Organizing Inter- and Transdisciplinary Research in TERRECO

TERRECO Seminar, Winter term 2009/10

Prof. Dr. Thomas Köllner
Professorship of Ecological Services (PES), University of Bayreuth

Goals

1. Learn about the difference of inter- and transdisciplinary research

2. Know about planning tools to organize inter- and transdisciplinary research

3. Kick-start inter- and transdisciplinary process in TERRECO

FROM DISCIPLINARY TO INTER- AND TRANS-DISCIPLINARY RESEARCH

The disciplines dealing with environmental problems

- Natural Sciences
  - Ecology
  - Hydrology
  - ...
- Social Sciences
  - Environmental Economics
  - Environmental Psychology
  - Human Geography
  - …
- Engineering
  - Industrial Ecology
  - …

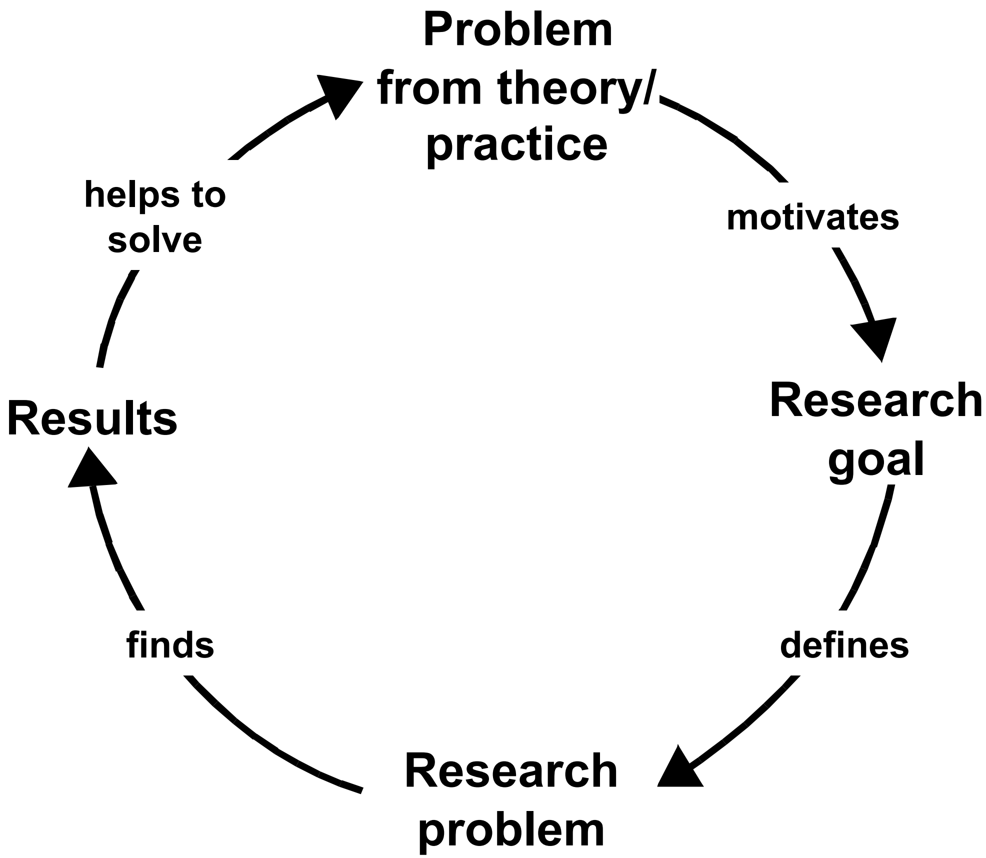
Definitions of inter- and transdisciplinarity

1. Interdisciplinary research means joint efforts of different scientific disciplines
   - Good for knowledge integration to better address (environmental) problems, which are by nature not organized along disciplines

2. Transdisciplinary research means joint efforts of scientists and societal actors
   - Good for defining research questions, which are relevant for societal actors
   - Good for better implementation of research results
   - But it means not that normative decisions are transferred from society to science!!!

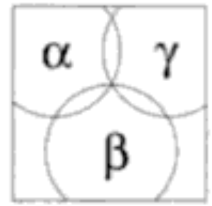
The research cycle

from Booth et al. (1995) The craft of research. University of Chicago Press.



What is integrated in inter- and transdisciplinary research?

- Different **disciplines** of natural and social sciences.



- Different **systems** such as water, soil, air, and anthroposphere.

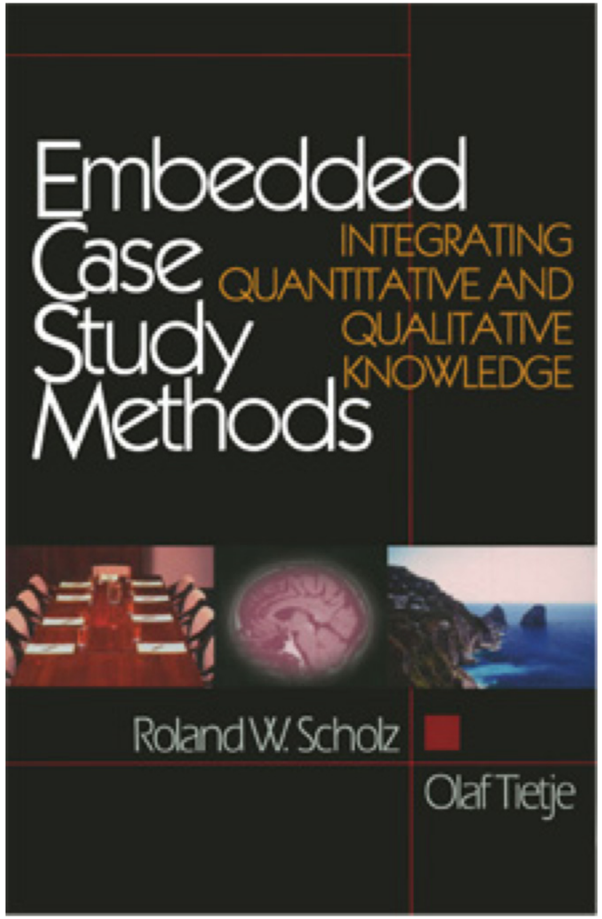
- Different **modes of thought** representaing different cognitive approaches.

- Different **interests of stakeholders**.

Source: Scholz and Tietje 2002

The inter- and transdisciplinary approach

- Scholz, R.W. and Tietje, O., 2002. Embedded case study methods: Integrating quantitative and qualitative knowledge. Sage Publications, inc.: Thousand Oaks, California.



…and how? Four types of knowledge integration

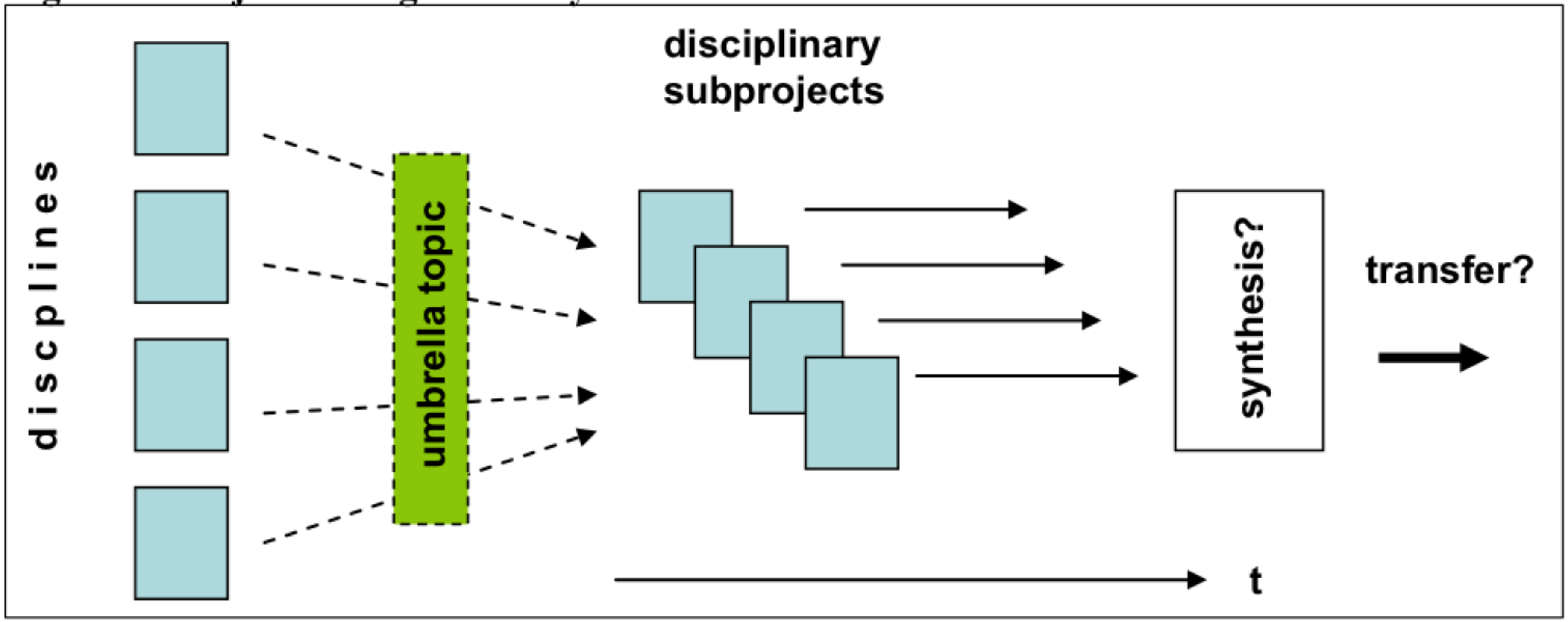
(adapted from Mieg 2008)

