From modeling a theory back to practice

Reflections on a system dynamics journey for sustainable water resources Management

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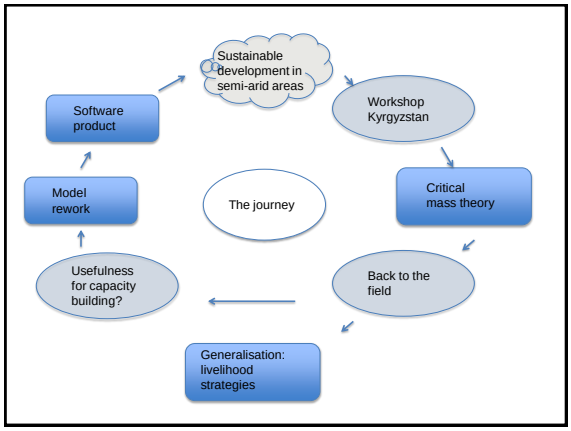
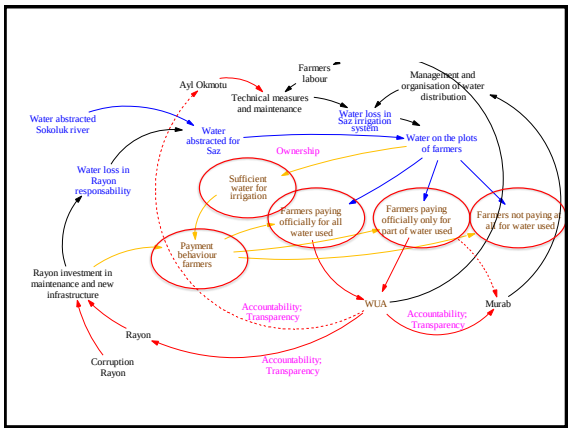
Content

- Introduction
- The journey
- Reflections: lessons learnt

Introduction

- NCCR North-South
  - Sustainable development with a focus on methodology
  - System dynamics: an instrument for (comparative) transdisciplinary research?
  - Pathways towards sustainable development
- Case studies
  - Kyrgzstan
  - Kenya





A theory of collective action

Granovetter: Threshold model of collective action (1978)

- People have different thresholds to enter collective action
- Distribution of thresholds matters

Schelling: Critical mass model of collective action (1978)

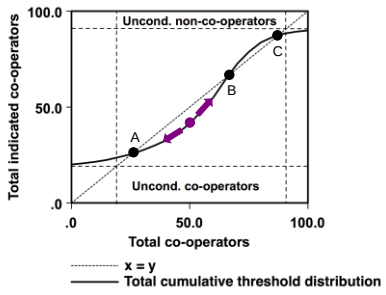
- Three categories of co-operators:
  - unconditional co-operators
  - conditional co-operators
  - unconditional non-co-operators

Game theory: Assurance game - not prisoner's dilemma

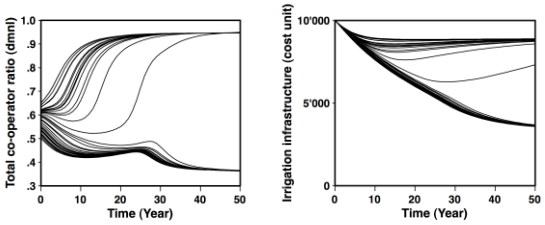
- Co-operation can emerge, if enough people feel sufficiently assured that others will also co-operate.

(Axelrod 1981, Baland and Platteau 1996)

Fundamental dynamic structure of a critical mass model



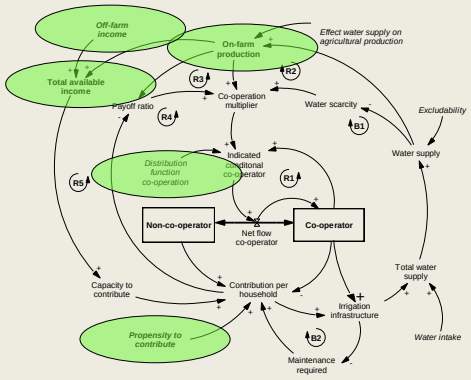
Variation of initial co-operation



Main problems

	Kyrgyzstan (Sokoluk river, Saz)	Kenya (Burguret river)
Insufficient payment, maintenance	+++	+
Deterioration of infrastructure	+++	+
Illegal abstraction upstream	++	+++
Conflicts	+	+++
Rapid population growth	+	+++
Variation of water flow	+ (low)	+++ (high)
Water availability (intake) per household in dry season	1 l/s per household	0.05 l/s per household
Problem pressure	+ (low)	+++ (high)
Dependence on irrigation	+++ (cash crop, livestock)	+++ (domestic use, livestock, cash crop)

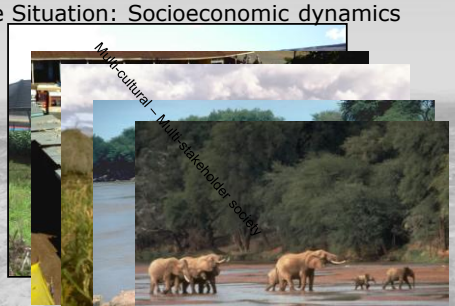
Towards an extended, stratified model for collective irrigation management



Back to practice: usefulness for capacity building and decision making?

