Three Gorges Project

Milani Chatterji-Len, René García Franceschini, Tchelet Segev

1.011 Project Evaluation and Management

5/17/2018

Table of Contents

Motivation **2**

Overview **2**

Location 2

Timeline 3

Benefits 4

Controversy 5

Project Scope and Problem Statement **5**

Stakeholder Analysis **6**

Overview 6

International Funding Agencies 6

Public Sector 7

Beneficiaries 7

Marginalized Groups 8

NGOs 8

Stakeholder Importance 9

Financial Analysis **10**

Funding Sources 10

Cash Flow 11

Alternative: Solar Power **14**

Analysis of Management **16**

Uncertainty **17**

Measurement Uncertainties 17

Future Uncertainties 17

Applications of this Work **19**

Dams in China Today **19**

Conclusion **20**

References **21**

Appendices **25**

Motivation

Our group had heard about the Three Gorges Project (TGP) in other classes, but did not know much about it. After doing a quick Google search about the project, we were amazed by its enormous scale. We were interested in studying the TGP in greater detail because of its controversy and potential for impact. As the dam with the highest power generation capacity in the world, it is a civil engineering feat. However, at all stages of the project, the Chinese government faced pushback from displaced people, international organizations and other stakeholders.

In addition, the TGP is fascinating to study because it was constructed in China, a country that is quickly developing and has a unique political environment. Infrastructure projects in low- and middle-income countries are especially exciting because they have the potential to mark a development milestone. In the case of China, there was a pressing need for alternative energy sources in order to fuel rising energy demand. Furthermore, the unchecked power of the Chinese government leads to interesting project outcomes and management practices.

Overview

Location

The TGP is located along the Yangtze River in China's Hubei Province. Hubei province is known as the 'Land of Rice and Fish' because it is one of China's leading rice-producing regions ("Chinafolio"). As shown in Figure 1, it is located upstream from Wuhan, the capital city of the province. This region has been adversely affected by floods. In 1954, the Yangtze River flooded and killed 33,000 people. It is also known for its historic significance, with archaeological sites throughout the province ("Chinafolio"). Currently Hubei province draws a large number of Chinese and international tourists because of the Three Gorges Dam.

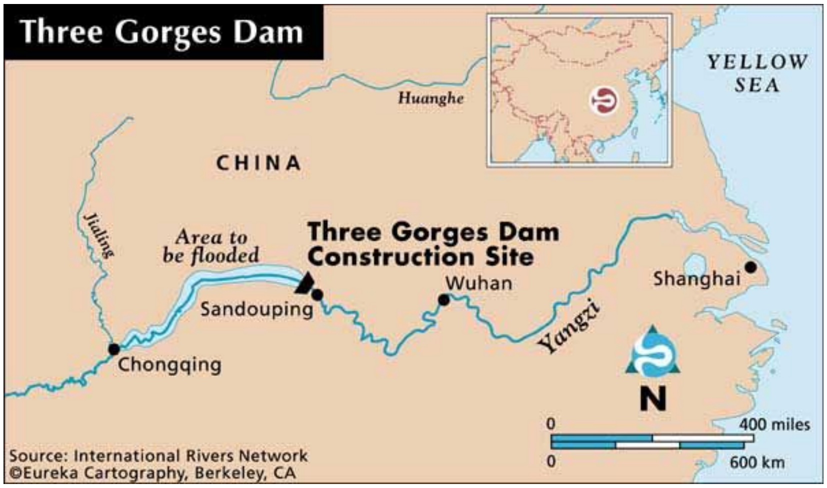


Figure 1. Location of the Three Gorges Dam in Hubei Province, China. ("International Rivers")

Timeline

The timeline of the TGP spans nearly a century. The idea for the TGP was first discussed in the 1920s by the Chinese Nationalist Party, and Mao Zedong ordered site feasibility studies in 1953. Nonetheless, the National People's Congress, the governing body in China, did not ratify the proposal to build the dam until 1992, and its construction did not start until 1994 due to the enormous scale of the project and surrounding controversy.

Statements by the Chinese government after the completion of the TGP indicate that the government was aware of some challenges surrounding it up to 17 years prior to commencement of construction. Due to contention within the Chinese government, approximately one third of parliament abstained or voted against the TGP (Bristow, 2011). This is an unusual occurrence given the normal consensus within the government. Still, construction finished in 2006, far in advance of the 2008 planned completion date. The last hydropower turbine was installed in 2012 ("Three Gorges," 2018). See a full timeline in *Figure 2*.

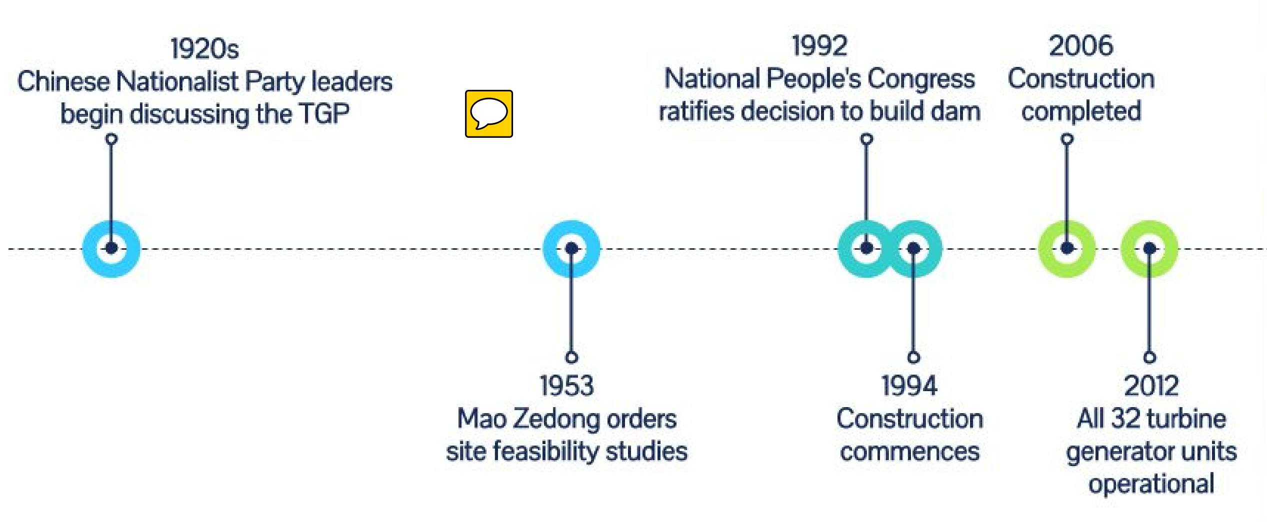


Figure 2. Timeline of the TGP from the 1920s to 2012.