	Type of research			
	multidisciplinary	**interdisciplinary**	**transdisciplinary**	**professional**
Synthesis	then	ongoing	first	as contracted
Audience	scientific community	scientific community / interested public	scientists and stakeholders	client
Epistemic integration	additive	partial	hierarchical	report
Typical project members	scientists	scientists, co-ordinators (also for external communication)	scientists, stakeholders, project management	staff (scientific and other)
Performance (what is paid for?)	scientific papers	scientific papers, scientific training	transfer, report, scientific papers, scientific training	project output (report, treatment)
Integration management	weak	on occasion	methodological, high input	task-oriented, efficient
Science-society knowledge transfer	haphazard, scientific conferences	through interaction, scientific / public conferences	through participation, a series of meetings and public events	contracted, meeting
Interdisciplinary output	exchange of methods	exchange of views; theory inputs	joint products; theory inputs	professional product

ORGANIZATION OF INTER-AND TRANS-DISCIPLINARY RESEARCH

Mulitdisciplinary projects

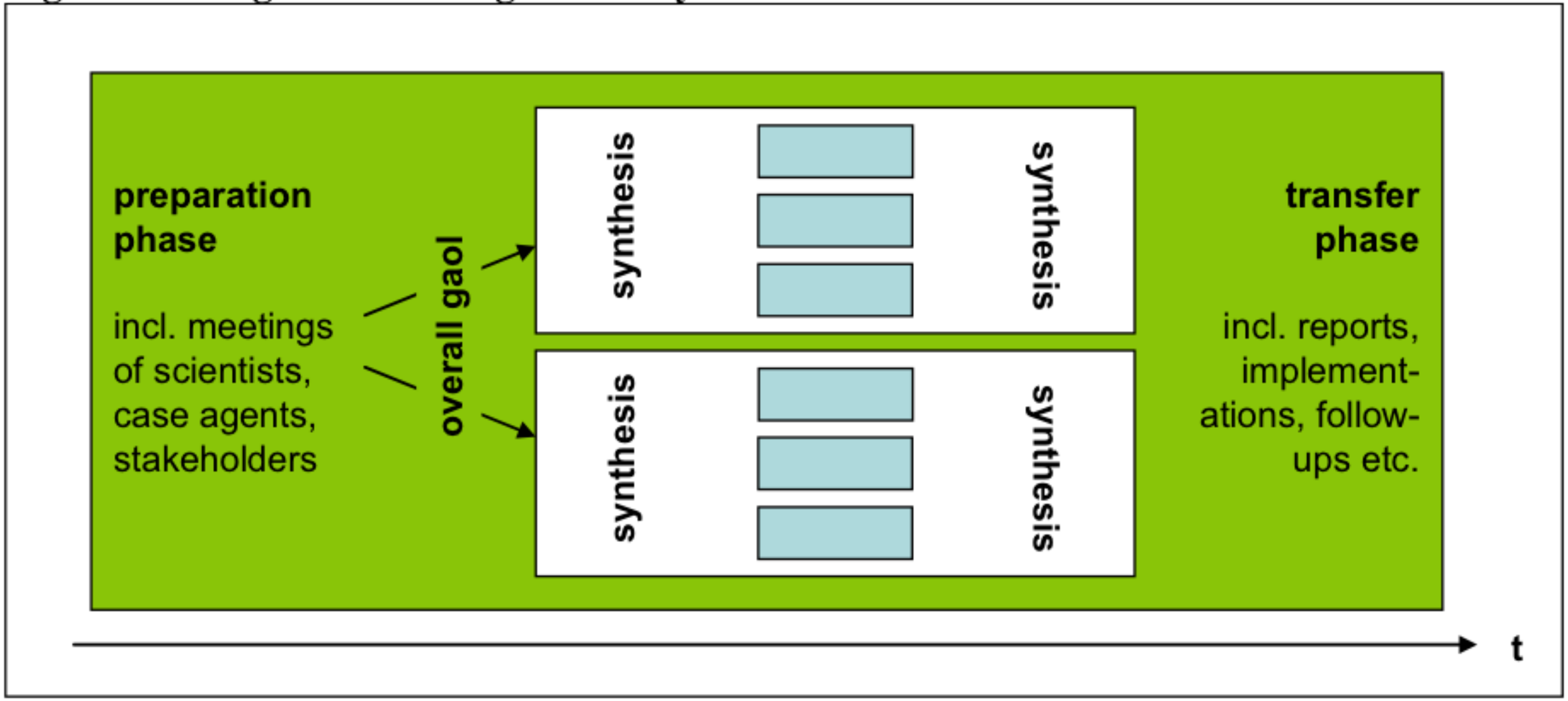
Figure 2: Project management "synthesis-then"



Mieg et al. Four types of knowledge integration management in interdisciplinary research on cities and the environment . Cities and the Environment (2008) vol. 1 (1) pp. Article 6, 1-11

Transdisciplinary projects

Figure 3: Integration management "synthesis-first"



Mieg et al. Four types of knowledge integration management in interdisciplinary research on cities and the environment . Cities and the Environment (2008) vol. 1 (1) pp. Article 6, 1-11

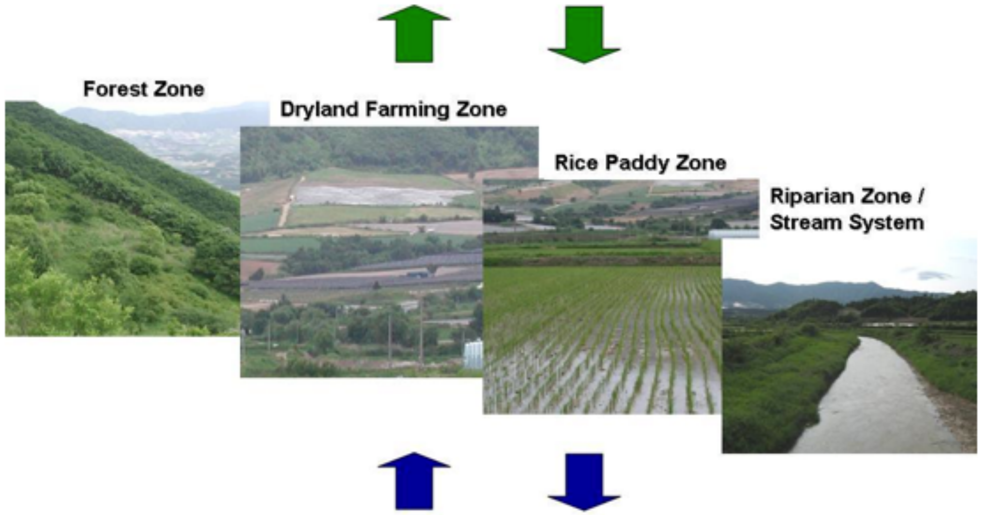
ORGANIZATION OF TERRECO

Complex TERRain and ECOlogical Heterogeneity

Evaluating ecosystem services in production versus water yield and water quality in mountainous landscapes

A joint education and research activity between Germany and South Korea (DFG / KOSEF)

Ecosystem Services in Production



Services in Water Quality and Yield

The TERRECO mission statement

1.4.1. Statement of Purpose and Summary

The goals of the TERRECO-IRTG, thus, focus on building a bridge between spatial patterns of ecosystem performance in complex terrain and derived ecosystem services critical for human well being. A coordinated assessment framework will be developed for landscape to regional scale applications to quantify trade-offs, and determine how shifts in climate, land use and social response to global change pressures influence ecosystem services. Within TERRECO, the abiotic and biotic studies of hydrology and water yield, agricultural and forest production, production-related biodiversity, soil processes and water quality in complex terrain are merged. In addition, the socioeconomic background of current land use is analysed within the framework of changing social-ecological systems. On this basis, a number of scenarios shall be identified that describe potential future change. The trade-offs related to more intensive land use with respect to agriculture versus quantity and quality of water obtained from these regions are evaluated and new tools for understanding and managing such areas will be provided.

