

RIVER UTILIZATION AND TRANSPORTATION FOR 21ST CENTURY: EXPERIENCES AND RECOMMENDATIONS FOR A SUSTAINABLE DEVELOPMENT

Kazuhiko Hasegawa^{1,*}

¹Osaka University, Suita, Japan (hase@naoe.eng.osaka-u.ac.jp)

(*) Corresponding author

ABSTRACT

From ancient times, rivers play a very important role. They are utilized in various ways; drinking water, water distribution into agricultural area, catching river fish as food, transportation, hydroelectricity, etc. They are also important for culture and wildlife reservation. Some rivers such as Ganges in India are important from religious meaning, too. In China, due to the rapid development of economy the river transportation is almost at its maximum capacity. The river transportation near Shanghai is the busiest area in Yangtze River, China. There are many problems such as the development of huge container terminals, very shallow river mouth area and crossing ferries make it difficult. Mekong River passes China, Myanmar, Laos, Thailand, Cambodia and Vietnam. In its upper stream it passes very steep mountain area and in the lower stream it passes a quite flat area. There are rainy and dry seasons. In Chinese area several electricity purpose dams are constructed. International collaboration is quite important. In Indonesia, coal is a very important natural resource and rivers play a very important role for its transportation. In this paper these examples are explained from the author's visiting experiences and the research, for the purpose to point out issues that should be considered to avoid making the same mistakes in the future development plans of many rivers such as the Amazon.

Keywords: river transportation; international river; rivers in Asia; river utilization; dam; sedimentation; sustainable development.

RESUMEN

Desde la antigüedad, los ríos juegan un papel muy importante. Se utilizan de diversas maneras, el agua potable para el consumo humano, la distribución de agua en las regiones agrícolas, el suministro de alimentos provenientes de los ríos, el transporte, la energía hidroeléctrica, etc. Los ríos también son importantes para la cultura y conservación de la vida silvestre. Algunos ríos como el Ganges en la India son importantes en el sentido religioso. En China, debido al rápido desarrollo de la economía, el transporte fluvial está casi en su máxima capacidad. El transporte fluvial cerca de Shanghai, es el área de mayor actividad en el río Yangtzé, China. Hay muchos problemas actualmente como el desarrollo de grandes terminales de contenedores, poca profundidad cerca de la boca del río y el cruce de transbordadores que dificultan la navegación. El Río Mekong pasa a través de China, Myanmar, Laos, Tailandia, Camboya y Vietnam. En su curso superior pasa por una zona de montañas muy empinadas y en su curso inferior pasa por una zona bastante plana. Hay estaciones lluviosas y secas. En la zona de China se construyen varias represas para generación de electricidad. La colaboración internacional es muy importante. En Indonesia, el carbón es un recurso natural muy importante y los ríos desempeñan un papel predominante para su transporte. En este artículo estos ejemplos se explicarán a partir de experiencias de visitas del autor y de sus investigaciones, con el propósito de señalar los puntos clave que deben ser considerados para evitar cometer los mismos errores en los futuros planes de desarrollo de muchos ríos como el Amazonas.

Palabras clave: transporte fluvial; ríos internacionales; ríos en Asia; utilización de los ríos; presa; sedimentación; desarrollo sostenible.

INTRODUCTION

From ancient times, rivers play a very important role. They are utilized in various ways; drinking water, water distribution into agricultural area, transportation, hydroelectricity, etc. They are also important for culture and wildlife reservation. Some rivers such as Ganges in India are important from religious meaning, too. In China, due to the rapid development of economy the river transportation is almost at its maximum capacity. The river transportation near Shanghai is the busiest area in Yangtze River, China. There are many problems such as the development of huge container terminals, very shallow river mouth area and crossing ferries make it difficult. Mekong River passes China, Myanmar, Laos, Thailand, Cambodia and Vietnam. In its upper stream it passes a very steep mountain area and in the lower stream it passes a quite flat area. There are rainy and dry seasons. In Chinese area several electricity purpose dams are constructed. International collaboration is quite important. In Indonesia, coal is a very important natural resource and rivers play a very important role for its transportation. In this paper these examples are introduced from the author's visiting experiences and the research, for the purpose to point out issues that should be considered to avoid making the same mistakes in the future development plans of many rivers such as the Amazon.

