Water, Energy and Food Security:

integrated technology solutions for sustainability

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Who am I? A snapshot

- Adjunct Professor in the School of Civil, Environmental & Mining Engineering at The University of Western Australia
- Strategic business and project management consultant
- International adviser on practical strategies for emergency management and climate change adaptation.
- Societal Implications/Quality of Life Track Chair, IEEE 2014 Conference on *Technologies for Sustainability*
- Distinguished Lecturer, IEEE Society on Social Implications of Technology (SSIT) and Chair, SSIT Distinguished Lecturer Program
- Chair/Coordinator SSIT Chapters, and Chair, SSIT Australia Chapter
- SSIT Representative on IEEE-USA Committee on Transportation and Aerospace Policy (CTAP)

Five Key Discussion Points

- The Water, Energy and Food Security Nexus
- What do we mean by ‘sustainability’?
- Integrated technologies for Water Security
- Integrated technologies for Energy Security
- Integrated technologies for Food Security

Discussion Point #1

The Water, Energy and Food Security Nexus

Water Security, Energy Security and Food Security for all are the primary aspirations of the global community.

HOWEVER

Jointly, they form the single most important and challenging problem the global community faces today.

WHY

Because Water, Energy and Food are inseparably linked, and global concerns about limited access to these three fundamentals for life are compounded by growing concerns about their future availability and sustainability.

THEREFORE

To effectively deal with this Global Strategic Problem poses significant political, cultural and technological challenges.

Water Security

Water security is defined in the Millennium Development Goals as "access to safe drinking water and sanitation", both of which have recently become a human right.

While not part of most water security definitions yet, the availability of and access to water for other human and ecosystem uses is fundamental from a nexus perspective.

Energy Security

Energy security is defined by the United Nations as "access to clean, reliable and affordable energy services for cooking and heating, lighting, communications and productive uses".

While not specifically stated, it is certainly implied that this must be achieved while respecting environment concerns.

Food Security

Food security is defined by the Food and Agricultural Organization (FAO) as the "availability and access to sufficient, safe and nutritious food to meet the dietary needs and food preferences for an active and healthy life".

The emphasis on "access" in these definitions highlights that security is not about the average availability of resources (e.g. annual or seasonal), but incorporates reliability of supply during extreme situations, and the resilience of the population affected.

The Water, Energy and Food Security Nexus

- The ***water, energy and food security nexus*** is the term adopted to highlight that the three sectors – water security, energy security and food security – are inextricably linked.
- An improved understanding of these linkages will enable increased efficiency, better trade-off outcomes, enhanced synergies and improved governance of resources.
- By developing a nexus approach in the context of increasing population, climate variability and land use change the demands for basic services and growing desires for higher living standards can be more appropriately addressed.

