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Coevolution of Social and Ecological Systems an Analytical Economics approach



Peruvian *campesinos* protesting against Conga Gold Mine 2011
<http://www.economist.com/node/21541420> [Reuters]

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WINS Inception Workshop,
Humboldt-Universität zu Berlin,
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Overview – 4 Questions

- Georgescu-Roegen's Analytical Economics - a General Theory for Institutional Economics
- Scientific Communities using Georgescu-Roegen
- Some Ideas as to how these Communities might enrich and benefit from working with/in WINS
- A few Recommendations regarding future Design and Development of WINS





(Chapters 1-9 of GR, 1971)

Economic Process & Analytics of Change

this position was
developed in
collaboration
with
Kozo Mayumi

Economics is about qualitative biological change

Georgescu-Roegen, N. 1971. *The Entropy Law and the Economic Process*.
London: Harvard University Press, Distributed by Oxford University Press (GR, 1971).

Wicksteed's production function [$P = f(a, b, c, \dots)$]
“an acme of imprecision”

Georgescu-Roegen, N. 1990. Production process and dynamic economics. In: Baranzini, M., Scazzieri, R. Ed.
The Economic Theory of Structure and Change. Cambridge: Cambridge University Press: p. 205 (GR, 1990).

following on from his work at Harvard, in the 30s, on Consumption Theory and Activity Analysis, reflecting on his time back in Romania during WWII ...

(1) *“Romania’s institutions were not adapted to the Walrasian principle of profit maximisation”*

Georgescu-Roegen, N. 1976. *Energy and Economic Myths: Institutional and Analytical Economic Essays*. Oxford: Pergamon: xi (GR, 1976).

(2) *“One certainly would not expect a society that cannot live according to the Walrasian distribution theory to commit suicide rather than adopt another system”*

Georgescu-Roegen, N. 1966. *Analytical Economics: issues and problems*.
Cambridge, MA: Harvard University Press: p. 339 (GR, 1966).



“...*an arithmomorphic model has no value unless there is a dialectical reasoning to be tested*”

- GR, 1971:341 emphasis original

- 1894** **Wicksteed's** production function $P = f(a, b, c, \dots)$
mischievous math | *role of time not specified*
- 1950s** **Boulding** proposes the recipe as a metaphor
list of ingredients | *role of time not specified*
- 1960s** **Georgescu-Roegen** finds some value in Boulding's metaphor
explicitly adds mixing instructions | *timing is everything*
- 1970s** **Georgescu-Roegen** *implicitly* contextualises the metaphor
adding the economic *Anschauung* of a society (cuisine) |
the final cause fixes the time-frame

Farrell, K.N. and K. Mayumi. 2009. Time horizons and electricity futures: an application of Nicholas Georgescu-Roegen's general theory of economic production. *Energy* 34(3):301-307.

Georgescu-Roegen's flow fund model a brief introduction to the concepts

a constructive critique of Walras / Wicksteed / Leontief; of reliance on a fixed algebraic distinction between stocks and flows

process-specific flow/fund replaces freeze-frame stock/flow distinction

a biological theory of value / energy doing useful work

- usefulness depends upon purpose; no purpose, no useful
- purpose determines what is the point of focus
- focus, combined with capacity for scope, determines the temporal and spatial boundaries of process
- the temporal and spatial boundaries of the specified process determine the flow/fund status of the elements of production

GR, 1971

Brennan, T. 1997. Economy for the Earth:

The labour theory of value without the subject/object distinction. *Ecological Economics* 20:175-185.

Farrell, K.N. and K Mayumi. 2009. Time horizons and electricity futures:
an application of Nicholas Georgescu-Roegen's general theory of economic production. *Energy* 34(3):301-307.



Flows and Funds

“Flows are elements that enter but do not leave the process or, conversely, elements that exit without having entered the process. Funds ([typically] capital, people and Ricardian land²) are elements that enter and exit the process unchanged, transforming input into output flows” (Mayumi, 1999:191).

Mayumi, K. 1999. “Embodied energy analysis, Sraffa’s analysis, Georgescu-Roegen’s flow-fund model and viability of solar technology. In: Mayumi, K, Gowdy J, Eds. *Bioeconomics and sustainability: essays in honor of Nicholas Georgescu-Roegen*. Cheltenham: Edward Elgar:173–93.

² Mayumi includes here, the following note:

“in this representation, outflows of any kind are represented by positive coordinates, inflows by negative coordinates”



Grannies Cookies / Georgescu-Roegen's General Theory cuisine specifies the space/time structure of the process

list of ingredients | *timing not specified*

- 3 eggs
- 2 cups flour (fine)
- 3/4 cups cane sugar
- 3/4 cups brown sugar
- 1/2 lb butter (room temperature)
- 2 tsp vanilla extract
- 1 tsp baking soda
- 1 tsp salt
- 1 lb chocolate

mixing instructions | *timing is everything*

- pre-heat oven to 325F
- set the butter out to warm if you have not done so already
 - (do not cook or microwave the butter! - if you forgot, chop the chocolate and wait)
- chop chocolate into pieces smaller than a hazelnut but bigger than a pea
 - put the chocolate somewhere cool, for use later in the recipe
- sift flour, baking soda and salt together
 - put the flour mixture somewhere dry, for use later in the recipe
- mash the butter in a large bowl until it is smooth
- add the cane and brown sugar to the butter and mix until smooth
- add the eggs to the butter and sugar mixture and mix until smooth
- add the vanilla to the butter, sugar and egg mixture and blend
- in small stages add the flour mixture to the batter in the big bowl
 - (make sure to incorporate each round of flour before adding more)
- in small stages add the chocolate chunks to the batter/flour mixture in the big bowl
- using two table spoons, place golf ball sized dollops of batter on to an ungreased cookie sheet
 - (make sure to leave at least 2 inches 'growing room' between dollops)
- bake at 325F for 8-12 minutes (but check them sooner) until golden brown and firm to the touch

list of ingredients

mixing
instructions

Farrell, K.N. and Mayumi, K 2006 'Time and Tradition in the Works of Nicholas Georgescu-Roegen.' Presented at the Biennial International Workshop: Advances in Energy Studies "Perspectives on Energy Future" | Porto Venere, Italy 12-16 Sept., 2006



Purpose, Production and Apple Trees



**Produced or Producing?
Product or Capital?
Flow or Fund?**

**to the farmer – the tree is a
producer of fruit (fund)**

**to the carpenter – it's a supply
of wood (flow)**

**to the bee – a producer of
nectar (fund)**

**to the termite – a direct source
of food (flow)**

Silva-Macher, JC and K.N. Farrell. 2014. The flow/fund model of Conga: exploring the anatomy of environmental conflicts at the Andes–Amazon commodity frontier. *Environment, Development and Sustainability* 16(3)747-768.