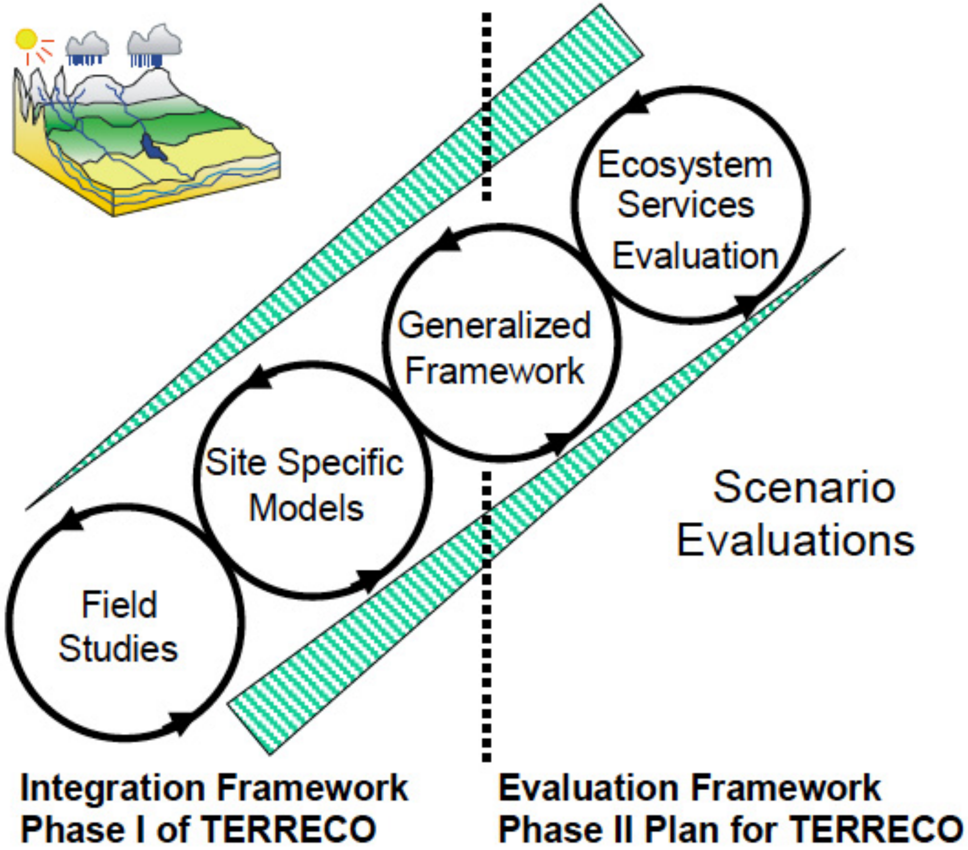


Figure 10. Information flow and shift in emphasis expected during the development of TERRECO (Phase I plus Phase II).

TERRECO Workpackages

- WP I: Climate and Energy Exchange as Determinants of Ecosystem Services 15
- WP II: Sustainable Water Quality and Water Yield from Complex Terrain 17
- WP III: Ecosystem Gas Exchange, Production, and Biodiversity Impacts 19
- WP IV: Landscape Function, Ecosystem Services and Social-Ecological Systems

Running Projects

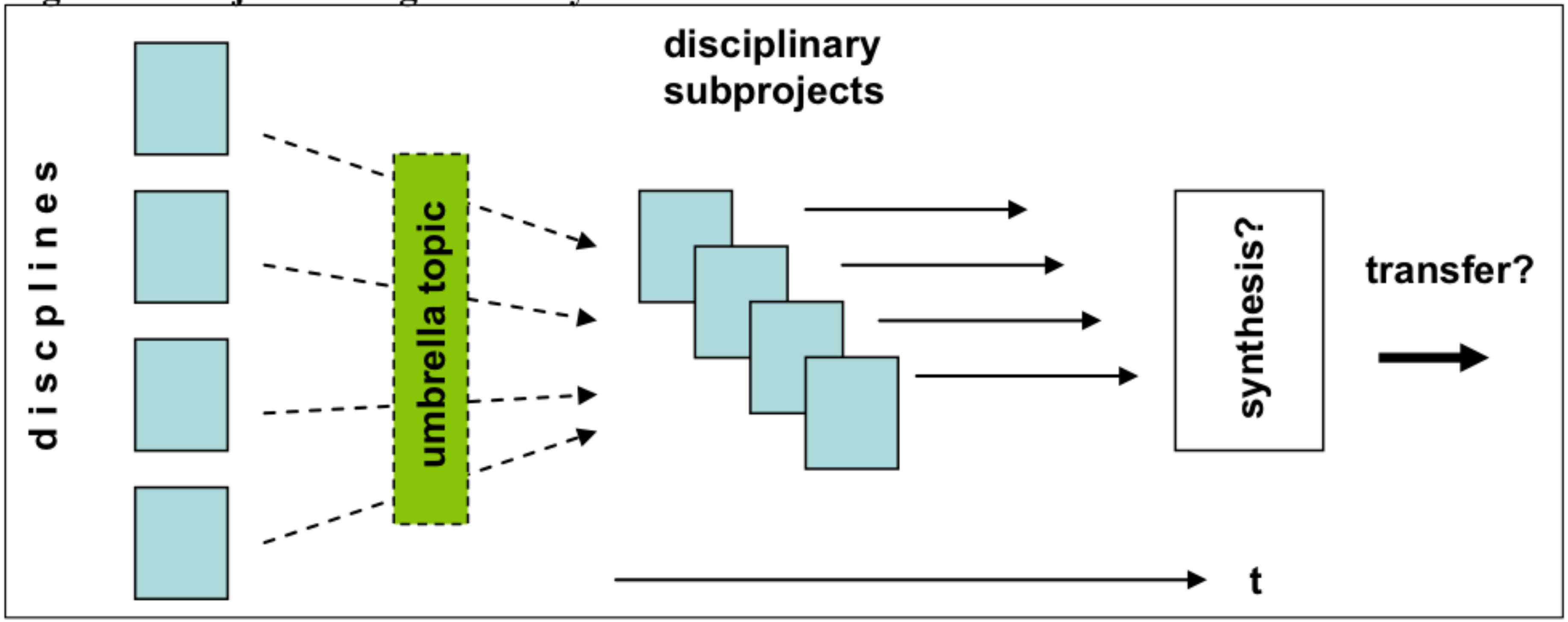
DFG-TERRECO-05	*Fluxes of dissolved and fine particulate organic matter from terrestrial to aquatic systems in dependence on temperature and precipitation regime* Coworkers: **Stefan Strohmeier**, **Egbert Matzner**, **Ji-Hyung Park**
TERRECO-01	*Mesoscale meteorological modelling using micrometeorological measurements in mountain regions* Coworkers: **Chong Bum Lee**, **Johannes Lüers**, **Thomas Foken**
TERRECO-02	*Spatial assessment of atmosphere-ecosystem exchanges via micrometeorological measurements, footprint modelling and mesoscale simulations* Coworkers: **Peng Zhao**, **Johannes Lüers**, **Thomas Foken**, **Chong Bum Lee**
TERRECO-03	*Remote sensing of surface meteorological variables in combination with mesoscale meteorological modelling*

.
.
.

TERRECO-26	*The social context of decision making that influences land use in response to climate change in Korea* Coworkers: **Susann Trabert**, **Detlef Müller-Mahn**, **Bomchul Kim**
TERRECO-27	*The Impact of Socio-Economic Land Use Decisions on Ecosystem Services in Small Catchments* Coworkers: **Patrick Poppenborg**, **Thomas Koellner**
TERRECO-28	*Optimizing fertilizer use for efficient and economic production at landscape scales in Korea* Coworkers: **Bumsuk Seo**, **John Tenhunen**, **Thomas Koellner**
TERRECO-29	*Floristic Composition of Bibosoops as Mediated by Seed Dispersal* Coworkers: **Insu Koh**, **Chan Ryul Park**, **Dowon Lee**
TERRECO-30	*Effect of polymers on plant residuals decomposition in agroecosystems* Coworkers: **Yasser Mahmoud Awad**, **Yong Sik Ok**, **Yakov Kuzyakov**

Mulitdisciplinary projects

Figure 2: Project management "synthesis-then"



Mieg et al. Four types of knowledge integration management in interdisciplinary research on cities and the environment . Cities and the Environment (2008) vol. 1 (1) pp. Article 6, 1-11

