Water supply and the development of Hong Kong

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Abstract The development of Hong Kong has been closely linked to the establishment and expansion of water supply. However, it has been a constant challenge to provide sufficient water for the population. Importation of water, greatly expanded reservoir storage and conservation have helped improve supply. The drought of 1963 is used to illustrate the difficulties posed by shortage of water, whilst the role of water in sovereignty, public health and recreation/conservation is illustrated.

Key words Hong Kong; impact upon society; water supply

INTRODUCTION

The Water Supplies Department (WSD) of the Government of the Hong Kong Special Administrative Region (SAR) has nearly always been responsible for water supply. Legislation for operating the waterworks system is prescribed in the Waterworks Ordinance and Regulations which are amended and revised when necessary. All urban areas have access to mains supply, while over 95% of people living in rural areas and on the outlying islands also have access to mains water. Despite a well developed supply system, until the 1980s water shortages were not uncommon. The Chief Executive of the Hong Kong SAR, Tung Chee Hwa, has observed that “it has been a continuing challenge to provide sufficient water for Hong Kong’s growing needs”. He goes on to add that “Great engineering ingenuity has been shown, especially in the last 50 years, to provide the precious water” (Tung, 2001). Relatively few accounts of the impact of water shortage upon the Hong Kong economy and society have been given, and it may be of interest to document some examples, along with the challenges involved and the solutions adopted in providing water.

PROBLEMS OF WATER SUPPLY

The water supply problem arises, in part, from the fact that groundwater resources are limited. Furthermore, there are no sizeable rivers or lakes. There are, however, other contributors to the water supply problem, notably climate. Although on average Hong Kong is well watered, considerable variation of annual rainfall exists. For example, for the period 1948 to 2002 average annual rainfall at the Hong Kong Observatory was 2240 mm but exhibited a coefficient of variation of 21%. The problem of annual variability is compounded by the seasonal distribution of precipitation receipt. More than 80% of annual rainfall occurs during the summer season.

Describing the development of water supply from 1841 to 1939 Molyneux (1977) states “Time and again new schemes were introduced which were intended to solve the
water supply situation for the future; but every time the demand for water increased with the rising population and rising living standards and the water supply became inadequate." Other researchers who attest to the importance of population expansion and pressure upon water supply include Fessier (1971), Peart (1993) and Chen (2001).

**SOLUTIONS TO SUPPLY PROBLEMS**

Until the early 1960s Hong Kong attempted to solve the water supply problem solely by developing internal water resources. With its lack of groundwater and variable rainfall yield, Hong Kong has been forced to utilize surface water stored in impounding reservoirs. These reservoirs, linked to water gathering grounds by means of catchwaters and tunnels, have been the engineering response to supply. Initially use was made of streams and in 1851 the first well was sunk to supply the city of Victoria. However, even at this early date there was pressure on supply. Consequently, plans were made to impound a supply of water in a reservoir at Pokfulam. Work began on the scheme in 1860 and the first supplies reached the city at the end of 1863. This scheme marks the beginning of the long running development of infrastructure in an attempt to secure a reliable water supply and set the pattern until the 1960s. Water from streams and catchwaters would be impounded in reservoirs. Other important early schemes include Tai Tam, Aberdeen and Shing Mun Valley. Despite the addition of the Tai Lam Chung and Shek Pik schemes, in 1959 and 1963, respectively, supply was still precarious, and, furthermore, there was a shortage of natural reservoir sites. The observation of Molyneux (1977) that "There was certainly no over-year storage to enable the run-off from one wet season to be kept in storage in case of below-average rainfall in the next wet season" reveals how precarious supply was. In the villages of the New Territories people traditionally relied on wells and streams for domestic water supply.

Hong Kong adopted three solutions to try and solve the water supply problem. In November 1960 the Chinese authorities signed an agreement to supply 22.7 Mm$^3$ of water to Hong Kong from the Shum Chun reservoir. Since then Hong Kong has obtained an ever increasing amount of water from Guangdong Province and it is now the major source of water. From 1981 the East River never supplied <40% of potable water used in Hong Kong.

In a bold move to increase water storage the WSD authorized the creation of a reservoir from the sea. On the northern shore of Tolo Harbour an inlet, Plover Cove, was turned into a freshwater reservoir. Construction began in 1960 and was completed in 1968 although further expansion was finished in 1973. A second reservoir from the sea, High Island, at the east of the Sai Kung peninsula was authorized in 1971 and completed in 1978. High Island and Plover Cove reservoirs have a storage capacity respectively of 281 and 230 Mm$^3$ of water. The water supply improved dramatically after their completion.