YANGTZE RIVER (CHANG JIANG)

Yangtze River, popular name in the world, is the third longest river in the world (Figure 1), but in fact, it is the name of the very lowest part of the whole river which is called Chang Jiang simply meaning 'long river'. In this paper the name Yangtze River is used instead.



Figure 1: Yangtze River (<http://factsanddetails.com/china.php?itemid=460>).

The big cities alongside this river are Chongqing (Figure 2), Wuhan, Nanjing and Shanghai from the upper stream. Nanjing is one of four old capitals of China and the largest city in 14-15 century in the world. Chongqing is assigned as national central city in China as well as Beijing, Guangzhou, Shanghai and Tianjin. Wuhan is also one of centers of industry, finance and transportation in China. Shanghai is one of the most fast growing cities in the world.



Figure 2: Photo of Changqing (<http://en.wikipedia.org/wiki/Chongqing>).

Shanghai is of course the most downstream city and there are many ships navigating. Another river called Huanpo Jian passes through the center of the city and this river is much famous as a sightseeing spot, but at the same time it plays a very important role for inland waterway transportation, too (Figure 3). The river is joining to Yangtze River in the end, and merges with another busy inland waterway (Figure 4).



Figure 3: River Transportation in Huanpo Jian, Shanghai, 2012.

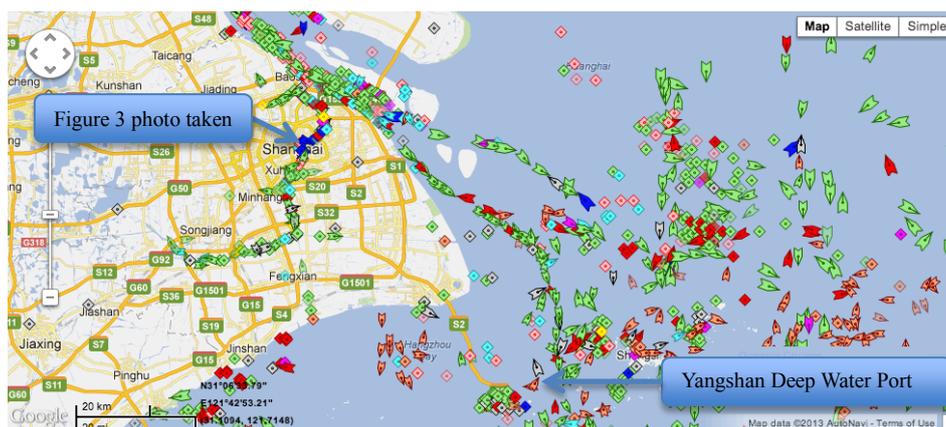


Figure 4: Ships navigating around Shanghai, China (<http://www.marinetraffic.com/ais/> with Go to Area :Shanghai).

As the area is Yangtze delta, the water depth is very shallow. Yangshan Deep Water Port (Figure 5) is a mega size container terminal connected by Donghai Bridge (Figure 6).



Figure 5: Yanshan Deep Water Container Terminal (http://en.wikipedia.org/wiki/Yangshan_Port).



Figure 6: Donghai Bridge connecting Shanghai and Yangshan Deep Water Port
(http://en.wikipedia.org/wiki/Donghai_Bridge)

This area is also famous for the offshore wind farm (Figure 7). China is now the largest wind energy production country in the world (since 2010) and further big projects are still going on[1].



Figure 7: Shanghai Donghai Bridge Offshore Wind Farm.

Apart from Shanghai, the biggest project in Yangtze River is the Three Gorges Dam. The river has transported large quantities of soils every year downstream from the mountain area to the whole area and it makes so many floodings too. The dam has been completed in 2009 for the purpose of producing hydroelectricity and reducing flooding which, however, continued even after its completion[2]. The dam is constructed between Chongqing and Wuhan (Figure 8) and the area is called Three Gorges famous for the scenery (Figure 9).



Figure 8: The position of Three Gorges Dam in Yangtze River (made from
<http://www.people.com.cn/GB/jinji/222/10814/10819/20030528/1002496.html>).