Benefits

The TGP is the world's largest hydropower project ("International Rivers"). The dam is a straight-crested structure made of 28 million cubic meters of concrete and 463 thousand metric tons of steel. The US Geological Survey states that the energy production capacity as of 2016 was 22.5 gigawatts, but actual energy production is much less than capacity due to seasonal variations in water levels (US Geological, 2016). To give context, the Hoover Dam produces 2.1 gigawatts of power, less than ten times that of the TGP (US Bureau, 2017).

Another central goal of the project was to control flooding in the Yangtze basin, although it is unclear whether this was done successfully (O'Hara, 2005). In addition, the dam was designed to allow ocean-going freighters to navigate far inland, providing economic benefits ("Three Gorges," 2018). TravelChinaGuide.com, the largest online Chinese travel agency, expected the dam to generate tourism (Travel China, 2018). The project would also demonstrate that China was on par with the wealthiest countries in the world with respect to infrastructure.

Controversy

The World Bank and other international organizations refused to fund the dam because of environmental, safety, and equity concerns (“International Rivers”). There is severe erosion along the banks of the Yangtze river which has led to frequent landslides, both an ecological and safety issue (“Three Gorges,” 2018). Additionally, the dam has caused increased propensity and severity of droughts in downstream lakes, to the point that some cities have started rationing water (Wong, 2011).

Displacement was an enormous equity concern: an estimated 1.4 million people were displaced due to the flooding to fill the reservoir (Wong, 2011). A total of 13 cities, 1,350 villages, and 140 towns were submerged (Kuhn, 2008). Corruption led to inequitable distribution of relocation spending (Hum, 2003). In addition, since many farmers in the region did not hold formal land titles, they were never provided displacement compensation. Furthermore, there were, and continue to be, political concerns due to the vulnerability of the dam to Taiwanese military attacks and other terrorist attacks (BBC, 2004).

Project Scope and Problem Statement

The scope of this analysis spans from 1993, just before construction started, until 2093, a one hundred year lifespan. No major costs or benefits were incurred in proportion to the total multi-billion dollar pricetag in the timespan between project inception and the beginning of construction. Challenges related to planning and political decision-making prior to construction will be discussed.

In our analysis of the TGP, we will address whether the project costs outweighed its benefits within the specified time and spatial scope. We will include both the positive and negative externalities associated with the project. Subsequently, we will suggest alternative sources of energy generation with greater benefit-cost ratios and higher net present values.

Stakeholder Analysis

Overview

The assessment of saliency of stakeholders was executed according to the following criteria. Power was assigned based on whether the Chinese government would allow the stakeholder to have sway over its decision-making. We identified the Three Gorges Corporation (TGC) as a powerful stakeholder because they were the owner and operator of the project, and were government-backed. The shipping industry was also powerful due to their huge importance to the Chinese economy. We assigned legitimacy to stakeholders who had ethical concerns and the reputation to back up said concerns. Hence, international funding agencies and NGOs fall in this category. Urgency was assigned on the basis of whether stakeholders have needs that must be met immediately, including many marginalized groups and NGOs. The TGC also falls into this category due to its need to deliver the project. Similarly, the Chinese population is an urgent stakeholder due its pressing energy demand.

International Funding Agencies

Because of the large scale of the Three Gorges Project, international funding sources were important players in the feasibility of project construction. Critics of the project urged large international agencies to not fund the project, emphasizing that its completion was impossible without foreign support (New York, 1999). The World Bank refused to support the TGP due to its harmful environmental and social effects. Disapproval from well-known and respected international funding agencies cast a bad light on the TGP. Had the World Bank funded the project, it would have been a powerful stakeholder because it imposes environment and safety regulations on projects it funds. Other export loans made up 19% of project funds, thereby playing an essential role in the project (Tang, 2008).

Public Sector

The largest public sector player in the TGP was the Three Gorges Corporation, which was in charge of construction and operation of the dam and other projects in China. The Yangtze Valley Planning Office and local governments also played a role in the project. As shown in Figure 3, the Three Gorges Corporation was an important stakeholder because they had power, legitimacy and urgency. Money from the Three Gorges Project Construction Fund was funneled through the Three Gorges Corporation, which gave them power to control the project from start to finish (Jiazhu, 2002). Since the corporation is part of the national government, its decisions are difficult to challenge because of the Chinese national government's strength. They were also urgent to complete the project in order to reap the benefits of power consumption as soon as possible.

Beneficiaries

The two major beneficiaries are the general Chinese population and the shipping industry. The Chinese population gained increased access to large amounts of electricity to meet their growing energy demand (Morgan et al., 2012), while the shipping industry was better able to navigate the Yangtze River, lowering costs by 35% (Tang, 2008). The shipping industry profits increased significantly as a result of the TGP. The Chinese population is a demanding stakeholder, while the shipping industry is a dormant one.

