Flood Mitigation and Disaster Relief Strategy of China

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I. Situation and Development of Flood Mitigation

i. Geographic condition and Hydrology

China is situated at the eastern part of Asia, west of the Pacific Ocean, with wide territory and numerous rivers. China is characterized by high in west part and low east part, gradually descending in elevation from the west towards the east to form three steps. The total land area is about 9.6 million km², with land frontier 22.8 thousand km. China is one of the most typical monsoon climate countries in the world, with two-third area influenced by monsoon. Southeast monsoon can reach Eastern China and southwest monsoon covers coastland of Southwestern and Southern China. Most part of China is characterized by humid and rainy, rain-heat synchronous in summer. Northwestern China is dry and rainless, stretching into the inlands of Eurasia.

The total length of river in China is about 430,000 km, one of the most numerous rivers in the world. There are more than 20 rivers longer than 1000 km, 50,000 rivers larger than 100 km² in catchment area, 1500 rivers larger than 1000 km² in catchment area, 79 rivers larger than 10000 km² in catchment area. The total area of Yangtze, Yellow, Huai, Hai, Songhua, Liao and Pearl River Basin is about 4,300,000 km², amount to 45.6% of the territory. Most of these rivers are distributed in the east and south part of China, characterized by rainy and humid. On the contrary, there are seldom rivers in the northwest part of china.

China has uneven precipitation distribution timely (monthly and yearly) and spatially. It is so different from Southeast coastal area, where annual precipitation can reach 1600mm, to inland area, where that is less than 200mm. China is dominated by mountainous area, two third of total territory, including mountain, plateau and hill, which is mainly located in west of china, with low population density. Compared with
elevation of land, water level of is relatively low. On the other hand, East China is mainly plain region, characterized by high population density and boomed economy. Compared with low elevation of land, water level is relatively high, so it is the concentration region of flood, with huge flood loss. At same time, the coastal area is often struck by typhoon and rainstorm.

ii. Flood and water logging

It is record that there are more than 2700 big flood in china since 2000 year ago, which strongly point out that china has frequent flood disasters. In recent 20 year, there is no river in the seven major rivers (Yangtze, Yellow, Huai, Hai, Songhua, Liao, Pearl) escaping from big flood. Flood is the top trouble for Chinese in all natural disasters. About 63% of the total loss by natural disaster is contributed by flood since 1990’s, which amounts to 1.7% of corresponding GDP. China’s civilization and development have always been closely related to flood mitigation, which is very important component of Chinese civilization history.

iii. Development of flood mitigation

Before 1949, flood mitigation capacity is relatively poor, with seldom infrastructure and low standard, as a result, flood seized lots of property. In 1949, there is almost no dike in condition in all the 42,000 km dikes except limited section such as down stream of Yellow River and middle stream of Yangtze River. At that time, there are only 6 large-scale reservoirs, which are mainly constructed in Northern China, with total storage volume 27.6 billion m$^3$, and 11.8 billion m$^3$ flood management volume. Almost all the major rivers, lakes and detention region run without controlling works. Yellow river was heavily blocked in the downstream because of sedimentation, flood of Yellow River overflow to the Huai River Basin and occupied Huai River channel, which produce wide waterlogging. There is only one discharge route in Hai River Basin, with limited discharge capacity. So there were frequent flood and waterlogging in Yellow, Huai and Hai River Basin mainly because insufficient discharge capacity of river channel in the plain.

After 1949, china launched construction and river training for flood mitigation. Totally 280,000km river dike and 14,000km coastal dike were constructed or rehabilitated.
85,000 reservoirs were built, with total storage volume of 565.8 billion m$^3$. 124 flood storage and detention regions were developed in Yangtze, Yellow, Huai and Hai Rivers, with 117.2 billion m$^3$ storage volume. The river channels were dredged and trained, new channel were constructed to improve discharge capacity. Flood and water logging control works and facilities were developed in both urban and rural area, including 21,140,000 hm$^2$ cultivated land with water logging prevention facility. To reduce sedimentation into the river, about 900,000hm$^2$ land with soil erosion problem was rehabilitated. These measures greatly improved flood mitigation capacity in china and established preliminary flood mitigation system.