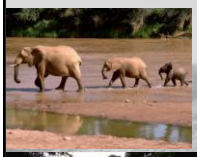
- Problem focus
  - Applicable to Kenya?
- Rely on hypotheses for modeling
  - Find mix of agricultural practice (rain fed, irrigated, livestock) to optimize river water productivity
- Theoretical framework
  - Plant water requirements
- Model structure
  - Simple, (quasi)linear structure, ‚physical' model (water flow)
- Output
  - prototype

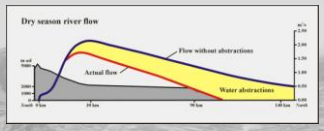
The Situation: Socioeconomic dynamics

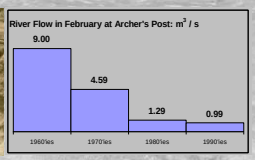


- Very high dynamics
- Very high diversity
- Great disparities
- Immense pressure on land and water

Implications: Pressure on Water Resources



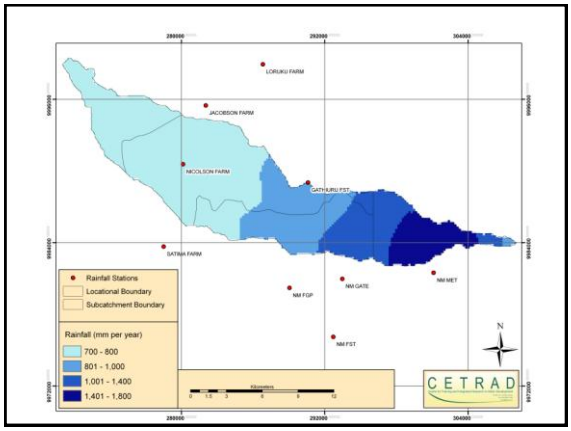


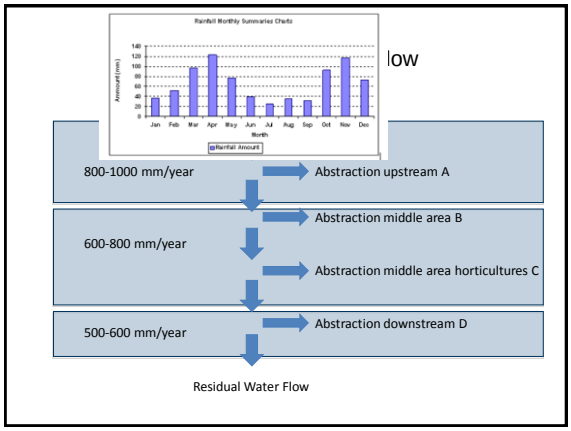


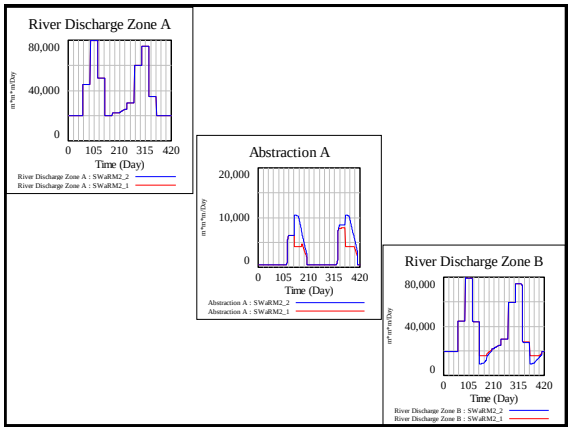
The river dried up for a stretch of 60- 90 km upstream of Buffalo Springs in 1984, 1986, 1991, 1994, 1997, 2000, 2002, 2003, 2004, 2005

What *is* the Problem?

- Population development and land use change dynamics
- Conflicts between upstream and downstream users
- Potentials and limitations of collective irrigation management
- Limited access of smallholders to financial credits
- Agricultural practices to optimize river water productivity
- ...


LORUKU FARM
JACOBSON FARM
NICOLSON FARM
SATHURU FST.
SATIMA FARM
NM GATE
NM MET
NM FGP
NM FST.
Rainfall Stations
Locational Boundary
Subcatchment Boundary
Rainfall (mm per year)
700 - 800
801 - 1,000
1,001 - 1,400
1,401 - 1,800
N
CETRAD


Rainfall Monthly Summaries Charts
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month
Rainfall Amount
low
800-1000 mm/year
Abstraction upstream A
Abstraction middle area B
600-800 mm/year
Abstraction middle area horticultures C
500-600 mm/year
Abstraction downstream D
Residual Water Flow


River Discharge Zone A
80,000
40,000
0
0 105 210 315 420
Time (Day)
River Discharge Zone A : SWaRM2_2
River Discharge Zone A : SWaRM2_1
Abstraction A
20,000
10,000
0
0 105 210 315 420
Time (Day)
Abstraction A : SWaRM2_2
Abstraction A : SWaRM2_1
River Discharge Zone B
80,000
40,000
0
0 105 210 315 420
Time (Day)
River Discharge Zone B : SWaRM2_2
River Discharge Zone B : SWaRM2_1

Reflection: lessons learnt

- Problem focus
  - (Collective) irrigation management
- Rely on hypotheses for modeling
  - Systems behaviour (possible solution, reference modes)
  - Underlying mechanisms (structure)
- Theoretical framework
  - Transparent modeling
  - relate to (disciplinary) scientific discourse
  - Applicable to other areas? Clarify preconditions

Reflection: lessons learnt

- Small models offer numerous options for extensions
- Manage complexity
  - (small) models → large number of scenarios (policies)
  - Assist user to explore and to manage this large variety
- Software product (not system dynamics model)
  - Usability
  - Graphical user interface (drag and drop)

System dynamics for transdisciplinary research

- Potentials
  - Integrate different pieces of disciplinary as well as of local knowledge
  - Offer a consistent and testable theory
  - Provide quantitative, dynamic simulations.
- Challenges
  - involvement of and communication with local stakeholders
  - validation procedures
  - comparison/combination with other modelling methods (e.g. agent-based or object-oriented modelling approaches)
  - how to take into consideration uncertain and unknown future developments.