Soils as a water resource: Some thoughts on managing soils for productive landscapes to meet development challenges

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Based at
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Objective: finding examples of accelerated landscape transformations and associated investments needs in developing contexts

- Water, soils, global boundaries & demand

- Can we manage for multiple benefits?
  Some examples of transforming landscapes

- Raising demands on research: states, processes and realistic expectations and better informed investments
Limits and boundaries at global scale

Rockstrom et al 2009

Oxfam/Raworth, 2011
Green and blue water dependency

More than half of production from rainfed areas
More than 75% of production from rainfed areas
More than half of production from irrigated areas
More than 75% of production from irrigated areas

Global total:
7,130 cubic kilometers
(80% from green water,
20% from blue water)

CA 2009.
Is there scarcity? A measure of food (dietary) demand

Blue water scarcity

Closing in on blue water shortage

Closing in on green water shortage

[Graph showing available blue water and total available water for various countries, with annotations for specific regions and countries like Ethiopia, India, and Pakistan.]
### Aggregate ~future crop water needs (2050)

<table>
<thead>
<tr>
<th></th>
<th>HIGH WP</th>
<th>LOW WP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Use</td>
<td></td>
<td>~7000</td>
</tr>
<tr>
<td>Future needs (2050)</td>
<td>~2300</td>
<td>~4000</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>~9300</td>
</tr>
</tbody>
</table>

Future of 9000 – 11000 km³/yr to produce food crops in 2050

**Bar Chart**
- Blue water
- Green and blue water

**Source:** Rockstrom et al 2010

**Email:** jennie.barron@sei-international.org
Water crisis? The facts….

Water for drinking: very little!!
Water for food, fodder fibre

Water for ecosystem services to sustain human livelihoods and economies
- Water, soils, boundaries & demand

- Can we manage for multiple benefits?
  Some examples of transforming landscapes

- Raising demands on research: states, processes and realistic expectations and better informed investments
Threshold features can work to advantage addressing soil-water continuum, but multiple levers needs addressing simultaneously.
States and processes of productive landscapes

<table>
<thead>
<tr>
<th>Degraded</th>
<th>Balanced</th>
<th>Intensive Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPP (equiv.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SWC</td>
<td></td>
<td></td>
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<tr>
<td>Water storage</td>
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<tr>
<td>Water quality</td>
<td></td>
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<tr>
<td>Carbon seq.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Degraded system with low agricultural and ESS productivity, poor soil water capacity, lack of natural water storage, reduced water quality, and lack of carbon sequestration.

Intermediate system with high agricultural and ESS productivity, good soil water capacity, robust natural water storage, improved water quality, and high carbon sequestration.

High yield system with emphasis on high yield agricultural but at the cost ESS productivity. Reduced soil water capacity, lack of natural water storage, reduced water quality, and lack of carbon sequestration because ESS systems marginalized for high yield agriculture.
3 examples of transforming landscapes

Kothapally/Osman Sagan (ICRISAT/IND)

Nariarle (INERA/ BF)

Makanya (SUA/TZ)
Example Kothapally micro watersheds/Osman Sagan Basin

From degraded to productive micro watershed in 15 years
- Tropical semi-arid 4.7 km², less than 1 m soil depth
- 90% rainfed /30-40% irrigation during dry season
- Completely under SWC, infiltration strategies with shallow wells (storage)

Livelihood & environmental benefit
• 1.5-2 crop seasons/year = more biomass
• high value=income
• Less sediment loss

Livelihood & environmental cost
• Reduce outflow from 19% to 10%
• More reduced during dry years

Garg et al, 2011; forthcoming
Barron forthcoming
Karlberg et al forthcoming
Example Kothapally micro watersheds/Osman Sagan Basin

Taken to scale Osman Sagan (1 000 km$^2$): Ex situ & Max Int severely reduce water inflow (-3%), but also sediment by 30-50% Farmers income benefit outweigh urban reservoir water costs