Institutions and Social-Ecological Co-evolution in Georgescu-Roegen's Analytical Economics (Chapter 10 GR, 1971)

referring to Lotka's term exosomatic evolution:

“[i]n place of slow adaptation of anatomical structure and physiological function in successive generations by selective survival, ... increased adaptation [in the human species] has been achieved by the incomparably more rapid development of ... ‘artificial’ aids to our native receptor-effector apparatus, in a process that might be termed exosomatic [outside the body] evolution”

Lotka, Alfred J. (1945) ‘The Law of Evolution as a Maximal Principle’
Human Biology 17 (3):167-194, p.188 emphasis original

- acquired knowledge, become tacit knowledge – institutionalised
- phenotype become genotype – population level manifestation
- niche construction embeds habituated patterns – co-evolution
- human biology & human evolution are institutionally attenuated

Farrell, K.N., & Vatn, A. (2004). Exosomatic instruments of production and the human species: Historical and normative epistemological foundations of ecological economics. In: Proceedings if paper presented at the 8th Biennial conference of the international society for ecological economics, Montreal.



Georgescu-Roegen's Demon

a purposeful sorter

(Chapter 10 GR, 1971)

humans use technologies, including institutions [*hammers, money, markets, laws, courts, customs, habits, taboo, ritual, etc.*] to sort matter into low entropy

choices about the purpose of economic activity set the parameters of economic processes - Cadillacs or crops?

GR, 1971; 1976

“Choices regarding what constitutes social-ecologically appropriate human behavior and how this should be regulated are the raw materials with which fit institutions may be ,brought into being.”

Farrell, K. N., and A. Thiel. 2013. Nudging evolution? *Ecology and Society* 18(4): 47

Applications of Analytical Economics

- Generally based on Georgescu-Roegen's Major Work:
The Entropy Law and the Economic Process
1971, Harvard University Press: Cambridge, MA.
- materials from both Chapters 9 and 10 of that text are used widely in evolutionary and ecological economics
 - C.9 is mathematics: used in bioeconomics and energetics studies and in agro- and industrial economic modelling
 - C.10 is social theory: used in political ecology
 - the two are rarely used together, in spite of that having been, it would seem, his intention ...

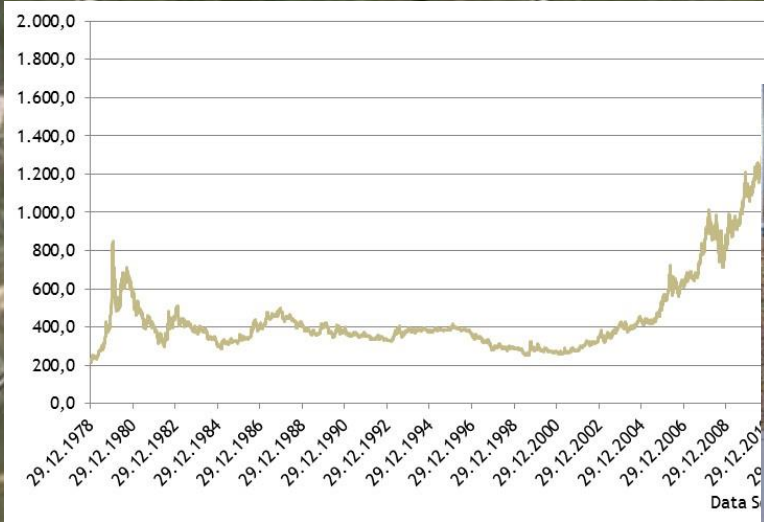


Cajamarca

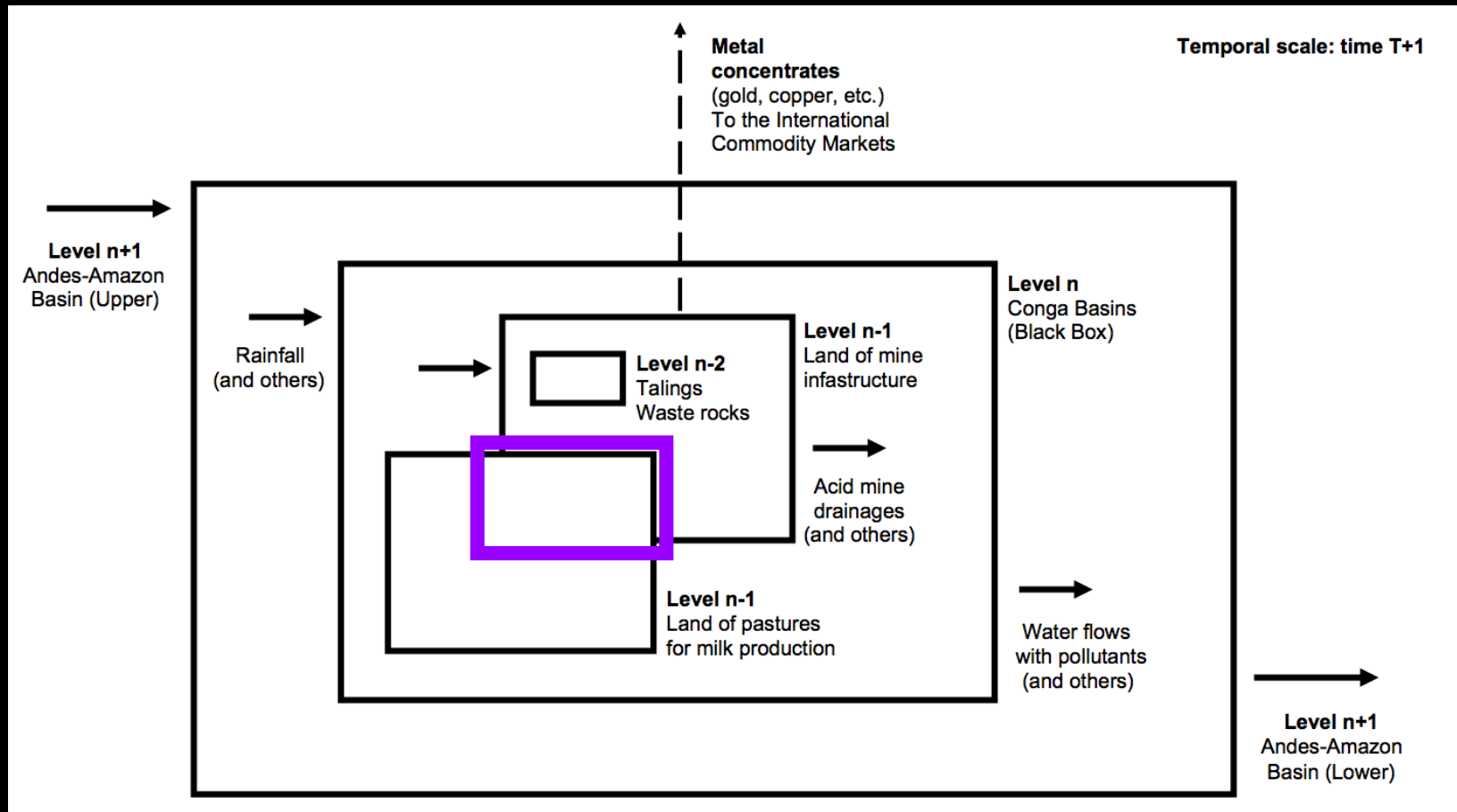


Conga Mine Deposit

Decommissioned Yanacocha Mine



Representing Purposive Complexity as Parameters for Process Elements



Silva-Macher, J.C. and K.N. Farrell. 2014. The flow/fund model of Conga: exploring the anatomy of environmental conflicts at the Andes–Amazon commodity frontier. *Environment, Development and Sustainability* 16(3)747-768.

