National Education Series for Teachers: (1) Rivers of Our Country

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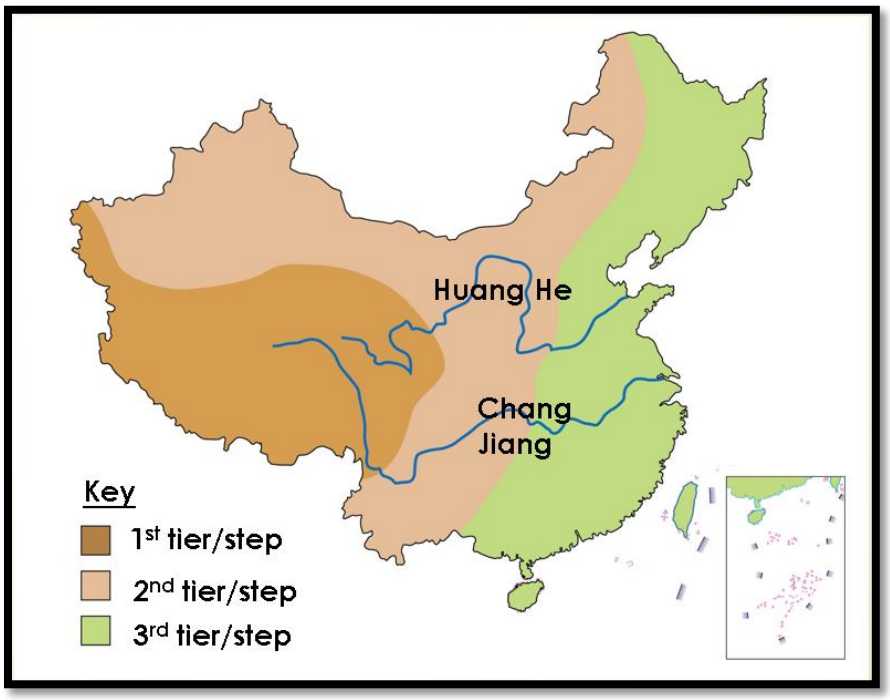
## I. Distribution and the formation of rivers in our country: geology and physiography

### A. The Physiography of China

- ”3 steps”




- Highest : Qinghai-Tibet Plateau (average elevation 4000 m)
- Middle : Loess plateau, Inner Mongolia, Yunnan-Guizhou highlands (average elevation 1000-2000 m)
- Lowest : Eastern / Coastal plains (average elevation below 500 m)

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B. Climate regimes

- Tibet – Mountains / Indian Monsoon
- NW China – Inland
- E China – East Asian Monsoon

C. Geology

**Gravels and conglomerates**

- Describe by its main contents
  - e.g. if most are cobbles -> *cobble conglomerate*
  - Angular clasts -> breccia
  - Sedimentary breccia vs fault breccia
  - Other names: Rudite, rudaceous = conglomerate; conglomeratic

**Port Island (Cretaceous red sandstone/siltstone)**

**Cross bedding**

- Indicate changing direction of flow / energy

**Palaeozoic regional geology : the Indosinian orogeny:**

**after breakup of Gondwana, when Neotethys opened**

Correlating Indosinian orogeny with sedimentary environments

| | |
|---|---|
| Devonian | Bluff Head Fm |
| Permian | Tolo Harbour Fm |
| Carboniferous | Lok Ma Chau Fm<br>Ma On Shan Fm<br>Yuen Long Fm |

Triassic - No outcrop

| | |
|---|---|
| Middle Jurassic | Tai O Fm |

Mesozoic regional geology: South China magmatism due to subduction of Palaeo-Pacific Plate

**Cenozoic**

- India-Asia collision
  - Faulting associated with collision
- Opening of South China Sea
  - Opening of extensional basins