There were also stakeholders who benefited from the project but were also adversely affected by it. Downstream residents, for example, were categorized as beneficiaries and as marginalized groups. They gained access to more electricity and faced less flooding (China Three Gorges Dam Corporation, 2007-2015). However, they were also negatively impacted by some of the unanticipated consequences of the dam project: increased droughts (Wong, 2011). Construction workers also experienced the duality as beneficiary and marginalized group. They benefited from the multi-year job opportunities offered by the TGP project. However, their working conditions were subpar and unsafe, leading to over 100 worker deaths (Handwerk, 2006). The TGP Corporation did not have strong incentives to improve worker safety because construction workers are demanding stakeholders, lacking both power and legitimacy.

Marginalized Groups

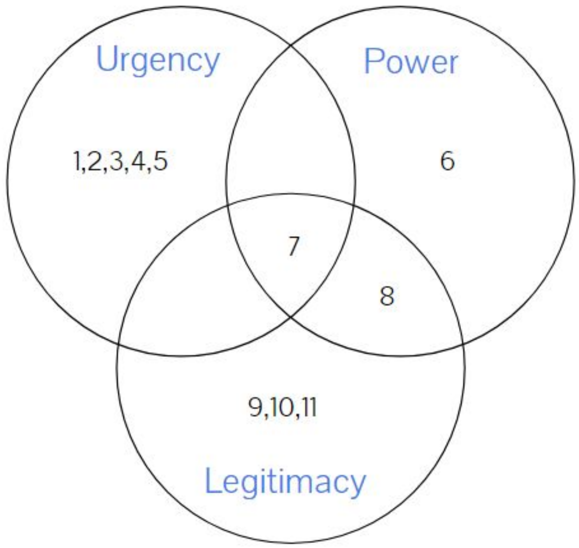
Construction workers, downstream residents, displaced people and fishermen are all classified as marginalized groups because their livelihoods were negatively affected by the project. To make matters worse, the Three Gorges Corporation did not provide compensation in an equitable manner (Hum, 2003). Fishermen were negatively impacted because aquatic organisms suffered from the increased pollution of the Yangtze River, and the drying out of the river downstream of the dam (Wong, 2011; Songguang et al, 2007). Because of their need, all stakeholders classified as marginalized groups are demanding.

NGOs are tasked with representing the interests of the marginalized groups. NGOs can lend legitimacy to marginalized groups, with the benefit that their own legitimacy is magnified by working closely with the stakeholders they represent.

NGOs

This category includes local and international organizations that voiced concern about the project's construction. It is comprised of environmental protection groups, human rights groups, and archaeological interest groups. Environmental protection groups expressed concern regarding pollution, while human rights groups were more interested in worker safety and the relocation of upstream residents (New York, 1999; Kuhn 2008). Archaeological interest groups opposed the project because flooding to fill the reservoir would lead to the destruction of more than 1,200 archaeological sites (Encyclopædia Britannica).

Because NGOs are established institutions, they carry more legitimacy than either the marginalized groups or the beneficiaries. Although they have both urgency and legitimacy, their lack of power made it challenging for NGOs to push modifications to the TGP.



1. Construction workers
2. Fishermen
3. Downstream residents
4. General Chinese population
5. Displaced persons
6. Shipping industry
7. Three Gorges Corporation
8. Environmental, archaeological, and human rights groups
9. World Bank
10. Research institutions
11. Yangtze Valley Planning Office

Figure 3. A venn diagram of stakeholders in the TGP.

Stakeholder Importance

The stakeholder analysis highlights the complete control the TGC has over the construction of the dam, as compared to the negligible influence many beneficiaries and advocacy groups had over the TGP. Furthermore, the analysis showed how international funding organizations withdrawing their support did not influence the outcome of the project, as the central organization, the TGC, still supported the project and its financing. Additionally, the analysis illustrates why the TGC did not consider marginalized groups' perspectives in the project development and execution processes, as Chinese infrastructure development methods do not acknowledge marginalized groups' concerns as legitimate. Ultimately, the results indicate that the TGC is the single most important stakeholder for the completion of the project.

Financial Analysis

Funding Sources

We assumed the funding source for the Three Gorges Project Construction Fund was the primary method that state capital flowed into the project, and that it originated from the tax imposed on Chinese energy consumption. When calculating revenue from the tax imposed on energy consumption, we made the following assumptions. First, we assumed that the levy for Chinese energy was established at start of construction (Dec 1994) and continued for the duration of the project until 2012. The government charged 0.3-0.7 cents/kWh (Jiazhu, 2002), so we took an average of 0.5 cents/kWh and discounted based on the article publication date of 2002. We assumed only 50% of the levy goes to the TGD (because of competing interests, overhead costs and potential corruption) and that the government imposed this levy on 75% of the Chinese population. We utilized Chinese population and energy consumption data from the World Bank for our calculations (World Bank 2014; World bank 2016). We estimated power revenue and export credit from graphs in the Morimoto & Hope 2004 article and discounted according to publication date (Tang, 2008).

State capital (the construction fund) made up ~50% of the funding source (Jiazhu, 2002) and total project cost was $88 billion. The remainder was assumed to have come from foreign loans, as Tang suggested, and was combined with known values for export credit (Tang, 2008; Morimoto & Hope, 2004). The percentages can be seen in Figure 4, with absolute values at $45.7 billion, $23.1 billion, $2.6 billion, and $16.6 billion from the TGP Construction Fund (the energy tax), power revenue, domestic loans, and export credit or loans, respectively, discounted to 2018. Power revenue refers to revenue generated from the TGP between 2003-2009 and revenue from the existing Gezhouba hydropower plant downstream between 1993-2009.