Figure 9: Three Gorges area in Yangtze River (<http://www.yangtze.com/three-gorges/three-gorges-yangtze-river/>, <http://www.chinatour360.com/yangtze/river/three-gorges/>).

The dam made large capacity of hydroelectricity, but at the same time 13 small cities disappeared and 2.3 million people were forced to be resettled[3] (Figure 10). This makes hot discussions inside and outside China(see e.g. [4]). According to Ref. [3], “in order to maximize the utility of the Three Gorges Dam and to diminish sedimentation, China plans to build a series of dams upstream of the Yangtze river, including Wudongge Dam, Baithetan Dam, Xiluodu Dam and Xiangjiaba Dam. The total capacity of those four planned dams is 35,500 MW. Water quality issues are being addressed by increased implementation of treatment plants for industrial and municipal sewage water, since for the time being over one billion tons of wastewater are released annually into the river, which presents a major threat to aquatic biodiversity”. Figure 11 is the vertical profile of the series of dams in Yangtze River and Figure 12 is a photo where river is turned in red by waste water probably by dissolved iron from the reinforced concrete of buildings. There are so many problems including wildlife protection, sedimentation, flooding etc., but it is also true that these dams “help to improve China’s air quality and its related respiratory health problems, by avoiding annually a significant amount of atmospheric emissions; approximately 100 million tons of carbon dioxide, 2 million tons of sulphur dioxide, around 10,000 tons of carbonic oxide, about 3700,000 tons of nitrogen oxides, as well as a large quantity of industrial waste discharges, which will greatly alleviate environment pollution and acid rain in China, its neighbouring countries and regions”[3]. Balancing industrial development and environmental protection is really a difficult problem for developing countries, and we need certain framework to judge these big projects including local people. The Three Gorges Dam project was given consideration as early as 1919, but finally approved only in 1992. There were many discussions not only the budget problem, but it anyway completed 2006. At this moment, we need to support Chinese government and try to control flooding, sedimentation, waste water and ship navigation. It will be a model case for a big river project.



Figure 10: A village disappeared by the completion of Three Gorges Dam[4] (left) (http://www.edwardburtynsky.com/Sections/The_Film/Manufactured_Landscapes.html), comparison of the water area before and after the completion of Three Gorges Dam (middle) (<http://www.learnnc.org/lp/multimedia/9387>) and the reservoir observed by Google Earth® 2008.

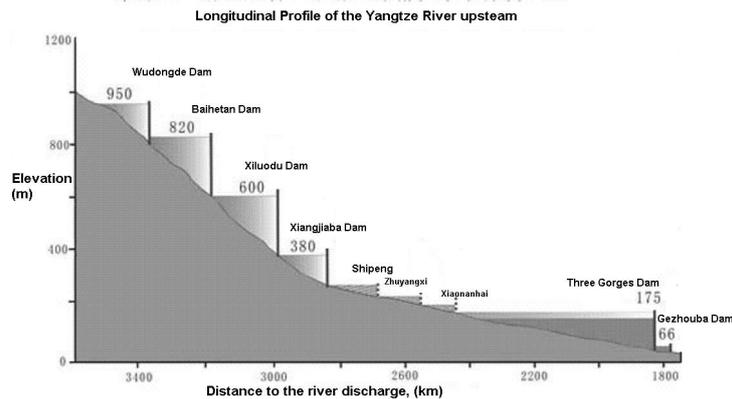


Figure 11 Series of dams in Yangtze River (http://en.wikipedia.org/wiki/Three_Gorges_Dam).



Figure 12: Yangtze River turned into red near Chongqing, Sep. 6, 2012 (<http://deeksha777.blog88.fc2.com/blog-entry-171.html>).

From the viewpoint of inland waterway navigation, there are five successive locks each 280 meters long and 35 meters wide, with a water depth of 5 meters, handling 10,000 ton barges constructed near-by the dam (Figure 13). According to the web site[5], a ship lift is also planned to be constructed. Quoting the article, it said “the ship lift is designed to be capable of lifting ships of up to 3,000 tons. The original plans specified a lift with the capacity to lift 11,500 ton vessels. The vertical distance travelled will be 113 metres, and the size of the ship lift's basin will be 120x18x3.5 metres. The ship lift, when completed, will take 30 to 40 minutes to transit, as opposed to the three to four hours for stepping through the locks. One complicating factor is that the water level can vary dramatically. The ship lift must work even if water levels vary by 12 meters on the lower side, and 30 metres on the upper side”. There is heavy traffic connecting Chongqing and Wuhan as well as Yangtze River cruising. These locks themselves are good sightseeing spots, too.