**The legend of the formation of the Iguazu Falls**

- Legend has it that a deity planned to marry a beautiful woman named Naipí, who fled with her mortal lover Tarobá in a canoe. In a rage, the deity sliced the river, creating the waterfalls and condemning the lovers to an eternal fall.
- The general geology was established starting when the Atlantic Ocean opened and South America separated from Africa, some 93 million years ago
- Rifting and fault scarps occur with seafloor spreading, as well as some influence from subduction of Pacific Ocean under Chile from the east starting in Miocene (23 Ma) until Pliocene (2.5 Ma)
- The Iguazu river flows into the continent away from the coast due to the structural uplift (tilting) of the basalts
- The structural uplift initiated the river erosion (incision) and channel formation (meandering) processes

## II. Rivers and civilisations: Huang He

The settlement Asikli Höyük (阿西里克霍伊尤) in Turkey, near an obsidian source, was a place where the material was worked into blades for trade purposes

- The layout of the village consisted of densely packed rectangular houses
- The mud-brick buildings had no foundations, but the floors were finely paved with pebbles.
- There were no doors to the houses.
- Entry was from the roof.
- The roof was an important platform for work and other social activities, including cooking, eating, and sleeping.
- The average room size was 12 square meters, with as few as two or three and as many as five or six dwellings forming a compound focused around a courtyard that served as a workspace for the processing of food and obsidian.
- These compounds, in turn, were part of neighborhoods divided by streets and alleys.

**Tin Trade Routes of the Bronze Age**

**Another reason : Bronze Age trade**

- People sought access to raw materials, especially metals
- Therefore, certain centers came to dominate broader expanses of territory.
- This development also stimulated long-distance trade and diplomatic relations between major powers.
- Artisans made weapons, tools, and ritual objects from bronze, and culture and technology spread to neighboring regions, such as southern China, Nubia, Syria-Palestine, Anatolia, and the Aegean.

**Depositional aeolian processes**

- Reduced wind velocity results in sediments deposition

**Dust settling**

- Loess deposits

**Sand drifting along a pan / flat**

- Sand dunes - hills of loose wind-borne sand
- Size, shape, and orientation of dunes are determined by available sand, vegetation, and wind
- Only 10% of desert surface
- Sand drift in the leeward side