With China’s boomed development of economy, urbanization and population, land requirement conflict between people and flood is intensified because of shortage of land resources. Runoff and sediment situation of flood changes with human activity and its influence on flood mitigation:

- Targeted flood increased after extraordinary flood or worse flood combination. For example, after 1998’s flood, designed peak discharge in controlling station of Songhua River increased by 12-44%; in Taihu River Basin, designed peak discharge (once in 100 years) increased by 36-101% because of newly precipitation combination.

- Enlargement of impermeable area because of urbanization, or speedup of concentration process because of dike construction in upstream and tributary and shrink of natural detention area, made peak discharge higher than before. For example, designed discharge in Wuzhou station of Xijiang River increased by 5.2% and 9% respectively for once in 20 year and once in 10 year flood. The peak discharge of once in 10 year rainstorm in Panyu, Guangzhou increased by 20% after transformation from typical agricultural area to industry area.

- Sediment concentration changed owe to varied runoff, ground cover, erosion treatment and construction. In recent 20 years, although total amount of sediment decreased, the concentration increased because of less runoff and water in the river.

- Shrink of natural flood storage and detention regions aggravated flood situation, induced by sedimentation and reclamation of lakes and ponds. Total area of lake
decreased by 15%, compared with 1950’s.

- Runoff in Northern China decreased because of continuous draught and human activity. Some rivers were frequently dried out. River channels and estuaries were blocked by sedimentation, which weakened discharge capacity. For example, discharge capacity of Hai River decreased by 20-75%. Downstream of Yellow River is aggraded 0.1m annually, and main channel continuous raised, which is higher than outside, as a result, discharge capacity declined sharply. Bankfull discharge reduced from 6000m$^3$/s in 1980’s to 2000-3000 m$^3$/s in 2000. In Southern China, water level-discharge relation of many controlling station had a remarkable change, which means higher flood water level even on condition of tiny flood. This kind of change is result of unreasonable measures, such as local contraction works and dikes, local dike reinforcement, and internal drainage system development, etc.

- Bottomland was seized by developed and enlarged urban and town, river channel was contracted by supplementary construction of road, railway and waste residue. Contraction of channel raised water level, hazardous to dike.

New situation of flood and water logging is listed as follows:

- Downstream plain area of the main rivers have an improved flood mitigation capacity owe to development of flood management system, as a result, impacted area is reduced. When designed flood occurs, total impacted area will be only 57% of historical number for the downstream of Yangtze, Yellow, Songhua, Liao, Pearl, Hai and Huai rivers.

- Population and capital was concentrated in the developed urban, which increase unit loss and total loss although impacted area of flood is decreased. At same time, flood will impact more agricultural area because cultivated area is increased especially in flood plain area.

- Possibility of flood resulted from broken dike is reduced owe to dike construction, but drainage in plain area is more difficult because of raise of water level of flood. Water logging problem is exacerbated by weak of regulation volume with development of urbanization and shrink of permeable area, which can be seen in

Flash flood is increasingly remarkable especially casualties of the disaster, owe to deteriorated local erosion, population development in vulnerable area and occupation of natural flood storage region. Effective strategy and measure should be strengthened for flash flood prevention.

