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Schistosoma japonicum Infection: A Hidden Cost of China's Three Gorges Dam?

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Introduction

In 1919, Dr. Sun Yat-Sen proposed improving shipping conditions and developing hydroelectric power generation in the "Three Gorges" section of the Yangtze River. During the 1930s, research on the project done by the Kuomintang government concluded that such improvements were indeed feasible (Yao 1992:17). A plan for building a dam in the Three Gorges area was approved in 1958. However, the tremendous cost of building the dam prevented it from actually being constructed at that time (Fearnside 1988:616). In 1986, an extensive re-examination of the project began. It was concluded that the project was not only technologically feasible and economically reasonable, but that it would be better to build it than not to do so. Commencing construction as soon as possible was also recommended (Yao 1992:17). On April 3, 1992 the plan for the Three Gorges dam was approved by the National People's Congress, by a vote of 1,767 to 177, with 664 abstentions (Li 1992:24). In December, 1994 construction of the dam officially began (Topping 1995:132).

The Yangtze is the third largest river in the world. The Three Gorges (Xiling, Wu, and Qutang) are located in Western Hubei province in central China. The area is characterized by rapids currents and a steep drop, forming a storehouse of water resources (Yao 1992:17). The Three Gorges dam is to be the largest in the world. At 185 m high and 1983 m across, the dam will create a reservoir of 54,000 km². The major objectives for building the dam are flood control, navigation, water supply, and hydroelectric power generation (Edmonds 1991:112). Once constructed, the dam is expected to generate 13,000 megawatts (mw) of electricity with a power generating efficiency of 10mw/km² of reservoir area. These figures are higher than those of other major hydroelectric projects across the globe (Fearnside 1988:617).

Not only is the Three Gorges dam to be the largest in the world, it is perhaps the most controversial. While Chinese leaders strongly support the dam, technical experts and intellectuals have expressed serious doubts about the project's feasibility, as well as serious concerns for the dam's impact on the environment (Edmonds 1991:112). The concerns of environmentalists include natural habitats, fauna, erosion, reservoir siltation, estuary salinization, earthquake

hazard, and microclimate. Opponents to the dam have also expressed social concerns. Upon creation of the reservoir, countless cultural landmarks and archaeological sites will be lost. Population transfer is another main concern, as 1.4 million people will have to be resettled due to the flooding of their lands (Fearnside 1988:618).

Estimates of the cost of the project range from 57,100 million up to one billion yuan. Opponents of the dam are concerned that both time and cost of building the dam have been underestimated. There is also a fear that several hidden costs have not been considered at all. The Gezhouba dam (38 km upstream of Three Gorges) was scheduled to be completed in five years. In reality, the dam took 18 years to complete and cost four times the original estimate (Edmonds 1991:120). Judging from the Gezhouba project, concerns that the cost of the Three Gorges dam may be underestimated are not unfounded.

One factor that has largely been ignored in the literature is the dam's impact on public health. According to the World Health Organization, "the construction of dams and formation of reservoirs and irrigation systems...can cause rapid environmental degradation, and health risks may arise even before there is any awareness of the danger and before preparations have been made to overcome it" (Hunter, Rey, Cho, Adekolu-John, and Mott 1993:5). Water resource development projects, such as the Three Gorges dam, have a strong tendency for exacerbating parasitic diseases (Hunter et. al. 1993:4). Among such diseases is schistosomiasis, which has long been a public health problem in China.

The purpose of this paper is to consider the environmental impact assessments (EIA) and cost-benefit analyses of the Three Gorges project, and their reliability. By demonstrating that the schistosomiasis problem in China may well be exacerbated by the dam, I will illustrate the inadequacies of EIA and cost-benefit analysis of the project. I hope to show the reader the inherent danger in underestimating the hidden costs of projects such as the Three Gorges dam.

Environmental Impact Assessment and Cost-Benefit Analysis of the Three Gorges Dam

Ziyun reports that according to the Chinese Ministry of Water Conservation, in order to utilize water and land resources effectively, and maintain the ecological balance, EIAs must be conducted during the planning and designing

stages of resource development projects. The main objective of EIA is to "discover the possible natural and social environmental impacts of all possible approaches to the project, so that the optimum plan maximizes national economic benefits and minimizes adverse environmental effects" (Ziyun 1986:347). The EIA of a proposed water resources project should identify potential negative environmental impacts so the optimum alternative can be selected, and mitigation procedures can be developed (Ziyun 1986:349).