Water, Energy and Food Security Nexus

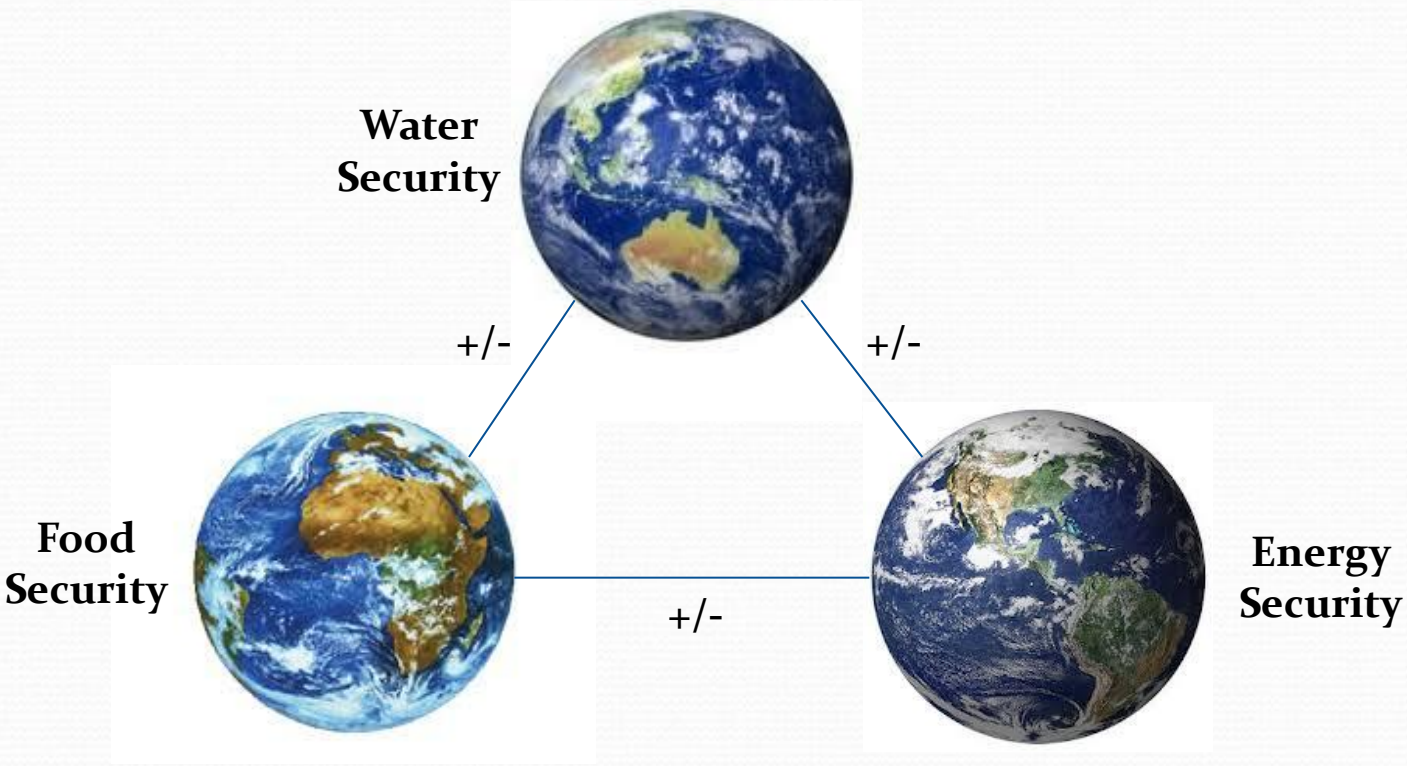


Fig. 1: Water, energy and food security in a triadic nexus.