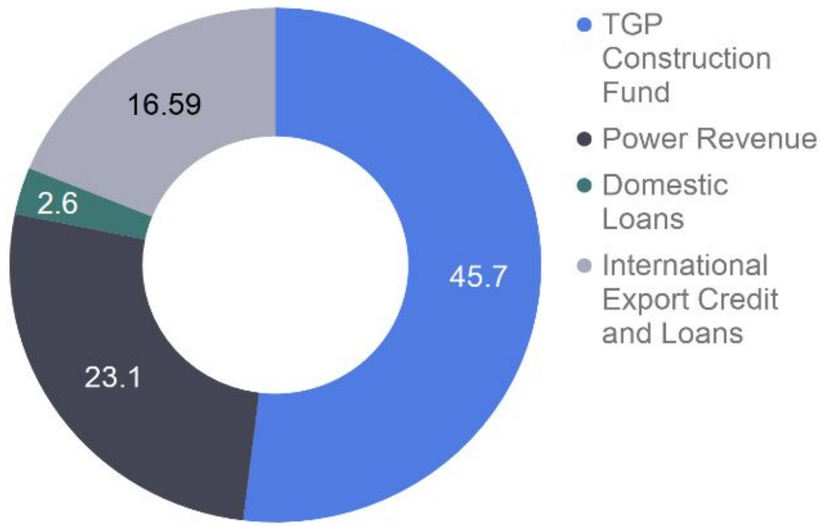


Figure 4. Three Gorges Dam Funding Sources (values in billions of USD).

The TGP was financially feasible because of the large government levy on other power sources during project construction. Its financial success is evidenced by the fact that the project was completed ahead of schedule (Tang, 2008). Finishing ahead of time, let alone completing the construction on time, would not have been possible without adequate support. From the financial perspective, the project was successful as the revenue generated to fund the project was enough to cover construction, resettlement, and archaeological loss costs.

Cash Flow

In the cash flow diagram for the TGP, shown in Figure 5, we include the most influential factors from project inception in 1993 to 100 years after project inception. We include three costs and three benefits:

1. *Construction:* costs put in for construction of the project.
2. *Resettlement:* costs incurred at the beginning of the project to relocate people whose farms and homes would be flooded by the construction of the TGP. Our calculations only accounted for households with land tenure.

3. *Archaeological Loss:* value of lost archaeological sites due to flooding of the area upstream of the TGP. Losses extend throughout the 100 years because of the loss in tourism.
4. *Clean Power:* monetary measure of the quantity of greenhouse gases, primarily carbon dioxide, that were not emitted as a result of switching from coal power, the primary source of power in the area.
5. *Economic Growth:* measure of jobs that were created in the area both as a direct result of construction jobs for the TGP, and as an indirect result of greater access to energy in the nearby area increasing industry.
6. *Power Generation:* revenue from selling power to customers.

There are other costs and benefits that resulted from the TGP, such as O&M costs and flood control benefits. However, Morimoto and Hope show that these unconsidered benefits and costs are relatively small compared to the six main ones. For example, they put the cumulative mean NPV of O&M costs (the largest of the neglected costs) at $5 billion, much smaller than the smallest of the main costs (resettlement), which stands at $12 billion, and ten times smaller than the largest cost (construction), which stands at $50 billion. Likewise, flood control benefits also stand at $5 billion, while the next largest benefit (clean Power) stands at $17 billion (Morimoto and Hope, 2004). Thus, considering just these six main costs and benefits is an appropriate approximation of the total costs and benefits.

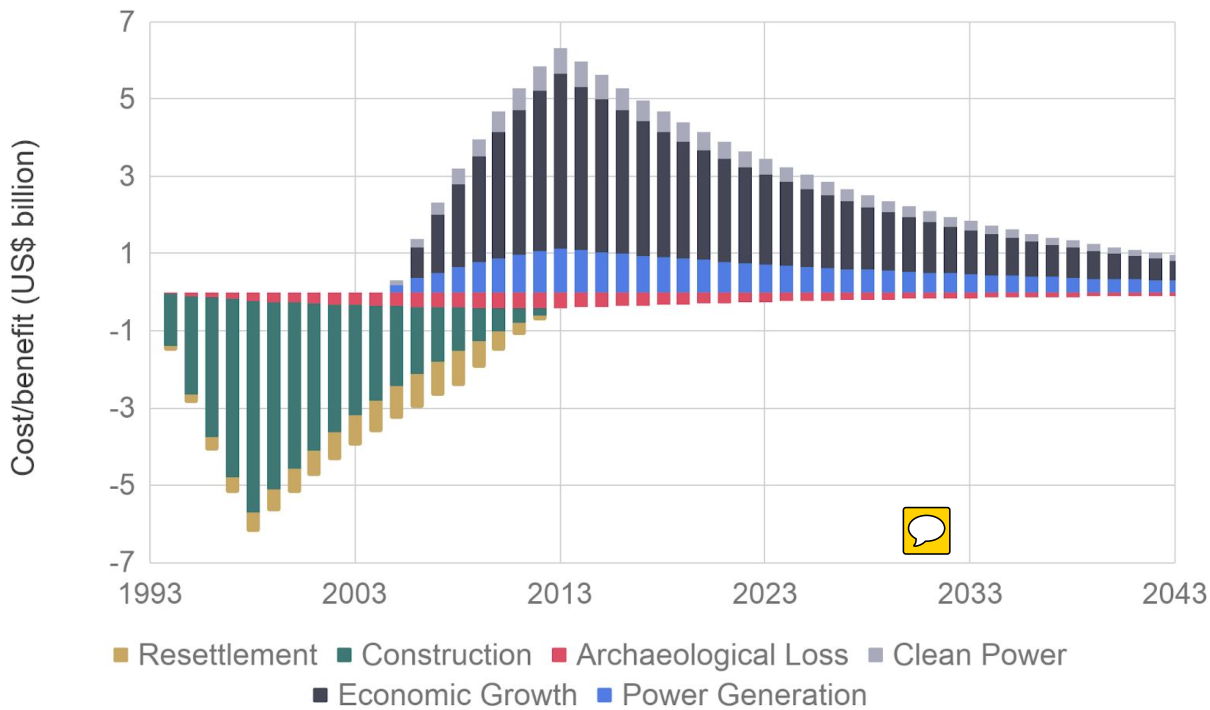


Figure 5. Three Gorges Dam Cash Flow Diagram.

