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

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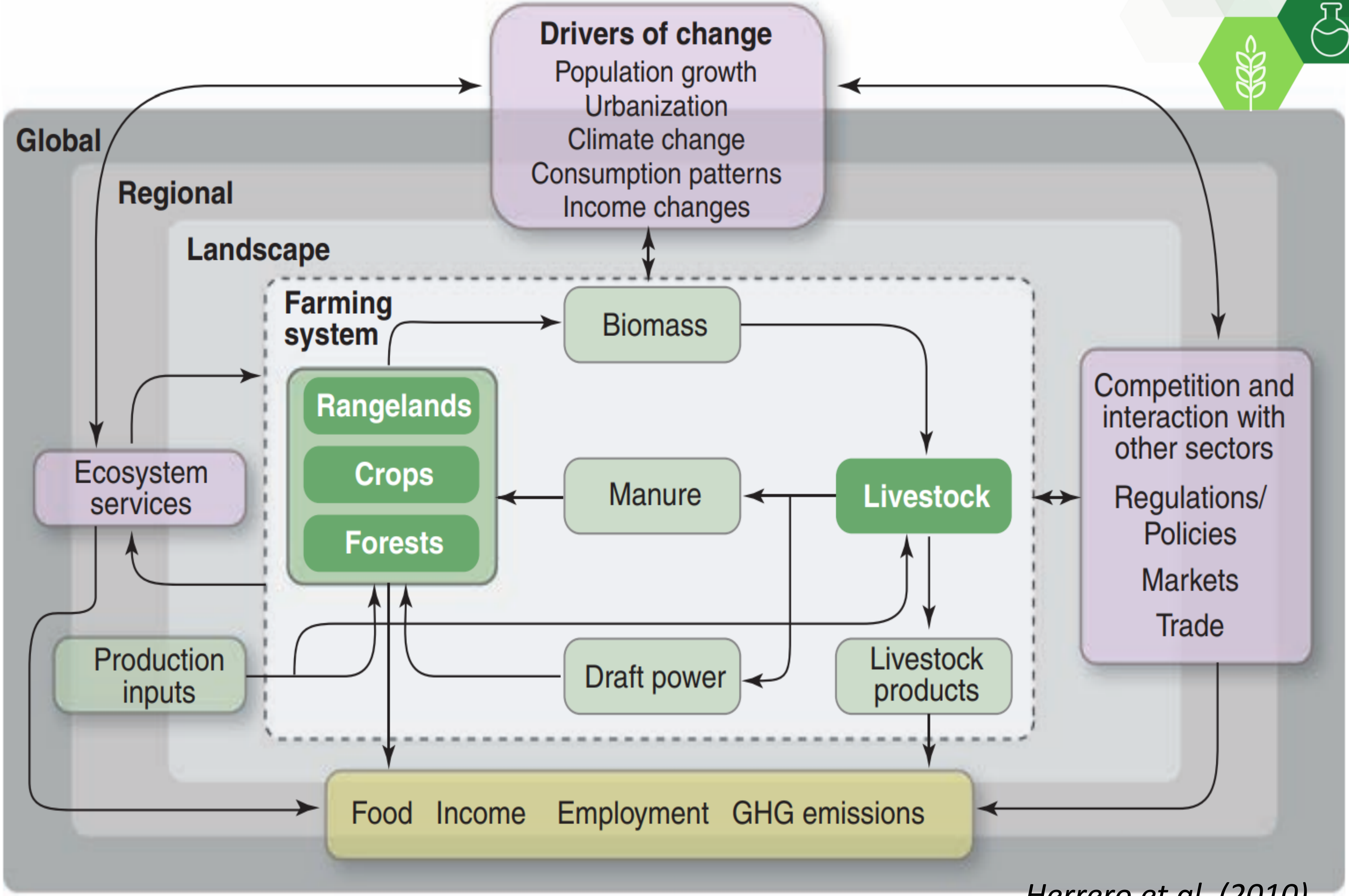
ICRISAT INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