Steps for making an EIA include the following: 1. a comprehensive survey of the environmental setting to obtain data as a base for analysis, investigation, and assessment, 2. a notation of the pattern of water regulation and distribution as it will be after the project is complete, 3. a review of existing projects to identify similarities and contrasts concerning environmental impacts (Ziyun recommends analyzing the environmental characteristics of other projects and making predictions of the quantitative and qualitative changes of environmental parameters based on this data), and 4. the selection of the optimum plan from among the various alternatives (Ziyun 1986:347). Ziyun writes that the EIA for the Three Gorges dam should include a description of the project, description of the setting, the impact of the project on the natural environment (water quality, soil, etc.), the impact of the project on the human environment (resettlement, human health, etc.), a comprehensive assessment of impacts, and suggestions (Ziyun 1986:349).

It should be noted that feasibility studies and EIAs of the Three Gorges dam intend only to produce suggestions on how to improve the project's design and reduce its impacts. They are not intended to serve as inputs to the decision on whether to build the dam (Fearnside 1988:617). Because the dam will be built regardless of its impact on the environment (both natural and human), it is important that planners focus on the reduction of such impacts. This in turn needs to be reflected in the cost-benefit analysis of the project. Proponents of the project cite the hydroelectric capacity of the dam as a major financial benefit. Even during construction the accumulated electricity output is estimated to reach 435.8 billion kilowatt hours (kwh) and earn 40 billion yuan. After construction is complete the annual income is expected to be 7.5 billion yuan (Yao 1992:21).

However, in China, for projects such as Three Gorges more attention is paid to design planning than financial planning. Planners have usually not been trained to think about how to extract the maximum financial return from a project. Many are likewise reluctant to attempt to assess broader "social costs" of a project. Thus, comprehensive cost-benefit analysis is seldom employed (Lampton 1983:17). This no doubt accounts for cost estimates to be significantly lower than actual costs. Schistosomiasis has received little attention in EIA, and certainly has not been considered a significant factor in cost-benefit analysis. Proponents of the project claim there is little evidence to suggest the reservoir created by the dam will create many shallow bays which could

serve as breeding grounds for snails, the vector of schistosomiasis. Worries of increased parasitic disease are thought to be unfounded (Edmonds 1991:117). However, as I will demonstrate below, the threat and cost of schistosomiasis should not be dismissed so easily.

Human Schistosomiasis

Schistosomes are digenetic trematodes in the superfamily Schistosomatoidea, which parasitize humans and other animals. Their life cycle begins when infected humans excrete the schistosome's eggs into fresh water. In fresh water the eggs hatch and release fully developed larvae, which are picked up by the parasite's intermediate hosts (several species of snail). The larvae then mature and produce large numbers of cercariae which break out of snail tissues into the water. Upon human contact the cercariae penetrate the skin and circulate throughout the body, where adult worms grow, lay eggs, and repeat the cycle. The 3 major species of human schistosomes are *Schistosoma haematobium*, *S. mansoni*, and *S. japonicum*. *S. haematobium* adults reside in the veins of the bladder and result in urinary schistosomiasis, while *S. mansoni* and *S. japonicum* reside in the mesenteric veins of the bowel and produce intestinal schistosomiasis (Jordan, Webbe, and Sturrock 1993:5).

Schistosomiasis is generally broken down into two phases: acute and chronic. The acute phase is characterized by initial invasion, producing a skin reaction at the point of penetration, fever and cough as the cercariae migrate to the lungs and liver, and maturation of the cercariae, resulting in acute febrile illness. The acute phase is rare in urinary, but well recognized in intestinal, schistosomiasis. The chronic phase includes established infection, characterized by hematuria or intestinal and other digestive manifestations, and late infection and complications such as portal hypertension, fistula, or renal failure (Jordan et. al. 1993:123). There are several anti-schistosomal drugs available for treatment. The most important drug in China, praziquantel, is effective against all human schistosomes. However, drug therapy alone is not enough to stop transmission of the disease (Chen 1989:175).

Schistosomiasis is endemic in many parts of the world, including Africa, South America, the Middle East and Asia. Transmission occurs in a variety of ecological situations. However, all are characterized by human contact with water colonized by intermediate host snails in communities with poor sanitation, in which some members are infected (Jordan et. al. 1993:87). *S. japonicum* is endemic to China. Infection with *S. japonicum* is considered more severe than that of other schistosome species. This is because the life span of *S. japonicum* is longer, immunity to reinfection is incomplete, and the female worms of *S. japonicum* have a higher egg output and lay their eggs in clumps which induce intense tissue reactions (Jordan et. al. 1993:244).

