Criteria and indicators for developing a framework for assessment of sustainability of agricultural/farming systems with focus on rainfed agriculture

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Presented during National workshop on Sustainability of Indian Agriculture: Methodology and Indicators was organized at NIAP, New Delhi during 18-19 June 2019.
Currently the vulnerability to climate change and price variability in a context with water scarcity/low average rainfalls and degraded soils are key concerns.
Triple Bottom Line of Sustainability

SUSTAINABILITY

PEOPLE  PLANET  PROFIT
Sustainable Agriculture Development

Natural Resources

- Natural resources, are fundamental for the structure and function of agricultural systems and for social and environmental sustainability, in support of life on earth.
- Historically, global agricultural development has been narrowly focused on increased productivity rather than on a more holistic integration of NRM [Natural Resource Management] with food and nutritional security.
- A holistic, or systems-oriented approach, can address the difficult issues associated with the complexity of food and other production systems in different ecologies, locations and cultures.
- Resolution of natural resource challenges will demand new and creative approaches by stakeholders with diverse backgrounds, skills and priorities. Capabilities for working together at multiple scales and across different social and physical environments must be developed.
Sustainable Agriculture Development

Risk and Sustainability – Two Sides of the same coin?

Risk is an important indicator across the Five Sustainability Dimensions

Considering risk and sustainability together is part and parcel as sustainability, in strategic terms it is about realizing Resilience.

How do we know the unknown?
- Managing complex system risks with dynamic interdependencies

How do we manage Known Knowns and Known Unknowns?
- Variability
- Assumptions
- Limitations
Key questions

- What sustainability goals are targeted?
- How are they ranked, aggregated or compared in terms of trade-offs?
- What are the missing indicators?
- What are the boundaries of the system assess between the farming system and the household?
We conducted a relative sustainability assessment of different farm types in AP

**Economic**

**Social**

**Environmental**

**Limitation:**
Avoided establishing benchmarks, relative
Sustainability in Agriculture
Five Dimensions

Productivity

Environmental Sustainability

Economic Sustainability

Social Sustainability

Human Well-being

SUSTAINABLE INDICATORS
### Application of sustainability assessment: Upgrading strategies
#### An examples from SSA

<table>
<thead>
<tr>
<th>Categories</th>
<th>Innovations</th>
<th>Aim</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Natural resource Management / Crop production</strong></td>
<td>Rainwater harvesting</td>
<td>Improve water retention</td>
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<tr>
<td></td>
<td>Fertilizer micro dosing</td>
<td>Improve nutrient use efficiency</td>
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<td></td>
<td>Optimized weeding</td>
<td>Optimize use of labor</td>
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<tr>
<td><strong>Post harvest processing &amp; biomass energy supply</strong></td>
<td>Byproduct for bioenergy</td>
<td>Inputs for cooking</td>
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<td></td>
<td>Improved processing devices</td>
<td>Mobile devices flexibility</td>
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<td></td>
<td>Improved stoves</td>
<td>Reduce energy consumption</td>
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<tr>
<td><strong>Markets and income generation</strong></td>
<td>New product development</td>
<td>Oil from sunflower</td>
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<td></td>
<td>Optimized market</td>
<td>Use bags for conservation</td>
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<td></td>
<td>Poultry crop integration</td>
<td>Utilization of byproducts</td>
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<td></td>
<td>Market access system</td>
<td>Sell at better price</td>
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<tr>
<td><strong>Consumption</strong></td>
<td>Household nutrition education</td>
<td>Increase awareness of nutrient rich food</td>
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<tr>
<td></td>
<td>Kitchen garden training</td>
<td>Food security</td>
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</tbody>
</table>
Sustainability Indicators: Productivity

**Conventional Indicators**
- Yield, Yield gaps & Variability
- Crop Diversity
- Cropping Intensities
- Nutrient & Pest Management
- Stocking Rate
- Animal Health

**More indicators to be considered**
- Biological Inputs
- Conversion Efficiency
- Fodder quality
- Input Intensity & Efficiency
- Pest Pressure
- Water use Efficiency
Economic Sustainability

Conventional Indicators

- Agriculture Income
- Labor Productivity
- Market Access
- Credit Access
- Input Access
- Household Purchases

More indicators to be considered

- Income Variability/stability of income
- Risk & Resilience
- Capital Productivity
- Labour Intensity
- Synergizing crop and livestock production
- Alignment to domestic/international trade
- Farmers’ ability to participate into farming systems development
- Creating value per unit of resources - post harvest - value addition
**Human Well-being**

**Conventional Indicators**
- Food Security
- Food Self-Sufficiency

**More indicators to be considered**
- Nutrition Security
- Food Safety
- Quality of Life
- Labor reduction/drudgery
Social Sustainability

**Conventional Indicators**

- Technology adoption
- Farmer Preference
- Information Access
- Social Capital
- Farmer Participation
- Gender empowerment

**More indicators to be considered**

- Social and Gender Equity
- Farmer Knowledge Integration
- Resilience
- Resource Conflicts
- Animal Welfare
- Collective action for managing common resources
## Environmental Sustainability

### Conventional Indicators

<table>
<thead>
<tr>
<th>Indicator</th>
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<tbody>
<tr>
<td>Bio-diversity</td>
</tr>
<tr>
<td>Chemical Inputs (Benchmarks)</td>
</tr>
<tr>
<td>Soil Erosion</td>
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<tr>
<td>Soil Carbon Sequestration</td>
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</tbody>
</table>

### More indicators to be considered

<table>
<thead>
<tr>
<th>Indicator</th>
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</thead>
<tbody>
<tr>
<td>Beneficial Micro-organisms</td>
</tr>
<tr>
<td>Ecological Thresholds- Safe-limit chemical usage</td>
</tr>
<tr>
<td>GHG Emissions</td>
</tr>
<tr>
<td>Nutrient Balance</td>
</tr>
<tr>
<td>Trade-offs/Synergies</td>
</tr>
<tr>
<td>True pricing of various environmental impacts</td>
</tr>
<tr>
<td>Overexploitation of (water) resources vs higher (water) resource use efficiency</td>
</tr>
<tr>
<td>Ecological (water/carbon) foot prints</td>
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</tbody>
</table>
Sustainable Indicators
Identifying Metrics, Developing Benchmarks

How to merge qualitative and quantitative data to derive an accepted benchmark?