CGIAR RESEARCH PROGRAM ON Grain Legumes and Dryland Cereals

Farming system organization and its surrounding environment

Currently the vulnerability to climate change and price variability in a context with water scarcity/low average rainfalls and degraded soils are key concerns



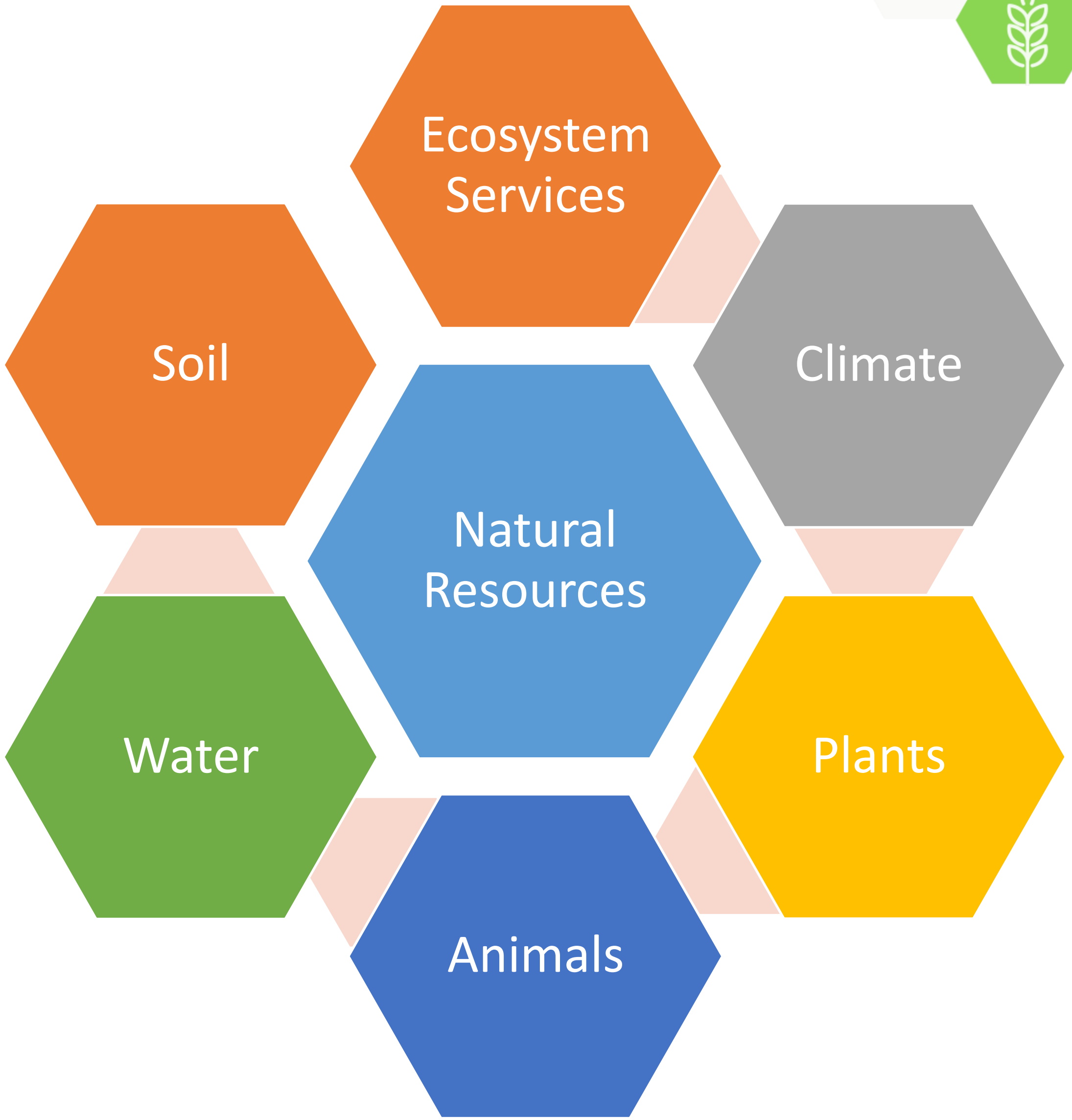
Herrero et al. (2010)