Figure 13: Locks at Three Gorges Dam (http://www.excite.co.jp/News/photo_news/p-99725/, http://www.chinatourmap.com/three_gorges_dam/images/shiplock.html)

MEKONG RIVER

There are also so many dams and their projects throughout China[6], but most cases they are domestic matter. However, if the case is in international rivers, the matter is not so easy. The river originating maximum conflict in Asia is Mekong. Figure 14 is a typical conflict on this river[7].

IRN
International Rivers Network

Briefing Paper 3
OCTOBER 2002

China's Upper Mekong Dams Endanger Millions Downstream

The Mekong River is the heart and soul of mainland Southeast Asia. Over 60 million people depend on the Mekong and its tributaries for food, water, transport and many other aspects of their daily lives. The river supports one of the world's most diverse fisheries, second only to Brazil's Amazon River.

This complex ecosystem, and the livelihoods of millions who depend on it, is threatened by China's plans to build eight large dams on the upper reaches of the Mekong in Yunnan Province.

The scheme will drastically change the river's natural flood-drought cycle and block the transport of sediment. These environmental changes will affect the livelihoods of millions of people living downstream in Burma, Thailand, Laos, Cambodia and Vietnam. Despite these serious potential impacts, construction of the Upper Mekong dams has proceeded without consultation with China's downstream neighbors, and without any real assessment of the likely impacts to the river and its people.

A Grand Cascade

China plans to build eight dams on the Upper Mekong to supply power to southwest China and Thailand. The first dam in the scheme, the Manwan Dam, was completed in 1996 without prior consultation with China's downstream neighbors. No Environmental Impact Assessment of downstream impacts was carried out. When the reservoir was filled in the 1992-1993 dry season, Thai authorities complained that the dam caused unusually low water levels downstream in the province of Chiang Rai.

Construction of the second dam, Dachaoshan, started in 1996 and is scheduled for completion by 2003. The Asian Development Bank, which claims it would not fund a dam on the main-stream of the Mekong, funded the transmission lines for the project.

A third dam, Xiaowan, began construction in December 2001 and is expected to be completed



Mekong River near Baoshan, China

in 2012. At 292 meters in height, Xiaowan would be one of the highest dams in the world. Impoundment of water during the wet season for Xiaowan would increase dry season flows by up to 70% as far as 1,000 km downstream in Vientiane, Laos. The dam would block 35 percent of the silt that nourishes the fertile floodplains downstream.

The remaining five projects are currently in the planning stages. Jinghong is expected to begin construction in the next few years. The governments of China and Thailand have formally signed an agreement to jointly develop the 1,500 MW Jinghong Dam despite Thailand's current massive oversupply of electricity. Thailand is also negotiating with Yunnan Province over importing some of the power produced by Nuozhadu Dam.

Impacts to Downstream Areas

The Upper Mekong dams threaten to disrupt the Mekong's complex riverine ecosystem upon which millions of people depend for fish and agriculture. About 90% of the population in the Mekong basin is engaged in agriculture and depends on wild caught fish from the Mekong and its tributaries for 80% of their protein needs. The Mekong River Commission (MRC) estimates that the total value of fish caught per year in the lower Mekong basin is more than \$1 billion.

The health and integrity of the Mekong's ecosystem depends largely on two main factors: the annual and predictable flood-drought cycle of the