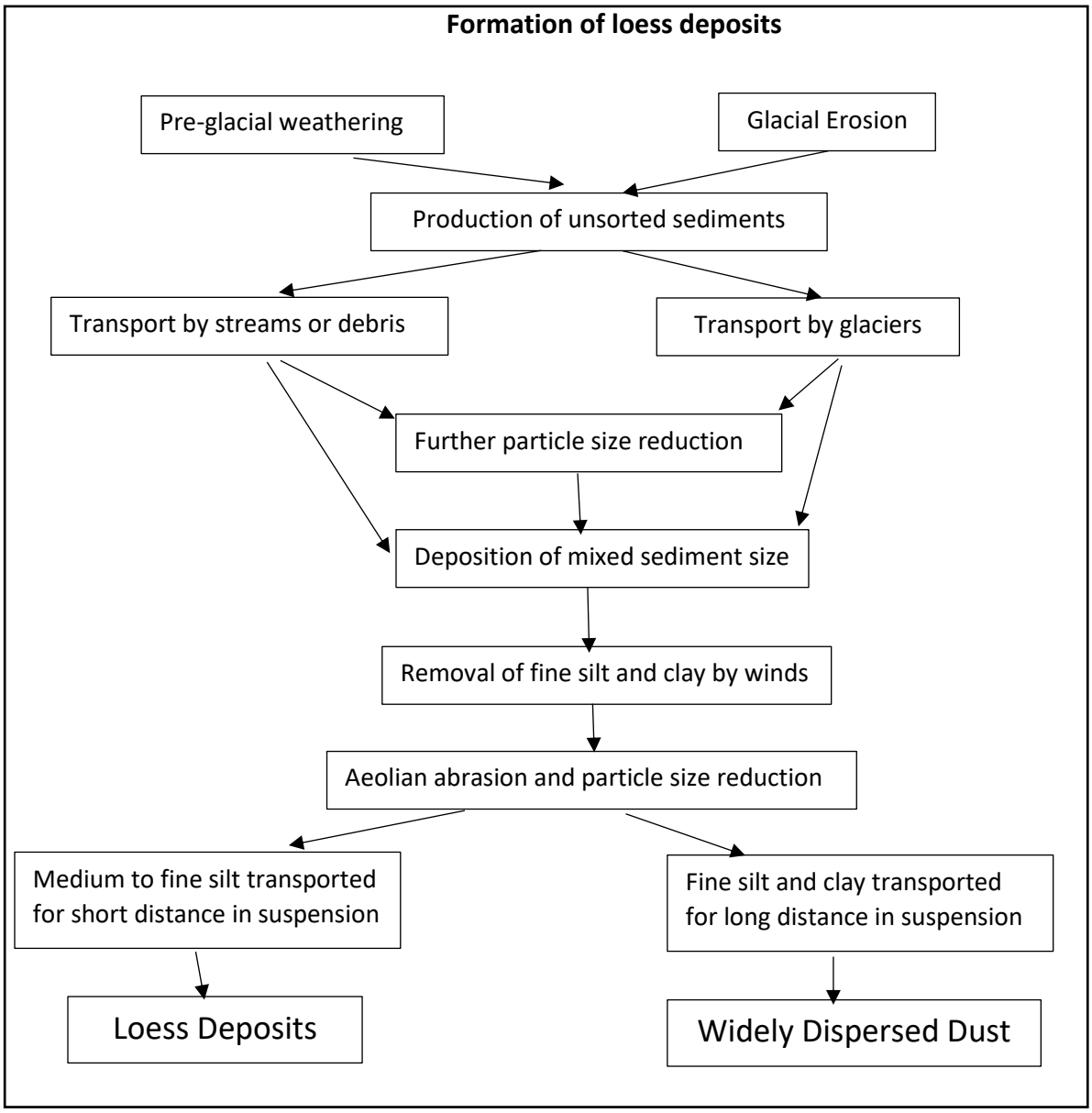
**Loess deposits**

- Loess: wind-blown deposit comprised predominantly of silt-size particles (20-60 mm).
- Loess deposits cover ~10% of the surface of the planet. They are up to ~300 m in thickness in China.
- Loess deposits typically exhibit varying stages of soil development.

**Why so many silt**

One popular theory is glacial, evidence:

- Loess is very fine sediment
- Extensive, thick loess deposits generally formed in areas bordering large, continental glaciers
- Loess is thickest just downwind of major river valleys




**Glacial flour**

- a fine-grained silt formed by glaciers grinding and pulverizing rock.
- glacial flour are made by glaciers, then carried by meltwater streams and deposited in the floodplain
- As stream water levels dropped in autumn, the floodplain dried out and became susceptible to scouring by the wind
- Winds can send plumes of glacial flour kilometers away from the glaciers

**Loess from the Columbia River Basin**

Loess deposits are (usually) of glacial outwash silt. They thin downwind.

**Global loess**

- Origins
  - Desert
  - Glacial
- Layers of dust from Patagonia appear in Vostok cores just prior to Interglacials

**Earliest settlement in China**

- In northern China the shift toward plant-specialization took place at around 8500 BCE (end of last ice age)
- The humid south differentiated itself from the cooler and more arid north.
- As the forest retreated, the locals saw the expansion of wild millet, particularly in the loess-rich areas along the Yellow River.
- Loess, a fertile, mineral-rich soil, is found almost exclusively in this area in China.
- It is ideal for agriculture.

**Chasing after millet**

- Millet also had the advantage that unlike rice, which had specialized ecological needs, millet spreads easily in land cleared of forest.
- Soon several millet-tending village cultures came into existence, such as Shizitan 獅子灘, located along the Qingshui River 清水河(西洛水) a tributary of the Yellow River.
- Another was farther to the northeast along the Yellow River and west of Lake Baiyangdian 白洋淀.
- Here, along the lake's swampy shores, we see a set of villages known collectively as the Nanzhuangtou 南莊頭 culture.
- Stone grinding slabs, rollers, and bone artifacts indicated the extensive gathering of wild millet.
- Banpo 半坡 is located in the Yellow River Valley (near the modern-day city of Xian)
- Well- organized settlement belonging to the Yangshao Culture (5000 to 3000 BCE)
- flourished at the ecological intersection of forests to the south and steppe to the north.
- It had the benefit of the large fertile plains of the Wei, Fen, and Yellow rivers 汾渭平原 that were excellent for millet.
- They were partially embedded in the ground with the earth taken from the excavation used to make an embankment around the hut to deflect rainwater.
- It also served as insulation from the cold winds.
- Steeply pitched thatch served as roof.
- Entrance ramps sloped down into the dwelling.