INTEGRATION OF KNOWLEDGE IN TERRECO

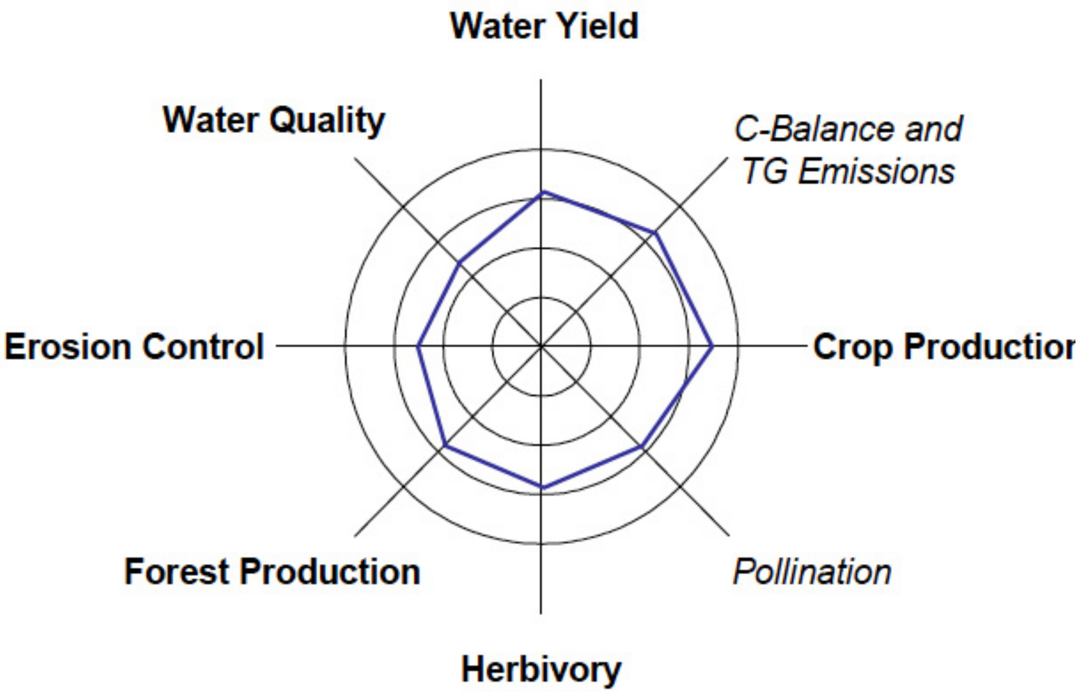
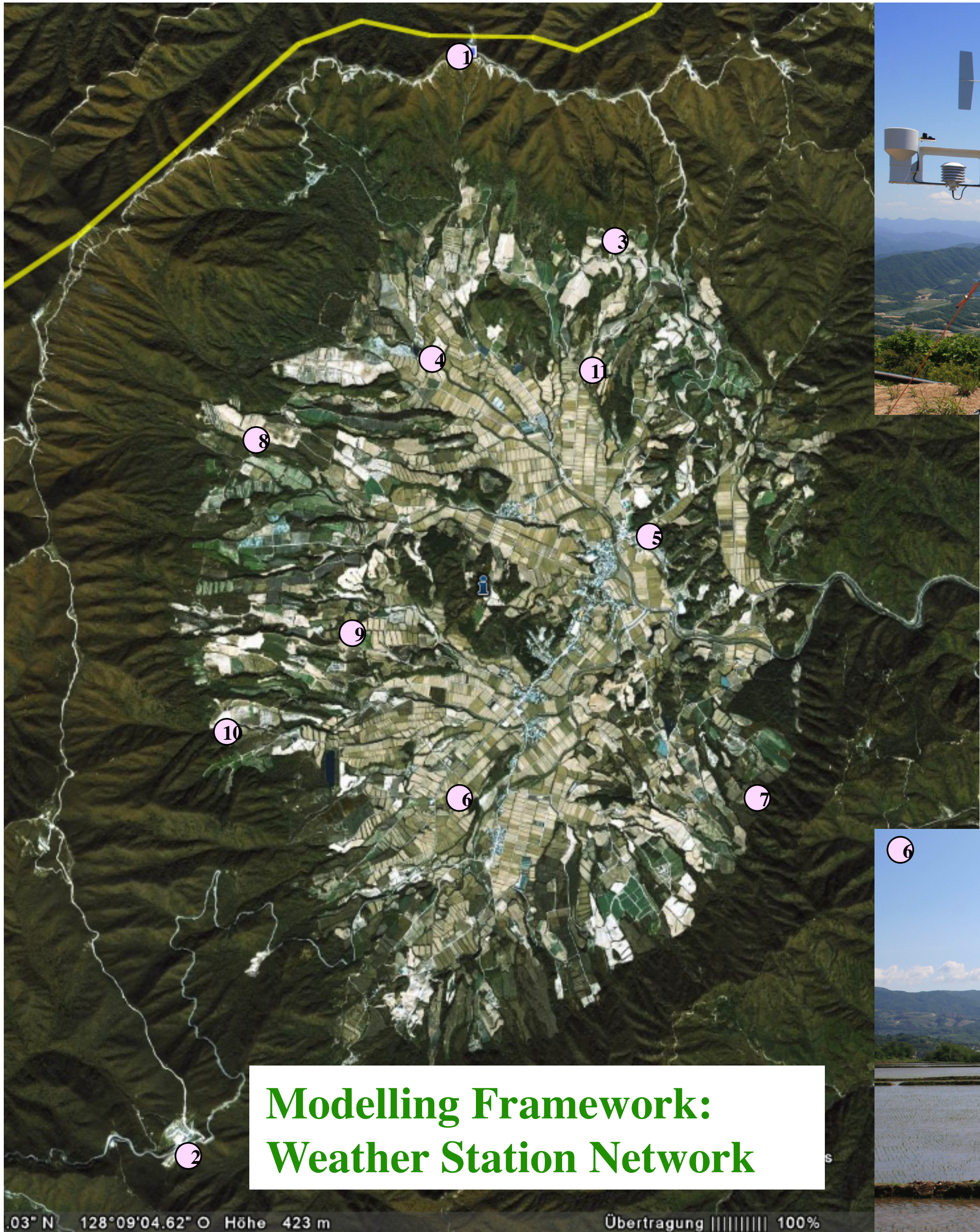


Figure 2. TERRECO ecosystem services (blue line) indicating a level obtained for each. Bold type = components of the trade-off between production and water quality interpretable in economic terms. Italics = services examined qualitatively.

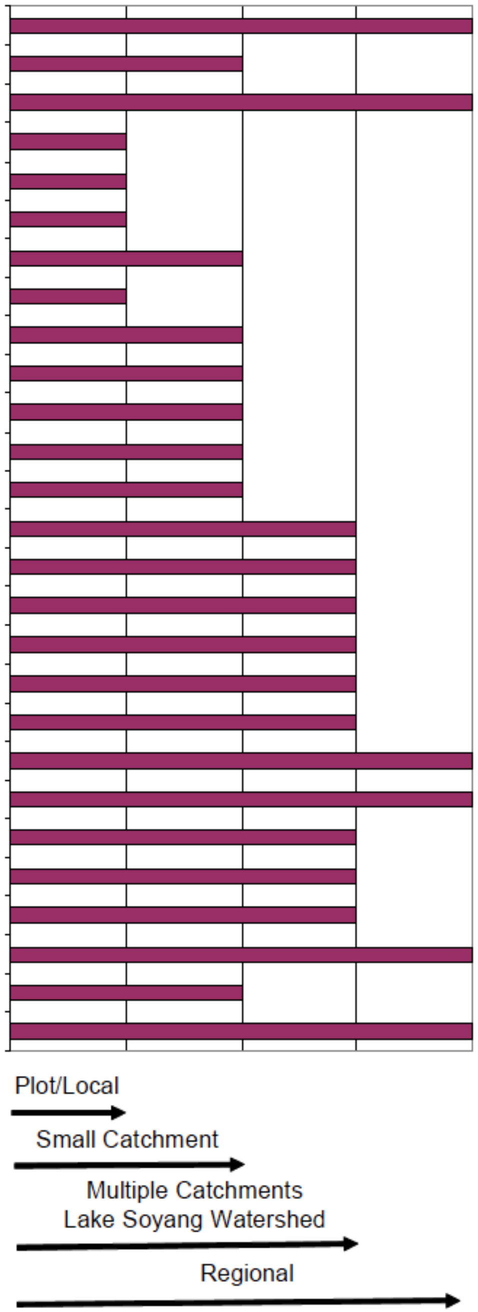
Modelling Framework: Weather Station Network



Spatial Scale of Individual TERRECO Projects

Investigator	Short Title	Proj. No.
Chong Bum Lee	Climate Model MM-5	1
Johannes Lüers	Atmos. Coupling / ACASA	2
Sinkyu Kang	MODIS Meteorology	3
Dennis Otieno	Forest Water Use	4
Egbert Matzner	Organic Matter Sources	5
Ji-Hyung Park	Hydrology / OM Coupling	6
Taesoek Ahn	Soil / Aquatic Enzymes	7
Yakov Kuzyakov	Element Cycles	8
Kyongha Kim	Hillslope Hydrology	9
Bruno Glaser	Soil Management / Erosion	10
Jae E. Yang	Agric. Soil Organic Carbon	11
Bernd Huwe	Pedon Water Flows	12
Jan Fleckenstein	Hyporheic Exchange	13
Bomchul Kim	Reservoir Organic Carbon	14
John Tenhunen	Agricultural Production	15
Gerhard Gebauer	Trace Gas Emissions	16
Gian-Reto Walther	Ecology of Weed Invaders	17
Ingolf Steffan	Insect Ecosystem Services	18
Chan-Ryul Park	Insect and Bird Populations	19
Jong-Hwan Lim	Dynamic Vegetation Model	20
Sinkyu Kang	Ecohydrological Simulation	21
John Tenhunen	Spatial Production Model	22a
John Tenhunen	Economics and Scenarios	22b
Stefan Peiffer	HydroGeosphere Model	23
Joon-Soon Kim	Forest Economics	24
Detlef Müller-Mahn	Rural Decision Making	25
Detlef Müller-Mahn	Society and Global Change	26

