its present water use practices and increases its water use efficiency, potential losses from water shortage may be reduced by 40%.

Key words: Amudarya, Central Asia, economic loss, employment, gross domestic product (GDP), Rogun dam, scenario,Tajikistan, Uzbekistan, water.

INTRODUCTION

A distinctive feature of Central Asia is the uneven distribution of water and energy resources. Kazakhstan, Turkmenistan, and Uzbekistan have almost all of the proven reserves of hydrocarbons (oil and natural gas), while Kyrgyzstan and Tajikistan have approximately 90% of all hydropower potential (UN, 2007). The upstream countries of Kyrgyzstan and Tajikistan together potentially control about 68% of the total water flow in the Aral sea basin, while the downstream countries of Kazakhstan, Turkmenistan and Uzbekistan consume the most water (Libert et al., 2008). Such a large disproportion in water origination and allocation has transferred the problem from just a hydrological issue to a political one (Libert et al., 2008). As a result, disputes and strains over the use of scarce water resources within the region are escalating (Sievers, 2002). "Nowhere in the world is the potential for conflict over the use of natural resources as strong as in Central Asia" (Smith, 1995).

In 2008, Tajikistan announced intentions to resume construction of Rogun dam on the Vakhsh River, a tributary to the Amudarya River, to supply Tajikistan with much needed energy (Schmidt, 2008). Rogun hydropower plant (RHP) construction began in 1976, but was halted in 1991 with the breakup of Union of Soviet Socialist Republics (USSR). The anticipated changed water regime due to Rogun dam operations may affect the economy of downstream Uzbekistan. Vakhsh River (the Amudarya's second biggest tributary) flow accounts for 27% of the total flow of the Amudarya River. Rogun dam (RD) could make Uzbekistan dependent on water allocation from Tajikistan during the irrigation season. This paper illustrates the likely post-dam changes in the Amudarya River's annual flow patterns and identifies potential implications on Uzbekistan's economy.

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Abbreviations: RD, Rogun dam; **GDP**, gross domestic product; **RHP**, Rogun hydropower plant; **USSR**, Union of Soviet Socialist Republics; **RR**, Rogun reservoir; **BAT**, best available technology.

Figure 1. Map of Central Asia (Star – Rogun dam site). Source: Blueyurt Central Asia (2010) and Jalilov (2010).

THE SITUATION

The economies of all Central Asian countries, except Kazakhstan, are largely dependent on agriculture. Currently, 60% of the rural population in the Aral sea basin is involved with agriculture and agri-business (UN, 2007; Elhance, 1997). Agriculture of the region is almost fully dependent on irrigation (ICG, 2002). Main irrigated crops include cotton, wheat, rice, fruits, and vegetable (World Bank, 2003).

The third largest country of the region by area, Uzbekistan (Figure 1), has more than 9 million hectares of arable land; whereas Kyrgyzstan and Tajikistan collectively have only 2,610 million hectares of arable area (FAO, 1997). Uzbekistan has 1,645 million hectares of irrigated land area along the Amudarya River and uses 28 km^3 of water annually to irrigate those lands (Statistical Bulletin, 2006). Agriculture accounts for 32% of Uzbekistan's gross domestic product (GDP) and agriculture-related industries employ 36.2% of the labor force (Gemma, 2003). Agricultural production is not diversified and largely consists of cotton (*Gossypiumhirsutum* L.) and wheat (*Triticumaestivum*) (Abdullaev et al., 2009). Cotton is a major strategic crop that earns approximately one-third of the country's hard currency revenue through export (Gemma, 2003). Other agricultural crops are rice (*Oryza sativa*), jute (*Corchorus capsularis*), tobacco (*NicotianaTabacum*), and fruits and vegetables (Bloch, 2002).

Hydropower accounts for 27.3% of electric power production in Central Asia. Tajikistan gets 98% of its electricity from hydropower (UN SPECA, 2004) and is keenly interested in developing more hydropower by switching its existing reservoirs to electricity generation, with RD playing a major role. RD will supply electricity for domestic use and for export to China, Pakistan, and south Asian countries (Wegerich et al., 2007). Uzbekistan's concern is that much of the stored water will be released from Rogun reservoir (RR) during winter to generate electricity, and, as a consequence, water flow will be reduced during the summer irrigation season, which will have a negative impact on Uzbekistan (Libertet al., 2008).However, it should be mentioned that an operation of RR could be different if Tajikistan would be able to export electricity to Pakistan or India – which will need the electricity during the summer.