Based on Giampietro, M. & K. Mayumi. 2004. Impredicative loop analysis: Dealing with the representation of chicken-egg processes. In M. Giampietro, *Multi-scale integrated analysis of agroecosystems* Boca Raton: CRC Press: 171–230.

0,250 tons / USD : material moved / capital equipment
 6,2 tons / USD : waste generated / waste infrastructure

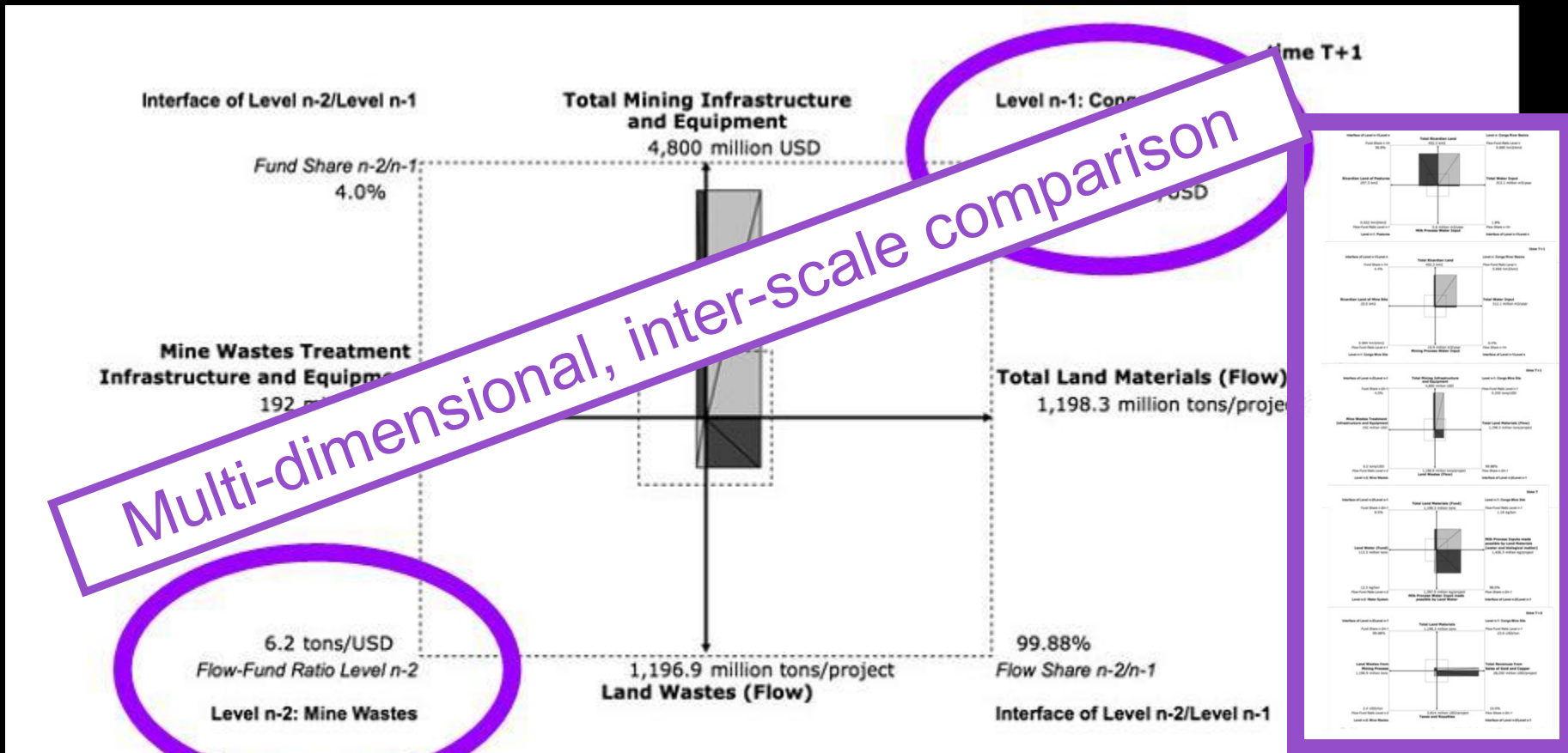


Fig. 6 Mining infrastructure versus land materials (as flows). Source own elaboration inspired in Giampietro

Silva-Macher, J.C. and K.N. Farrell. 2014. The flow/fund model of Conga: exploring the anatomy of environmental conflicts at the Andes–Amazon commodity frontier. *Environment, Development and Sustainability* 16(3)747-768.

Based on Giampietro, M. & K. Mayumi. 2004. Impredicative loop analysis: Dealing with the representation of chicken-egg processes. In M. Giampietro, *Multi-scale integrated analysis of agroecosystems* Boca Raton: CRC Press: 171–230.



Tibetan Pastoralism A Social Ecological System



Photo Credit: Jampel DellAngelo



**a Purposive Sorter at the heart
of a complex, evolving
Social-Ecological System**

**Khandro Tsering Chödrön
Tibetan Lama (1929-2011)**

Source:
chronicleproject.com/stories_295.html

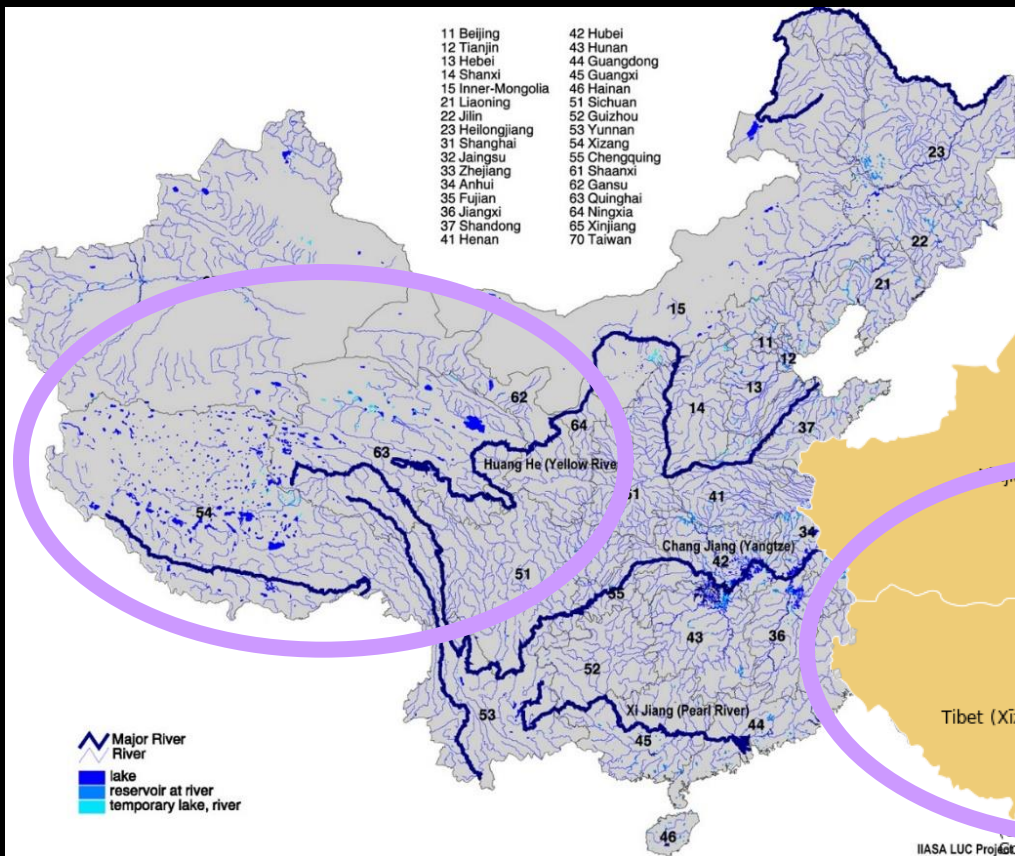


Khandro Tsering Chödrön in Exile
Tibetan Lama (1929-2011)
source:<http://www.rigpawiki.org>