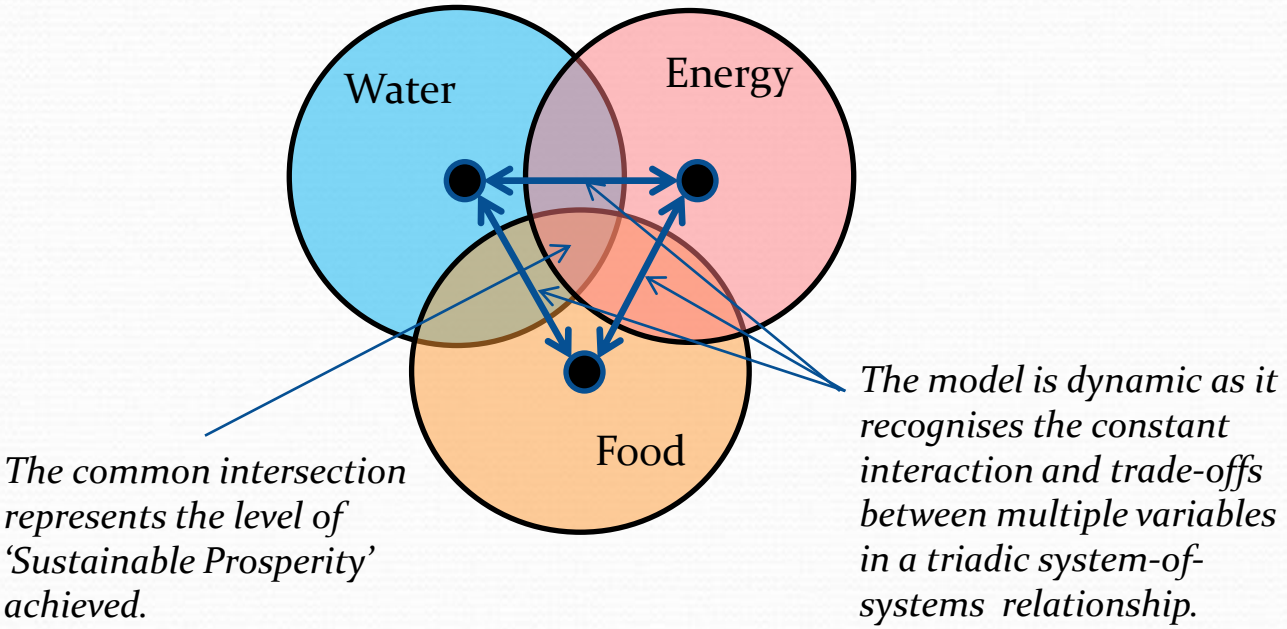


Fig. 2: Convergence of the water, energy and food security sectors correlates to a level of achieved *prosperity*.

The Optimal Target State

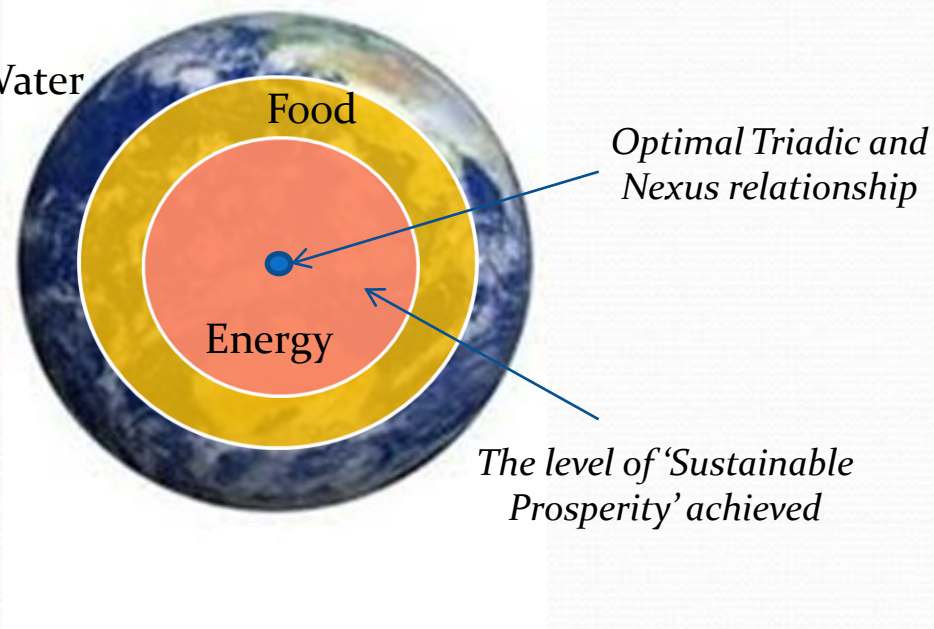


Fig. 3: An example of the optimal target state of Water, Energy and Food Security, where the three sectors share a common centre and Energy Security is the limiting capacity.

If only it was that simple!