The feasibility study, completed by the German construction company Lahmeyer International, indicates three separate stages in building of RD: Stage I, the dam's height will be 225 m with a total volume of reservoir of 2.78 km^3, a live storage volume of 1.92 km^3, and a capacity to produce 1000 MW (this will give energy output of 5.6 TWh/yr); Stage II, the dam's height will be increased to 285 m (volume 6.78 and live storage 3.98 km^3; and Stage III, the dam's height will reach 335 m (reservoir volume 13.3 km^3, live storage 10.3 km^3 (Schmidt et al., 2006). Wegerich et al. (2007) argues that neither Stage I nor Stage II would be detrimental for Uzbekistan, but Stage III would threaten Uzbekistan's agricultural production. ICG (2002) report states that further development of Tajikistan's hydro energy potential based on construction of new RD would allow Tajikistan complete control of water flow to Uzbekistan and will have negative consequences on downstream countries' seasonal water allocations. Hence, the paper has an assumption that RD will be constructed on its full height. The objective of this research is to estimate the monetary impacts of RD on Uzbekistan and propose mitigation measures to minimize these impacts.

METHODS AND ASSUMPTIONS

The principal method used to assess the downstream effects of RD was a case study using Nurek dam, a similar, existing dam, as a proxy since very little detailed information about the specifics of RD is available[2]. Nurek dam is the largest existing dam on the Vakhsh River, located approximately 30 km downstream from RD (Wegerich et al., 2007). Nurek reservoir has a full storage volume of 10.5 km^3, which took 11 years to fill (Savchenkov et al., 1989). The filling rate of RR was modeled after the filling history of Nurek.

The peak flow of the Vakhsh Rivers occurs in July, when flow reaches 4.15 km^3, and minimum flow level of 0.16 km^3 is observed in January (UNECE, 2007). This flow regime is mainly the result of melting snow and glaciers in Tien Shan Mountains into the Vakhsh River (Konovalov, 2009). In order to be able to generate electricity in winter, RR has to store water in summer, which is also supported by Tajikistan electricity consumption which can experience a significant shortage of electricity during winter months (Kayumov and Kabutov, 2005). Therefore, the assumption is that RR will store water from April to September (summer) and release water to generate electricity during the low-flow months from October to March (winter), which means that much of the capacity of RR to generate electricity would occur during winter months.

The baseline condition was characterized using the most current socioeconomic data available for Uzbekistan (CIA, 2009). Data related to flows, agricultural production and sales, employment, and GDP were used to characterize the baseline. Farm-level conditions were based on a typical composite hectare. The monetary value of one hectare of irrigated land for farmers is the sum of revenue from cotton, wheat, and vegetables calculated according to their shares in the composite hectare. One composite hectare (100%) consists of cotton (44%), wheat (48%), and vegetables (8%), which are the main irrigated crops, in Uzbekistan (World Bank, 2003). The World Bank (2003) estimates the gross economic income of cotton, wheat, and vegetables as US $825, $400, and $1,369 per hectare, respectively (world price projected for 2015).

Government revenue results from buying domestic agricultural production and reselling it on the world market. The world price for cotton was US $1,305 and for wheat was US $130 per metric ton (World Bank 2003, price projected for 2015). So, the estimated value of one hectare of irrigated land for the government of Uzbekistan was US $694 per hectare.

Employment changes as a result of changes in water flows were estimated based on a simple ratio of GDP to employment, which may be conservative since the revenue-to-employment ratio in agriculture is generally lower than in other parts of the economy. The number of people affected was estimated by dividing the total revenue change by the countrywide average GDP per capita.

Two 'ex post' RD scenarios were developed. The 'worst case' scenario assumed that Uzbekistan's water users would not adapt to changing flow regimes and would continue with the status quo water use with respect to irrigated agriculture. To assess the impacts of changed Amudarya River flows on Uzbekistan agriculture, the assumption was that reduced summer flow in the Amudarya River will be unequally distributed among the in-country upstream and downstream water users because of lack of water distribution infrastructure and poor water management (ICG, 2002). Therefore, upstream (in-country) water users will withdraw the same water volume as they did before RD and downstream water users will experience a water shortage. This assumption can be justified because in 2000-2001 Uzbekistan experienced a severe drought, which has been called the 'worst in 95 years' (Deputy Agriculture Minister Abdurakim Dzhalahov in CNN.com, 2000). During this drought water scarcity was the worst in the downstream regions of the Amudarya (Wegerich, 2002). The land area that would not get irrigated was estimated by dividing the average water requirement per hectare into the available water.