Source:
<http://en.wikipedia.org/wiki/User:ASDFGH>



Source:
 IIASA LUC Project
 Digital Map of the World
 Main rivers in China - high resolution map
http://www.china-food-security.org/data/maps/rivers/riv1_h.htm



Source:
<http://en.wikipedia.org/wiki/User:ASDFGH>



Tibetan Pastoralist have been obliged to settle changed sorters - changed system

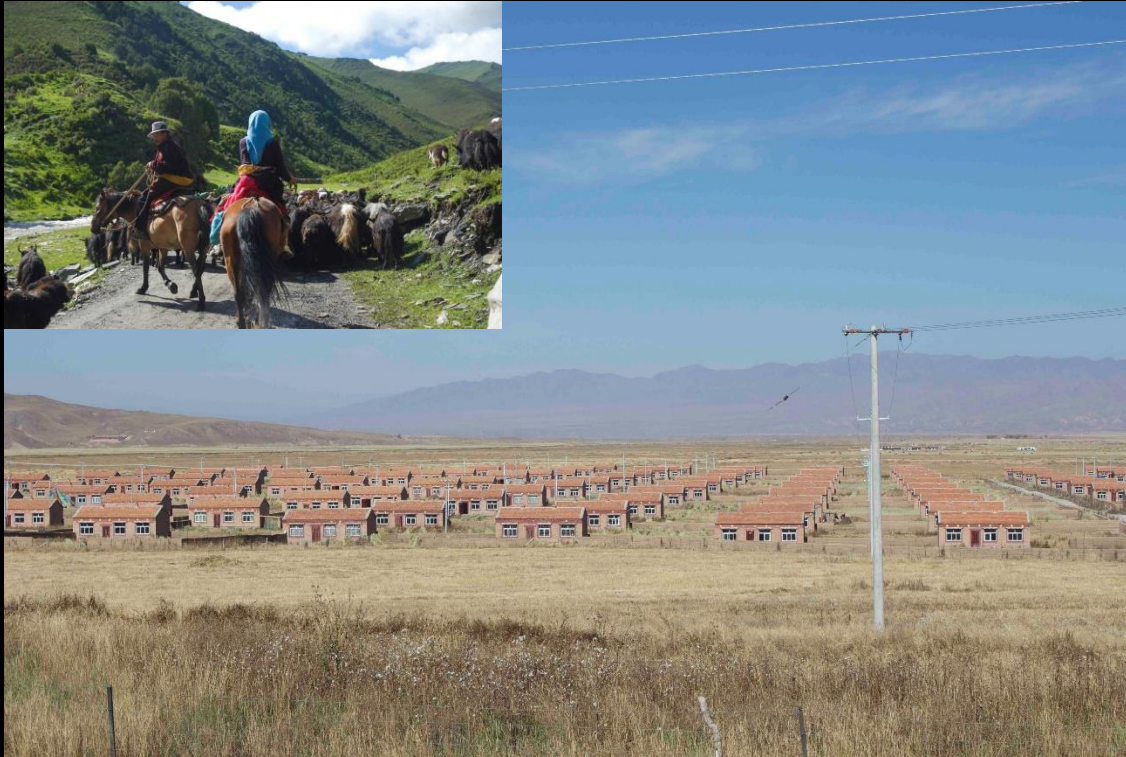


Photo Credits: Jampel DellAngelo

Khandro Tsering Chödrön
Tibetan Lama (1929-2011)

source:<http://khandrotseringchodron.org/>



The IIParakuiyo
Photos: Adam Mwarabu



the Great Ruaha River, her Usangu Plains



and her people(s)

maps accessed online
via the CIA Factbook

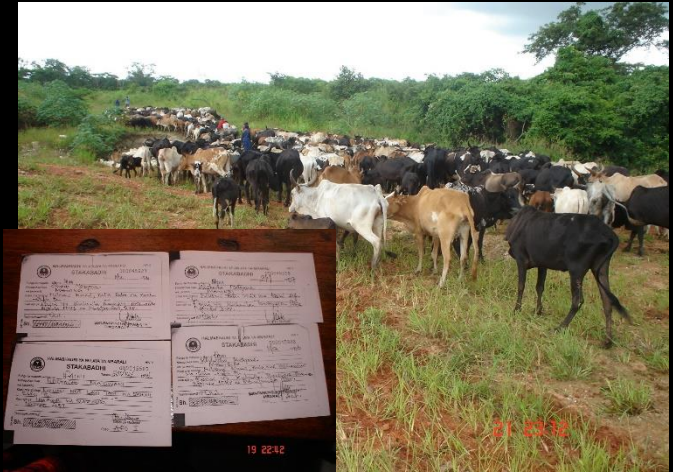


Ihefu – Usanagu Wetlands,
Mbarali, Tanzania
Photo: Adam Mwarabu



I' Parakuiyo wymyn
forced to resettle after
the Mbarali evictions
Photo: Adam Mwarabu

Mbarali Evictions, 2006-2008
Photo: Adam Mwarabu



Western and Eastern Usanagu Wetlands,
Mbarali, Tanzania (source: Google Earth 2008)



Kilosa Evictions, 2009
Photo: Adam Mwarabu

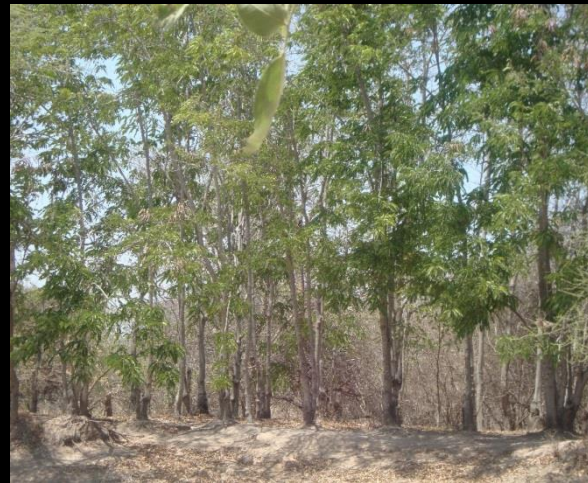


Mbeya

Mwanalwala

Matebete

Western and Eastern Usanagu Wetlands,
Mbarali, Tanzania (source: Google Earth 2014)