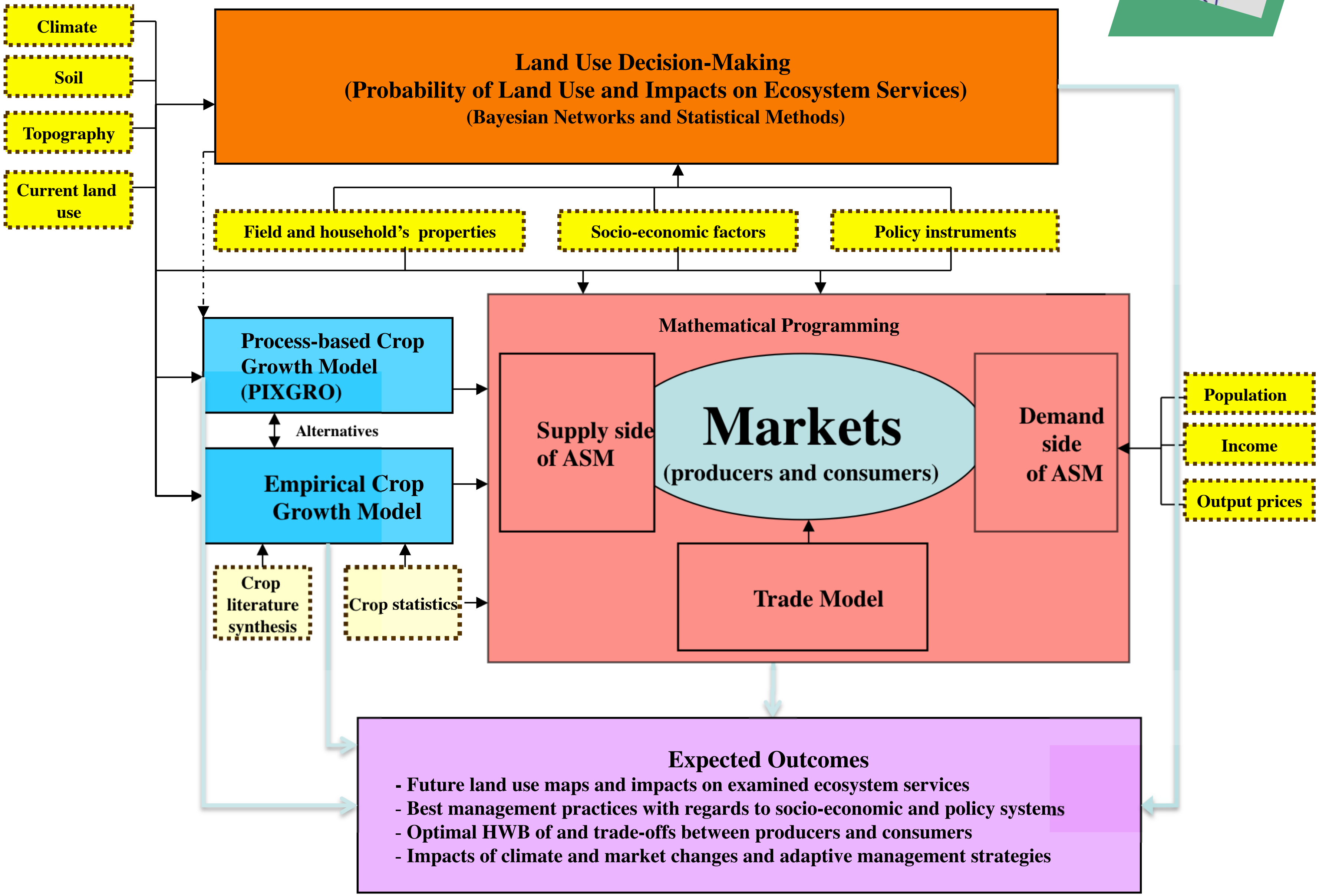
Scale of Information



In parallel to the natural science simulations, understanding of the decision making processes that determine landscape level ecosystem services must be achieved via analysis of existing social-ecological systems in the Haean Catchment (P25), within the Soyang Lake Watershed (P26), and regionally across Central Korea (right panels in Fig. 11). Thus, the approach of WP IV is transdisciplinary (Rapport et al. 1998), following the framework of coupled social-ecological systems described by Berkes et al. (2003). Mountain areas are well

suited for the approach because the consequences of man/environment linkages can be quite obvious, and unsustainable interactions may be more catastrophic than in other types of landscapes. Furthermore, the relationship between mountain areas and their surrounding landscapes are important in the development of scenarios, for example with respect to ecological buffer effects or to socio-economic relations. The response in land use within mountainous terrain may depend on policies intended for the benefit of populations outside of these regions (Fig. 11).

Global Change Framework:



PLANNING TOOLS FOR INTERDISCIPLINARY RESEARCH

Input-output tables verbal

Task 2 Socio-economic response to ecosystem change				
FROM	**Inputs**	**Activities**	**Outputs**	**TO**
A 1.1.1, A 1.2.1, A 1.3.1 A 1.1.4, A 1.2.3, A 1.3.3 A 2.3 a A 3.1, A 3.3	(a) Land cover maps for study regions (b) Scenarios of climate change and landscape change **Comment**: Land cover change (Rasterbasis, Pixel) over time, boundaries of land-cover development considering climate (c) Good and service provision (d) Current sectoral land-use policies and trends	**2.1 Status quo Analysis and Construction of Socio-Economic Scenarios of Land Use/Cover** (Land use/cover scenarios on the regional level as result of natural factors as well as private and social level decision-making, stakeholder workshops: collaboration with Task 1)	(a) Status quo analysis of land use decision–making of relevant regional actors (Attitudes, belief systems, perceived opportunity costs and land use intentions as well as planned adoption of policy interventions, e.g. PES or zoning) (b) Status quo analysis of land cover of study regions (land cover type, topography, governance and likelihood/risk of transformation for each pixel) (c) Development of socio-economic land use and land cover scenarios in case study regions (incl. land cover transformation matrix based on likelihood/risk of land use change), embedded in context scenarios of landscape and climate change of the study regions (Task 1), in scenarios of policy intervention in the regions (Task 3), and macro-economic scenarios.	A 3.1 A 2.3 A 3.1 A 1.1.4, A 1.2.3, A 1.3.3 A 2.4, A 3.3
A 1.1.4, A 1.2.3	(a) Selected ES in defined spatial contexts	**2.2 Quantification and valuation of ES**	(a) Quantification and valuation of selected ES for the status quo and	A 2.3 A 2.4

Table X. Collaborations between SP's

		Provider									
		SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	SP10
Recipient	SP1		Model input data	Model input data	Model input data	Model input data	Model input data				Land Use and Land Cover Maps
	SP2			Ecotourism based on NTFP; Cooperation resilience				Ecotourism		Ecotourism	
	SP3		Ecotourism based on NTFP; Cooperation resilience					Use of NTFP		Carbon trade	
	SP4		Vegetation parameters			Soil parameter Cooperation erosion		Land use prediction			
	SP5				Cooperation erosion						
	SP6		Vegetation parameters		Mosquito breeding habitat						
	SP7		Ecotourism	Use of NTFP		?				Workshops and data exchange	
	SP8		Data for Evaluation of ESS	Data for Evaluation of ESS	Data for Evaluation of ESS	Data for Evaluation of ESS	Data for Evaluation of ESS	Data for Evaluation of ESS		Data for Evaluation of ESS	Valuation of ESF/ESS
	SP9		Ecotourism	Carbon trade		Information sustainable use of soil		Workshops and data exchange			Payments for ecosystem services e.g. carbon sequestration
	SP10		Information on NTFP		Information on water availability	Information sustainable use of soil	Information on productivity			Information on policies and institutional framework	