The 'more likely *case'* scenario assumed that Uzbekistan would take measures to adapt to changing flow regimes, specifically, improved irrigation water management. Recent evidence during low flow years suggests irrigators adapt to lower flows (Wegerich, 2002). Further adaption to low flows could be induced by the government through pricing systems and incentives to use best available technology (BAT). Farmers would be free to choose what technology to implement, which could include using groundwater resources, using recycled water, or switching to less water consuming crops (Pimentel et al., 1997). Other technologies might include sub-surface drip irrigation, precision agriculture, or growing high value crops (Ayars, 2010). However, land in Uzbekistan is the state property and farmers can rent land for up to 49 years (Abdullaev et al., 2009), in addition, state procurement policy takes 100% of cotton and 50% of wheat under fixed state prices. This presumes that farmers have no real incentives to save water. However, Uzbekistan has the luxury of time to change existing conditions in agriculture and be prepared for future challenges caused by the construction of RD. The government should use that time for developing better water resources planning and management tools and technologies, and make efforts to change in people's attitude to face and overcome the difficulties which may cause RD project in Tajikistan.

The analysis here focused on the first order effects of changed flow regimes. Due to the relatively low portion of water used by other sectors of Uzbekistan's economy compared to agriculture, the other sectors were neglected in this assessment. However, this assumption does not imply that the rest of economy would not be

[2]The arithmetic to quantify aspects of Rogun Dam/Reservoir was linear relationships between Nurek and Rogun. Details are available in Jalilov 2010.

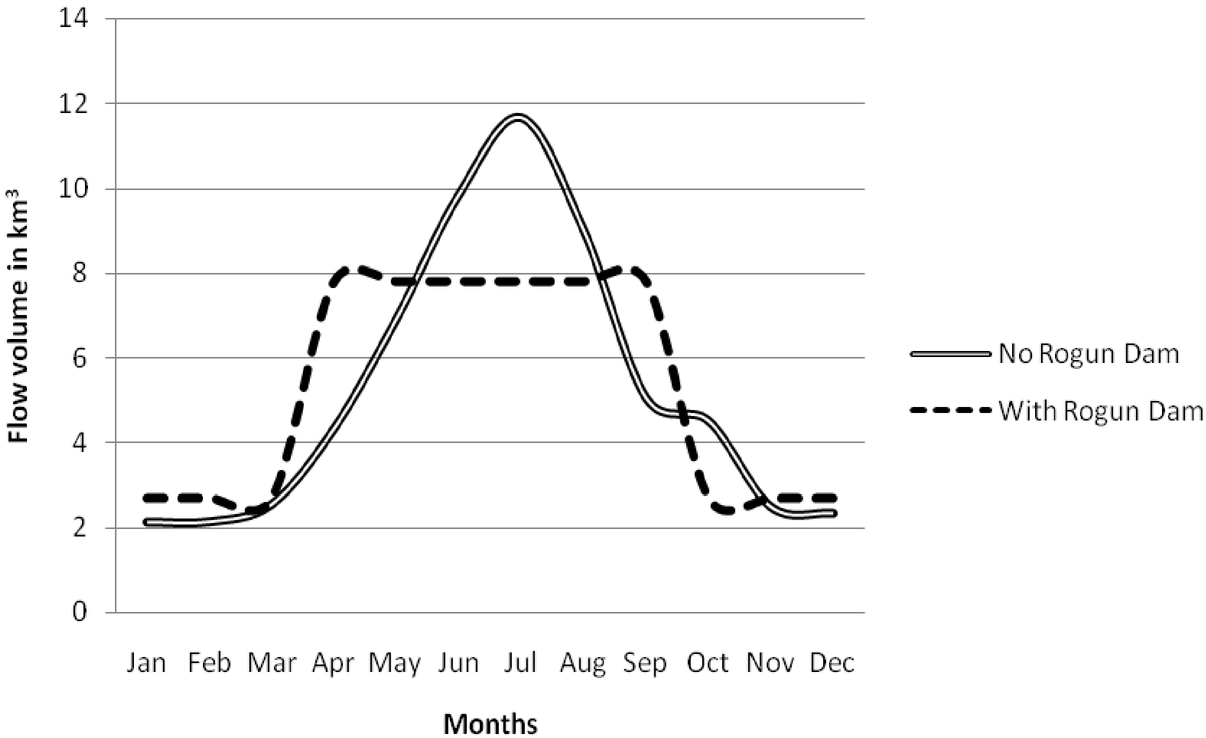

Figure 2. The Amudarya River hydrograph as the river enters Uzbekistan, with and without RD. Data used in this figure was extrapolated from UNECE (2007) and results of own computations.

impacted, since other sectors of the economy are closely linked with agriculture (Abdullaev et al., 2009).