How to come to a consensus on the indicators and the metrics?

**Normalized value for each indicator:** say 0 to 1, but few indicators relating to degradation and loss e.g. erosion, biodiversity loss the value could be -1 to 0.

**Weights for each domain:** experts and stakeholders, but that could be different for different scales- regions or livelihood systems or time period
## An example of indicators at different scales

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Field scale metrics</th>
<th>Farm / Household metrics</th>
<th>Community metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Beneficial macro-organisms</strong></td>
<td>Parasitism rate of pests by beneficials</td>
<td>Pollination rate</td>
<td>Abundance of species of conservation concern</td>
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<tr>
<td></td>
<td>Pollinator diversity</td>
<td>Population of beneficial organism</td>
<td></td>
</tr>
<tr>
<td><strong>BIODIVERSITY</strong></td>
<td>Functional diversity</td>
<td>Genetic diversity as number of varieties planted</td>
<td>Functional diversity</td>
</tr>
<tr>
<td></td>
<td>Presence and abundance of indicator species</td>
<td>Crop diversity dynamics, typological, based on land use over time</td>
<td>Presence and abundance of indicator species</td>
</tr>
<tr>
<td><strong>C sequestration</strong></td>
<td>Soil organic carbon mg C/g soil</td>
<td>C sequestration rate</td>
<td>Land scape level crop diversity</td>
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<tr>
<td></td>
<td>Mg C/ha</td>
<td>Standing tree biomass</td>
<td>Standing tree biomass</td>
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<td></td>
<td>Reduction in kg chemical fertilizer or pesticide</td>
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<td></td>
</tr>
<tr>
<td><strong>Chemical input reduction</strong></td>
<td>kg chemical fertilizer replaced</td>
<td>Applied Reduction in number of pesticide applications</td>
<td></td>
</tr>
<tr>
<td><strong>Ecological thresholds</strong></td>
<td>Carrying capacity</td>
<td></td>
<td></td>
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<tr>
<td><strong>Ecosystem services</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ENVIRONMENTAL IMPACT</strong></td>
<td>Mj inputs/kg of product</td>
<td>Total value of inputs used in system</td>
<td></td>
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<tr>
<td></td>
<td>Mj inputs/Mj food energy output</td>
<td>Ecological footprint analysis</td>
<td></td>
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<td></td>
<td></td>
<td>Lifecycle analysis</td>
<td></td>
</tr>
<tr>
<td><strong>EROSION</strong></td>
<td>C-value (erosivity)</td>
<td>Volume of gully erosion; area of rill erosion/landsides</td>
<td>% farmers reporting erosion</td>
</tr>
<tr>
<td></td>
<td>Farmer reported change in soil depth</td>
<td>Land area with erosion control technologies implemented</td>
<td>Participatory erosion mapping</td>
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<tr>
<td></td>
<td>Total soil lost/ha/year</td>
<td></td>
<td></td>
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<tr>
<td><strong>GHG emissions</strong></td>
<td>NH3 emissions</td>
<td>Total c/kg feed digested</td>
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<tr>
<td></td>
<td>Total CO2/kg grain yield</td>
<td>Total CO2/kg milk or meat yield</td>
<td></td>
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<tr>
<td></td>
<td>Total CO2/ha</td>
<td></td>
<td></td>
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<tr>
<td><strong>NUTRIENT BALANCE</strong></td>
<td>Nutrients applied–nutrient export in grain</td>
<td></td>
<td>Participatory resource mapping</td>
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<tr>
<td></td>
<td>Total nutrient import–total nutrient export</td>
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<tr>
<td></td>
<td>Mineralizable soil N</td>
<td></td>
<td>Cycling index</td>
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<tr>
<td></td>
<td>N mineralization rate</td>
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</table>
We have just initiated a study on farming systems sustainability assessment

- Considering five domains at farming systems/farm household level
- Integrated assessment- whole farm modelling- to generate scenarios
- Agent based modelling capturing landscape level aspects

- West Africa- Niger and Burkina Faso
- SAT India
Type of data:

1. Primary household level data
2. Secondary data
   - How to capture trends which could be considered as permissible..
   - The level of use of modern inputs should not be seen in relative term only. Need to define an absolute value for chemical use etc
   - Need to consider the indirect positive impact of certain commodities in dry regions for example small ruminants to replace that otherwise
   - Need to visualize that if we consider a practice less sustainable: do we have an economically viable alternative or visualize that it could be possible that if the existing practice is discouraged, what the farmers might adopt far more unsustainable practice..
Difficult to measure

- Erosion
- GHG emissions
- Carbon sequestration
- Nutrient balance
- Risk: production risk and perceived risk
Impact assessment

Co-Design

Engage Stakeholders

Baseline

Constraints

Entry points

Productivity

Economic

Social

Environment

Trade-off analysis

Systems modelling

Constraints

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Baseline
Impact assessment

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Productivity
Economic
Environment
Social
Human

Baseline
re-design1
re-design2
Thank You for your attention