- This house form goes back thousands of years and is typical of the northern hunting cultures that lived in Siberia and that spread into the Americas.
- The dead were buried either in the back of nearby caves, or outside the village in simple pits in a communal burial area.
- Children, it seems, were interred in urns just outside their homes.
- Within the town, we find structures with large open plazas and storage holes, which are indicative of civic hierarchy and organization.
- At the center of the town was a large house, presumed to be a ritual lodge, which was built of a heavy timber construction of a type that was to become traditional in Chinese architecture.
- There was also a large open space, used no doubt for ritual functions.
- One area of the village was dedicated to the production of pottery, indicating the emergence of proto-industrial specialization.
- One of the oldest kilns in the world can be found here.
- Pottery was used not only in the daily life, but in mortuary rituals.

**Rice production along the Yangtze**

- The history of the transformation of wild rice, which grew in northern India and in the monsoon regions of Southeast Asia, into an agricultural product is somewhat obscure
- around 8000 BCE a rice-oriented economy began to work its way eastward along the Yangtze River, reaching areas between coastal Zhejiang and the Tai Lake region.
- The people of Hemudu 河姆渡 (5000–4500 BCE) became perhaps the first rice-growing specialists.
- The reason might have something to do with plant diversity, or rather the lack of it.

**Dwellings**

- Hongshan houses were square to rectangular in shape, with sides ranging from 4 to 12 meters and were multi-family dwellings.
- Though the culture was organized into farmstead communities, there were no nucleated hamlets or villages, but rather dispersed aggregations of houses on slopes above the rivers. Each community had its own ceremonial facility

**From archaeology to mythology**

- A period of political instability and decentralisation during the middle Shang (ca. 1400– 1250 BC), reflected in remains of multiple regional centers, including Huanbei Shang City to the north of the Huan River at Anyang
- Then the Shang dynasty established its last capital city (Yin) in the area south of the Huan River

**Yinxu**

- The late Shang dynasty was centered at its new capital city, Yin (or Yinxu), in modern Anyang, Henan.
- Yin was developed mainly on the south bank of the Huan River after the Huanbei walled site was abandoned for unknown reasons.
- Regional surveys along the Huan River Valley have revealed marked population growth from the middle Shang to the late Shang
- Yinxu was discovered as the result of the deciphering of Shang inscriptions on oracle bones. Excavations at the site began in 1928.

**Luoyang**

- The city of Luoyang (now Zhengzhou)
- A city built and measured 9 li x 9 li (1 li = 304 m)
- Founded by the Duke of Zhou in 1038BC
- The reconstruction is superimposed upon the excavation map of the walls of the Northern Wei dynasty Luoyang (535AD)
- Chang'an City was located at the most open part in the middle of Guanzhong Basin.
- The basin was a relatively closed olive-shaped geographic unit.
- It is around 300-km long from east to west; and is about 20 km at the narrowest and more than 100 km at the widest from south to north.
- In the mind of the ancient Chinese, the Guanzhong Basin was closely connected to Chang'an City.

## III. Rivers and archaeology: Did Yu the Great tame a megaflood?

**Lajia ruins and flooding**

- The Jishi Gorge Landslide probably caused an ancient flood
- This flood was reportedly an important cultural event in China as early historiographies of China, such as the Shujing (Book of Documents) and Shiji (Records of the Grand Historian) report a devastating flood on the Yellow River over 3,500 years ago.
- Emperor Yu the Great reportedly tamed the flood (probably actually managing the aftermath of the river changes caused by the flood), whereupon he established the first Chinese dynasty, the Xia, thus changing civilisation forever.