Triple Bottom Line of Sustainability

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

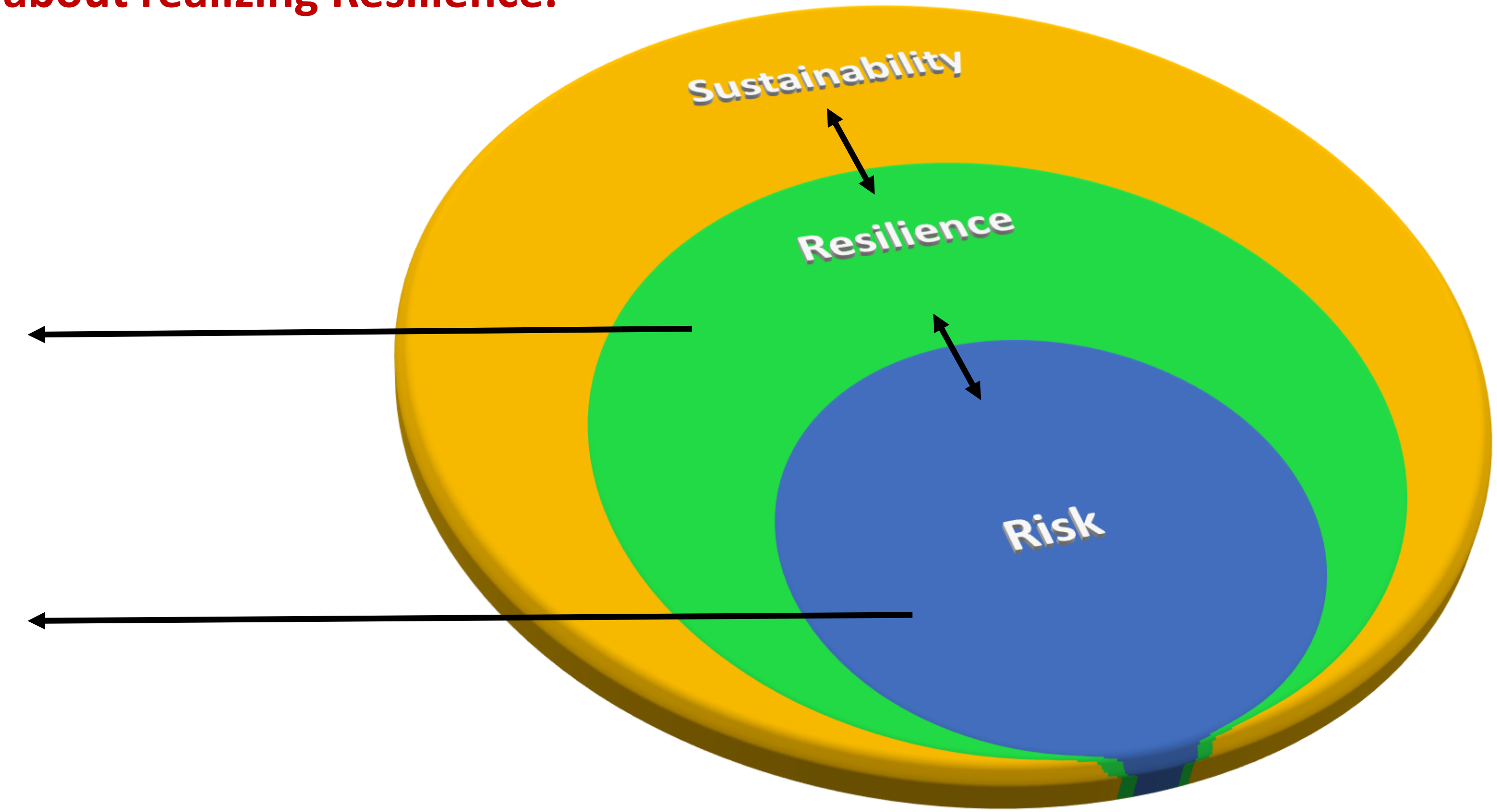
Risk and Sustainability – Two Sides of the same coin?