Figure 14: International Rivers Network, Briefing Paper 3, 2002

18-7

The Mekong, or Mekong River is the longest international river in Asia. It starts from Tibet and passes through China, Myanmar, Laos, Thailand, Cambodia and Vietnam. In 1995, Laos, Thailand, Cambodia and Vietnam established the Mekong River Commission (MRC) [8] to assist in the management and coordinated use of the Mekong's resources. In 1996 China and Myanmar became "dialogue partners" of the MRC and the six countries now work together within a cooperative framework[9]. However, as shown in Figure 14, not only China, but also other countries have some conflicts with local people about fishery, water quality, ship transportation etc. Some NPOs and NGOs are working in Thailand[10], Japan[11] etc. In the upper part Mekong is a very important shipping route for Northern Myanmar, Laos and Thailand, because China is the major supplier of daily goods to these area and systematic land transportation is quite hard due to poor road condition and steep mountains. There are a dry and a rainy season in general, and in rainy season the stream is quite rapid and the navigation is quite difficult, on the contrary in dry season, it is again quite difficult to navigate, because of shallow and rocky river condition. This tendency increases after the upper Mekong River dams construction. Figure 15 is the dams constructed or to be constructed in upper Mekong and in Figure 16 there is a series of pictures taken by the author at Mekong between Myanmar and Laos in January, 2006.



Figure 15: Dams constructed or to be constructed/planned in upper Mekong[10].



Figure 16: Sticking bamboo to check the water depth and go through narrow rapid stream within rocks (upper Mekong between Myanmar and Laos, 2006).

Contrarily in the middle Mekong in Cambodia, the area is almost flat and a huge area will be flooded in rainy season, although the water depth is still very shallow. Tonle Sap (meaning large fresh water river) near Siam Reap famous for Angkor Wat is the largest fresh water lake in Asia and the area has dramatic seasonal changes (Figure 17).



Figure 16: Tonle Sap with its flood plane in rainy season (http://en.wikipedia.org/wiki/Tonl%C3%A9_Sap) and a floating village (<http://blog.conservation.org/2012/01/ci-photojournal-cambodia/>).

Mekong Delta, southeast area including Ho Chi Minh City in Vietnam, is quite rich for various spices and active living, fishing and transport area, too. Nowadays Asian Highway AH1 is crossing the delta. Can Tho Bridge, a part of AH1 and the 12th longest bridge in the world, crosses it, but due to the bridge height above the river surface, the ferry boat service was terminated (Figure 17). Now, most river transportation is barges and small size container ships as well as local cargo and fishing boats, but in the near future, this kind of bridges here and there will be a bottleneck for river transportation.



Figure 17: Can Tho Bridge crossing Asian Highway No.1, Can Tho, Vietnam (<http://www.jigneshbapna.com/facts/15-worlds-longest-bridges.html>).

RIVERS IN SUMATRA AND KALIMANTAN ISLANDS, INDONESIA

There are many rivers and they are used for transportation of local products such as wood, coal and others. In Sumatra, at Palembang, Musi River is crossed by Ampera Bridge which was lift type until 1972, but now it does not move (Figure 18). In the upper stream there is a good coal mine, however, the transportation is done by railway and the capacity of production is limited by this railway capacity. There are timber and palm oil productions in this island, too. Road condition is not so good, so much efficient transportation is required. Again the problem is the balance between the development and the environmental protection. In Kalimantan, timber, coal and natural gas etc. are playing the roles of big industry, but the island is also famous for orangutan. Now Trans-

Kalimantan highway is almost completed, but deforestation is rapidly spread out and huge amounts of soils are conveyed through the rivers. In the river mouths, there are middle-class ports, and dredging is continuously necessary. Trans-Kalimantan highway has high risk to enlarge the phenomena for long time.



Figure 18: Ampera Bridge before 1972 (left, <http://beingindonesian.com/post/2902055855/submission-delicatelittleflower-thanks-ampera>) and after (right, http://tripwow.tripadvisor.com/slideshow-photo/stop-at-kamaro-island-palembang-indonesia.html?sid=53460974&fid=upload_13196314658-tpfil02aw-16150), Musi River, Palembang, Sumatra, Indonesia.



Figure 19: Delta area (<http://eol.jsc.nasa.gov/newsletter/coralreefs/Ch10/STS050-97-65.htm>) and Samarinda, river mouth city of Mahakam River (<http://www.indonesiatravelguides.com/samarinda-historic-city-on-the-banks-of-the-mahakam-river.html>), South-East Kalimantan.