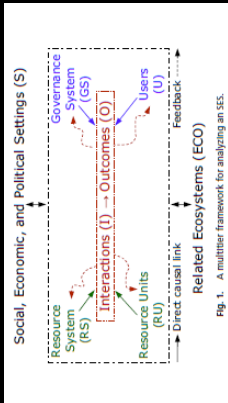


Local Photos all Taken by Evelyn Kaney, 2013



Some Ideas on how the communities using Georgescu-Roegen might enrich and benefit from working with/in WINS (3)

(1)



(2)

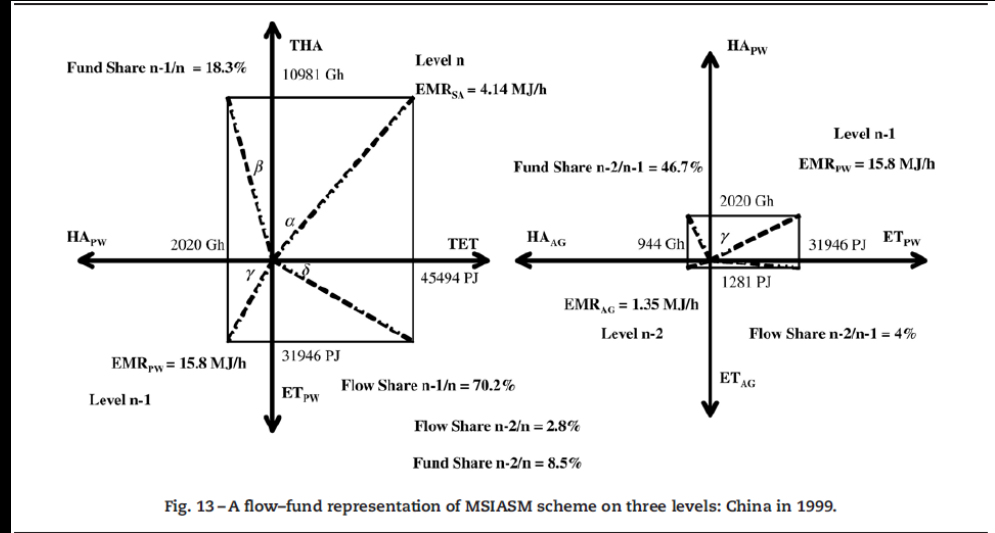
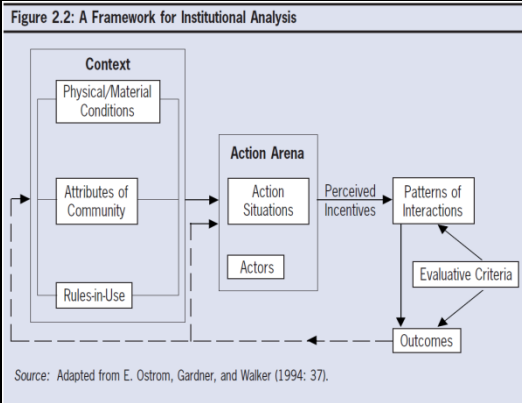


Fig. 13 - A flow-fund representation of MSIASM scheme on three levels: China in 1999.

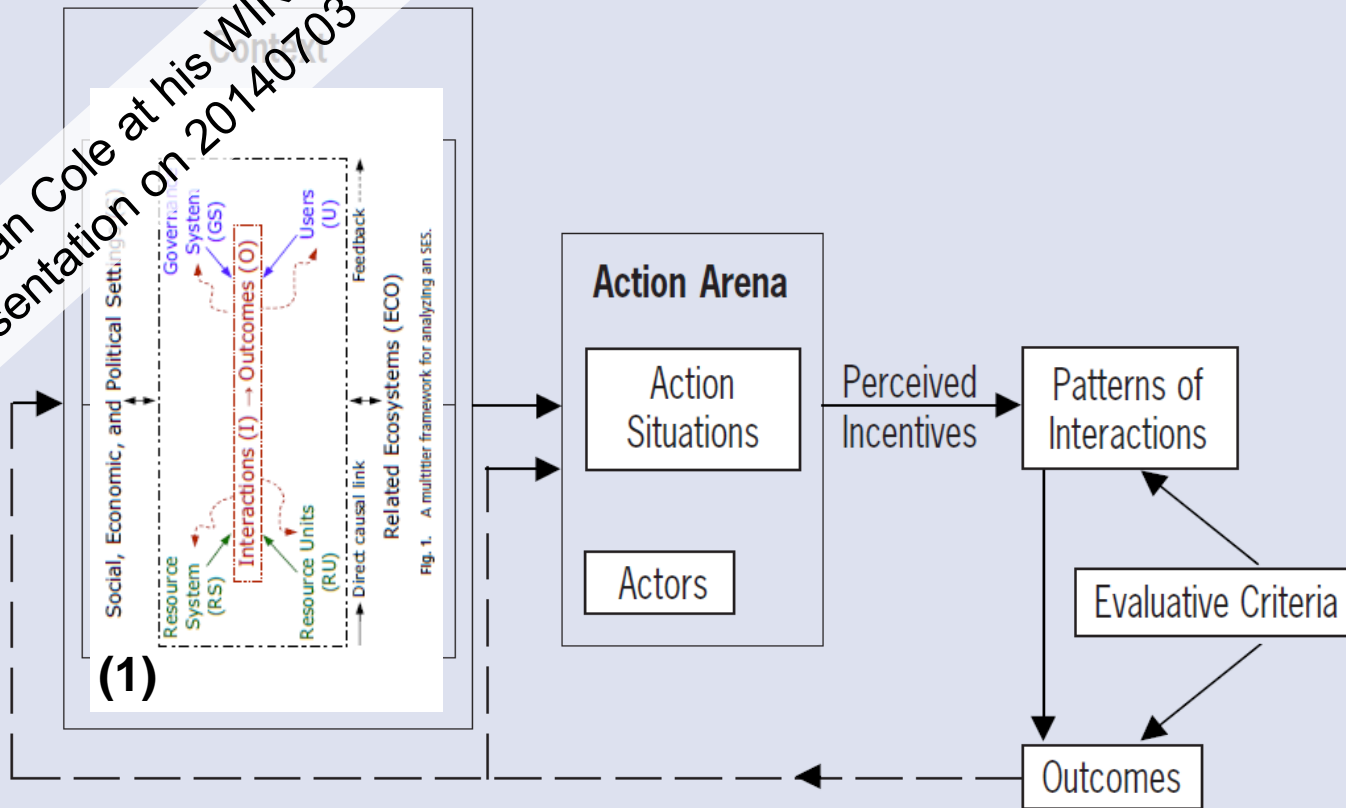
Georgescu-Roegen's Analytical Economics provides a basis for constructing process-specific functional math equations, suitable for modelling dynamic relationships between physical and social systems

(1) Ostrom, E. 2007. A diagnostic approach for going beyond panaceas *PNAS* 104 (39) 15181-15187.