In our analysis, we include social and environmental costs, which are more difficult to quantify than economic costs. To compute the value of social costs such as resettlement and archaeological damage and environmental costs such as biological degradation, we relied on estimates from existing literature. While it is challenging to assign numerical values to these costs, it is important nonetheless to include them in the analysis by attempting to fit appropriate values. For example, the value of farmland being inundated serves as a proxy for the cost of resettlement (Morimoto & Hope, 2004).

We assumed throughout our calculations a discount rate of 5%, and discounted to 1993 USD. We calculated a net present value (NPV) of $60.48 billion, an internal rate of return (IRR) for the TGD at 9%. However, Jiazhu's 2002 journal article listed a 14.8-15.6% IRR (Jiazhu, 2002). The difference is likely because we accounted for social factors including resettlement costs and archaeological losses, which are normally not included in benefit cost analysis. By all three metrics, the TGP's benefits ultimately outweigh the costs. While this means that the project was worthwhile from a quantitative point of view, we wanted to see if we could find an alternative that could provide many of the same benefits, while also avoiding some of the ethical and equity pitfalls that the TGP fell for.

Alternative: Solar Power

We investigated the alternative of using a solar farm to generate the same 22,500MW that the TGP generates (USGS, 2016). We scaled up the 100MW construction costs from (Aguilar, 2016) to the TGP power generation scale. By doing so, we disregarded the potential benefits of economies of scale; that is, that the marginal cost of each solar panel would decrease as you install more of them. Furthermore, we assumed that economic growth, clean power benefits, and electricity revenue are the same, but start in year 1 because construction is faster due to the modularity of solar farms. We assumed construction is completed within a year. We assumed resettlement is 10% of the TGP (because of greater flexibility in solar farm(s) placement) and archaeological costs is 5%, and both have maxima incurred at the first year.

By assuming the same clean power benefits, which is reasonable because both hydro and solar power are forms of renewable energy replacing coal, we ignore the fact that the dam was built with cement, which has a larger carbon footprint than solar panels do.

Additionally, based on (Aguilar, 2015 p. 60), we assumed additional construction costs at 10% of construction costs at year 1 (accumulated O&M costs) every 15 years. It is important to recall that we ignored O&M costs for the TGP as the cost was relatively small compared to the capital costs. We did the same for the alternative (except for the 15 year replacement costs), and believe that the consistent omission in both makes them more comparable.

Finally, the Aguilar research we based our estimations off of are from a solar farm in Ghana. We recognize that Ghana and China have very different climates. However, since China is vast, we believe that it is possible for the government to find locations that are ideal for solar farms, in particular desert regions, much like a lot of Sub Saharan Africa is.

A solar farm that produces 22,500MW (the amount that the TGP would produce) would require approximately 481 km^2, which is the equivalent of a circle with a 12.4 km radius. While this would make for an impractically massive project, solar panels do not need to be all in the same location. Thus, much of the work can be done in a parallel and segmented fashion. Furthermore, by being closer to the energy buyers, energy planners can minimize losses associated with energy traveling from source to destination. Although we recognize these potential benefits with regards to energy losses, we do not attempt to estimate them in our analysis.

Based on these assumptions, we found a 100-year NPV of $219.26B, a BCR of 7.41, and an IRR of 33%. Under all three of these metrics, the solar farm is clearly a superior option to the TGP. As shown in Figure 6, although there would be a hefty initial construction cost, the benefits are made available much earlier. The comparison between the TGP and the solar farm is summarized in Table 1.

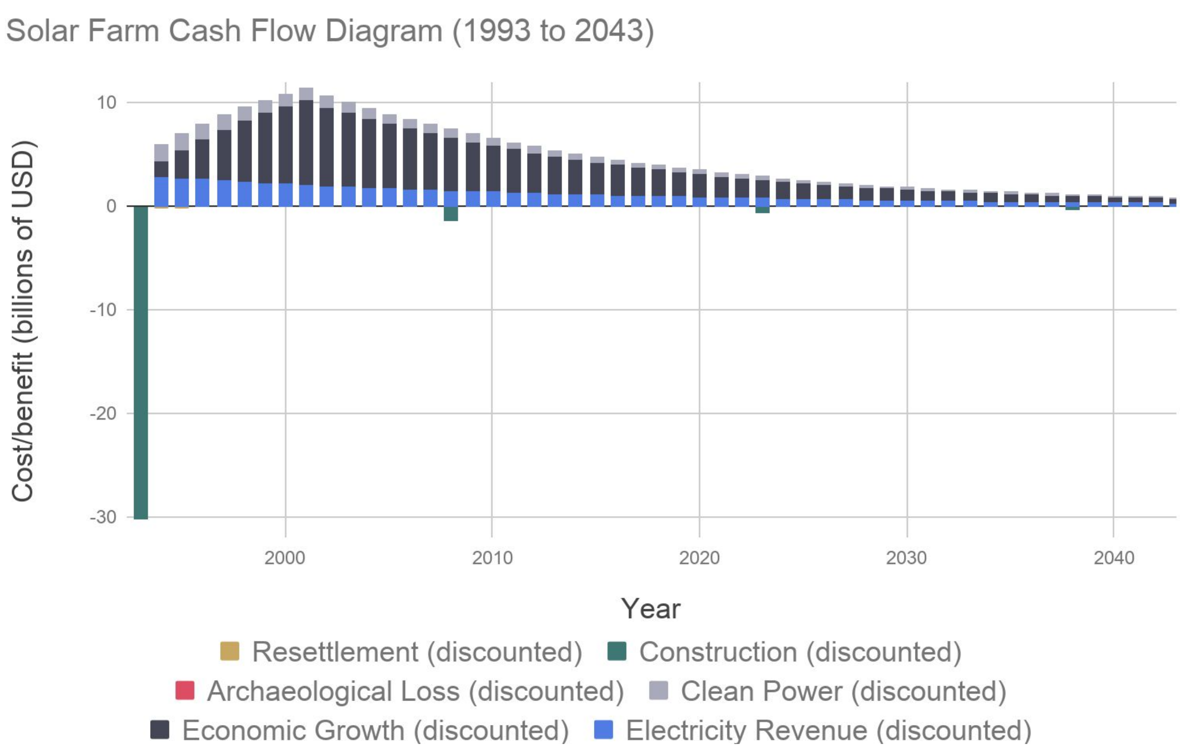


Figure 6. Solar Farm Cash Flow Diagram.