There has been a growing trend towards demand management as a means of improving water supply and Hong Kong is no exception. Lo (1998) reports that four types of measures have been adopted to promote water conservation in Hong Kong, namely institutional mechanisms, legal instruments, financial incentives and technical measures. Hong Kong has a variety of legal instruments applicable to water supply and
these are specified in the Waterworks Ordinance and Regulations under which provision is made for water rationing: the most extreme form of mandatory conservation. It is under the category of technical measures that Hong Kong has been most innovative in terms of water conservation. As Lo (1998) reports “A key measure for conservation of potable water is the provision of an alternative supply of sea water, which is utilized for toilet flushing, air-conditioning, cooling and fire fighting”. Use has been made of sea water for supply since the late 1950s. At present around 79% of the population has a sea water supply (Ip & Chan, 2003), and in 2002 this saltwater equalled 25% of potable water supply. Whilst sea water use for flushing is very beneficial, Ip & Chan (2003) identify a number of problems, which includes the need for a dual water system which may raise costs. Lo (1998) also includes individual consumer metering under the category of technical measures and he suggests that this is a major reason for the low domestic consumption of potable water in Hong Kong at around 115 1 capita\(^{-1}\) day\(^{-1}\).

Although some of the water used by the agricultural sector comes from the WSD, the Agriculture and Fisheries Department helps farmers to obtain water for crop irrigation. For example, surface reservoirs have been built to store water for use in irrigation when a shortage of water occurs, although some of these may be managed by the WSD.

**THE FUTURE**

In terms of future development the WSD (2002) indicate that demand is predicted to rise to 1050 Mm year\(^{-1}\) in 2021. They suggest that by utilizing local resources of 295 Mm year\(^{-1}\) along with a maximum of 1100 Mm year\(^{-1}\) of Dongjiang water, no shortage of freshwater is anticipated in the foreseeable future. Of the potential new resources, namely, expansion of existing gathering grounds, desalination and recycling effluent, importing more water from the Dongjiang was the most cost effective.

**IMPACT UPON SOCIETY**

The significance of an adequate supply of potable water is evidenced by the comments of the Government of Hong Kong (1964) following the drought of 1963, namely, that “The position of industry on which the economy and employment of the colony largely depends, was to some extent at issue...”, whilst Botelho (1957) observes that “the importance of water in the development of the urban areas has been brought home time and again to the community, when limited rainfall resulted in shortages, very severe at times”. Chow (1991) observed that water consumption increased 20 times over the 44-year period from 1946 to 1990 due to an increase in population, raising of living standards and industrial development, and this alludes to the link between water and development.

Figure 1 presents a graph plotting population and water consumption for the period 1946–2002. A clear interdependence between population and consumption of water can be seen. It would appear that despite the frequent restrictions upon supply Hong Kong managed to grow and expand. This is not to say, however, that lack of water did
not cause problems: it did impact upon life. An interesting case for examining the role of water upon the development of Hong Kong is afforded by the year 1963 which saw the lowest recorded rainfall and, because of the impossibility of storing extra water for the next year in reservoirs (Molyneux, 1977), a large reduction in water supply occurred. The quotation at the start of this section from the Hong Kong Government implies that the effects on the economy and society were drastic and threatened the future of Hong Kong. However, Fig. 1 plots some indicators of exports and industrial output during the period 1948–1967. It can be seen that industry and the economy were scarcely affected by the drought. Why might this be so? The answer lies, perhaps, in the measures adopted by the Government to conserve supplies in times of shortage. In Hong Kong during droughts the primary requirements of society, namely, essential domestic needs and as far as practicable, the total needs of the industrial and commercial sectors, are met for as long as possible. Secondary requirements, i.e. the less essential needs of the domestic sector and other uses such as recreation would not be met during drought situations. Fessler (1971) indicates that where factories could demonstrate need, water supplies continued on a 24-h basis. Consequently, industry could survive during times of difficulty in supply. Rationing of supply by limiting access meant that only essential domestic needs would be met. Hardship was therefore greatest for domestic consumers. However, this is not to say that commerce and industry was not impacted for, as Ho (2001) indicates, trades that were seriously affected by the lack of water included those that require large amounts of water to produce end products, or for cleaning purposes. The list of affected businesses given by Ho (2001) includes restaurants, canteens, laundries, barber shops, beverage and
brewing industries, bleaching, dyeing and construction. As an example Ho (2001) indicates that by the end of June 1963 barbershops were experiencing a 30% business reduction whilst construction had a 40% decline in business activities. Restaurants were forced to buy water from additional sources or have workers queue for water at public standpipes. In consequence restaurants raised their prices to cover these extra costs. Laundries also raised prices. Fessler (1971) observed that water restrictions in hotels is bad for the tourist industry.

The agricultural sector was also affected and Wong (1971) reported that the drought of 1963–1964 had two adverse effects upon local agriculture: “it reduced crop yields or even caused complete crop failure, and second, it delayed the planting of a crop at the proper time or even preventing planting...” Figure 2 presents some indices of production for agriculture during the period 1958–1967. The Government of Hong Kong (1964) reported that due to drought in 1963 paddy production raised only 9162 t of polished rice at around 1.48 t ha\(^{-1}\). In a normal year they suggest an average yield of about 2.97 t ha\(^{-1}\). Ho (2001) reports that due to the drought in 1963 the second autumn rice crop could not be planted. However, Fig. 2 does indicate that some vegetable crops were less severely affected. Other aspects of agriculture also suffered, with Ho (2001) suggesting that due to the heat and lack of water, animal stocks declined. The decline may not have been too severe as recorded statistics for cattle, pigs and poultry showing no great reduction (Fig. 2). Rainfall and the runoff it generates in streams or rivers provides the source of water for fish ponds in Hong Kong and is needed to lower the natural salinity of many ponds (Wong, 1984). Wong (1984) also identifies three further ways that water shortage has adverse impacts upon pond fish production. Reduced water depth causes a reduction in stocking density; the farmers ability to drain the ponds to prevent overfertilization is governed by water availability and drought may cause premature harvesting of ponds, due to the lowering water levels.