(2) Ostrom, E, C. Gibson, S. Shivakumar, K. Andersson. 2002. *Aid, Incentives and Sustainability. An Institutional Analysis of Development Cooperation*. Sida Studies in Evaluation 02/01. Infocenter, Sida, Stockholm
AND Ostrom, E. R. Gardner, and J. Walker. 1994. *Rules, Games and Common-Pool Resources*. University of Michigan Press, Ann Arbor.

(3) Ramos-Martin, J, M. Giampietro, K. Mayumi. 2007. On China's exosomatic energy metabolism: An application of multi-scale integrated analysis of societal metabolism (MSIASM) *Ecological Economics* 63(1): 174-191.





Source: Adapted from E. Ostrom, Gardner, and Walker (1994: 37).

(1) Ostrom, E. 2007. A diagnostic approach for going beyond panaceas *PNAS* 104 (39) 15181-15187.

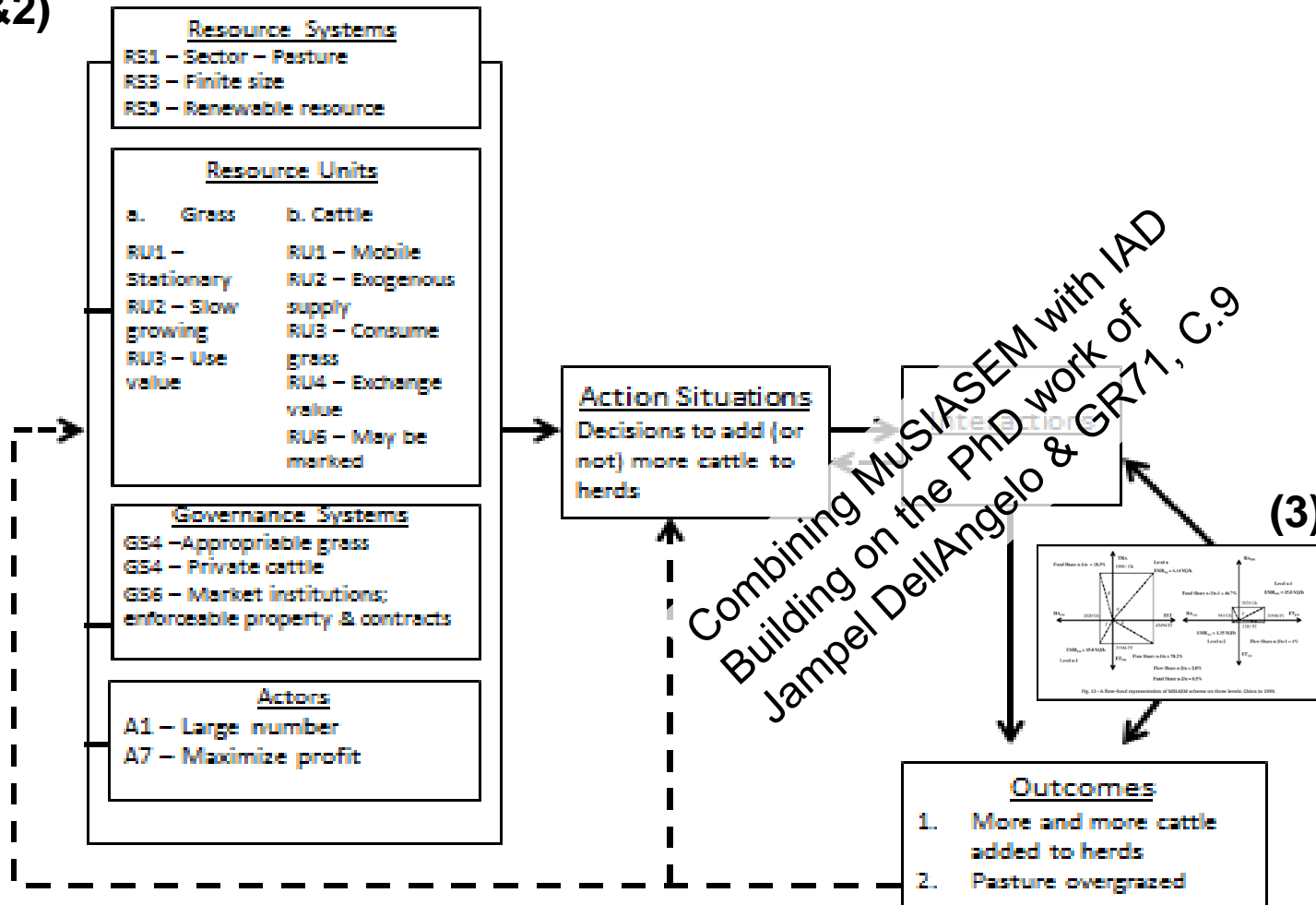
(2) Ostrom, E, C. Gibson, S. Shivakumar, K. Andersson. 2002. *Aid, Incentives and Sustainability. An Institutional Analysis of Development Cooperation*. Sida Studies in Evaluation 02/01. Infocenter, Sida, Stockholm

AND Ostrom, E. R. Gardner, and J. Walker. 1994. *Rules, Games and Common-Pool Resources*. University of Michigan Press, Ann Arbour.

(1&2) Cole, D., M. McGinnis and G. Epstein. 2014. Toward a "New Institutional Analysis of Social-Ecological Systems" (NIASES).

Prepared for WINS Seminar July 3, 2014, Humboldt Univ. DRAFT – Not for distribution. Please contact authors for updates.

(1&2)