Metric	TGP	Solar
NPV (US$ bil)	60.48	219.26
BCR	1.83	7.41
IRR (%)	9	33
Breakeven year	2020	1998

Table 1. Summary of results for TGP and Solar Farm analyses.

While the solar option seems very appealing, we recognize that th are limitations to this analysis. The most important is that the technology was not available at the time that construction of the TGP began. Thus, the Chinese government would have had to forgo immediate benefits for at least a decade. Furthermore, a solar farm at this scale has not been implemented before, so there are likely challenges regarding losses in transforming from DC to AC, greater variability in available energy, etc. Also, the analysis did not consider the tradeoffs associated with land management if large swathes of land are covered with solar panels. Much more research on the technical limitations of solar energy should be conducted for a more accurate financial analysis.

Analysis of Management

In addition to quantitative analysis, there are qualitative factors in the form of management practices that merit mention. The safety practices in the construction of the TGP were abysmal, resulting in over 100 deaths (Handwerk, 2006). Additionally, money laundering and misuse was a major challenge with TGP management. In particular, NGOs report that $45.5 million of funds originally allocated to displacement was not spent on relocation purposes (Shanghai Daily, 2013). Also, $1.1 billion intended for purchasing and constructing an underground hydroelectric plant was found to have been misused (Reuters, 2015).

Nonetheless, there were some impressive outcomes from the TGP, including an early completion in 2006, ahead of the scheduled 2008 completion date (Bosshard, 2011). Furthermore, the Chinese government retroactively decided to award all 1.8 million displaced people $75 per year for 20 years (Bosshard, 2009). Hence, the TGP is an example of two extremes of project management successes and failures.

Uncertainty

Measurement Uncertainties

The financial analysis in this report assumed a 100 year lifespan for the dam. We base this assumption on the lifespan of the Hoover Dam, a dam of comparable size to the TGP, which has lasted for eighty years so far (US NPS, n.d.). However, there are already cracks appearing along the Three Gorges Dam, so the lifespan we assigned may be unrealistic (Glionna, 2010). There is also measurement uncertainty associated with valuation of social and environmental impact, which is subjective. For example, there are numerous methods to quantify the environmental benefit to reducing greenhouse gas emissions. Similarly, it is difficult to measure the exact number of people displaced, especially since some did not have formal land titles. Assigning a value to each person’s land is difficult because there is tradition and emotion associated with their homes that cannot be expressed adequately in monetary values.

Future Uncertainties

The largest future uncertainty is that Chinese energy demand can only be roughly estimated. The magnitude of financial benefits from energy generation vary based on what energy prices look like in the future. Energy pricing can fluctuate with demand, or future Chinese government policies. In addition, the impact of climate change on the TGP is uncertain. Changing precipitation patterns, which affects river flow and water volume, and hence energy generation of the dam, will affect benefits derived from the TGP. For example, in 2011, severe drought required dam operators to release water from the reservoir. If droughts this severe continue to occur, they could cut into the Three Gorges Dam energy generation (Reuters, 2015).

Furthermore, future environmental impacts remain to been seen. Already, unanticipated erosion along the banks of the Yangtze River has caused additional displacement. The water level in the dam reservoir fluctuates between 145 m and 175 m, which is destabilizing an estimated 178 km of the riverbank. Landslides around the TGP are already occurring, as seen in Figure 7. An additional 300,000 to 500,000 people will need to be displaced to ensure their safety (Bosshard, 2009, 2011). Stabilization is necessary for the 355 sites that as of 2012 had experienced landslides or rockfalls. Currently over 5,000 additional sites are being monitored for potential interventions (BBC, 2012). As explained, the many measurement and future uncertainties have already led to unanticipated outcomes from the TGP.

Figure 7. Soil erosion along the banks of the Yangtze River associated with the TGP construction. Image courtesy of Bosshard, 2009.

Applications of this Work

There are many applications of the analysis done in this report to other hydropower and renewable energy projects. Although the focus of this report was on comparing the costs and benefits of hydropower to solar power, the same framework can be applied when other hydropower projects are under consideration and other renewable energy sources' potential can be investigated. In particular, China has over 200 dam projects proposals (Biello, 2009). Although hydropower can be an improvement over fossil fuel based energy (depending on the magnitude of the environmental impact of the former), this report challenges governments and contractors to assess the potential of other renewable forms of energy.

Furthermore, the China Three Gorges Corporation is increasingly building other renewable energy sources throughout the world. For example, it is building a hydro powered dam in Ethiopia (Rice, 2010). Beyond the applications of this report, the TGC can apply the lessons learned from constructing the TGP to future dams, including estimating the number of persons who will be displaced, better controlling for erosion, and other unanticipated consequences of the TGP. Additionally, the TGC will be launching wind and hydropower projects in Brazil (De Clercq, 2015). This not only demonstrates that the TGC has the capability of implementing a diverse range of renewable energy options, but, in combination with their learning experiences from constructing the TGP and from the analysis of this report, perhaps the TGC will be more inclined to construct wind over hydropower plants. Hence, both through the challenges associated with constructing the TGP and from the results of this report, lessons can be applied to future renewable energy and hydropower projects.