II. Flood zoning

More than half of territory is in threaten of flood, including plain of mid-downstream of rivers, coastal storm vulnerable area and flash flood vulnerable area. It can be divided into 3 categories: flood vulnerable zone, flash flood vulnerable zone, according to comprehensive consideration of natural and social factors such as rainstorm, topography, river, population, GDP and influenced are and extent of historical flood.

i. Flood vulnerable zone

Flood vulnerable zone is defined as what could be easily submerged by flood, mainly located on the downstream of the large rivers and coastal area, which is almost coincide with historical flood plain. This category has a total area of 770,000km2, mainly including Songhua-Nen River plain, Sanjiang plain, Liao River plain, Yellow-Huai-Hai River plain, mid-downstream of Yangtze River plain, mid-downstream of Xijiang, the Yangtze Delta, the Pearl Delta, Sichuan Basin, and coastal area which is vulnerable by storm. They play an important role in china’s economic and social development, characterized by high population density and boomed economy. They support 42% of whole population, 62% cities and 29% cultivated land of whole country with only 8% land, producing 64% GDP. At same time, this is the most disharmonious area in china between social development and flood disaster, where flood management is very tough and urgent. Till now, there is protected zone with total area 620,000km2, which has 39%, 62%, 25% of whole country’s population, GDP and cultivated land.

The protected region of Yangtze, Yellow, Huai, Hai, Songhua, Liao and Pearl River is located in the mid-down stream and coastal area, mainly including Songhua and Liao River plain, Yellow-Huai-Hai River plain, mid-downstream of Yangtze River, the Yangtze Delta, downstream of Pearl river and the Pearl Delta, which support 17%
cultivated land, 26% population, 43% GDP of whole country with only 5% land resources. It is the most developed area in china, which has significant meaning for state development and social stable.

ii. Flash flood vulnerable zone

Flash flood vulnerable zone is defined as what could be struck by flash flood, mud-rock flow and landslide, including mountain, hill, terrace, loess plateau, valley, inter-mountainous basin and piedmont plain. The zone covers 4630,000km2, 48% land, 44% population, 33% cultivated land, 32% GDP of whole country. There are 210 cities and 1363 counties included totally. The most flash flood vulnerable area is located in southwest china, Qinba mountain area, rolling country of south of the lower reaches of the Yangtze River, of which there are 430,000km2 land has once in 5 year flash flood, 660,000km2 land has once in 5-20 year flash flood. Till now, there is no effective countermeasure to prevent flash flood owe to insufficient monitoring and forecasting system, poor management and unreasonable development.

iii. Low-level flood zone

The zone mainly covers Inner Mongolian Plateau, Qinghai-Tibet Platean, Northwest China, desert and Gobi, with a total area of 4,200,000km2. There is only few population with density lower than 30 cap/km2. Because the zone is located in the aridity and semi-aridity region, where maximum precipitation in 24h is lower than 50mm, there is only scattered local rainstorm, which is usually harmless because of low population density.

III. General strategy of flood mitigation and disaster relief

i. Main issue of present flood mitigation and disaster relief

Although china has established preliminary flood mitigation system, it is still need to be further perfected to support social sustainable development when following factors are considered:

- Infrastructure is not fully completed.
- Rainstorm prevention system is not established yet.
There are many construction with low design standard, insufficient corollary facilities and poor quality. Most dikes has a low flood prevention standard as once in 10-20 years, except some section surround cities and downstream of Yellow river, whose standards can reach 50-100 year and 50-60 year flood respectively.

Many flood storage and detention region are not operational because there are many people living in the region.

Flood management system is not completed especially non-construction measures such as legislation, river basin management, risk management, forecasting and management system, etc.

General speaking, flood mitigation capacity is not sufficient for big flood. There are only 7.3% of protected region in the seven rivers (Yangtze, Yellow, Hai, Huai, Songhua, Liao and Pearl) qualified according to plan’s target, and only 5.9% of that is higher than once in 50 years. The present capacity of most of the 272 cities which belong to flood vulnerable zone is lower than once in 20-50 year flood, and only 24% is higher than once in 50 year flood. If targeted flood occurs, 285,000km2 land will be submerged. There are 26.2% area with high risk in the main protected region, which support 35.9% population and 39.6% GDP of the whole country.

ii. General strategy of flood mitigation and disaster relief

With economic and social development, China’s government updated it’s knowledge on flood control, as a result, the strategy is transferred to reasonable and sustainable way. Now, to achieve sustainable development goal, scientific development and human-nature harmonious development are established as guideline for flood management, which is adjusted from flood control strategy. It means that construction and non-construction measures such as construction, legislation, command, economy, technique and education measures will coordinated for flood management on basis of integrated water resources management, comprehensive consideration of river training, water resources conservation, allocation, and environmental protection.