FINAL REMARKS

In this paper, the author has considered several rivers in Asia, *i.e.*, Yangtze River in China, Mekong in Indochina Peninsula and some cases in Indonesia from author's visiting experience assisted by information available in Internet sites and by specific references. On this bases, the author highlights several issues associated with each river. They can be summarized as follows:

- (1) In Yangtze River, environmental issues and heavy waterway traffic problems are urgent. The rapid economical development and increase of population make the problem more difficult day-by-day. The policy makers should consider the matters seriously and settle up a system or organization. We will support this great country's sustainable development utilizing big rivers and canals throughout China.
- (2) In the case of Mekong, some experience from Rhine and Danube Rivers in Europe or from Amazon River in South America may work, but for this purpose China and Myanmar should

join Mekong River Commission as regular members. Water resource quality and flood control are quite important for the development of upper Mekong areas.

- (3) Indonesia and Vietnam are already two leading countries in ASEAN (Association of South-East Asian Nations). However, the development of infrastructures is still depending on ODA (Official Development Assistance) projects from Europe, Japan and other countries. The projects are helping these countries very much, however they should not forget that they have originally beautiful nature including harmonized life style with rivers and that they need not to rush to be environmentally destroyed countries.
- (4) Water problem will be the most important issue in 21st century. Japan is one of the few countries where there are both high-quality river water and tap water created by the mountains and forest behind. Seventy percent of the land is not utilized and kept as natural reserve including planted forest. On the other hand, in Singapore a big ongoing project is to change the river mouth of Kallang River to a catchment. In the Netherlands rivers and canals are a very important national income resource even though they pay much efforts to control flood. They have quit the reclamation project of Ijssel Lake after completion of the closed bank in the referendum to save nature. After long debate, in 1985 [12] the Danish Parliament passed a resolution that nuclear power plants would not be built in the country and there is currently no move to reverse this situation. As a result, now Lolland Island in Denmark is now famous for its ecological wind farm[13]. Each country should find its own way for sustainable development for next generations. Once natural equilibrium is destroyed, it takes long time and huge cost to recover.

ACKNOWLEDGMENTS

The author would like to send his gratitude to Japan Society of Science Promotion (JSPS) which gave him the opportunity to visit several Asian countries on the core universities exchange program on river transportation, especially for the coordinators Prof. Emeritus Kujiji Kose of Hiroshima University, Japan and Prof. Emeritus Sugiono of Surabaya Institute of Technology, Indonesia.

His gratitude is also for Prof. Alberto Francescutto of University of Trieste, Italy for giving this opportunity.

REFERENCES

- [1] 2013 Offshore Wind China Conference & Exhibition Distributed Generation China, "2012-2013 China's Offshore Wind Projects Construction Timetable", <http://www.offshorewindchina.com/english/>, 2013
- [2] USA Today, "China flooding has killed 701 in 2010; worst toll since 1998", http://usatoday30.usatoday.com/news/world/2010-07-21-china-flooding_N.htm, USA Today, 2010
- [3] Thaulow, H., Tvede, A., Simon, T., Seelos, K., "Managing Catchments for Hydropower Generation" in "*Handbook of Catchment Management*", ed. Ferrier, C. and Jenkins, A., Willey-Blackwell, 2010, pp.253-284
- [4] Baichwal, J., "Manufactured Landscape", documentary film (90 min.), Canada, 2006
- [5] Wikipedia, "Three Gorges Dam", http://en.wikipedia.org/wiki/Three_Gorges_Dam
- [6] Wikipedia, "List of Dams and Reservoirs in China", http://en.wikipedia.org/wiki/List_of_dams_and_reservoirs_in_China
- [7] International Rivers Network, "China's Upper Mekong Dams Endanger Million Downstream", Briefing Paper 3, International Rivers Network, 2002
- [8] Mekong River Commission, <http://www.mrcmekong.org/>

[9] Wikipedia, "Mekong", <http://en.wikipedia.org/wiki/Mekong>

[10] Save the Mekong, <http://www.savethemekong.org/index.php>

[11] Mekong Watch, <http://www.mekongwatch.org/english/>

[12] <http://www.world-nuclear.org/info/Country-Profiles/Countries-A-F/Denmark/#.UYpX58pYWSp>

[13] Magnoni, S., Bassi, A. M., "Creating Synergies from Renewable Energy Investments, a Community Success Story from Lolland, Denmark", *Energy*, Vol. 2, 2009, pp. 1151-1169