WATER STRESS: SOME SYMPTOMS AND CAUSES—A CASE STUDY OF TA'IZ, YEMEN by Chris D. Handley, Aldershot: Ashgate, 2001.

The book gives a detailed analysis of an extreme water crisis that developed in and around the city of Ta'iz in Yemen, having an urban population of 400,000 and a rural population of about 350,000 people. Water supply deliveries almost collapsed, as the taps in the homes would give water only once in about 40 days. The quality of the water is well below the recommended standard of the World Health Organization (WHO). Per capita consumption of water is also lower than WHO standards. How did such a crisis develop? Well, that is the very subject of the book. The author, Chris Handley (School of Oriental and African Studies, University of London), succeeded to present a comprehensive analysis, integrating very well the physical geographical aspects with the human, social and institutional dimensions.

The city of Ta'iz is situated in an elevated region, 1000 to 3000 meters high. The upper catchment of Wadi Rasyan gives water to the aquifer that supplies the city. Average annual rainfall in the catchment ranges from 300 mm in the lower parts to 800 mm in the higher sections of the landscape. The impact of water use and the return of polluted wastewater on the environment have been extreme, resulting in the demise of the main aquifer. Fieldwork covered the period 1995 to the end of 1998. Causes and roots of the water crisis from earlier periods are also examined.

Chapter two deals with the autopsy of an aquifer, put to 'death' by human mismanagement. The water supply of Ta'iz has been derived from groundwater sources since the 1960s. The earliest well-fields were of low quality water, located close to the city and developed in a USAID project. However, as these wells are situated downstream from Ta'iz, urban wastewater caused severe pollution. Hence water resource development shifted 12 km to the north of the city by 1976. This source became exhausted in 1987, leading to the emergency drilling of six more wells in the same area. In 1989 the water pipeline was extended further north to a sandstone area. However, by 1995, water supply to the city dropped to only once per 40 days, while salinity reached more than 1,500 μS/cm.

Groundwater flow models were developed that include aquifer geometry, permeability of the alluvium, wadi inflows, rainfall, evaporation, runoff, and recharge. Competition in water use between the city and the farmers aggravated aquifer depletion. But even without irrigated agriculture the water resources would have been exhausted by urban use. The calibrated mathematical hydro-geology model enables assessing how long it would take to revive the aquifer, returning it to a sustainable steady-state condition, if irrigated agriculture ceased and abstraction for the city remained low. Thus one basin would recover after about five years and another after ten years.

Groundwater in the area usually contains high concentrations of sulphate, sodium and chloride. Domestic wastewater is a problem. Sewage provisions to the homes were not developed at the same rate as water connections. Moreover, the water shortages in the city provided less dilution for the sewage, causing greater pipe corrosion and

leakage. The result is that surface water and groundwater downstream of the city are polluted by urban wastewater. This wastewater is used by farmers to irrigate millet, but high salinity causes a rapid decline in yields and soil quality. The inhabitants in this area are forced to use this polluted water also for domestic purposes, as there is no alternative water source.

Industrial wastewater adds heavy metals and other toxins to the area downstream from the city. In summary, 'the loss of soil fertility, the increase in toxin levels and especially heavy metals in the food chain and the legacy of polluted groundwater and surface waters of the area are severe... the prolongation of polluting activity over the past 25 years has ensured a significant build-up of pollutants in the unsaturated and saturated zones' (p. 60). The author concludes that an environmental 'time-bomb' has been set off, not only in Ta'iz but also in many Yemeni urban areas, which will leave its mark on generations to come.

Chapter three presents a socio-economic analysis of water allocation and water use. The annual renewable water resources in Yemen have been estimated at 2.1 billion cubic meters, which is slightly higher than in Israel. With a population in Yemen of 16.8 million people, this translates to a theoretical water availability of 125 m^3/capita/year. The world average is approximately 7,500 m^3/capita/year. Some general water requirement rules for an individual human being are as follows: drinking water 1 m^3/year, domestic purposes 100 m^3/year, food production 1000 m^3/year.

The agricultural terraces are a most impressive feature of the landscape in Yemen. Rainwater harvesting and runoff agriculture have been practiced here since time immemorial, dating back to at least 1000 BC. The shift to groundwater based irrigation agriculture is very recent, partly financed by remittances of one million Yemenis working in Saudi Arabia and the Gulf states from the mid-seventies until the Gulf War of 1990-1991. Agriculture in Yemen today occupies about 5 percent of the land. There is more cultivable land than available water resources. Agricultural water use in the studied area is 75 percent based on rainfall. This rainwater cannot be used of course for any other purpose. Water used by agriculture from stream flows is about 10 percent. It is difficult to use this water differently, as much is polluted and the remainder allocated under strict rules. Only groundwater used by agriculture could be reallocated, but this comprises only 22 percent of agricultural water use in the area. Total water use in the Upper Wadi Rasyan area is summarized in the table on the next page.

A detailed discussion concerning the anatomy of the water crisis is given in the fourth chapter, followed by the conclusions of the book in chapter five. An integrated, interdisciplinary approach to water use is essential to understand the determinants of water allocation and the introduction of sustainable measures. The author used the data from Ta'iz to critically examine the following issues:

1. The relevance of demand management;
2. The role of adaptive capacity, particularly social;
3. The relative importance of economic and political factors;

Sector	*Average annual water use* (million m^3)
Rainfed agriculture	100
Groundwater irrigation	30
Stream-fed agriculture	3
Domestic use	2.5
Livestock	0.4
Total water use	135

4. The contribution of plural legal and institutional frameworks;
5. The significance of virtual water and population growth;
6. The potential for sustainable development.

The private sector has failed to maintain water quality standards. However, private drinking water treatment companies have proliferated as the quality of public water declined. The proportion of income spent on water is above the level recommended by the World Bank, i.e., 2 percent of household GDP. The wealthy can afford water, but the poor are queuing for free water from standpipes. Water scarcity is extreme, only 25 litters of water are available per capita per day. An important result from the investigation is that only a small amount of water may be used for reallocation: the 30 million cubic meter of renewable groundwater that is currently used for irrigated agriculture. However, the cessation of irrigation is not advocated, as it would not solve the water scarcity problems. Nevertheless, industrial use of water per cubic meter produces 2,300 times more income and 300 times more jobs than irrigated agriculture.

So, what about food supply? Average household consumption is 24 sacks of 50 kg wheat or flour per year. This is mainly derived from food imports. The production of food grains in Yemen has remained static at around 500,000 tons per year, while imports of cereals have risen five-fold from 500,000 tons in 1975 to 2,500,000 tons in 1996. It is no coincidence that dependency on large-scale food imports began with the migration of workers to Saudi Arabia and the Gulf states.

The author suggests that the long-term solution for the chronic water scarcity is desalination of seawater, but this may be too costly in the current socio-economic setting of Yemen. The book contains a wealth of information and is highly recommended as a detailed case study about the development of extreme water shortages and severe pollution problems in relation to the non-sustainable use of groundwater in a semi-arid region. Other dryland regions in the world, including Israel, should take this case very seriously as a warning. The correct water policy decisions have to be taken and implemented now, in order to prevent future water shortages and deterioration of water quality in their own respective cases.

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