Red: cooperation

	A	B	C	D	E	F	G	H	I	J	K
1	**MEASURED DATA AND PARAMETERS and Output**	**SP1**	**SP2**	**SP3**	**SP4**	**SP5**	**SP6**	**SP7**	**SP8**	**SP9**	**SP10**
2		**Integrated Model**	**Wald1**	**Wald2**	**Hydrology**	**Soil Quality**	**griculture/Pests**				**Poilicy and land u**
3	**x = Data which are going to be measured**	Schaab	3öhning-Gaese	Worbes		Scheu	Peters				Koellner
4	**(x) = Data that will/could be measured if no one else is sampling**	3öhning-Gaes	teffan-Dewent	Schmitt	Breuer	Brandl	Kalko				Wünscher
74											
75											
76	**regeneration**										
77	pollinator diversity		x								
78	pollinator visitation		x								
79	seed set		x								
80	disperser diversity (birds, bats)		x								
81	seed dispersal (birds, bats)		x								
82	predator diversity		x								
83	predation rates		x								
84	seedling regeneration		x								
85	cattle herbivory (exclosures)		x								
86											
87	**cattle**										
88	cattle density		x								
89	grazing schemes		x								
90											
91	**NTFP**										
92	growth rates		x								
93	abundance		x								
94	harvesting rates		x								
95											
96	regeneration potential of different regimes		x								
97	utilisation of NTFP		x								
98	alternative utilisation of NTFP		x								
99	impact of cattle on regeneration		x								
00	alternative feeding options		x								
01											
02											
03	**ecosystem services**										
04	pollination rates						x				
05	seed set						x				
06	predation rates						x				
07	plant damage						x				
08	crop yields						x				
09	cropy quality						x				
10	Malaria infection						x				
11	Health costs						x				
12											
13											
14	**ESS/ESF**										
15	Biodiversity value of farms						x				
16	ecosystem functionality on farms						x				
17	monetary value of pollination						x				
18	monetary value of predation						x				
19	monetary value of malaria prevention						x				
20											
21											
22	**Land use decision making**										
23	Financial benefits: Revenue from market per land use types										x
24	Physical benefits: Amount of food, fibers, timber and ecosystem services per land use type										x
25	Financial costs: Machinery, fertilizer input per land use type										x
26	Physical costs: Labor input in hours per land use type										x
27	Expectations of costs and benefitsfor next time step of land use types m.										x
28	Subjective norms for land use types m										x
29	Perceived behavioral constraints for land use type m										x
30	Land use behavior										x
31	Land cover										x
32	PES adoption										x
33											

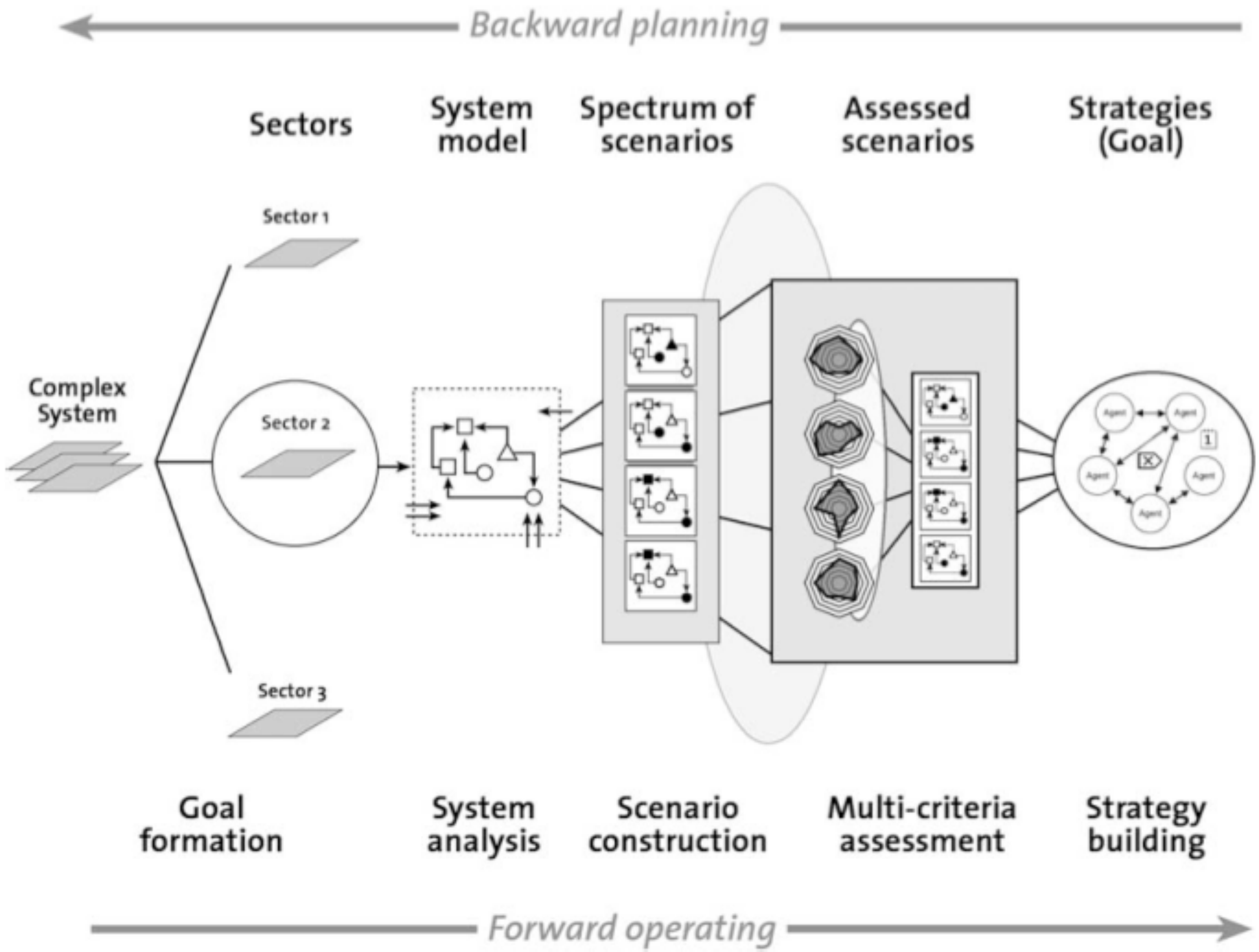
MODEL INPUT PARAMETERS	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	SP10	
	Integrated Model	Wald1	Wald2	Hydrology	Soil Quality	griculture/Pests				Poilicy and land use	
Model	Schaab	3öhning-Gaese	Worbes		Scheu	Peters				Koellner	
x denote necessary data, (x) optional data	3öhning-Gaes	teffan-Dewent	Schmitt	Breuer	Brandl	Kalko				Wünscher	
atmosphere											
vegetation											
LAI (if available, seasonal development of LAI)				x							
canopy height (seasonal development)			x	x							
maximum root depth				x							
albedo				x							
roughness length (z_0)				(x)							
stomatal resistance (r_c)				(x)							
soil											
bulk density (profile)					x						
soil depth (profile)				x						x	
texture (profile)											
Ksat (profile)				x							
pF curve (profile)				x							
infiltration rates (profile)											
rock fragments (profile)				(x)							
pH (profile)					(x)						
Corg					x					x	
soil albedo				x							
inorganic N concentrations (range, seasonality)											
hydrology											
interception capacity [%]				(x)							
farm management											
applied irrigation volume				x						x	
date of irrigation application				x						x	

PLANNING TOOLS FOR TRANS-DISCIPLINARY RESEARCH

Transdisciplinary Integrated Planning

- Step 1. Goal formation
  - Start with a normative guiding question concerning the development of the system under consideration. The guiding question defines the specific problem constellation (competed resources, indication of over-use, etc.), the purpose of the planning and decision-making process, the system boundaries, the time restrictions, the contextual information required, etc.
- Step 2. System analysis
- Step 3. Scenario construction
- Step 4. Multi-criteria assessment
- Step 5. Strategy building

A. Wiek, A.I. Walter / European Journal of Operational Research 197 (2009) 360–370



Backward planning
Sectors
System model
Spectrum of scenarios
Assessed scenarios
Strategies (Goal)
Sector 1
Complex System
Sector 2
Sector 3
Goal formation
System analysis
Scenario construction
Multi-criteria assessment
Strategy building
Forward operating

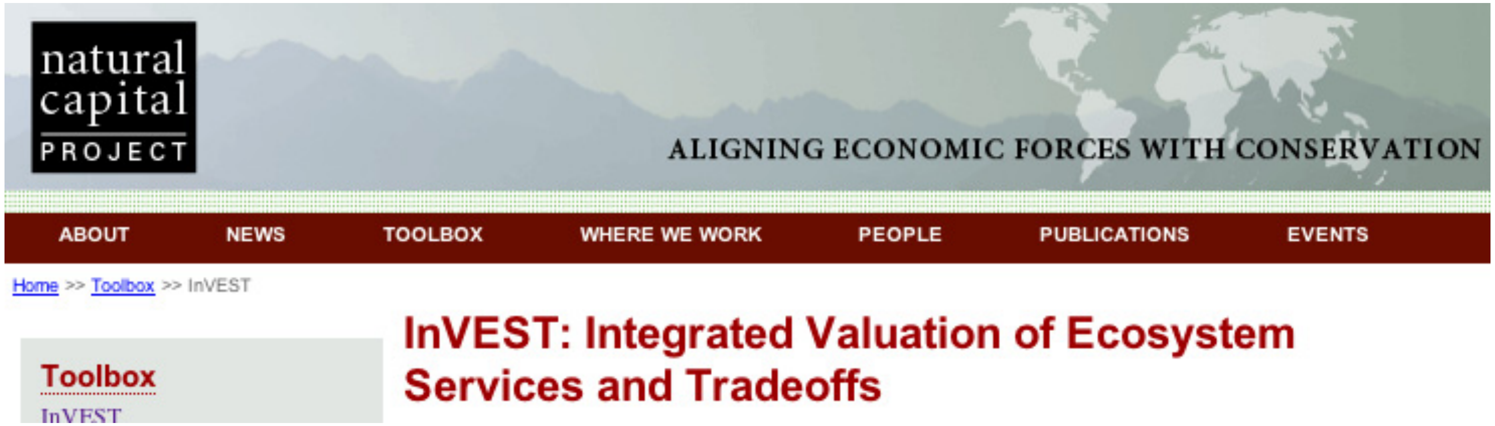
Logical Framework (LogFRAME) Methodology