The acute stage in *S. japonicum* infection is well recognized and frequently fatal, sometimes in epidemic proportions. Acute cases and epidemics occur during the flood

season in the lake areas of the Yangtze basin (Jordan et. al. 1993:130). In advanced *S. japonicum* infection ascites is often present due to portal hypertension and hypoalbuminemia. The prognosis of ascites due to schistosomiasis is usually poor (Jordan et. al. 1993:256). The major cause of death in *S. japonicum* infection is blood loss due to varicose veins in the esophagus. Additional symptoms of schistosomiasis due to *S. japonicum* infection are edema, anemia, impotence in men, amenorrhea and sterility in women, weakness, loss of working capacity, shortness of breath upon exertion, and emaciation. Finally, heavy infection during childhood can result in dwarfism (Jordan et. al. 1993:259).

Water Resource Development and Schistosomiasis

Jordan et. al. write that "the man-made ecological changes resulting from the construction of large dams and irrigation schemes, any of which in an endemic area is a potential cause of increased transmission of schistosomiasis. The effects of major development projects and their extent are difficult to predict" (Jordan et. al. 1993:87). Ecological changes around large water resource development projects can both modify the incidence and prevalence of diseases already endemic in a region, as well as favor the introduction of new parasitic diseases. Intermediate host snails can be introduced by workers, fisherman, animals, and even birds (Hunter et. al. 1993:10). The most significant reported increases in disease prevalence and public health importance, due to changes caused by water resource development, do in fact concern schistosomiasis (Hunter et. al. 1993:25).

The Diama dam and schistosomiasis in the Senegal River Basin

Following Ziyun's recommendation to examine existing projects, the construction of the Diama dam on the Senegal river and the resulting introduction and rapid spread of schistosomiasis, illustrates the difficulty of predicting the impact of environmental changes on the ecology and epidemiology of parasitic diseases. The Senegal river is the second largest in West Africa, and forms the northernmost border between Senegal and Mauritania. The Senegal River Basin (SRB) is semi-arid with an average annual rainfall ranging from 100-600mm. The temperature ranges from 22-38 C, and monsoons are not infrequent. Approximately 2 million people inhabit the area (Vercruysse, Southgate, and Rollinson 1985:250). In the 1970s-80s several developments in the SRB were proposed, to improve living standards in the region by increasing agricultural production (Malek and Chaine 1989:182). The Diama dam was completed in 1985. Diama is a low (1.5 m) water control dam located at the mouth of the river near the city of Saint-Louis (Gryseels et. al. 1994:209). The main functions of the dam are to prevent the intrusion of salt water, create a reservoir of fresh water, and supply water to Lac de Guiers and Lac R'Kiz (Malek and Chaine 1989:182).

Serious efforts were made to assess the possible ecological impacts of the development projects in the SRB.

One such assessment was conducted by USAID and Organisation pour la Mise en Valeur du Fleuve Sénégal (OMVS). A Survey of existing health conditions in the SRB was included in the assessment. The surveyors found that while urinary schistosomiasis was endemic to the region there was a low infection rate. There was no evidence that *S. mansoni* (intestinal schistosomiasis) transmission occurred anywhere in the SRB (OMVS report p.119). It was concluded that "no upsurge in schistosome infections is anticipated. A significant increase in schistosome transmissions because of greatly expanded use of irrigated perimeters is by no means certain...Schistosomiasis transmission in the Delta, currently insignificant is not expected to show much change with the construction of the Diama dam" (OMVS report p.121).

Three years after completion of the Diama dam an outbreak of *S. mansoni* infection occurred in the city of Richard-Toll, Senegal--100 km from the mouth of the river (Stelma et. al. 1993:701). In the village of Ndombo (4 km south of Richard-Toll) the first case of *S. mansoni* infection was reported in January, 1988. Within 4 years of the first case, virtually everyone in the area became infected. The outbreak has been linked to the dam, which caused the water to become permanently fresh and the level stabilized. This led to a mass invasion of *Biomphalaria pfeifferi* snails-the intermediate host of *S. mansoni* (Stelma et. al. 1993:704). The situation in the SRB demonstrates that EIA of a water resource development project is not always adequate. Disease monitoring systems and adequate health services must also be put in place, even if the risk appears to be small (Gryseels et. al. 1994:215).