## IV. Rivers and hazards: Floods and droughts, flood risk management of our country

- 2019 June - rainfall in the southern provinces of Jiangxi and Hunan had hit record highs.
- In Guizhou province, an entire town was submerged under 2m of water.
- In Guangxi province, 20,000 homes went without electricity and streets in Guilin got flooded.
- Flooding is naturally unavoidable in deltas
- Can positively enhance valuable biodiversities (floodplains, wetlands)
- Important for agricultural activities (fertilization of paddy rice field)

**Pearl River Delta**

- The PRD is located in a tropical-subtropical climatic zone with frequent cyclonic patterns (that is, typhoons, surges and intense rainstorms)
- The delta is suffering from both inland (fluvial) and coastal flood risk.
- The fluvial floods frequently occur from the upper stream of the three major tributaries of the Pearl River: Xijiang (West River), Beijiang (North River) and Dongjiang (East River).
- The worst flooding event was recorded in 1915 when big floods coming from both North River and West River encountered at the PRD with the return period of 1 in 200 years.
- Breach of levees : Guangzhou was inundated for seven days and caused widespread damage in more than 935,000 ha of farmlands
- 100 thousand inhabitants lost their lives or were injured, and some 6 million inhabitants were affected in the delta.

**Traditional inland and river flood management**

- PRD has a long history of protection measures. Dykes and river channel diversion have been used for centuries since the Ming Dynasty
- In modern times, local governments continue to depend on hard engineering approaches.
- Hong Kong and Shenzhen authorities, for instance, rely mainly on river regulation through construction of artificial channels and embankments for flood protection against one- in-50 year events.

**“Hard” engineering measures**

- Levees and dykes for embankment
- dams and reservoirs
- sea walls
- beach nourishment

**“Hard” vs “soft” engineering**

- Channelized river silts up without frequent dredging, so reducing flood protection by 50%
- Engineering defences are insufficient!

We need:

- “soft” protection measures such as flood warning and risk mapping are necessary for urbanized cities
- Overall, the PRD and most Asian coastal regions currently face tough challenges, with a lack of holistic FRM policy existing against a canvas of rapid socioeconomic growth and emerging climate change threats.

**A tech approach**

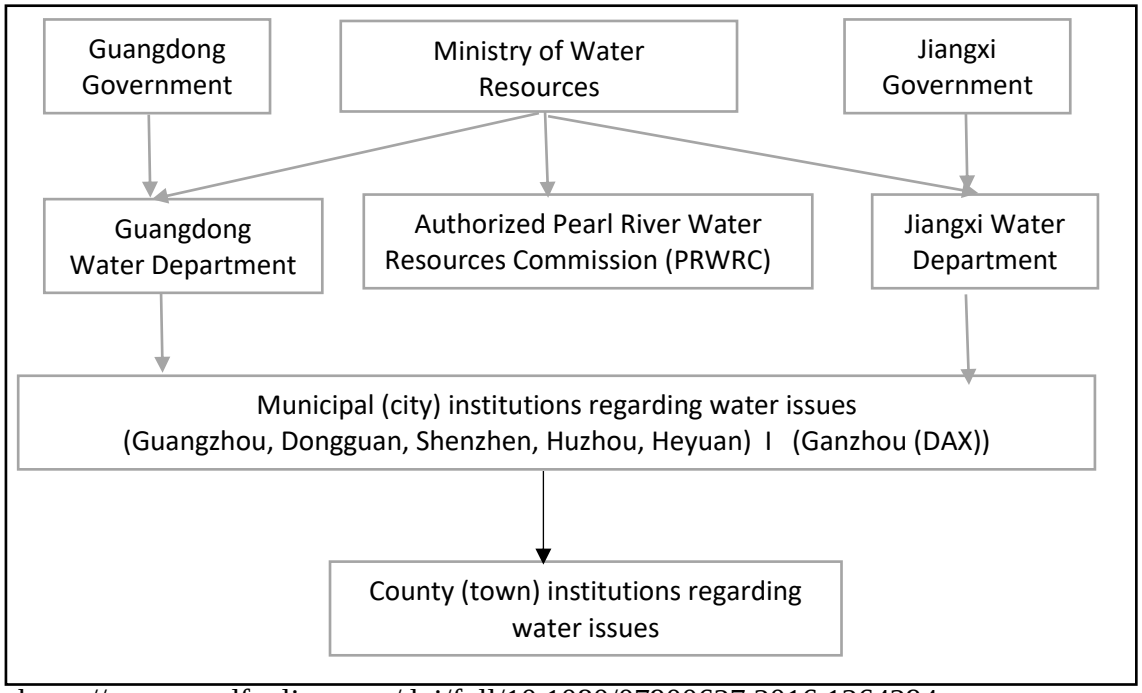
- An existing traffic island at the junction of Wylie Road and Princess Margaret Road transformed into a “*rain garden*”.
- It absorbs more rainwater – the garden is underlain by a series of soil layers with different particles sizes.
- This prevents rainwater from accumulating on streets and in drains, thus mitigating the risk of flooding.