Dams in China Today

In 2015, the Chinese government's Ministry of Environmental Protection blocked the construction of another hydropower project along the Yangtze River that was proposed near Chongqing, the Xiaonanhai dam. Although it is unclear what factors lead to the ultimate blocking of the planned project, strong dissent by environmental groups may be a factor. The proposed site for the dam was in a protected area that was designated to counterbalance the negative environmental impacts of the TGP. This decision indicates that the environmental legacy of the TGP may have lead to increase caution in approving hydropower projects. Additional factors that dissuaded the government from approving the project were the corruption scandal surrounding Bo Xilai, the former chief of the Chongqing party and the high multi-billion dollar price tag (Wong, 2017).

Nonetheless, hydropower construction is a major part of the Chinese government's plan to generate 15% of its power from renewable energy sources by 2020, and to reduce emissions 40-50% by the same year (Ball, 2015).

Conclusion

From the controversy associated with mass displacement of people and extensive environmental destruction to finishing ahead of schedule and successfully constructing the largest dam in the world, the Three Gorges Corporation's legacy is mixed. Despite not accounting adequately for environmental and social costs, the analyses in this report demonstrated that the costs still outweighed the benefits when accounting for both positive and negative externalities associated with the TGP. However, the results simultaneously indicate that a solar farm with comparable energy output would yield a higher NPV, at $219 billion in comparison to $60 billion. The analysis demonstrated that renewable energy projects with fewer negative externalities can yield higher NPVs. The framework used to compare renewable energy options in this project can be applied to future projects in the energy sector, both in China and internationally.

References

Aguilar, L. A. (2015). Feasibility Study of Developing Large Scale Solar PV Project in Ghana: An Economical Analysis. Chalmers University of Technology. Retrieved from http://publications.lib.chalmers.se/records/fulltext/218869/218869.pdf

Ball, P. (2015, January 14). The Chinese are obsessed with building giant dams. Retrieved May 16, 2018, from http://www.bbc.com/future/story/20151014-the-chinese-are-obsessed-with-building-giant-dams

BBC. (2012, April 18). China dam may affect 100,000 more. *BBC News*. Retrieved from http://www.bbc.com/news/world-asia-china-17754256

BBC. (2004). Troops Sent to Protect China Dam. The BBC. Retrieved from http://news.bbc.co.uk/2/hi/asia-pacific/3654772.stm

Biello, D. (2009, October 13). Damming the Yangtze: Are a Few Big Hydropower Projects Better Than a Lot of Small Ones? Retrieved May 14, 2018, from https://www.scientificamerican.com/article/damming-the-yangtze/

Bosshard, P. (2009). Lessons from China's Three Gorges Dam | The Asia-Pacific Journal: Japan Focus. *The Asia-Pacific Journal*, *7*(48). Retrieved from https://apjjf.org/-Peter-Bosshard/3262/article.html

Bosshard, P. (2011, June 17). Analysis: Lessons From China's Dams. Retrieved May 14, 2018, from https://www.internationalrivers.org/resources/analysis-lessons-from-china-s-dams-1667

Bristow, M. (2011, May 19). China acknowledges dam "problems." *BBC News*. Retrieved from http://www.bbc.com/news/world-asia-pacific-13451528

China Three Gorges Corporation. (2007-2015). CTG Annual Report. Retrieved from http://www.ctgpc.com/en/_304039/_304171/index.html

Chinafolio. (n.d.). Hubei Province. Retrieved from http://www.chinafolio.com/provinces/hubei-province/

De Clercq, G. (2015, June 18). Portugal's EDP springboard for China Three Gorges investment abroad. *Reuters*. Retrieved from https://www.reuters.com/article/us-edp-china-three-gorges/portugals-edp-springboard-for-china-three-gorges-investment-abroad-idUSKBN0OY1HU20150618

Glionna, J. (2010, August 26). In China, Three Gorges Dam's image showing some cracks. *Los Angeles Times*. Retrieved from http://articles.latimes.com/2010/aug/16/world/la-fg-china-three-gorges-20100816

Handwerk, B. (2006, June 9). China's Three Gorges Dam, by the Numbers. *National Geographic News*. Retrieved from https://news.nationalgeographic.com/news/2006/06/060609-gorges-dam_2.html

Hum. (2003). China: Three Gorges Dam. The BBC. Retrieved from http://www.bbc.co.uk/blogs/opensecrets/3Gorges1.pdf

International Rivers. (n.d.). Three Gorges Dam. International Rivers. Retrieved from https://www.internationalrivers.org/campaigns/three-gorges-dam

Jiazhu, W. (2002). Three Gorges Project: the largest water conservancy project in the world. *Public Administration and Development*, *22*(5), 369–375. https://doi.org/10.1002/pad.241

Kuhn, A. (2008). Concerns Rise with Water of Three Gorges Dam. NPR. Retrieved from https://www.npr.org/templates/story/story.php?storyId=17723829

Morimoto, R. & Hope, C. (2012). Applying a cost-benefit analysis model to the Three Gorges project in China. Impact Assessment and Project Appraisal. Retrieved from https://www.tandfonline.com/doi/pdf/10.3152/147154604781765888

National Geographic. (2006). China's Three Gorges Dam, by the Numbers. Retrieved from https://news.nationalgeographic.com/news/2006/06/060609-gorges-dam_2.html

O'Hara, L. (2005). The Three Gorges Dam Project. Mount Holyoke. Retrieved from https://www.mtholyoke.edu/~lpohara/index.html

Power Technology. (2011). Three Gorges Dam Hydro Electric Power Plant, China. Retrieved from https://www.power-technology.com/projects/gorges/

Reuters. (2015, September 10). China uncovers more accounting problems with Three Gorges Dam. *Reuters*. Retrieved from https://www.reuters.com/article/china-corruption-dam/china-uncovers-more-accounting-problems-with-three-gorges-dam-idUSL4N11G39T20150910