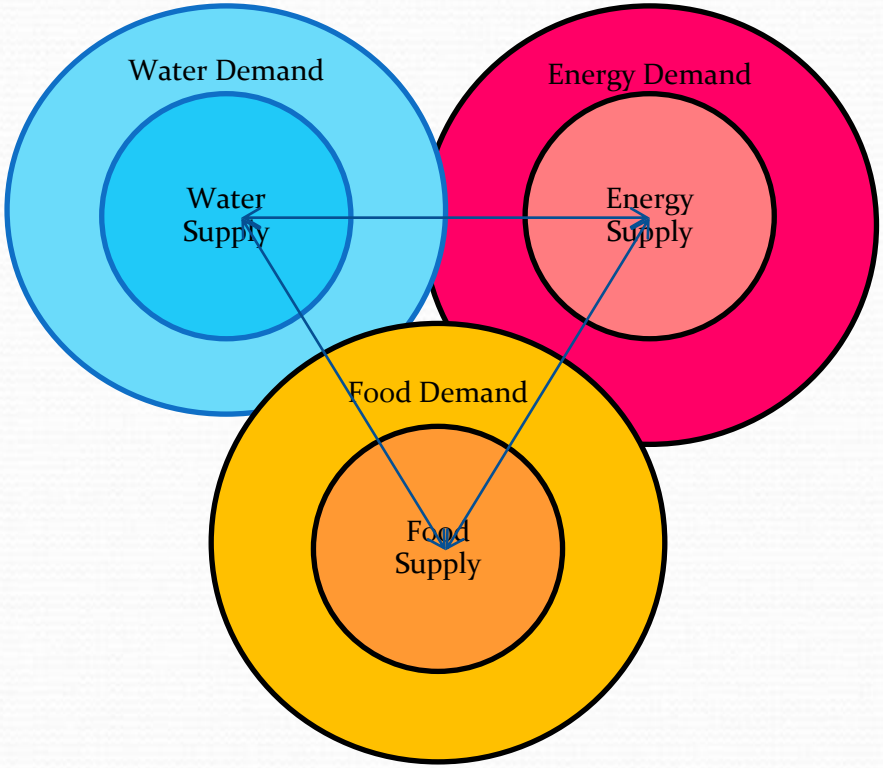


Fig. 4: While Demand exceeds Supply, the water, energy and food security systems cannot converge to a point of common intersection.

Take-away thoughts

- Overall, the nexus perspective provides an informed and transparent framework for sustainably meeting increasing demand. Hence, it is important to incorporate the nexus perspective in future local, national and international planning activities that focus on the interaction with water, energy or food at all levels.
- Water, Energy & Food Security in a Changing Climate

Issues & challenges

- The 'nexus' debate is primarily about natural resource scarcity, that will be exacerbated by changes in population and climate.
- Some natural resources are renewable and seemingly endless, such as solar, wind, geothermal etc.

BUT

- The vast proportion of natural resources required to generate fresh water, energy and food are limited: land, soil nutrients, and fresh potable water.

Discussion Point #2

What do we mean by ‘sustainability’?

A nexus approach must also consider sustainability and growth strategies at the local, regional and national level as integral parts of the overall equation.

Thinking of water, energy and food security in a nexus perspective requires reframing of the discussion on ‘sustainability’ and ‘growth’, and a more rigorous consideration of the consequences, couplings and cascading effects of their associated strategies.

Sustainable development and capacity building

*"**Sustainable development** is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."*
(Brundtland Report, 1987)

- *"The concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and*
- *The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs."*

- Generally accepted that sustainable development necessitates a convergence of economic development, social equity, and environmental protection.
- It is a visionary model, and over the past 25 years governments, businesses, and civil society have accepted sustainable development as a guiding principle.
- Yet the concept remains elusive, implementation continues to prove difficult, and arriving at a commonly accepted definition of 'sustainable development' is still a challenge for all the actors in the development process.

Why?

Firstly, *sustainable development* is being interpreted too literally as 'sustaining the development of something', which – unless time-constrained – is unrealistic.

Secondly, the strategic construct of the development process is being generally promoted as 'forever upward' (or 'for infinitum') rather than a cycle of considered adjustment.

