Water-Energy-Agriculture Nexus in Vakhsh River Basin of Tajikistan

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INTRODUCTION

This study focuses on the conflict between Tajikistan and Uzbekistan over the planned construction of the Rogun dam in the Vakhsh river basin of Tajikistan.

Tajikistan is a landlocked country. Mountains cover 93% of the land area, half of which are more than 3,000 meters high. Tajikistan is abundant in water resources thanks to its geographical location.

The Vakhsh river is a tributary of the Amu Darya and is shared by (from upstream to downstream) Kyrgyzstan, Tajikistan and Uzbekistan. Planned Rogun hydropower plant will be 335m high, as the highest dam in the world, with a generating capacity of 3,600 MW. Further downstream the Vakhsh river there is Nurek dam existing since 1980s with a generating capacity of 3,000 MW. Still, Tajikistan suffers from deficit of electricity in winter, when the country in mountains is very cold. Rogun hydropower plant, to be constructed just in the upstream of the Nurek dam, is supposed to enhance the power generation of the country in winter.

Uzbekistan strongly opposes to construction of the Rogun dam because it would change the runoff (discharge) pattern of the Amu Darya and affect its irrigated agriculture (Jalilov, 2010). Uzbekistan is one of the world's largest exporters of cotton, which is supported by its huge irrigation system in the Amu Darya river basin. On the other hand, Tajikistan needs electricity in winter. It implies that Tajikistan and Uzbekistan have conflicting interests regarding the season when water should be discharged from the Vakhsh river basin to the Amu Darya: Uzbekistan needs water in a summer for the irrigated cropland for cotton farming, while Tajikistan needs to release water from the reservoirs in a winter for power generation.

The World Bank carried out a feasibility study of the Rogun dam (Laldjebaev, 2010) and concluded that the Rogun dam is financially viable and environmentally sound, even if Rogun dam would not change the runoff from the Vakhsh river basin to the Amu Darya (World Bank, 2014a).

The World Bank's report concluded that the cotton production in Uzbekistan would not be impacted by the Rogun dam. The government of Uzbekistan however argued that the existing runoff pattern of the Vakhsh river basin (to the Amu Darya), which is presently regulated by the Nurek dam, is too new to be recognized as "historical flow". Uzbekistan insists that the runoff pattern of the Vakhs river basin should be reverted to the pre-Nurek dam era (before 1980s).

Whether the argument by Uzbekistan is valid or not from the viewpoint of international law, is an open question. However, few analysis has been carried out about implications of Uzebekistan's argument on water, energy and agriculture of the Vakhsh river basin.

OBJECTIVES

This study tries to (a) reveal how water, energy and agricultural production are closely related in the Vakhsh river basin, and (b) suggest possible alternatives and implications of these alternatives from technical and political viewpoints.

METHODOLOGY

A water-energy-agriculture model has been developed for the Vakhsh river basin. This model deals with hydropower generation by the Rogun and Nurek hydropower plants and water discharge by the Rogun and Nurek dams.

Several small dams and associated hydropower stations exist in the Vakhsh river basin, downstream of the Nurek dam. However, these dams are for run-of-the-river hydropower plants and their capacity is too small to change the hydrological regime of the Vakhsh river basin. The model thus addresses directly only the Nurek and Rogun dams, which may affect the runoff from the Vakhsh river basin to the Amu Darya (in which Uzbekistan has a large share).

Two possible scenarios are considered in this study. Scenario 1 is just as suggested by the World Bank's study, namely the runoff pattern to the Amu Darya should not be changed. Scenario 2 is to revert the runoff pattern to "pre-Nurek days" as insisted by Uzbekistan. Simulations were carried out with the model to find the way how two reservoirs (Rogun and Nurek) should be controlled to maximize the power generation in winter.

The data on the Vakhsh river basin, namely hydrology, power generation by the hydropower plants, water withdrawal and return flow for irrigation, released by the World Bank (2014b) are used for this study, both for calibration of the model and simulations.

RESULTS

Figure 1 shows the power generation (by the Rogun and Nurek dams) as the output from the developed model, with the hydrological data in 2004 to 2007.

As compared with the status quo (i.e. only the Nurek dam exits as a large dam in the Vakhsh river basin), power generation in winter is significantly larger with the Scenario 2, while it is marginally larger with the Scenario 1.

The power deficit in Tajikistan (in case of 2009) from October to March is assumed to be 135, 362, 275, 443, 627, 419 GWh/month respectively (Fields, et al, 2013). These deficits may be resolved by the additional power generation with the Scenario 1. The balance of power in October to March is to be +789, +381, +341, +237, +319, +654 GWh/month respectively. On the other hand, with the Scenario 2, the power balance remains negative in four months of November through February. The balance of power in October to March is to be +380, -91, -70, -216, -128, +454 GWh/month respectively.