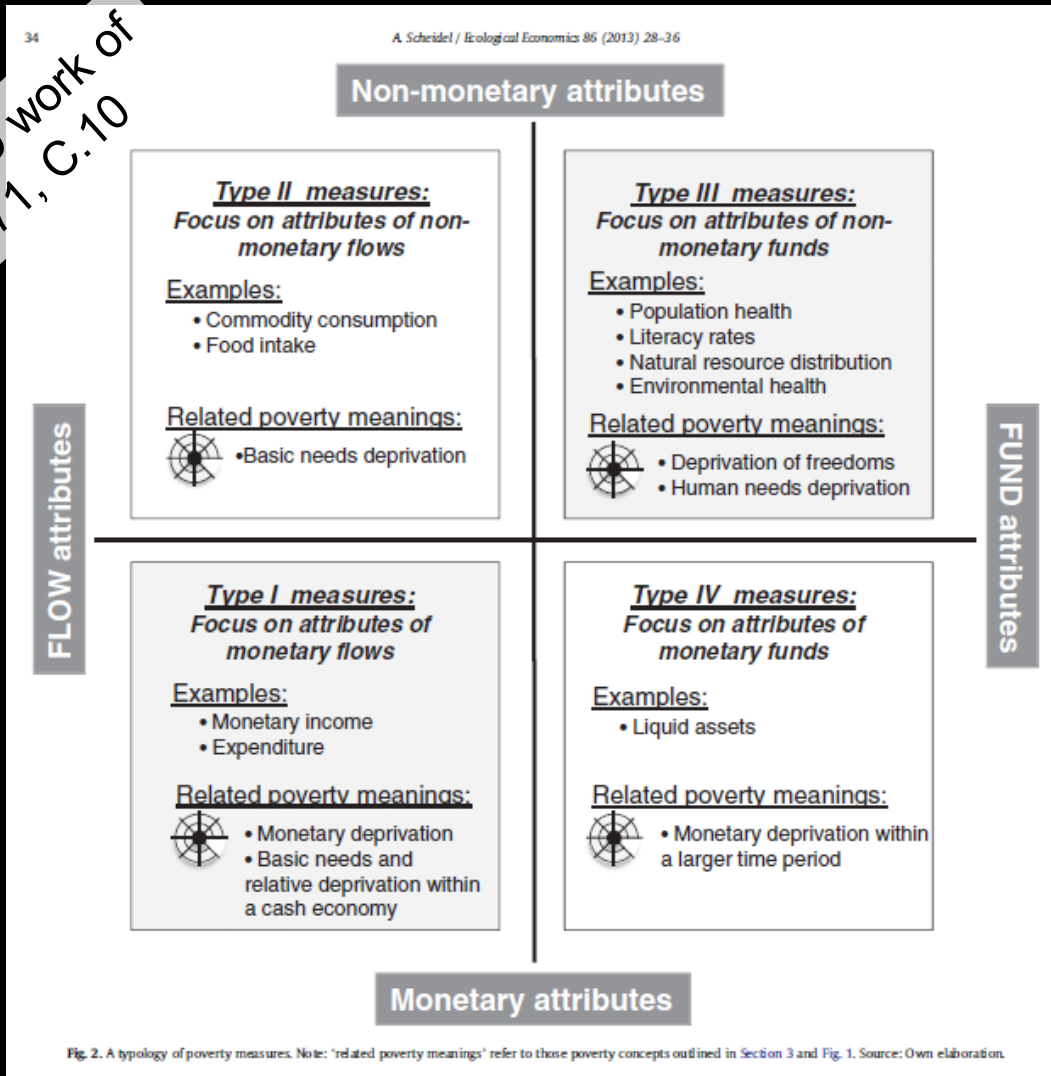


(1&2) Cole, D., M. McGinnis and G. Epstein. 2014. Toward a “New Institutional Analysis of Social-Ecological Systems” (NIASES). Prepared for WINS Seminar July 3, 2014, Humboldt Univ. DRAFT – Not for distribution. Please contact authors for updates.

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(4)

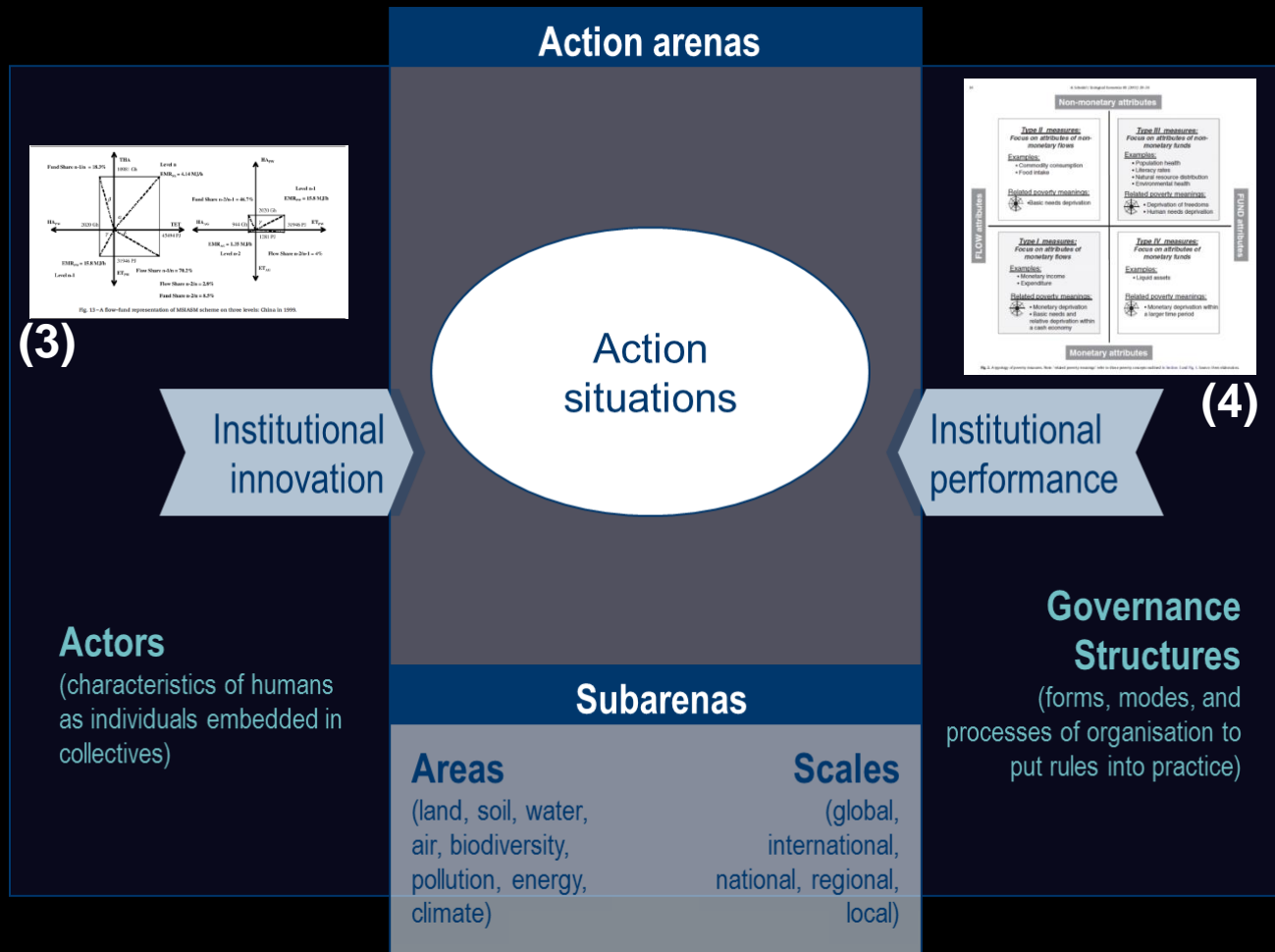
orbuilding on the PhD work of
Arnim Scheidel & GR71, C.10



(4) Scheidel, A. 2013. Flows, funds and the complexity of deprivation: Using concepts from ecological economics for the study of poverty. *Ecological Economics* 86: 28-36.



perhaps combining MuSIASEM with the IoS



Hagedorn, K., Arzt, K., Peters, U., 2002. Institutional Arrangements for Environmental Co-operatives: A Conceptual Framework. In: Hagedorn, K. (Ed.), *Environmental Co-operation and Institutional Change: Theories and Policies for European Agriculture*. Edward Elgar, Cheltenham: 3-25

(3) Ramos-Martin, J, M. Giampietro, K. Mayumi. 2007. *Ecological Economics* 63(1): 174-191.