Sustainable development

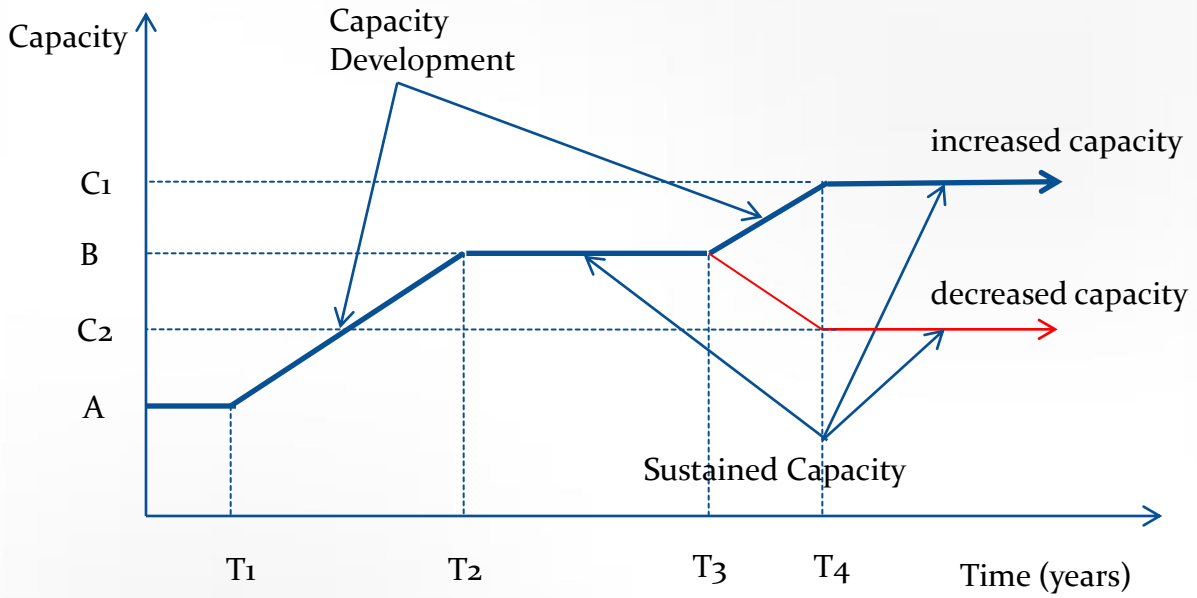


Fig. 5: Sustainable development explained in terms of its two separate phases of 'capacity development' and 'sustained capacity'.

Continuous “adjustment” model

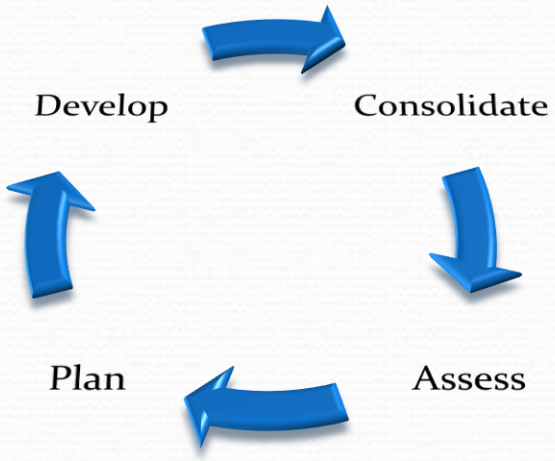


Fig. 6: A typical four-stage continuous adjustment model

Sustainable development *is the ongoing process of institutional societal change to ensure the direction of economic investment, use of the earth's resources, and technological advancement are maintained in harmony and meet basic human needs while offering the potential of prosperity for present and future generations without compromising the natural environment on which humanity relies for quality of life.*

(Hall, 2014)

Note: This definition requires consideration of what is meant by 'prosperity'.

Take-away thoughts

Oxford Dictionary (Online) definitions:

- ***Sustainability / sustainable*** is the ability to maintain [something] at a certain rate or level
- ***Capacity*** is the maximum amount [something] can contain or achieve [with a given capability]
- ***Capability*** is the ability or power to do, experience or understand something
- ***Resilience*** is the capacity to recover quickly from difficulties [and to change or adapt in response to new conditions]
- ***Robustness*** is the ability to withstand or overcome adverse conditions (wrt a process, system, organisation, etc.)