RESULTS AND DISCUSSION

This part of the study is divided into four main parts: one, identification of potential changes anticipated during RR filling stage, two, identification of potential changes anticipated when Rogun Reservoir is full and working in electricity generation mode, three, assessment of those changes under the “worst case” scenario, and four, assessment of those changes under adaptive management measures, “adaptive” scenario.

The 12.4-year filling stage of RR will not have a substantial impact on Uzbekistan agriculture. RR will capture approximately 2% of mean annual discharge of the Amudarya River during filling. The main impact will be when RR is in full operation mode accumulating water in summer and releasing water in winter, which differs from the flow regime needed by downstream irrigated agriculture.

With RHP operating in full electricity generation mode in winter, the Amudarya River flow entering Uzbekistan in the summer is predicted to decrease by 18% and to increase by 54% in winter (Figure 2). This suggests that: one, during May to September (irrigation period), Uzbekistan will have a shortage of water; and two, from September to May, Uzbekistan will experience water abundance, which may lead to flooding.

The likely bookend outcomes were identified as worst case (business-as-usual) and more likely case (adaptive management scenario). In reality, the outcome is likely to fall somewhere between these predicted extremes.

Worst case scenario

The ‘worst case’ scenario assumes Uzbekistan irrigators will maintain their present water use patterns. This scenario is clearly a no-win option for the Uzbekistan economy as the country would have to remove 506,000 hectares of land (about 11% of the country’s irrigated agricultural land area) (FAO, 1997) from agricultural production, which means 336,000 people may lose their jobs (Table 1). Production of cotton and wheat would decline. Industrial production, such as textiles, food processing, machine building, metallurgy, petroleum, and chemicals would likely be impacted by the decrease in agricultural production. As a result, Uzbekistan’s GDP

Table 1. Comparison of estimated impacts felt by Uzbekistan under two scenarios: 'Worst case' and 'more likely case'.

Type of impact	Outcome		Difference between outcome
	Worst case	More likely case	
Irrigated land area reduced (hectare)	506,000	314,000	38% reduction
Lost revenue (US$ million)	609	378	38% reduction
Decline in GDP by (%)	2.2	1.4	36% reduction
Decline in budget revenue by (%)	6.9	4.3	38% reduction
People impacted (thousands)	336	208	38% reduction
Water shortage (km^3per year)	8.6	4.4	49% reduction

Data used in this table is the results of own computations based on data of CIA (2009).

would decrease by 2.2%, government revenues decreasing by 6.9%, and economic growth would likely decline.

More likely case scenario

The 'more likely case' scenario assumes that Uzbekistan will undertake reforms in agricultural water use, particularly in irrigation practices, and adjust irrigation requirements to fit potential water shortages. This scenario would allow Uzbekistan time to adjust agricultural water consumption by 15% over 12 years of RR filling, reducing the negative effects of changed water flows. This scenario also assumes an increase in water use efficiency in irrigated agriculture. Generally, a 15% reduction in water use would reduce negative impacts by 40%, meaning Uzbekistan will have to withdraw only 314,000 hectares of irrigated land compared to the 506,000 hectares if nothing is done. Moreover that reduction would reduce 1) the number of unemployed to 208,000; 2) the country's GDP by 1.4%; and 3) the revenue part of the budget by 4.3%. While this scenario also has negative results, the impacts are reduced with adequate planning.

POLICY IMPLICATIONS

Each country has a right to implement policy which would be most beneficial for the population of that country and would reflect trends of economic development of that country. Independently from the position of Uzbekistan, as a riparian country, Tajikistan will push forward the construction of RD and thus the government of Uzbekistan should focus future development strategies on changing water use practices in agriculture by introducing water pricing and applying advanced irrigation practices rather than the commonly used furrow irrigation. The revenue that is expected from water pricing should be strictly controlled and spent for the implementation of changes in water resources management and for education and training of mid and lower management personnel in irrigation regions.

Another solution may be that Tajikistan will share with Uzbekistan revenue from power generation of RR. In this case, these two countries should determine and make agreements on how much income Uzbekistan may lose due to the presence of RD and possibly get compensated from Tajikistan in the form of energy. This scenario might be a 'win-win' case for both Tajikistan and Uzbekistan. However, this case needs strong political desire from the governments of both countries, which are not currently observed.

Another finding was that the Amudarya River may have increased flow during winter, which may lead to flooding downstream. Therefore, assessing the social and economic impacts of RD on downstream areas during the winter period is encouraged.

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