Rice, X. (2010, March 25). Ethiopia's rush to build mega dams sparks protests. *The Guardian*. Retrieved from http://www.theguardian.com/world/2010/mar/25/ethiopia-gibe-hydropower-dam

Shanghai Daily. (2013, June 8). $45.5 million of Three Gorges relocation fund misused: audit. Retrieved May 14, 2018, from https://journal.probeinternational.org/2013/06/08/45-5-million-of-three-gorges-relocation-fund-misused-audit/

Sun, Q. (2013). Partial Social Cost Benefit Analysis of Three Gorges Dam: Impact Assessment

Tang, J. (2008, February). *China Three Gorges Project: a Case of Intensive Planning and Preparation plus an Innovative and Adaptive approach*. The World Bank. Retrieved from http://siteresources.worldbank.org/INTENERGY2/Resources/Tang.pdf

Three Gorges Dam. (2018). In Encyclopædia Britannica online. Retrieved from https://www.britannica.com/topic/Three-Gorges-Dam

Travel China Guide. (2018). Benefits from Three Gorges Project. Retrieved from https://www.travelchinaguide.com/attraction/hubei/yichang/three-gorges-dam-project.htm

Update and a Greenhouse Gas Externality Component Study. Dalhousie University. https://dalspace.library.dal.ca/bitstream/handle/10222/42660/Sun-Qian-MA-ECOM-Dec-2013.pdf?sequence=1

US NPS. (n.d.). "The Greatest Dam in the World": Building Hoover Dam--Reading 1. Retrieved May 14, 2018, from https://www.nps.gov/Nr/twhp/wwwlps/lessons/140HooverDam/140facts1.htm

US Bureau of Reclamation. (2017). Hoover Dam: Frequently Asked Questions and Answers. Retrieved from https://www.usbr.gov/lc/hooverdam/faqs/powerfaq.html

US Geological Survey. (2016). Three Gorges Dam: The world's largest hydroelectric plant. Retrieved from https://water.usgs.gov/edu/hybiggest.html

Wong, E. (2011). Three Gorges Dam Is Said to Hurt Areas Downstream. The New York Times.

Retrieved from https://www.nytimes.com/2011/06/03/world/asia/03china.html

Wong, E. (2017, December 21). China Blocks Yangtze Dam Project, Activists Say. *The New York Times*. Retrieved from https://www.nytimes.com/2015/04/11/world/asia/environmental-order-in-china-to-prevent-building-of-contested-dam.html

World Bank. (2014). Electric power consumption (kWh per capita). Retrieved from https://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC?end=2014&locations=CN&start=1971&view=chart

World Bank. (2016). Population, Total. Retrieved from https://data.worldbank.org/indicator/SP.POP.TOTL?locations=CN

Appendices

Classification	Stakeholder	Description	Importance	Type (P,L,U), Typology
International funding agency	World Bank	International corporation that provides loans towards construction of major projects, such as the TGP.	Potential major source of funding for the TGP, sets global standards for value of project.	L; Discretionary
Public sector	Yangtze Valley Planning Office	Planning office that originally advocated for the construction of the Three Gorges Dam. They were also tasked with drafting one of the first feasibility studies.	Generated initial push for project.	L; Discretionary
	China Three Gorges Corporation	Public corporation in charge of the construction and operation of the Three Gorges Dam, as well as a number of other energy projects in China.	They are the major stakeholder responsible for orchestrating project implementation and working with the various stakeholders to ensure project completion.	P, L,U; Definitive
Beneficiaries	General Chinese population	General population, not the ones physically affected by construction.	They were the main beneficiaries, since they obtained greater access to electrical power. They also paid for the construction of the TGP through the tax imposed on electricity.	U; Demanding
	Shipping industry	They ship cargo up and down the Yangtze River.	The flooding upstream of the dam increased access for cargo ships, especially larger ships.	P; Dormant
Marginalized groups	Fishers	Both upstream and downstream of the river. Primarily smallholder fishing boats.	Source of income threatened if dam negatively affects fish populations. Could gain money if dam expands fishing area.	U; Demanding
	Displaced people	Up to 2 million people, according to independent sources, that were displaced due to the flooding of their homes upstream.	Livelihoods are affected by the creation of the dam and the upstream flooding it necessitates.	U; Demanding
Marginalized group and beneficiaries	Downstream residents	Residents that were intended to be the main beneficiaries of flood	Potential beneficiaries of dam creation because it provides flood control.	U; Demanding

		control measures as a result of the dam. However, on occasion the dam has exacerbated droughts.		
	Construction workers	People involved in the building of the physical infrastructure.	Construction workers stand to benefit from added employment opportunities. However, working conditions were often unsafe, to the point where dozens of people were injured or killed during construction. Because of low safety standards and lack of human rights recognition in China, they are relatively powerless to change their situation.	U; Demanding
NGOs	Human rights groups	International NGOs voicing concern and raising awareness about the disappearances of Chinese opposers of the TGP, lack of or insufficient remittance distribution, deaths of construction workers, and other human rights violations	Similar to the environmental group, they are trying to hold the TGP accountable, but lack power due to funding and the Chinese government not prioritizing human rights.	U,L; Dependent
	Chinese and international research institutions	Institutions that researched the technical, economic and equity aspects of the dam.	Evaluate effects of dam, thereby challenging its value.	L; Discretionary
	Archaeological interest groups	NGOs attempting to preserve archaeological sites that were flooded during the construction of the dam.	Attempt to limit areas of archaeological significance that were flooded. Lack political power similar to rights and environmental NGOs.	U,L; Dependent
	Environmental protection groups	Support and protect the environment, including land and aquatic species, river banks, etc.	One of the only stakeholders trying to hold the TGP Corporation accountable for the environmental impact they are having. However, they have little power due to lack of funding influence and because of the top-down nature of Chinese government projects.	U,L; Dependent

Table 2. Stakeholders with their classification, description, importance, and typology.