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

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Empirical evaluation of sustainability of divergent farms in the dryland farming systems of India

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ABSTRACT

The present study argues that there are heterogeneous farm systems within the drylands and each farm system is unique in terms of its livelihood asset and agricultural practice, and therefore in sustainability. Our method is based on household survey data collected from 500 farmers in Anantapur and Kurnool Districts, in Andhra Pradesh State of India, in 2013. We carried out principal component analysis (PCA) with subsequent hierarchical clustering methods to build farm typologies. To evaluate sustainability across these farm typologies, we adopted a framework consisting of economic, social and environmental sustainability pillars and associated indicators. We normalized values of target indicators and employed normative approach to assign different weights to these indicators. Composite sustainability indices (CSI) were then estimated by means of weighted sum of indicators, aggregated and integrated into farm typolo-

Sustainability in Agriculture

Five Dimensions

Application of sustainability assessment: Upgrading strategies

An examples from SSA

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

Sustainability Indicators: Productivity

Conventional Indicators	More indicators to be considered
Yield, Yield gaps & Variability	Biological Inputs
Crop Diversity	Conversion Efficiency
Cropping Intensities	Fodder quality
Nutrient & Pest Management	Input Intensity & Efficiency
Stocking Rate	Pest Pressure
Animal Health	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	More indicators to be considered
Food Security	Nutrition Security
Food Self-Sufficiency	Food Safety
	Quality of Life
	Labor reduction/ drudgery

Social Sustainability

Conventional Indicators	More indicators to be considered
Technology adoption	Social and Gender Equity
Farmer Preference	Farmer Knowledge Integration
Information Access	Resilience
Social Capital	Resource Conflicts
Farmer Participation	Animal Welfare
Gender empowerment	Collective action for managing common resources

Environmental Sustainability

Conventional Indicators

- Bio-diversity
- Chemical Inputs (Benchmarks)
- Soil Erosion
- Soil Carbon Sequestration

More indicators to be considered

- Beneficial Micro-organisms
- Ecological Thresholds- Safe-limit chemical usage
- GHG Emissions
- Nutrient Balance
- Trade-offs/Synergies
- True pricing of various environmental impacts
- Overexploitation of (water) resources vs higher (water) resource use efficiency
- Ecological (water/carbon) foot prints

Sustainable Indicators

Identifying Metrics, Developing Benchmarks

Field Scale → Farm/ Household Scale → Community Scale

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

Indicator	Field scale metrics	Farm / Household metrics	Community metrics
Beneficial macro-organisms	Parasitism rate of pests by beneficials		
	Pollination rate		
	Pollinator diversity		
	Population of beneficial organism		
BIODIVERSITY	Functional diversity	Genetic diversity as number of varieties planted	Abundance of species of conservation concern
	Presence and abundance of indicator species	Crop diversity dynamics, typological, based on land use over time	Functional diversity
			Presence and abundance of indicator species
			Land scape level crop diversity
C sequestration	Soil organic carbon mg C/g soil	C sequestration rate	Standing tree biomass
	Mg C/ha		
	Standing tree biomass	Reduction in kg chemical fertilizer or pesticide	
Chemical input reduction	kg chemical fertilizer replaced	Applied Reduction in number of pesticide applications	
Ecological thresholds	Carrying capacity		
Ecosystem services		Replacement value of ecosystem services	
ENVIRONMENTAL IMPACT	Mj inputs/kg of product	Total value of inputs used in system	
	Mj inputs/Mj food energy output	Ecological footprint analysis	
		Lifecycle analysis	
EROSION	C-value (erosivity)	Volume of gully erosion; area of rill erosion/landslides	% farmers reporting erosion
	Farmer reported change in soil depth	Land area with erosion control technologies implemented	Participatory erosion mapping
	Total soil lost/ha/year		
GHG emissions	NH_3 emissions	Total c/kg feed digested	
	Total CO_2/kg grain yield	Total CO_2/kg milk or meat yield	
	Total CO_2/ha		
NUTRIENT BALANCE	Nutrients applied–nutrient export in grain		Participatory resource mapping
	Total nutrient import–total nutrient export		Cycling index
	Mineralizable soil N		
	N mineralization rate		