![Figure 2 Agricultural production (year ending 31 March).](image-url)
There was a tremendous drop in pond production of fish in 1964 as a result of the drought and this is reflected in Fig. 2. In terms of agriculture in general, Blackie (1957) reported that limitations of water supply was one of 10 fundamental problems facing farming and observed that “During prolonged dry spells, the farmers of the New Territories suffer severely from shortage of irrigation water”.

The very real impact of the 1963 drought was upon everyday life, some of which has been hinted at in the preceding section. An important conservation measure was rationing/restriction of supply. The Government imposed rationing of water on 2 May 1963 allowing the public 3 h of supply in the day. On 16 May this was reduced to 4 h supply on alternate days. On 1 June supply was reduced to 4 h every 4 days. Clearly only essential needs could be met with these restrictions and Ho (2001) identifies a number of ingenious ways people tried to make the limited supply last longer. The restriction of supply, and its associated burden on the population at large, permitted Hong Kong to survive the drought of 1963. It can be argued that it is restriction of supply that enabled Hong Kong to cope with the pressure upon water resources and is responsible for the population growth and economic activity increases reported in Fig. 1. The importance of supply restriction as a mechanism to cope with pressure upon water resources in Hong Kong cannot be underestimated.

There are other ways that water supply has impacted the development of Hong Kong and a particularly important one is identified by Ip & Chan (2003). They indicate that the switch from dry to water closets could only be made when a suitable and adequate supply of flushing water was available: this arrived with the adoption of seawater and in 1960 the Public Health and Urban Services Ordinance was passed which made specific reference to the provision of sanitary conveniences. The public health implications of water supply to Hong Kong are further illustrated by the outbreak of the plague in 1894, the first time that Hong Kong had registered victims of this disease. The outbreak continued into 1895 and 1896, and was related to high population density and poor public hygiene (Ho, 2001). Ho (2001) suggested that “The government’s ignorance with regard to the importance of an adequate water supply and a decent sewage system was a main factor for its spread”.

The creation of water catchment areas to feed impounding reservoirs has been the engineering approach adopted for internal resources. Currently, water catchment areas covered by the Waterworks Ordinance and Regulations occupy around 1/3 of the SAR. This response has been beneficial in terms of nature conservation and recreation. Many of the water gathering grounds afforested in the interest of water supply now form part of Hong Kong’s Country Parks. Moreover, the Waterworks Ordinance precluded catchment areas from development and provided some measure of protection to the environment. However, as the WSD (2002) indicate, further large-scale expansion of Country Parks, and hence areas suitable for water gathering grounds, is unlikely, due to resistance from local residents because of loss of development potential.

Water importation from China has played an important part in the history of Hong Kong. Indeed it has been recognized that ultimately, because of water, Hong Kong had to return to Chinese sovereignty (Dwyer, 1984). In addition there was a nervousness about the security of supply for as Speak (1997) notes “At any time China could have refused to supply water and the territory would have survived only for a few days”. Whilst Lo (1992) observed that “The Government was striving for self-sufficiency in
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water out of fear of China’s potential stranglehold”. Fessier (1971) describes concern over the reliability of supply from China during the Cultural Revolution and he indicates that in developing water supply in Hong Kong, the British had to consider politics, in addition to nature and economics. However, as Chen (2001) points out “China did provide extra water to Hong Kong in years of low rainfall, sometimes at the expense of Shenzhen and other neighbouring Chinese cities...”. In terms of imported water, recent concerns have focused upon the quality of the imported water (e.g. Chen, 2001). There is also growing recognition of competition for water with the regional economies in Guangdong Province which, as Chen (2001) indicates, are expanding rapidly.

Chiu (1973) offers an example of how the physical development of Hong Kong was impacted by water supply in the case of the Praya East Reclamation. He states “Another obstacle to the early implementation of the scheme was the inadequate water supply obtainable on the Island, since this would be yet further taxed by a large-scale development of residential areas. The final solution to this problem was found in the laying of a cross-harbour pipeline which began to supply the Island with water from the New Territories in 1930, the year in which the Praya East Reclamation was completed”. Indeed this provides a good example of how development and water supply were interrelated.

CONCLUSION

The fact that the five wells sunk to provide water for the city of Victoria in 1851 soon became inadequate, exemplifies the pressure on water supply for much of the history of Hong Kong, as does the experimentation with rain making. Fessier (1971) provides a fitting example to end this review of water supply and society in Hong Kong when he observes that the influx of refugees from China in the 1950s provided entrepreneurs and labour which helped develop manufacturing. The rise in population and industry stressed water supply, but the latter provided revenue/income to the government which persuaded it that investment in water supply was both necessary and prudent.

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