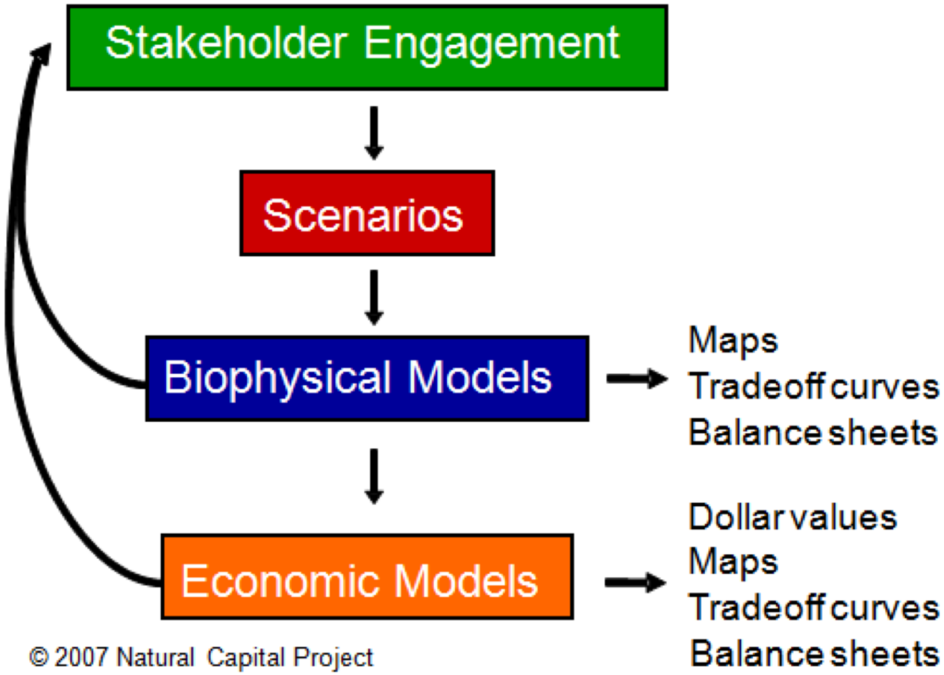
- The logical framework or *logframe is an analytical tool used to plan, monitor, and evaluate* projects.
  - It derives its name from the logical linkages set out by the planner(s) to connect a project's means with its ends.
  - Developed by US Department of Defense, and adopted by the US Agency for International Development in the 1960s.
  - Applied and modified by many bilateral donors, including Germany, the United Kingdom, the European Union, Canada, and Australia.

- Source: http://www.isnar.cgiar.org/gender/hambly.htm - International Service for Agricultural Research – "Engendering the Logical Framework – Helen Hambly Odame, Research Officer, ISNAR, August 2001

TRANSDISCIPLINARY RESEARCH ON ECOSYSTEM SERVICES IN TERRECO

Apply the InVEST tool by the TERRECO team





© 2007 Natural Capital Project

http://www.naturalcapitalproject.org

The output

- InVEST tool parameterized for Haean catchment
- Scenarios for ES calculated and mapped
- Proposals for potential improvement of InVEST tool elaborated

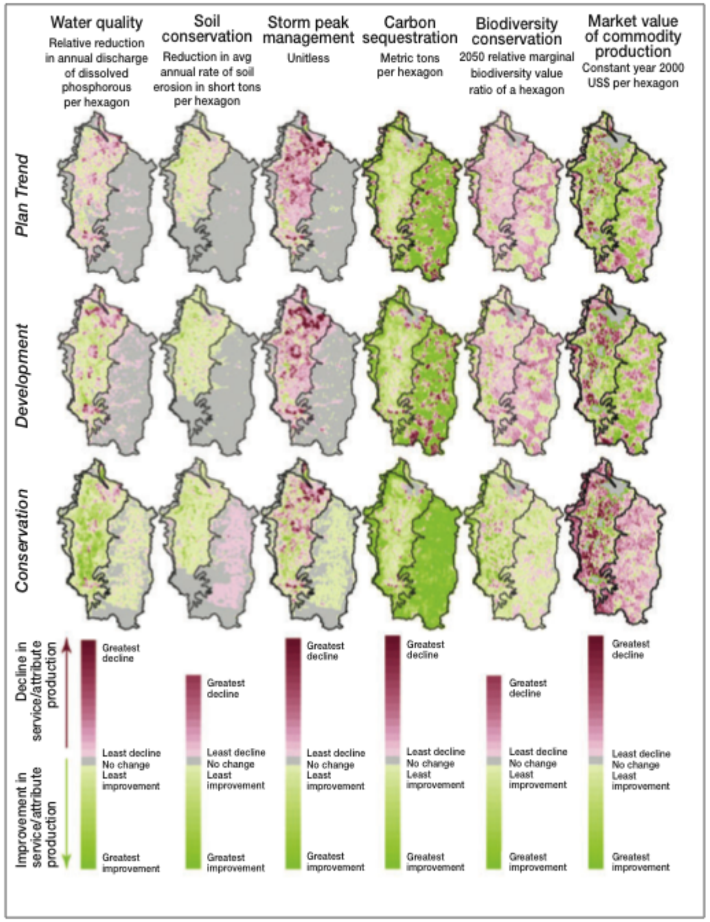
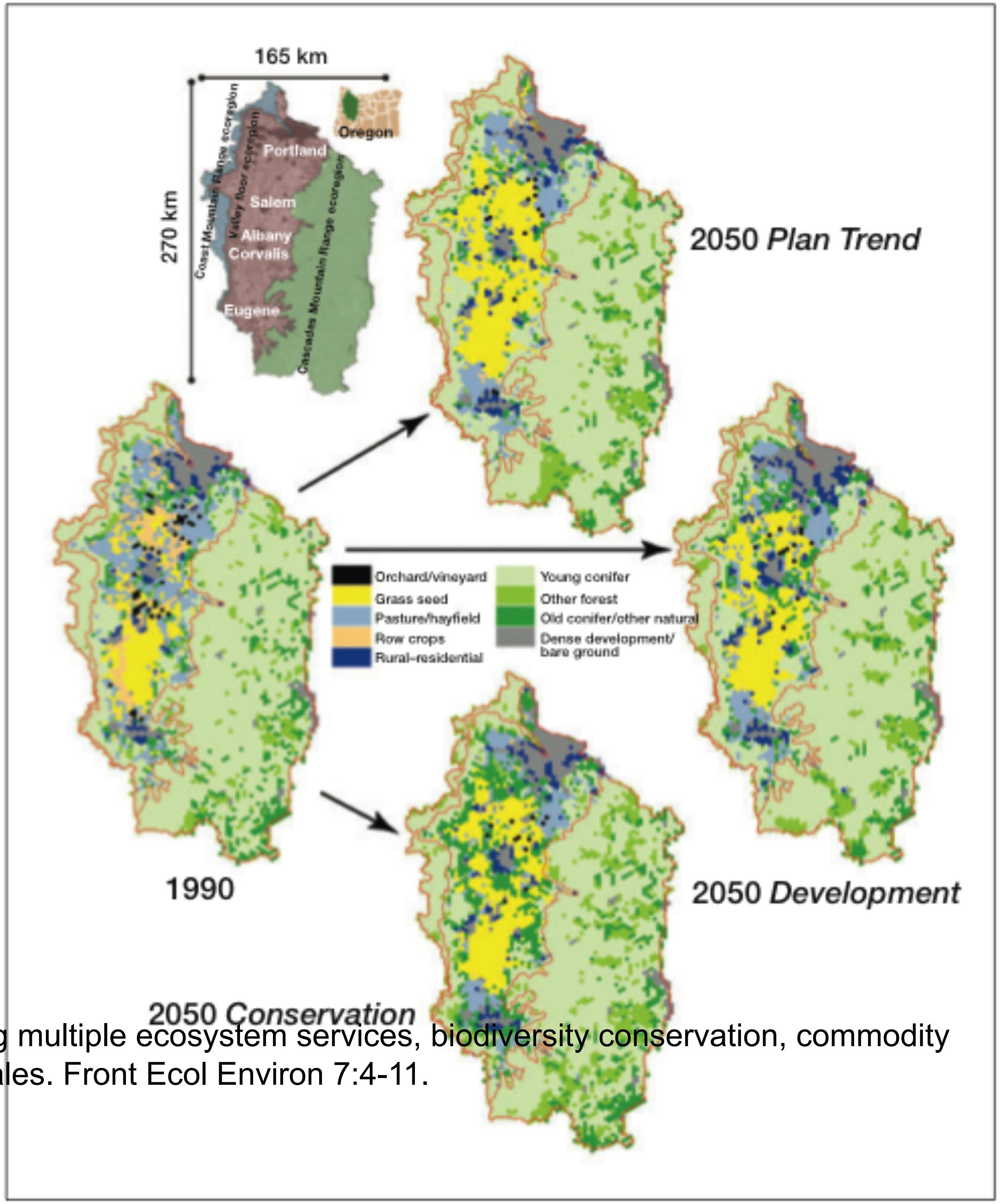