**The "Sponge City" concept**

- Land use planning · Legislation and regulation · Rainfall measurement
- Stream flow monitoring facilities · Warning system · Flood forecasting

**Example : Dongjiang River (DjR)**

- The DjR flows from Xunwu 江西尋烏 and Heyuan—> to Huizhou and Dongguan
- Then the DjR water is pumped to Shenzhen and Hong Kong through large pipelines




https://www.tandfonline.com/doi/full/10.1080/07900627.2016.1264294

**PRD is quite special**

- Hong Kong and Macau are special administrative regions, which are operated by different political jurisdiction systems, based on the 'one country, two systems' rule.
- In addition, Shenzhen was established as a special economic zone in 1984, which means that Shenzhen is not directly governed and managed by the Guangdong provincial government but enjoys a high level of self-governing administrative mechanisms.
- Accordingly, political and economic power could be categorized as descending from the highest levels in Hong Kong and Shenzhen to Dongguan, Huizhou, Heyuan and Xunwu.

Government structure : Four different administrative levels (nation, province, city and county), enhanced by the centralized governance system of the national ministries in Beijing.

**Stakeholder analysis**

- Why is there no action ?
- Analysis : the stakeholder analysis method is based on the levels of interest in and influence on water resources management
- In theory, a stakeholder is defined as a person or organization that has a certain interest or 'stake' in a specific issue
- For example, utilization of a resource or the activities of an organization

- Stakeholders may also have a certain degree of 'influence' over that particular issue or resource, e.g. freshwater resources

**Stakeholder analysis in the PRD**

- Significant social and economic differences between the upstream and downstream cities.
- Upper cities are poorer and less developed, and have less economic power.

Table 1. Socio-economic situation in the Dongjiang River basin, 2010.

| County/City | Population (millions) | Land area ($km^2$) | Urbanization (%) | GDP (US$ billions) | GDP per capita (US$) | Remarks |
|---|---|---|---|---|---|---|
| Xunwu | 0.32 | 2,311 | 35 | 0.45 | 1,435 | River source area in Jiangxi Province |
| Anyuan | 0.37 | 2,375 | 32 | 0.44 | 1,171 | River source area in Jiangxi Province |
| Dingnan | 0.21 | 1,318 | 40 | 0.41 | 1,972 | River source area in Jiangxi Province |
| Longchuan | 0.96 | 3,089 | 34 | 1.63 | 1,699 | River source and upstream area |
| Heyuan | 3.58 | 15,642 | 23 | 7.05 | 1,967 | River source and upstream area |
| Boluo | 1.04 | 2,795 | 46 | 4.36 | 4,202 | Industrializing and urbanizing midstream area |
| Huizhou | 4.60 | 11,356 | 62 | 25.5 | 5,559 | Industrializing and urbanizing midstream area |
| Dongguan | 8.22 | 2,460 | 86 | 62.7 | 7,627 | Downstream area with rapid industrialization |
| Guangzhou | 12.71 | 7,434 | 84 | 158 | 12,493 | Downstream area and regional economic centre |
| Shenzhen | 10.36 | 1,953 | 100 | 140 | 13,565 | Downstream area and regional economic centre |
| Hong Kong | 7.05 | 1,104 | 100 | 225 | 31,907 | Global-class economic centre near the downstream area |
| Basin total | 47.42 | 45,955 | - | 620 | 13,094 | - |

Source: Census (2010) and statistic yearbook (2011) of the cities and counties; Hong Kong Census and Statistics Department.

