AS Geography 1.2 Fluvial Environments *Student Notes*

Synoptic Link. The Hydrological Cycle is Used and Managed

- **The reasons for and methods of groundwater and river management in countries at different states of development.**

  You need to be familiar with at least two examples in order to illustrate the development issue. The emphasis is on management in a broad context.

- **Decision-making issues related to management of the hydrological cycle.**

  You need to be aware of the global dimension to the issues involved as well as possible regional conflicts concerning rivers that cross international boundaries.

Multipurpose Management of the Colorado River in the USA

During the last 100 years the Colorado has been transformed from an uncontrolled river into a valuable economic resource providing water for 40million, 120million kw of electricity and irrigation for 800,000 ha of farmland. It also provided flood protection for the growing population of its valley in Colorado, Utah, Nevada, California and Arizona. The river is so controlled that, except in occasional floods, no water reaches the sea in the Golf of California leading to serious environmental concerns.

The river rises in the snowfields of the Rockies where annual precipitation may exceed 2540mm although most areas are much dryer, averaging 500mm. Evapotraspiration rates are high in the hot summers and snow melt is essential for maintaining the flow. Prior to the construction of the dams, flooding was a major hazard for settlements and farmland serious floods occurred between 1905 and 1909.

The "Human Geography" Background

Population Growth: Since the 1950's there has been a rapid increase in population in the South West USA as people have migrated away fro declining industrial areas in the northeast. For example Arizona has seen a 22% increase in population between 1991 and 1998. This has increased the demand for water from the Colorado. San Diego obtains 70% of its water from the river. Other rapidly growth towns include Las Vegas, Phoenix and Tucson. Use of water is often extravagant. There is also pressure to build on the floodplain.

Agriculture: There has been a huge increase in demand for irrigation water for southern California in the fruit growing regions such as the Imperial Valley,. Further north in Colorado, Wyoming and Utah, water is needed for cattle and to irrigate fodder crops such as alfalfa. There have been conflicts in the past over water rights between different interest groups. Already 80% of allocated yields are used and there is much criticism of the wasteful methods used to produce crops which are surplus to the US's needs.

Energy: The raid growth in population has also increased energy demands, including the need for electricity.

Recreation: An affluent population sees water as a resource for recreational purposes such as boating, water sports, camping and rafting. National Recreational Areas such as Lakes Powell, Mead and Havasu attract over 1.5 million visitors a year by road, rail and air.

Management of the System

No authority has overall control of the entire river system. Management is through a number of federal and state funded projects, some of which are multipurpose. Cooperation between Mexico and the USE has been important as the river forms their shared border in the south.

The first large-scale project was the construction of the Hoover Dam to control floods and to generate HEP. Later dams also were to store and supply water for urban areas and irrigated farmland. These include the Glen Canyon Dam (Lake Powell) and the Davis Dam (Lake Mojave). Part of the management challenge has been to address the views of a range of often-conflicting interest groups ranging from farmers and urban populations to environmentalists and Native American groups.

Conflicts have also occurred between neighbouring states about water allocation. In 1922, the Colorado Compact as signed to agree on the allocation between 8 US States and Mexico. Mexican farms receive water along the Central Canal, although California is the main beneficiary.

Some of the Main Management Issues

Environmentalists and conservationist have successfully opposed aspects of the scheme in the Grand Canyon National Park at Echo Park in the Dinosaur National Park.

The Navajo Indians have successfully fought for water rights within their tribal territories and tradition Native American sites, such as Rainbow Arch in Utah, are protected.

There have been concerns about the limitations of the system to prevent floods in extreme conditions such as the El Niño Southern Oscillation in 1983 when heavy rainfall coincided with seasonal snowmelt. The event highlighted the conflict of interest that exists between spring flood control and water storage for the summer. The floods were effectively caused by human failure to lower water levels in time.

Ecological Issues

The changes in the fluctuations and volume of flow are having a severe effect on the riparian and estuarine ecology of the river below the dams.

Before the dams, the Colorado used to discharge between 125 and 130 million tonnes of sediments into the Gulf of California. Now nether sediment or water reaches the sea. This has had a devastating impact, not just o the ecology but also on the coastal processes of beach and bar formation in the Gulf. To combat this, artificial floods were induced in 1996 and 1997 to replace the sediments. Other reclamation projects have also been introduced to improve the habitat for fish, birds and other wetland species in the upper Colorado and Green Rivers.