Figure 4. *Maps of change in ecosystem services, biodiversity conservation, and market value of commodity production from 1990 to 2050 for the three LU/LC change scenarios. Carbon sequestration and commodity production values are not discounted.*

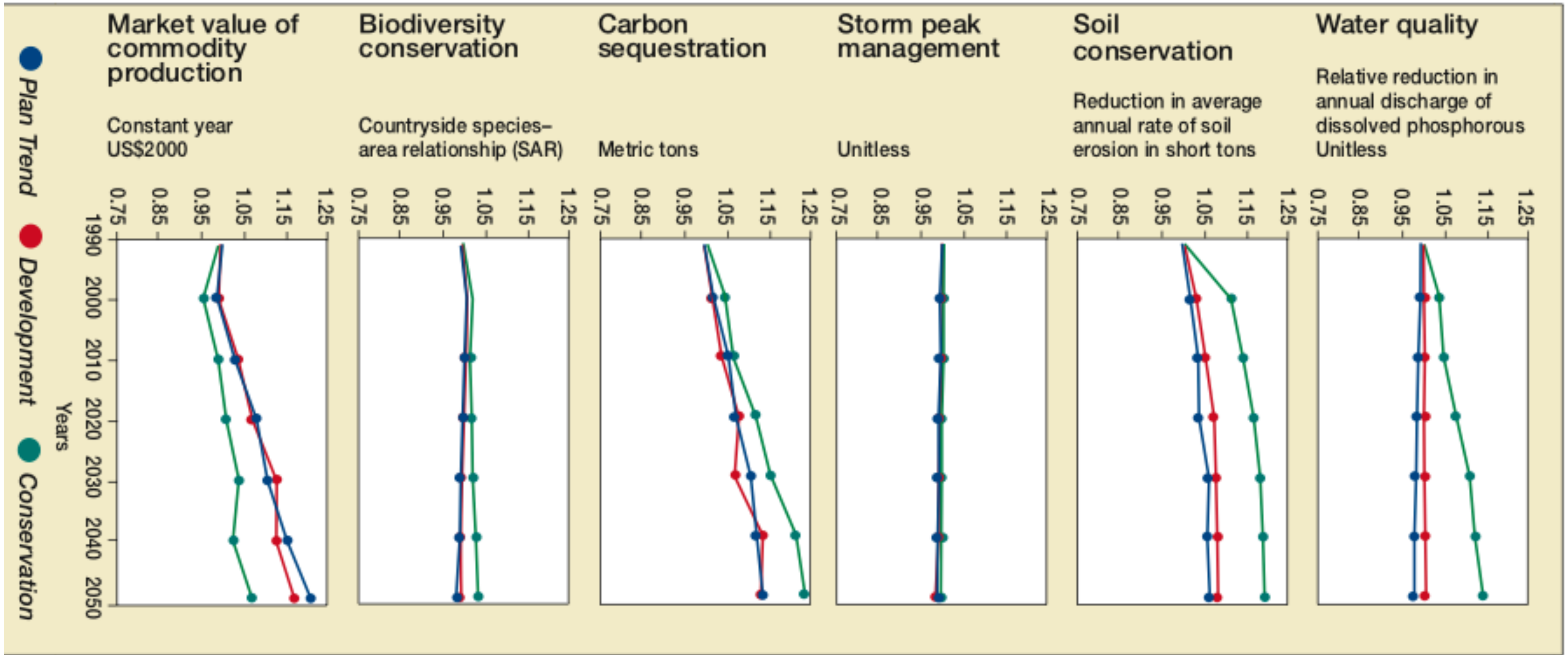
Literature: Nelson, E., G. Mendoza, J. Regetz, S. Polasky, H. Tallis, D. R. Cameron, K. M. A. Chan, G. C. Daily, J. Goldstein, P. M. Kareiva, E. Lonsdorf, R. Naidoo, T. H. Ricketts, and M. R. Shaw. 2009. Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. Front Ecol Environ 7:4-11.

Mapping of ES



Literature: Nelson, E. et al. 2009. Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. Front Ecol Environ 7:4-11.

Scenarios of ES development



Literature: Nelson, E. et al. 2009. Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. Front Ecol Environ 7:4-11.

Further reading on inter and transdisciplinary research

- Wiek und Walter. A transdisciplinary approach for formalized integrated planning and decision-making in complex systems. European Journal of Operational Research (2009) vol. 197 (1) pp. 360-370
- Stauffacher et al. Analytic and Dynamic Approach to Collaboration: A Transdisciplinary Case Study on Sustainable Landscape Development in a Swiss Prealpine Region. Syst Pract Action Res (2008) vol. 21 (6) pp. 409-422
- Stauffacher et al. Die Interaktion zwischen Wissenschaft und Gesellschaft in der transdisziplinären Umweltforschung . GAIA-Ecological Perspectives in Science (2008) vol. 17 (4) pp. 396-398
- Wiek. Challenges of Transdisciplinary Research as Interactive Knowledge Generation Experiences from …. GAIA-Ecological Perspectives in Science (2007) vol. 16 (1) pp. 52-57
- Hirschhadorn et al. Implications of transdisciplinarity for sustainability research. Ecological Economics (2006) vol. 60 (1) pp. 119-128
- Hinkel. Transdisciplinary Knowledge Integration. Cases from Integrated Assessment and Vulnerability Assessment . (2008) pp. 1-198

GROUP WORK: INTERDISCIPLINARY RESEARCH ON ECOSYSTEM SERVICES

Typology of ecosystem services

MEA Classification	Ecosystem Services ES
A) Provisioning Services	***A1) Biotic Production of Commodities** Capacity of ecosystems to produce consumable biomass (food, fiber, timber, oil/fat)
	A2) Biotic Production of Specialties Capacity of ecosystems to produce biochemicals and pharmaceuticals
B) Regulating Services	**B1) Climate Regulation** *a) Capacity of ecosystems to influence global climate through carbon sequestration and retention of other greenhouse gases b) Capacity of ecosystems to influence regional/local scale climate
	B2) Fresh Water Regulation *a) Capacity of ecosystems to regulate peak flow and b) base flow of surface water c) Capacity of ecosystems to recharge ground water
	B3) Erosion/ Sedimentation Regulation Capacity of ecosystems to stabilize soil and a) to prevent water erosion b) to prevent wind erosion
	***B4) Water Purification** Chemical, physical and mechanical capacity of ecosystems to clean a polluted water suspension
	B5) Air quality regulation
	B6) Disease regulation
	?B7) Pest regulation
	?B8) Invasion control
	***B9) Pollination**
	B10) Natural hazard regulation
C) Cultural Services	**C)** Capacity of ecosystems to provide spiritual/religious values, aesthetic values, educational values, recreational values
D) Supporting Services	***D) Basic ecosystem processes** a) Nutrient cycling (N-fixation), b) Soil formation, c) Photosynthesis, d) Transpiration
E) Biodiversity	**E)** Biodiversity has an a) intrinsic value and an b) functional one [it influences directly and indirectly the capacity of ecosystems to provide A) to D)]

Task: Identify interfaces between TERRECO-projects for four major ecosystem services

- Gather in groups focusing on one specific ecosystem service
- Interdisciplinary Ecosystem Service Groups (IESGs)
  1. Biotic production of commodities
  2. Climate regulation (carbon sequestration and retention of other greenhouse gases)
  3. Erosion regulation
  4. Water purification
  5. other?

- State in each group your research interests (Short!!)
- Identify interfaces between TERRECO-projects for a specific ecosystem services

Collaboration of projects on the ecosystem service: ______________________________________

Terreco-Project	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1																														
2																														
3																														
4																														
5																														
6																														
7																														
8																														
9																														
10																														
11																														
12																														
13																														
14																														
15																														
16																														
17																														
18																														
19																														
20																														
21																														
22																														
23																														
24																														
25																														
26																														
27																														
28																														
29																														
30																														

In the yellow part: Identify a possibility for close collaboration between two projects with a cross x

In the white part: Indicate an potential information flow with an arrow e.g. 28 -> 2 28 <- 2 28 <-> 2