We have just initiated a study on farming systems sustainability assessment

- West Africa- Niger and Burkina Faso
- SAT India

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

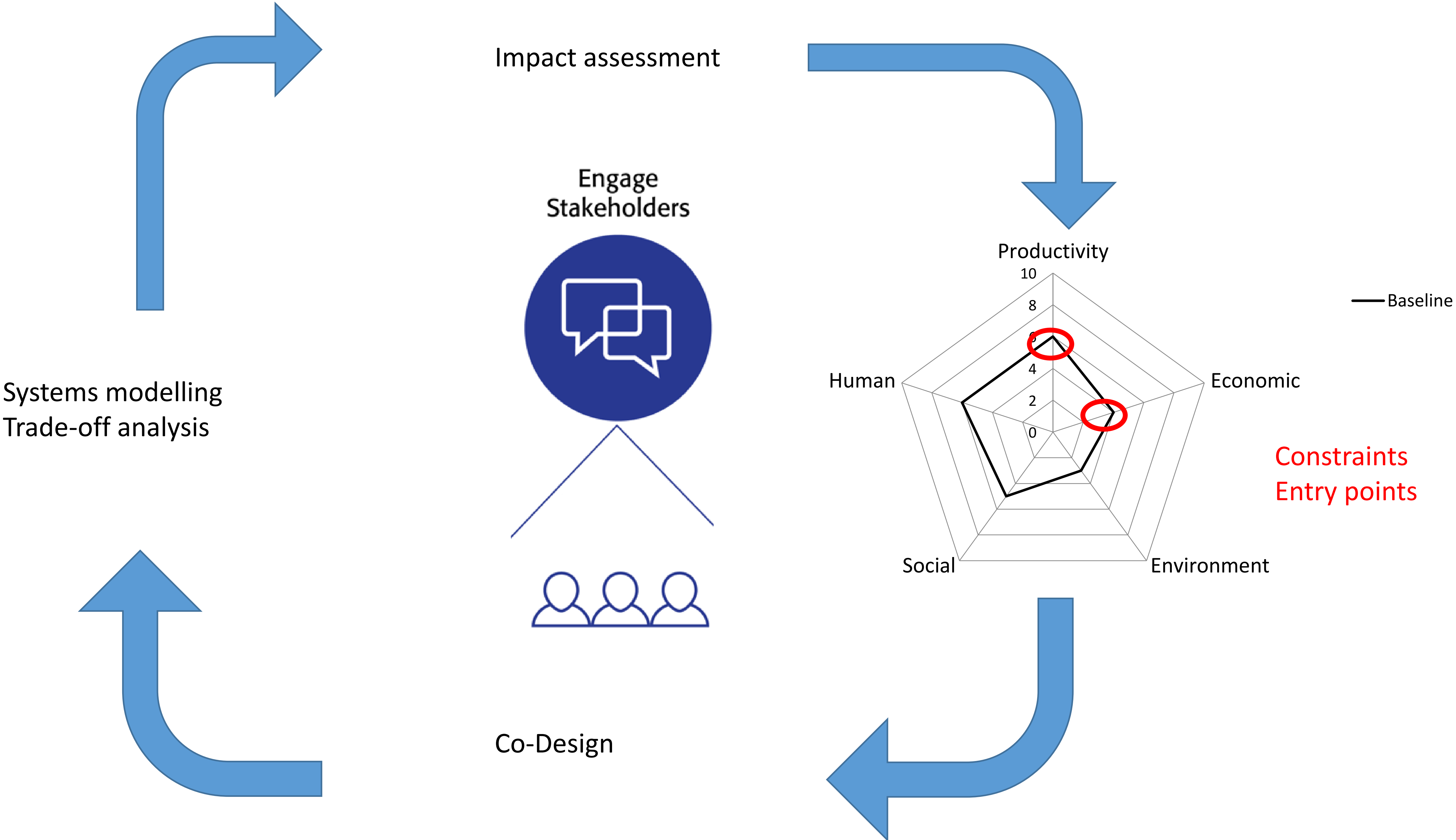
Type of data:

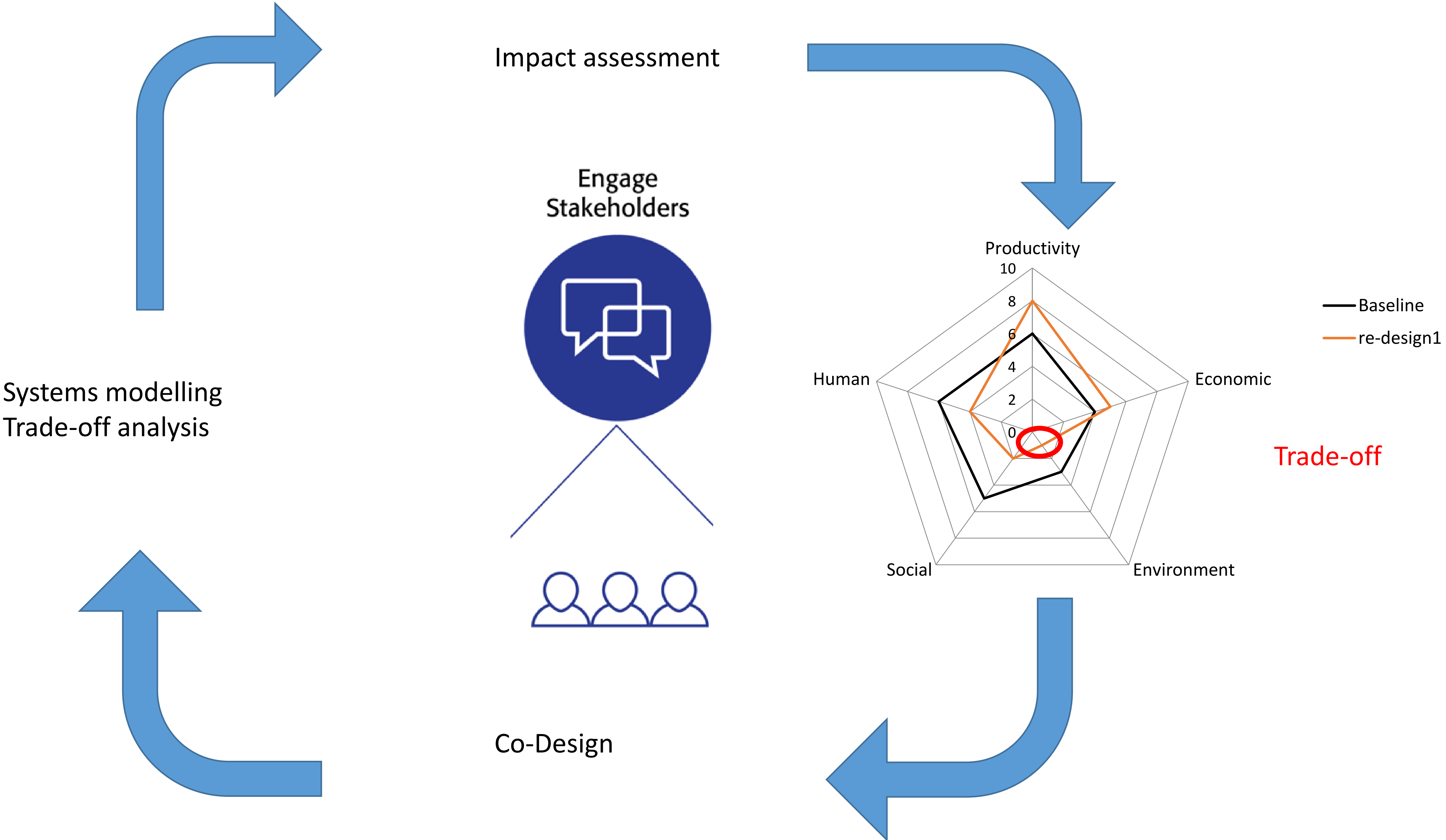
1. Primary household level data
2. **Secondary data**