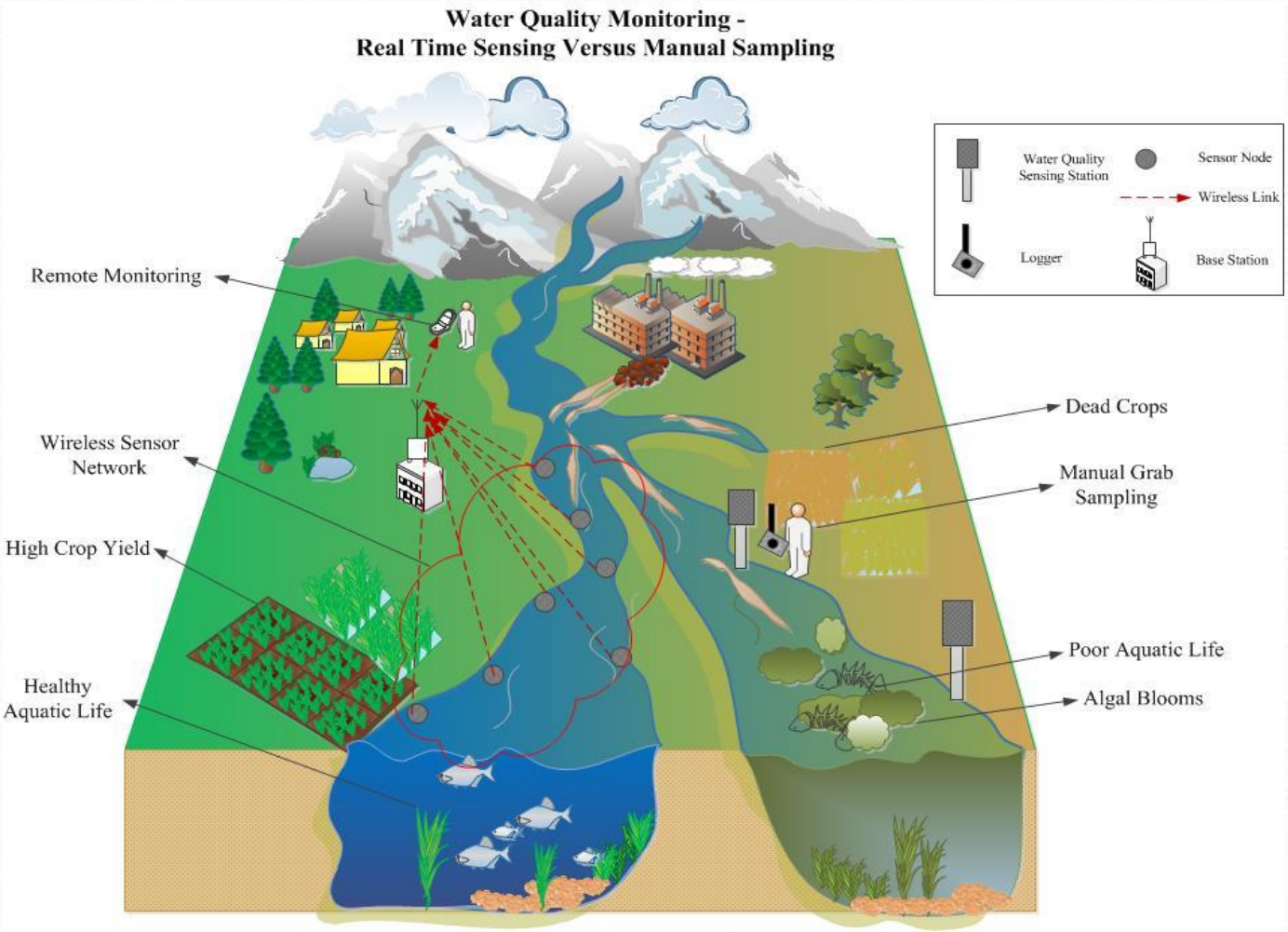
- Note: ***Robustness*** and ***Resilience*** are 'characteristics' of Sustainability; they are not competing concepts, but add integrity to a desired state of sustainability.