According to strategy adjustment of flood mitigation, construction is important measure, but other measures are also necessary for completed flood management system:
To regulate social development to accommodate natural condition, aiming to reduce flood loss.

To establish flood mitigation guarantee system, and to establish responsibility-share mechanism of flood mitigation and disaster relief.

To enhance public awareness of China’s flood issue, and to improve public involvement in flood mitigation and disaster relief.

Comprehensive consideration of flood management, water resources utilization and environmental protection.

To complete legal system for flood management and to strengthen capacity on legal enforcement.

To establish flood insurance and post-disaster reconstruction mechanism.

To broaden financial support for flood management.

To speedup construction of flood mitigation and draught relief command system, hydrometric station and decision making supporting system.

On basis on comprehensive consideration of flood characteristic, flood risk, disaster loss and social development, specific strategies are developed for different categories:

(1) flood management in large rivers

Mid-down stream plain region of the major rivers is the most developed area of china, and also the emphasis of flood management. Although preliminary flood mitigation system has been established, it is still not sufficient for economic and social development. Strategy is listed as follows:

- To strengthen water and soil conservation in the up-mid stream of rivers to reduce sediment.

- To construct controlling project to enhance regulation capacity for flood and sediment and utilization of flood water resources and sediment resources.
• To enhance levee and river training.

• To stable river channel and estuary to improve discharge capacity

• To rehabilitate flood storage and retention region to enlarge capacity of lakes and flood plain, to enable flood storage and retention region operational in effective way.

• To strengthen risk management.

(2) Flood management in the city

Large and mid scale city is the economic and cultural center of state, characterized by high population density, capital concentration, and rapid economic development. But, 90% of these cities are in danger of flood and storm, so the safeguard of these cities is the most important of china’s flood mitigation and disaster relief:

• To corporate flood management and city safeguard into city planning and layout, to escape from high flood risk region.

• To construct specific facilities for city and important economic development area, on basis of river basin and local flood management system, and to improve drainage system.

• To improve flood resistance capacity of infrastructure by itself according to national standards.

• To comprehensively consider city flood mitigation, infrastructure construction and environmental improvement, aiming for harmonious development.

(3) Flood management in small rivers and mountainous area

There are many small rivers in china except large rivers, characterized by huge number and wide distribution. They are mainly located in mountainous area, which is in danger of flash flood, mud-rock flow, landslide. Because flood in the mountainous area produced heavy casualties, flood management in the mountainous area should also be strengthened:
Treatment on small rivers will focus on safeguard of city and residential area, on basis of water and soil conservation and comprehensive management on small watershed, which should be coordinated with large river flood management system. Non-construction measure will be most important for flash flood prevention including forecasting system, emergency planning, resettlement and public awareness. Population and economy shouldn’t develop in high risk area. Valley plain and town is the main protection target, aiming to speedup mountainous economic development.

(4) flood management in coastal area

Coastal area is vulnerable to both flood and rainstorm, especially coastal area of East Eea and South Sea.

Flood management in coastal area focuses on large cities and economic center, aiming to enhancement of storm proof ability. Coastal storm prevention system includes high standard coastal levee and forecasting system. At same time, water resources utilization and ecological-environmental improvement will be comprehensively considered especially for the small rivers which separately discharge into the sea.

(5) flood management in aridity and semi-aridity area

With little precipitation, the geomorphy includes grassland, oasis, Gobi and desert, which has weak ecology and environment. General speaking, flood issue is not so tough as coastal area and downstream of river, but storm rainfall can flood in front-mountain plain and valley plain, where is the focus of flood management, combination with water resources utilization and ecological-environmental protection.