Abstract of the lecture

**Urban Water Challenges and Opportunities in Singapore**

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$$Sustainable\ Cities = \frac{1}{(Water \times Energy \times Temperature)^{Climate\ Change}}$$

Rapidly expanding cities of the world from giants like Shanghai and Sao Paulo to the regional centers like Monterrey and Nairobi are either the great hope for the future or the source of new nightmares. Will the city of the future be poor and polluted with islands of prosperity in the midst of oceans of despair?

The issues are greatly amplified by climate change, which is now forcing itself upon us - a new reality that cannot be ignored. Threat of sea level rise, greater fluctuations in freshwater flows compel us to look far into the future and anticipate developments in face of ever increasing uncertainties. The threat may not be urgent, but is nevertheless acute. Responses cannot be delayed. At least some decisions must be taken now in face of huge uncertainties.

Cities critically depend on water and energy, which are closely inter-related: we use energy for water and we use water for energy. For example, we use energy to heat, treat and move water. In addition to using energy for water, we also use water for energy. We use water as a coolant for thermoelectric power plants, and as a critical input for production of biofuels.

Unfortunately, the energy-water relationship introduces vulnerabilities whereby a constraint on one resource introduces constraints in the other. While the energy-water relationship is already under strain today, particularly in cities, trends imply that the strain will be exacerbated unless appropriate action is taken.

And where is temperature in all this? Global warming, the increase of the average temperature of the earth near the surface, is now commonly accepted. Especially in cities the temperature has been rising over the past century. Increased density and area covered by concrete buildings and asphalt roads absorb the sun's heat, and waste heat from air-conditioners, cars and industry cause temperatures to rise more quickly in urban centres than in the surrounding areas.

The hot city phenomenon has far-reaching environmental sustainability and human livability implications, ranging from the aggravation of health problems such as heat stress, increasing the intensity of urban air pollution, and contributing to extreme weather events - in addition to the ever-increasing use of air-conditioners, with impacts for energy supply, brownouts and greenhouse gas emissions.

In this context, the key questions are whether we can develop and deploy *flexible* building designs, environmental, energy and logistical systems to make evolving cities sustainable enough to mitigate the impact of changing climate and growing populations with ever more disposable income. Adaptations that are needed require economic and societal transformation comparable to the industrial revolution. Existing arrangements will be radically altered and new ones created across variety of sectors including water management, building technologies, transportation, information technologies, energy, materials and therefore entire supply chains systems.

To adapt means to be flexible. This in turn implies that we must learn how to incorporate right amount of flexibility in our technical plans and societal arrangements. But, do we know how to measure flexibility at all?

If we learn how to get it right then the city will attract people from the destructive activities of subsistence agriculture to wealth creating jobs in the city, where advanced environmental technology, efficient transit, ecological housing and dense information systems will enable them to live more lightly on the earth …and if we don't?