Discussion Point #3

Integrated technologies for Water Security

- Water quality management
  - Wireless sensor networks.
- Others?

Real Time Sensing v Manual Sampling



Discussion Point #4

Integrated technologies for Energy Security

- Biofuels from natural waste.
- Energy generation, storage and distribution.
- Others?

Biofuels from natural waste (Pacific islands)

- A natural resource that is in widespread abundance throughout the Pacific region is the coconut; commercial farming and copra production have long been solid contributors to the economies of many Pacific Island countries. However, a significant number of coconuts are not of commercial grade or even harvested at all, and as such they are a resource not realised.
- Coconuts are potentially 100% convertible into biofuel (biodiesel).
- The specific circumstances of small Pacific Islands call for local solutions. Since most Pacific island countries import their fuels at very high transport costs, it makes economic sense to find local fuel supplies. Even though the Pacific islands on a world-scale do not contribute much to the emission of greenhouse gasses, their case for mitigation assistance under the Kyoto Protocol becomes much stronger if they simultaneously look for environmentally beneficial alternatives to fossil fuels.
- There are a number of ways in which vegetable oils such as coconut oil can be used in compression engines. Another promising technology includes straight gasification of whole coconuts, however this requires further technological development.

- Energy generation, storage and distribution

  "The current energy policy lacks vision. The national pipeline of new wind farms is old technology that is damaging Australia's competitiveness. Building wind farms for 25 years is solving yesterday's problem with yesterdays solution; noting that 1.3 million households had already installed rooftop solar panels and the trend to leave national grids would continue.

  If governments insisted on picking winners they should instead focus on battery manufacture: build the batteries that will go into households that will take people off the grid."

  - Jeff Dimery, CEO Alinta Energy (The Australian, July 15, 2014)

  (Alinta is one of Australia's biggest energy companies and owns 14 gas and coal power stations around Australia)

Discussion Point #5

Integrated technologies for Food Security

- Urban/rooftop farming
- Underground farming
- Vertical farming – agriculture
- Vertical farming – fish
- Others?

- Urban/rooftop farming (New York, USA)
  - High-density living has led urban dwellers to search for new solutions for growing food, one being roof-top gardens. Brooklyn's 557 m^2 Eagle Street Rooftop Farm supplies fresh produce to its on-site market as well as nearby cafes and restaurants.

- Underground farming (Japan)
  - It's not only rooftops that are being utilised, Pasona O2 in Japan headed underground in the search for space to grow food. Set up in a disused bank vault, the farm's hydroponic crops flourish under artificial lighting.

- Vertical farming – fish (USA)
  - The vertical farming concept began with a challenge to Columbia University students to find new ways of feeding New York's teeming millions.
  - The answer was, special skyscrapers… and if they can produce plants, why not fish as well?
  - Space and resources, not least water, are at a premium - hence the development of techniques such as aquaponics, a variant of the water-frugal plant-growing technique of hydroponics.
  - Several cities are investigating vertical farming - Portland, Los Angeles, Las Vegas inside the US, Beijing, Incheon, Abu Dhabi elsewhere.

- Vertical farming – agriculture (Singapore)
  - The dense metropolis of Singapore is now home to the world's first commercial vertical farm. Built by Sky Greens Farms, the rising steel structure will help the city grow more food locally, reducing dependence on imported produce. The new farm is able to produce **1 ton** of fresh vegetables every other day, which are sold in local supermarkets.

Final take-away thoughts

- Crucial to the nexus debate is the universal understanding and acceptance among actors and decision makers of the key concepts of sustainable development, economic growth, and prosperity.
- Therefore, desired levels of capacity must recognize that our planet has finite natural assets which, even when managed responsibly and effectively, can only support a finite human population.
- To achieve any desired level of Water, Energy and Food Security (i.e. a level of targeted sustainable 'prosperity') requires us to think differently, do things differently, and do different things.
- The innovative integration of existing and emerging technologies to reach and sustain capacity levels is fundamental to sustaining our quality of life and providing for future generations.

Thank You

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