The water-food-energy-land nexus – types and typologies

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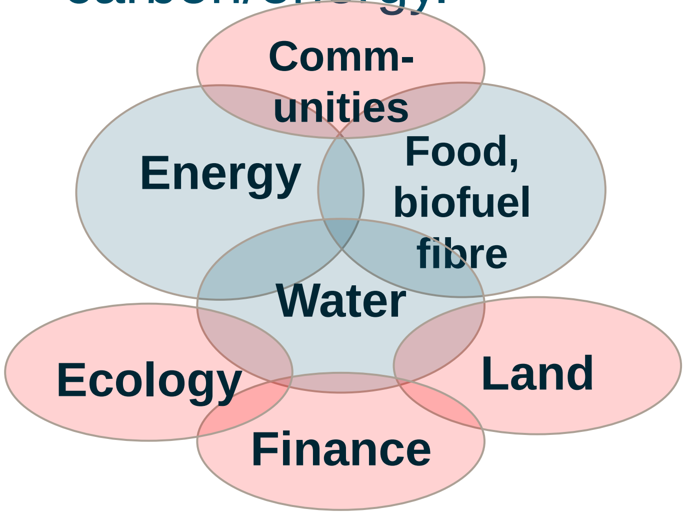
Theory and accounting doubts: *Having brought three fields together, each with considerable complexities – we are probing a significant theory problematic?*

- Purpose of this nexus? Behavioural change. Removing bottlenecks. National economic growth.
- The imprint of the political economy & geographies of each W-F-N
- The accounting doubts resources as inputs and outputs, or omitted resources. The inverse commons – carbon/energy.
- Miscommunication risks
- ‘Complexity blinder’ (Norgaard, 2010)



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The water-food-energy nexus: two typologies

How might the nexus be characterised?

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'for' = bulk direct link – e.g. hydropower
'through' = indirect, incidental – e.g. oil refining

Relationships – subjection

- Water for/through energy
- Energy for/through water

} National securitisation ← Scale

- Energy-water for food (in an era of scarcity & consumption)
- Water for biomass energy food/fuel/fibre/flowers (crop/land choice)
- Energy-water-food for humans/ecology/carbon (accounting and sustainable communities)

Relationships – linkages

- Scale & level – local, national, international
- Connected via cartesian networks – linear/sequential – parallel
- Consumptive regulation via scarcity, pricing and caps/licences
- Productivity/footprint: therefore direction/target & partial/total?
- Direct connections via policy momentum: (de)increasing/(de)linking
- Indirect connections via scarcity, price, geopolitics, political economy and 'incidental subjection'
- Temporal: Stable/predictable vs dynamic (e.g. seasonal)

The water-food-energy nexus
Subjection typology

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Type	Sub-type					
Water for/thru energy	Hydro-power (large & micro)	Other renewables	Hydrocarbons – Extraction (oil sands, shale fracking); Refining; Production; Cooling			
Energy for /thru water Wastewater	Supply mgt: Desalinisation. Reticulation.	Demand mgt Drip irrig. Greenhouses.	Quality Quantity	Current Lifecycle	Location/ placement/ distribution	Temp-erature
Energy-Water for food	Channelled Gravity (free?)	Human energy Animal energy	Pressurised/ Pumped Low/high		Renewables Non-renewables Supply dependability	
Water for crop (4xfs) energy	Food Grain staples. Vegetables	Biofuels – cane oilseeds,	Fibres – cotton		Flowers	
		Livelihood, land, markets, tech. & cropping patterns				
Energy-water-food**	Equivalent Coherent	Imbalanced & compensatory	Regulation: Growth, reduction & deficit. Allocation.		Purpose? Nested global stewardship via sustainable communities	

** Comparative accounting for food in a low carbon, scarce-resource world: Accounting and performance judgement – baseline of gravity irrigation?