(4) Scheidel, A. 2013. *Ecological Economics* 86: 28-36.



a recommendation accommodate modelling modularity

Embrace:

- the impossibility of an ultimate ‘meta-model’
as the only reasonable ultimate ‘meta-model’

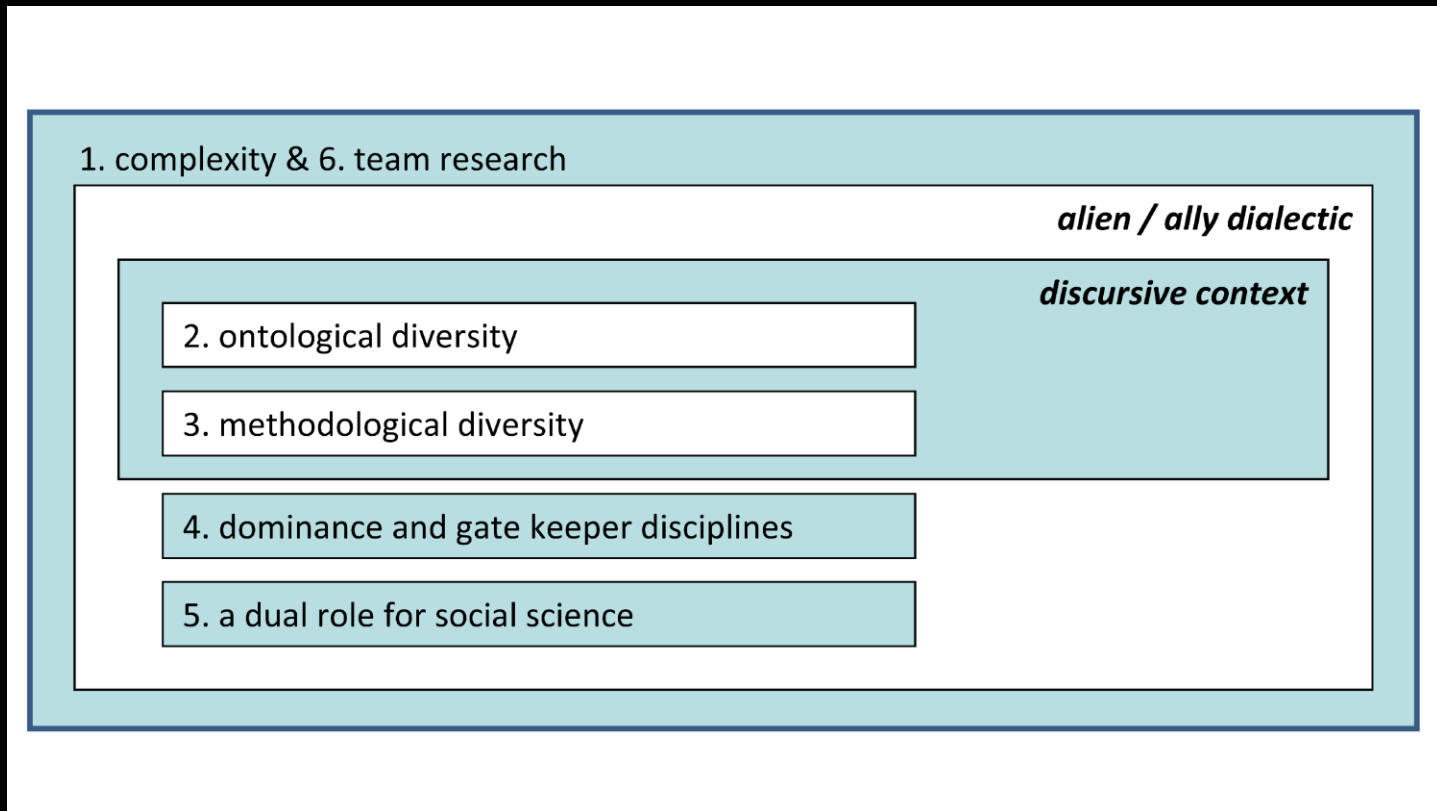
Conduct:

- purposive analysis of purposive processes

Think:

- outside the box before you set about
unpacking it

a working ontology of the typical SES research project



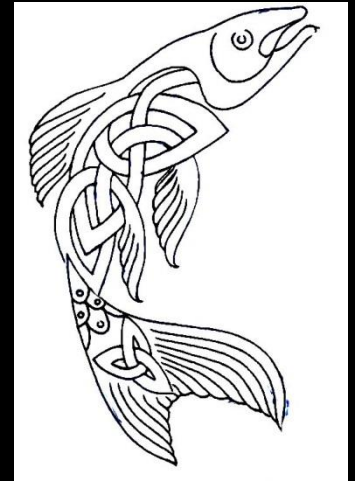
Farrell, Katharine N., Sybille van den Hove and Tommaso Luzzati (2013) "What lies beyond reductionism? Taking stock of inter-disciplinary research in ecological economics." In Beyond Reductionism: a passion for interdisciplinarity, eds. Katharine N. Farrell, Sybille van den Hove and Tommaso Luzzati. London: Routledge.

Mapping the Complexity of Interdisciplinary Team Level Discourses

		Ontological Compatibility		
		Absent	Weak	Strong
Methodological Compatibility	Absent	Political	political / ontological	Ontological
	Weak	political / methodological	Confusion & Creativity	ontological / technical
	Strong	Methodological	methodological / technical	Technical

Farrell, Katharine N., Sybille van den Hove and Tommaso Luzzati (2013) "What lies beyond reductionism? Taking stock of inter-disciplinary research in ecological economics." In Beyond Reductionism: a passion for interdisciplinarity, eds. Katharine N. Farrell, Sybille van den Hove and Tommaso Luzzati. London: Routledge.

and as with any journey of adventure...
keep things in perspective



Take the salmon as the point of focus, for example...

the young salmon swim off to the sea,
with a preordained purpose – stay alive
the mature salmon returns to the same river,
with a preordained but entirely different purpose – to reproduce

Take the forest as the focus and we can see the two purposes converge,

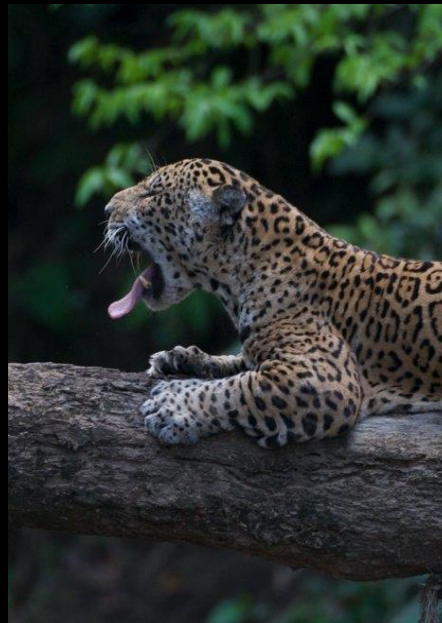
the young salmon swimming off to the sea have the purposes to collect low entropy and get safely back to their home river, bringing nutrients with them...

mature salmon, returning, have the purpose to give these nutrients to the forest, and to produce new young salmon that repeat the cycle of creative destruction...

thank you for your attention !



Katharine Farrell and Adam Mwarabu
Photo Taken by Richard Norgaard,
Nairobi, 2008



a jaguar at rest in the Amazon
Photo taken by Robert Williams
given to me by Jose Carlos Silva Macher: for inspiration



Peruvian *campesinos* protesting
against Conga Gold Mine 2011
<http://www.economist.com/node/21541420>
[Reuters]