Note: Currency rate in 2010: US$/CN¥ = 6.769; US$/HK$ =7.769

**Power Struggles**

- Ministry of Water Resources, Dongjiang River Commission Board (Pearl River Water Resources Commission) : most power, not affected
- Upstream areas : less affected, more power
- Downstream areas : more affected, less power
- Water supply companies : affected but have limited power

- NGOs, academics and consultants : not affected, very limited power
- Big communities or groups in the upstream area : may have considerable power to intervene in the management
- Upstream jurisdictions are located in rural and inland areas and downstream jurisdictions are located in urban and coastal areas, the effects of the top-down water-governance approaches on socio-economic inequalities are amplified.
- These inequalities may lead to opportunistic behaviour (i.e., over-exploitation of water and over-discharge of pollutant) and impede the prospects for effective coordination.

## V. Rivers in the future: Impacts of climate change and sea level rise on rivers

**But the whole PRD is at risk now**

- More than 86% of the PRD coastal area relies on flood protection infrastructures (dykes and embankments)
- Only a limited proportion could withstand a one-in-100 year event
- If a projected sea level rise of 30 cm occurs in the next 20 years, then a one- in-100 year storm surge would inundate 80% of the delta, with an estimated 1 million homes flooded, and economic losses exceeding RMB232 billion
- Improving the current flood protection standards in diverse deltaic and estuarine areas would be costly

**Especially when coupled with climate change …**

- A governmental report on PRD strategic regional planning addresses neither existing flood risks nor the possible effects of climatic change.
- Regional CCA remains at the public consultation stage, with limited consideration of implementing FRM.
- Past events have also shown that no institutions are specifically responsible for coastal flood mitigation.

**Hong Kong is no better …**

- In Hong Kong, for instance, the Drainage Service Department (DSD) mainly deals with urban flood problems and their Stormwater Manual illustrates ad hoc approaches that are not based on strategic long-term plans that take into account climate change projections.

**Arsenic – problem with concentration**

- Arsenic is highly toxic in its inorganic form.
- Contaminated water used for drinking, food preparation and irrigation of food crops poses threat
- Long-term exposure to arsenic from drinking-water and food can cause cancer and skin lesions.
- Only remedy - safe water supply.

- Location of known and potential arsenic-affected basins. Areas with high levels of arsenic are generally characterized by Holocene sediments (green) and large basins may be affected.

**High arsenic levels in HK**

In Coarse ash crystal tuff

- Tai Mo Shan
- Ma On Shan
- Sai Kung
- Lai Chi Chong
- SW Lantau

(Much lower in granite)

Anthropogenic contamination + High background

- Ngau Tam Mei
- Lok Ma Chau
- Lin Tong Mei

Eg. Associated with Pb-Zn-Cu mineralisation in Lin Ma Hang

**As in rice**

- Rice tends to take up more arsenic from the environment than other cereal crops, depending on the variety of rice and how it's grown.
- The arsenic in rice also tends to be a more toxic form.
- It has the potential to increase the risk of illnesses in humans, including cancer.

**Food Security**

- After decades of decline, the recent increase in food insecurity is being driven by conflict, economic slowdown, climate variability and extreme weather events.
- Nearly 690 million people, or 9% of the world population, were undernourished, and about 750 million, or nearly 10%, were exposed to severe levels of food insecurity in 2019.
- Food insecurity is projected to worsen by 2030.
- In 2020, over 50 million people were doubly hit – by climate-related disasters (floods, droughts and storms) and by the COVID-19 pandemic.