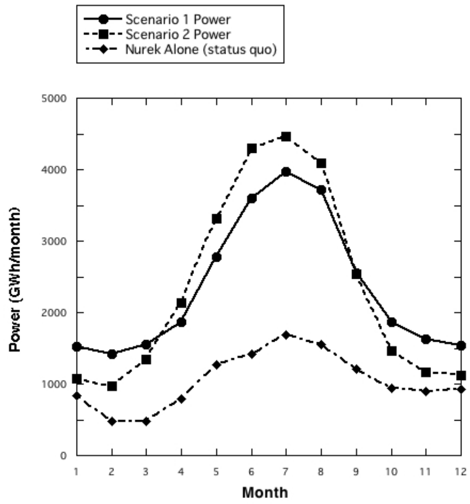

Fig1: Power generation by two power stations

Figure 2 shows the runoff pattern as the output of the model with the hydrological data in 2004 to 2007.

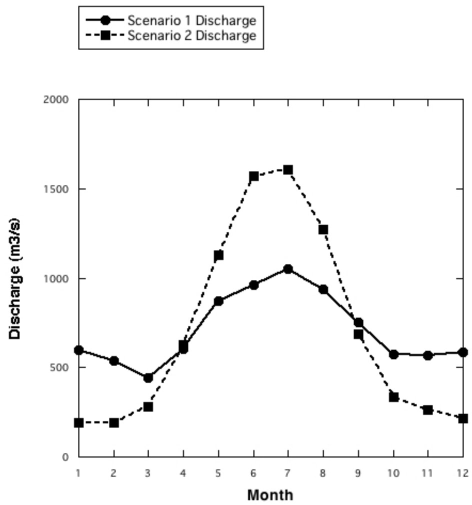

Fig2: Runoff (discharge) to the Amu Darya

The model was set so that these runoff patterns are the same as status quo for Scenario 1 and the same of pre-Nurek era for Scenario 2.

DISCUSSIONS

The output of the model for the Scenario 1 suggests that the present deficit of power (electricity) in Tajikistan may be resolved with the planned construction of the Rogun hydropower station. Since the hydropower station consumes no water, irrigated farmland in Uzbekistan (and Tajikistan) may be operated as it is practiced in these days.

Additional power generation by the Rogun hydropower station with the Scenario 1 is to be 15.5 TWh/year. Since the deficit of power in winter is around 2.3 TWh, Tajikistan may have approximately 13 TWh of "surplus".

One idea of making good use of this surplus is to export power to the power starving countries of Pakistan and Afghanistan (SNC-Lavalin, 2011) by constructing a long power line. The project known as CASA 1000 envisages that Tajikistan sells annually 3.75 TWh of electricity to these countries annually. Depending on the capacity of the power lines, more electricity may be sold to the foreign countries.

Still, Tajikistan ends up with about 9 TWh/year of surplus, which should be consumed for the sake of its inhabitants.

As for the Scenario 2, the runoff pattern to the Amu Darya under this scenario is exactly what Uzbekistan demands, namely the runoff pattern of pre-Nurek era. Operating the Rogun and Nurek dams (hydropower stations) under this scenario may be the best way for Tajikistan to secure Uzbekistan's concurrence to the planned construction of the Rogun dam.

The major cost associated with this scenario is that Tajikistan would still suffer from the paucity of electricity in November to February. A solution for this problem is that Tajikistan exports electricity in summer (as CASA 1000 project envisages) and imports either electricity or energy sources (natural gas or oil) from outside, e.g. from rich in natural gas Turkmenistan.

Additional power generation by the Rogun hydropower station with the Scenario 2 is assumed to be 15.5 TWh/year, the same amount as the Scenario 1.

This huge surplus of electricity may be used to modernize energy supply in the rural areas in Tajikistan.

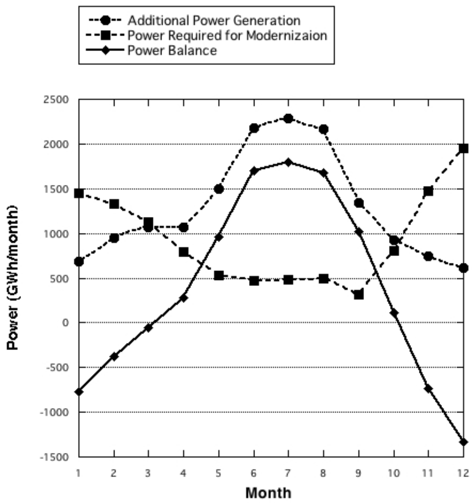

Fig 3: Power requirement for modernization

The power required for modernization in Figure 3 is based on the assumption that all the people in Tajikistan consume the same amount of electricity as practiced by those in the capital of the county, Dushanbe (Swinkels, 2014).

This assumption may sound absurd, while the authors do not assume so. It is because the energy consumption for heating in Dushanbe is much less than other countries. For example, Annual consumption of electricity per household/apartment is 5,767 KWh in Dushanbe and 16,343 kWh in Norway. Moreover, 4-level and 9-level apartment houses in Dushanbe consume only about 30% and 50% of similar series buildings in Moscow (USAID, 2012).

Figure 3 shows that the deficit in winter is inevitable even with Scenario 2, and that some measures should be taken to convert the surplus of electricity in summer into supply of the same in winter.

Further research should be conducted to examine, *inter alia*, (a) Introduction of water conservation technology in the irrigated farmland of Tajikistan and Uzbekistan, (b) reduction of electricity losses from present 17.7% to the global standard of 6 to 8% (UNDP, 2011), (c) improvement of production efficiency of the Tajikistan's state owned aluminum company (Norsk Energi, 2012), and (d) Impacts of Climate Change.

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