The Delta: Without regular water, the Colorado delta is now a wasteland, which has seen a rapid decline in fish (e.g. totoaba), birds, jaguars, porpoises and marine grasses.

The Salinity Problem

The Colorado has a naturally high salt content, made more concentrated by high evaporation rates and the salty shales over which the river passes on part of its course. Increased salinity causes particular problems in irrigation areas such as Utah (Green River) and, Arizona. In California and Mexico (particularly Baja California) the salinity and pollution content of the water mean that only limited cultivation is possible. Salt levels build up in the surface of the soil as the irrigation water evaporates. A desalinisation plant at Yuma has helped to improve water quality since 1993.

Sedimentation

Sediment, in the form of silt and sand, is building up behind the dams, reducing their useful lives. The clearer water downstream has more energy available to scour its bed leading to down cutting. This is evident from eroded beaches along stretches of the river in the Grand Canyon.

Hydro-electricity.

HEP is produced in the 7 major dams. It requires steady water flow. There is a problem of evaporation loss at Glen Canyon and Lake Mead. The need for a steady flow can conflict with the needs of high summer demand for water and the need to hold back floodwater in the spring.

The Three Gorges Project and the River Yangtze

Why Build the Three Gorges Dam?

The Yangtze (Chang Jiang) is China's longest river. It has huge potential for HEP and water resources, vital for China's development. Some of the most economically productive and densely urbanised areas, accounting for 40% of China's output, are in the middle and lower reaches of the Yangtze's valley, which are prone to devastating floods.
The project has been discussed since 1919, but severe floods in 1991 were a trigger action for the multipurpose scheme. Further floods in 1998 killed 4000.

The scheme is intended to:

1. Reduce flooding which has been made worse by siltation from poorly managed agricultural land which has made existing lakes and channels shallower
2. Provide vital water for urban areas
3. Provide irrigation water, some of which would be transferred to the neighbouring Northern Plain.
4. Provide HEP and
5. Improve river navigation.

The project was approved in 1992 and the Chang Jiang Province was designated an Economic Growth Region.

The Project

- The world's largest dam will be built at Sandouping, near the eastern end of the Three Gorges, just before the river enters a wide flat plain.
- The dam will be a maximum of 185m high and 1,983m long
- The lake will be 600 km long with a level of +145m in summer rising to 175m in October to hold back floodwater.
- The lake capacity will be 39.3 km^3
- The projects completion date is 2007.
- 13 cities, 140 towns and 1,300 villages will be submerged displacing 1.3 million people.
- The final cost will be in the order of $24 billion or more.
- Chongquig is developing large docks to handle larger vessels. This city will be the economic hub of the region.
- River flood defences are being raised and new roads are under construction. New roads, bridges and towns are under construction to house displaced people

(See separate information sheets for details of the issues raised by the project.)

The Mismanagement of the Rivers feeding the Aral Sea

The Aral Sea was once the worlds 4th largest lake, rich in aquatic fauna and flora. It had large-scale commercial fisheries and was used for transport and recreational purposes. It was also a refuge for huge flocks of wildfowl and migratory birds and it exerted a favourable climate on the surrounding area.

Since the 1960.s the lake has lost over 60% of its water and its surface area has shrunk by 40%. The lake surface has dropped by 14m. Salinity has increased threefold and much of its flora and fauna have been destroyed. The climate has deteriorated and dust storms around the lake margins are common as the soil becomes desiccated.

People have not only lost their livelihoods in fishing and lake transport and trade, but their health has suffered due to declining water quality and respiratory disorders relating to dust ad salt inhalation. The Aral Sea is now regarded as the greatest ecological disasters of the former Soviet Union.

So why has the lake dried up so suddenly?

The rapid desiccation of the Aral Sea, following extraction of water from the rivers that feed it to supply irrigation schemes, has left these boats high and dry and redundant.

The Irrigation Schemes of Central Asia and Kazakhstan

In the late 1950's and early 1960's, a decision was made to expand irrigated agriculture in the former Soviet Republics of Kazakhstan, Tajikistan, Uzbekistan and Turkmenistan so that crops such as cotton and rice could be cultivated.
Water was diverted from the Syr-Darya River and the Amu-Darya River for these irrigation schemes. Large quantities of fertilisers and herbicides were also used to boost production, which have also contributed to the declining water quality.
In many cases the irrigation systems were poorly designed, constructed and operated.