- 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
Engage
Stakeholders
Systems modelling
Trade-off analysis
Productivity
10
8
4
2
0
Human
Economic
Social
Environment
Baseline
Constraints
Entry points
Co-Design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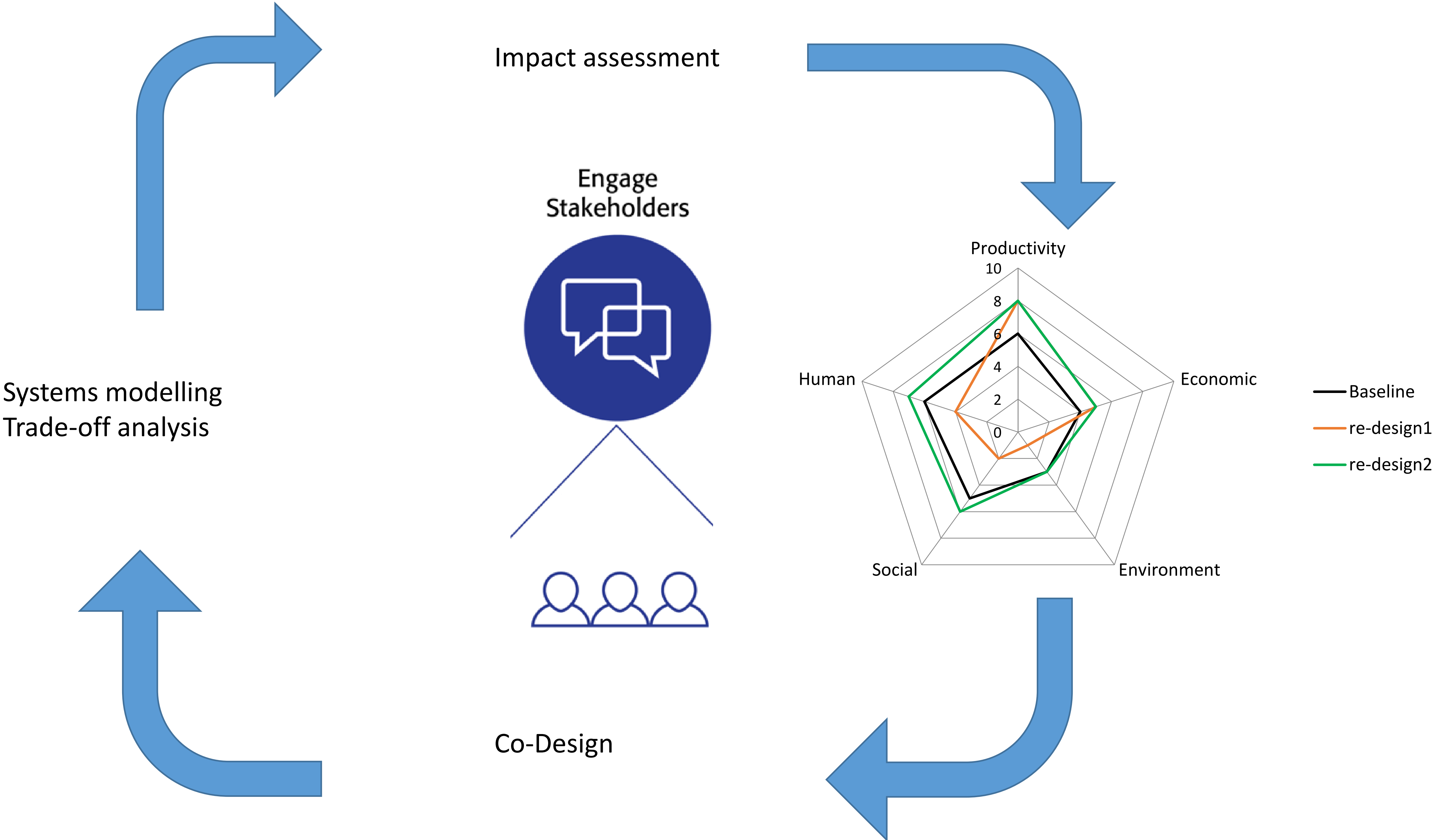
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re-design1
re-design2
Systems modelling
Trade-off analysis
Co-Design

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Thank You
for your attention

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