Figure 3b: Water balance of the Osman Sagar catchment area under four water management scenarios in dry, normal and wet years (data from 1978 to 2008)

Garg et al forthcoming
Example Nariarle watershed (BF)

From degraded to productive? watershed in 30 years
- Tropical semi-arid 1000 km², deep soils
- Peri-urban
- 70% rainfed /1-2% irrigation during wet & dry season
- under some SWC, plus small reservoirs with storage 2% of annual rainfall for multiple use
- Seasonal rainfall decrease

Livelihood & environmental benefit
- 1 rainfed + 1-2 irrigated crop seasons/ year
- high value irrigated crop=income
- Sustain more people (+10% in 10 yrs)

Livelihood & environmental cost
- Reduce outflow during dry season
- Water quality
- Management of structures

Unrealised potential:
- Improve current low yield rainfed 3-4times

Barron et al, forthcoming; Barron forthcoming

AGROENVIRON 2012 1-4 May 2012
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Livelihood activities according to local experts

Livelihood & environmental cost
- Reduce outflow during dry season
- Water quality
- Management of structures
- Inequity

Unrealised potential:
- Improve current low yield rainfed 3-4 times
Example Makanya watershed (TZ)

From degraded to more degraded watershed in 30 years
- Tropical semi-arid 320 km², varied soils
- 55% rainfed, 25% spate irrigation during wet & dry season
- under some SWC,
- Seasonal dryspell increase

Livelihood & environmental benefit
- Sustain more people (+200% in 50 years)

Livelihood & environmental cost
- No flow in landscape
- Over-use of spate irrigation
- Deteriorating ESS

1) Dependency on water to provide ESS for livelihood
2) Availability of water and change

Enfors & Gordon, 2007
Example Makanya watershed (TZ)

Unrealised potential:
- Improve current low yield rainfed 3-4 times, - yet not adopted/resilient to change

**Land cover in the Makanya catchment**

<table>
<thead>
<tr>
<th></th>
<th>1954</th>
<th>1982-3</th>
<th>2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural land</td>
<td>37%</td>
<td>44%</td>
<td>55%</td>
</tr>
<tr>
<td>Sparse bushland</td>
<td>23%</td>
<td>21%</td>
<td>18%</td>
</tr>
<tr>
<td>Bushland</td>
<td>34%</td>
<td>27%</td>
<td>23%</td>
</tr>
<tr>
<td>Forest</td>
<td>4%</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>Sisal estate</td>
<td>3%</td>
<td>3%</td>
<td>1%</td>
</tr>
<tr>
<td>Bare mountain</td>
<td>0%</td>
<td>2%</td>
<td>1%</td>
</tr>
</tbody>
</table>

**Loss of ecosystem services when agriculture expand**

**Loss of livelihood support system**

**Downward spiral undermining development opportunities**

Enfors & Gordon, 2007; Enfors et al 2009

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Summary productive landscape examples

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<table>
<thead>
<tr>
<th>Location</th>
<th>Pre 2000</th>
<th>Post 2000</th>
</tr>
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<tbody>
<tr>
<td>Kothapally (IND)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nariarle</td>
<td>Pre 1960</td>
<td>?? 2010</td>
</tr>
<tr>
<td>Makanya</td>
<td>Today, pre 1990</td>
<td></td>
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Transforming landscapes with soil and water

Desirability of agro-ecosystem embedded in landscape

Barron & Keys, 2011
- Water, soils, boundaries & demand

- Can we manage for multiple benefits?
  Some examples of transforming landscapes

- Raising demands on research: states, processes and realistic expectations and better informed investments
Processes and uncertainty

We know various systems, including social-ecological systems, can rapidly change and lose their 'systems characteristics': many are soil and water-related.
Mis match of processes and scales and the matter of urgency

Dearing et al 2010
Turbulent future, accelerating trends in the anthropocene: there are good examples

1) **Multiple levers simultaneously**: Healthy soils, water, nutrient, energy and people can transform landscapes, not one factor alone.

2) Globally there is enough food, land, water and knowledge to make a start.