Schistosomiasis in China and the Potential Impacts of the Three Gorges Dam

Although a lesson concerning the underestimation of schistosomiasis can be learned from the case of the Diama dam, it must be pointed out that China and West Africa are ecologically different. Unlike the SRB, the Three Gorges area has a subtropical climate with hot, humid summers and cool, dry winters. The temperature averages 3° C in January, and 28° C in July, but often drops below freezing in winter. The average rainfall in the area is greater than in the SRB (840-1,300mm) and flooding is expected in one out of every four years (World Bank 1995:12). The Three Gorges dam is also to be on a much larger scale than Diama dam, and will serve different purposes. Such differences, however, do not nullify the lessons learned from Diama as there are several other factors that indicate the Three Gorges dam may exacerbate schistosomiasis in the area.

History of schistosomiasis in China

China has had a long history with *S. japonicum*. Descriptions resembling schistosomiasis can be found in traditional Chinese medical texts dating back to 400 B.C. In 1971, eggs of *S. japonicum* were found in a corpse buried 2,100 years previously (Mao and Shao 1982:92). In 1905, the first diagnosis of *S. japonicum* in the world was made by an American doctor on a fisherman in Hunan province

In general, there is a failure on the part of government officials to appreciate that the health problems in water resource development projects are ecological in character, and that long term solutions require national coordination. The costs of disease are usually considered to be less than the potential economic benefits (Hunter et. al. 1993:83). The cost of schistosomiasis infection, aside from that of control and treatment programs, is difficult to assess. However, it is becoming more and more accepted that heavy infections have an adverse effect on productivity. Anemia, fatigue and lassitude due to schistosomiasis have been reported in several studies, and have been shown to affect productivity of working adults (Jordan et. al. 1993:134). Thus, effective control and/or prevention of infection should contribute significantly to economic development.

In China there has never been any doubt about the seriousness of *S. japonicum* infection. There are many accounts of whole villages being devastated by the disease and of "many households with schistosomiasis widows of three generations, and previously fertile lands being overgrown for want of labor, [leaving] no doubt about its economic importance" (Jordan et. al. 1993:135). The social costs of schistosomiasis, in terms of morbidity, mortality, and days of work missed, can be quite significant. A thorough risk assessment study thus becomes indispensable for estimating sustainability, making modifications, and anticipating needs for health services regarding water resource development projects such as the Three Gorges dam (Hunter et. al. 1993:122).

Conclusion

The rate at which dams are built in a given country may outstrip the capacity of the health care system to monitor the introduction, spread or aggravation of parasitic diseases (Hunter et. al. 1993:13). China has an effective monitoring and control system in place for schistosomiasis. However, China is already home to over half the world's large dams (18,800, while there are 17,400 throughout the rest of the world). The addition of the Three Gorges dam may cause China's schistosomiasis control system to become overburdened. Yet in this project, as in most development projects around the world, the health risks of parasitic diseases such as schistosomiasis have been given little attention in EIA and cost-benefit analysis (Hunter et. al. 1993:103).

The unanticipated increase in schistosomiasis after the construction of the Dama dam demonstrates how ecological changes and their consequences can be unpredictable. In the past, it was argued that planners of water resource development projects were unaware of the possible health consequences, being uninformed and ecologically naïve. This is now unacceptable (Hunter et. al. 1993:92). At this point it does not look as if construction of the Three Gorges dam will be stopped. Thus, it is crucial that planners become as ecologically informed as possible. The risk of increased *S. japonicum* infection must seriously be considered.

Unless they are anticipated and prepared for, health problems that may arise from large water resource develop-

ment projects may stifle all economic gains, as well as cause untold damage to the health and well-being of the people in the area (Traur  1989:228). The strong possibility that the Three Gorges dam will increase snail habitats and spread transmission of schistosomiasis through migrant workers, and resettled populations, suggests that the EIAs and cost-benefit analyses of the project need to be re-examined. The threat of schistosomiasis confirms fears that the project will have hidden costs. China has the experience and infrastructure for effective schistosomiasis control. But preparations for the dam's impact still need to be made, lest the system become overburdened. For as Ziyun reminds us, "the ultimate goal of a water resources project is to promote the welfare of the people, i.e. their quality of life" (Ziyun 1986:349).

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