The Remaining Issues

- The scheme is no longer under the control of one government. International co-operation is required to reach sustainable solutions.
- Local populations are in desperate need of safe drinking water.
- The sustainability of growing cotton under irrigation in desert regions needs to be considered. Economic activates that are less dependent on large quantities of water need to be considered.
- Agricultural efficiency needs to be reviewed. There are significant loss of cotton and rice in storage and transpiration. Crop rotation and appropriate technologies need to be used to improve efficiency.
- Irrigation systems need to be redesigned to reduce water loss and the allocation of water needs to be rationed.

River & Groundwater Management in Tunisia

Tunisia has only one permanent river, the Medjerda in the north. This river, and numerous reservoirs, depend largely on the winter rainfall of the Mediterranean climate. These water sources provide irrigation water to support a mix of arable and pastoral farming.

In the south it is much hotter and dryer. Annual rainfall is below 100mm and evapotranspiration rates are high in the $40^{O}C$ temperatures. Water has to be "harvested" fro the rain or obtained from groundwater supplies via artesian wells.

Recent Water Shortages

Water demand has increased in Tunisia as a result of population expansion, tourism and the permanent settlement of formerly nomadic people.

Houses built for the permanent settlement of formerly nomadic people in southern Tunisian, in an attempt to improve living standards. This has led to an all year round demand for water by people and their livestock.

Tourists expect verdant lawns and hot showers, despite the arid location.

New Technology v Traditional Methods

Tunisia receives less than $432m^3$ per person per year compared with a global average of $7,300m^3$. The government saw new technology as the answer by developing large-scale reservoirs and irrigation schemes. Many of the schemes follow designs used in the much wetter and cooler parts of Northern Europe but they have proved to be inappropriate in the hot, dry regions of southern Tunisia.

Traditional Methods

Under Islamic law, environmental protection is highly important. Water is believed to be a communal property and just enough is consumed to meet needs without wastage. In arid areas, traditional method has included rainwater harvesting by collecting and pooling the water around crops to minimise losses. Cropping is low density and water is channelled and collected behind low bunds or *jessours. .* Weeds are removed and the soil is regularly tilled to prevent the formation of impermeable crusts. Legumes are planted to trap nitrogen. The technique also helps to reduce the risk of flash floods and soil erosion.

On the fringes of the Sahara, groundwater management is important and it is brought to the surface in artesian wells in oases. Limited agricultural space is intensively used in a three tier system with a canopy of date palms, a middle layer of fruit trees (apricots, peaches, vines and pomegranates) and a ground layer of vegetables (carrots, onions, salad crops, cereal and fodder crops.
The labour intensive techniques provide food and cash crops for export. Little is wasted as date stones are ground to make a coffee substitute and the palm stems are used to make rope and to make fencing.

Traditional water management for Agriculture in Tunisia

Sustainable use of ground water is essential and water use is carefully controlled to minimise wastage. Payment for the water is made in the form of labour for repairing and maintaining the system.
The diagram shows how the traditional method of water management help to maintain supply.

Centralised Water Management

The problems of centralised government management are well illustrated by the Kairouan catchment in central Tunisia. Over 500,000 people live in the drainage basin with 110,000 in Kairouan. Traditionally a series of small dams along two wadis had enabled controlled irrigation. These dams were replaced by one large structure costing $120 million, yet it can only support 1000 ha compared with the 30,000 ha supported by traditional methods.

The new dam also provides drinking water for the coast but it has caused a depletion of ground water resources leading to vegetation losses, increased surface runoff and soil erosion, causing the dam to silt up. Declining crop yields in the catchment have resulted in rural depopulation (to urban areas) and the abandonment of farmland.

At present 64% of Tunisia's water is from aquifers. These will become depleted as tourism increases on the coast and in so-called "idyllic" oases locations. Settled populations have also increased the demand for groundwater supplies from oases, leading to potential conflict and increased water costs. Tunisia is now beginning to return to more traditional methods of water supply but this will need to be matched by a fall in consumer demand. In the long term, a mix of technological and traditional methods of water management will probably have to be the foundation of a sustainable future for Tunisia's water supply.

Other river management issues that you may wish to read about may include:

- International Conflicts of Interest in Managing the **Ganges**
- Floodplain management of the **Mississippi**
- The **Narmarda River** project in India
- Managing the **Rhine** as an international waterway in Europe.