3) Energy (labour?) and nutrients and land are more critical?

But a window of opportunity?
- Global recognition of issues
- Re-investment in agriculture
- Progressing adoption of addressing water and land
- Examples of economic incentives for good management
- ........
- BETTER DATA!!
BETTER DATA: Good news & remaining gaps

- Africa Soil Map (19 200 samples), but not-so-strong water attributes
- Africa Soils data base (ISRIC) 12 000 geo-ref profiles released 2012

Possible gaps:
- soil biological attributes: critical for nutrients, GHG & SOM and hence water flows, uptake and e.g. water productivity
- Methods & tools for water partitioning and flows in soils in transformed landscapes
So far, we value soils for water and for food. But maintaining/enhancing soils in good health for regulation and supporting services is imperative to retain water and transform landscapes, not just agricultural land.
Managing soils to manage water:
Soil and water management entry point but other factors to realise potential

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Critical levers to realise and accelerate benefits of managing soils for water

- SUBSTANTIAL INVESTMENTS!!
- Supply of affordable and available labour/energy, nutrients, water
- Market: for produce, supply, for ESS
- Knowledge: changing farming is knowledge intensive

Need viable ‘business models’ account for wider set of costs and benefits in rainfed agriculture: when public-when private investments relevant?
Thank you!
Water requirements for diets vs GDP(PPP) for year 2000

GDP(PPP) (US$/cap/y) vs Total dietary water requirements (m3/cap/year)

Lunquist, Barron et al 2007
Why should we bother? The anthropocene dilemma

The Quadruple Squeeze

- Human growth 20/80 dilemma
- Climate 550/450/350 dilemma
- Ecosystems 60% loss dilemma
- Surprise 99/1 dilemma

Population

Damping of Rivers

Urban Population

Transport, Motor Vehicles
SEI’s mission is to support decision-making and induce change towards sustainable development around the world by providing integrative knowledge that bridges science and policy in the field of environment and development.

SEI is an independent, international research institute specializing in sustainable development and environment issues for policy and decision making.
4 themes:

**Reducing climate risks**
Collaboration platforms for climate change adaptation; Economics of climate policy; Equitable approaches to mitigation and adaptation; Analytical frameworks on climate change

**Managing environmental systems**
Modelling carbon and water cycles; Integrating air pollution and climate change; Sustainable urbanisation; Energy and land-use planning; Sustainable biofuels and bionergy; Food security, health and biodiversity

**Transforming vulnerable communities**
Vulnerability approach to livelihood development; Strategic assessments for transformation; Avoiding socio-ecological traps

**Rethinking development**
Global assessments; New economics for sustainable development; Partnership in developing countries; Sustainable consumption and production; Analytical tools and scenarios; Planetary boundaries; SEI China Cluster
Current and past relevant projects in ecosystems, freshwater and development

• **AWM Solutions project** (2009-2011): IWMI, FAO, IFPRI, IDE INERA, Univ. Sokoine
• **Challenge Programme Water for Food Volta V1 and Limpopo L1Nile basin N3** (2010-2013):
  • Climate change and economics in Kenya and Tanzania
  • CIFOR work valuing forest & NFTP

• Climate Change, and water flows in watershed in transition (IPS 2010-2011)
• Local livelihoods and reliance on ecosystem services (IPS 2009-2010)

**In collaboration with Stockholm Resilience Centre/Stockholm University:**
• **SRC Sahel re-greening: transformation in climate change** 2009, 2010-2013
• **SRC : EU FP7 Whater: Rainwater harvesting revisited:** 2011-2014

- Direct on-going
- Indirect and/or recent
Modes of operation:

• From research to policy: strong research and evidence based

• Partnership: local to global

• Facilitating and hosting

  • Stockholm Resilience Centre (SRC) with Stockholm University and KVA Beijer
  • ECOSANRES Ecological Sanitation Research
  • BIO-EARN East African Regional Programme and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development
  • APINA Air Pollution Information Network in Africa