The water-food-energy nexus
Typology of *linkages & interconnections*

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Type	Sub-type		
Scale & level	Local community	Sub-catchment and river basin	National and international - securitisation
Cartesian	Linear sequence (upstream to downstream)		Networked, grid, circular
Consumption Distribution	Scarcity & sufficiency	Equity	
Productivity Efficiency	Sector calculations	Total WEFN calcs	Direction – caps. Definitions of wastes/wastages
Inter-dependency (Incidental?)	Volumetric from one of WEF to others	Additional resource interconnections with pricing & accessibility	Additional governance interventions & support Policy momentum. Decreasing/de-linking
Via political economy	Price & price fluctuations	Policy-political will to develop, contract or expand one sector	Private sector interests and risks – engagement, disengagement
Temporal dynamic	Stable, predictable.		Unpredictable, non-equilibrium. High inter/intra annual fluctuation

Policy formulation:
Energy-water for food (and accounting)

- Great difference between supplemental vs full irrigation
- Lift / suction energy versus distribution pressure energy
- Equiv of 6-7 mm/day to irrigate 0.5 ha (household livelihood)
- E.g. Treadle pumps. Lift of <2.0 metres
- (= Lift 75 kg approx 1000 metres = 735 kJoules)
- Treadle work-effort = 850 kJoules/day (1/2 cup rice = 450 kJ)
- Treadle work-effort equiv = 1600 kJoules/ha

Treadle pumps

- $50 bucket kits for 50 m2 = Cost US$10K/ha
- Assume 200 days per year irrigating
- Three year lifespan
- So what new metrics of cost, water consumption and work effort ?

Energy-water for food: Policy formulation in China via large-scale drip investments

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Water-saving irrigation techniques to boost crops

The central government Wednesday announced funding for water-saving irrigation technologies to be used in major grain-producing regions, a move aimed at boosting output.

China will invest $6.03 billion in water-saving irrigation projects covering 2.53 million hectares of farmland in Heilongjiang, Jilin and Liaoning provinces and Inner Mongolia Autonomous Region from 2012 to 2015.

Droughts, natural disasters, and a shortage of water resources have threatened stable grain growth, said the statement. The funding will be used mainly to promote trickle irrigation and micro-sprinkler irrigation in those regions.

http://www.globaltimes.cn/NEWS/tabid/99/ID/695165/Water-saving-irrigation-techniques-to-boost-crops.aspx

Policy formulation: Comparisons and large-scale pressurised drip irrigation investments

Operational costs only, not life-cycle or other emissions

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System	Area (ha)	Total lift (m)	Water depth mm	Season length days	Motor & pump eff %	Kg CO2 per m3 water	Total CO2 tonnes
Gravity	1.0	0.0	960	200	NA	0.0	0.0
Treadle	1.0	4.4	960	200	100%	0.462	0.06
Drip	1.0	20.5	960	200	45%	3.07	30.2
Sprinkler	1.0	55.5	960	200	45%	8.32	82.8
Drip	1.5 million	20.5	960	200	45%	3.07 (30**).	44.3 million

**Marginal carbon dioxide cost, assuming real water savings of 10% relative gain
China total emissions = 8 billions tonnes. This drip investment would be 0.65%
Wales’ emissions carbon dioxide annual = 36 million tonnes
Average UK citizen = 10 tonnes/pa

Policy formulation: Water for food/biofuel energy

- Water for energy for rice as food = 850 m^3/GJ (3 t/ha)
- Water for energy for jatropha = 200 m^3/GJ (2500 lit/ha)
- Or 3200 litres of water for one litre Jatropha bio-diesel
- Hydro-calorifically, rice is less productive than Jatropha
- Rice produces food energy and nutrition for people to manage land and water via gravity
- 1.0 ha of photovoltaics @ Tanzania latitude = 1200 GJ vs 40 GJ from Jatropha oil
- *And* energy for small yet scattered remote rural needs can be obtained in many ways (solar, wind, kerosene)

- = Value of comparative accounting for sustainable communities

Conclusions

- Scale and subjection
- Expansion of irrigated land (China, Africa): policy directions
- Food and water security – *sustainable communities &* irrigated production (area, depletion, technology, energy)
- Food, human energy & time is limited and to be divided between many daily activities (to assist/direct gravity flow)
- Comparative analysis (energy from other sources)
- Links to poverty?

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