Science for a Sustainability Transition

Major Advances, Gaps and Barriers to Progress

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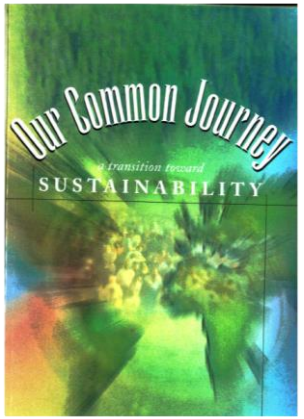
Goals for the Sustainability Transition

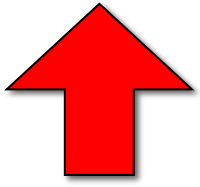
Meet the needs of a larger but stabilizing human population,

sustain the life support systems of the planet, and

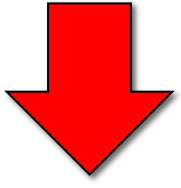
reduce hunger and poverty.



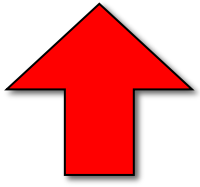
NRC. 1999. OUR COMMON JOURNEY



Meeting the needs of people



Sustaining life support systems



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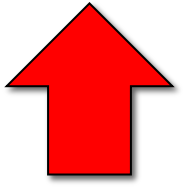


Sustaining life support systems

Priorities for Sustainability Science

- Create and use frameworks for integrative understanding of and problem solving in social-environmental systems.

- Create focused research programs on under-studied issues.

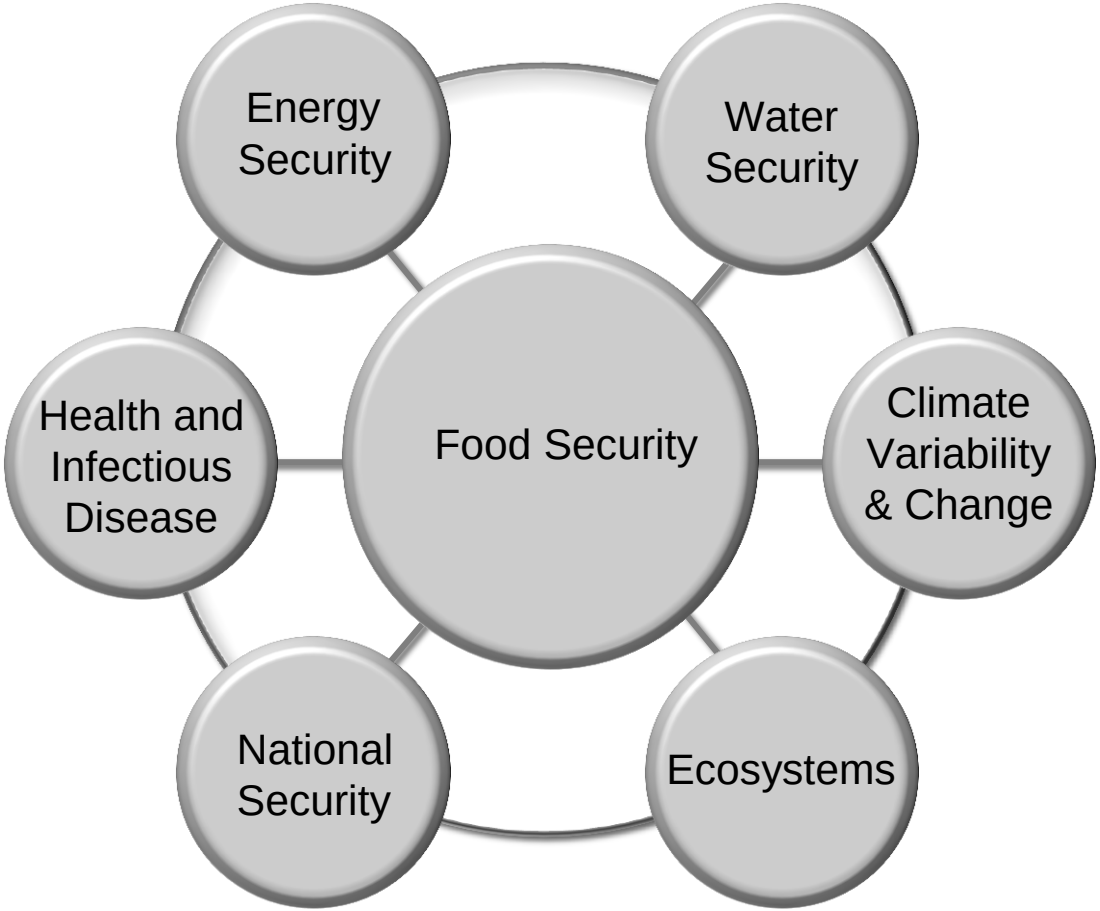
- Promote use of knowledge and tools for linking knowledge and action

NRC. 1999. OUR COMMON JOURNEY

Priorities for Action

WCED, 1987 Our Common Future	NAS-BSD, 1999 Our Common Journey	Kofi Annan, 2002 WSSD:An Achievable agenda
Population	Human Population	Health
Food Security	Agriculture	Agriculture
Species & Ecosystems	Living Resources	Biodiversity
Energy	Energy	Energy
Industry	Industry	-
Urban Challenge	Cities	-
-	-	Water

However, the important challenges are at the nexus



Slide from Roz Naylor

Proposed Research Programs in Sustainability Science (starting with our Common Journey and continuing)

Long term trends and transitions
Consumption patterns and drivers
Indicator systems and metrics
Models and assessment tools for complex SE systems
Monitoring systems
Vulnerability, resilience, adaptation analysis
Defining meaningful limits or boundaries
Trade-offs between well-being and environment
Effective guiding of a sustainability transition (behavior, incentives for change, monitoring and reporting, adaptive governance)
Evaluations of sustainability trajectories

Follow-on efforts to define science needs:

Kates, RW., W C. Clark, R. Corell, J. M. Hall, CC. Jaeger, I Lowe, JJ. McCarthy, H J Schellnhuber, B Bolin, N M. Dickson, S Faucheux, GC. Gallopín, A.Gruebler, B. Huntley, J.Jäger, N.S. Jodha, R. E. Kasperson, A. Mabogunje, PA Matson, H.Mooney, B. Moore III, T O'Riordan, and U Svedin. 2001. Sustainability science. *Science* 292: 641-2.

ICSU. 2002. Science and technology for sustainable development. 9. Paris

Clark, WC, Dickson, NM. 2003. Sustainability science: The emerging research program. PNAS 100: 8059-8061

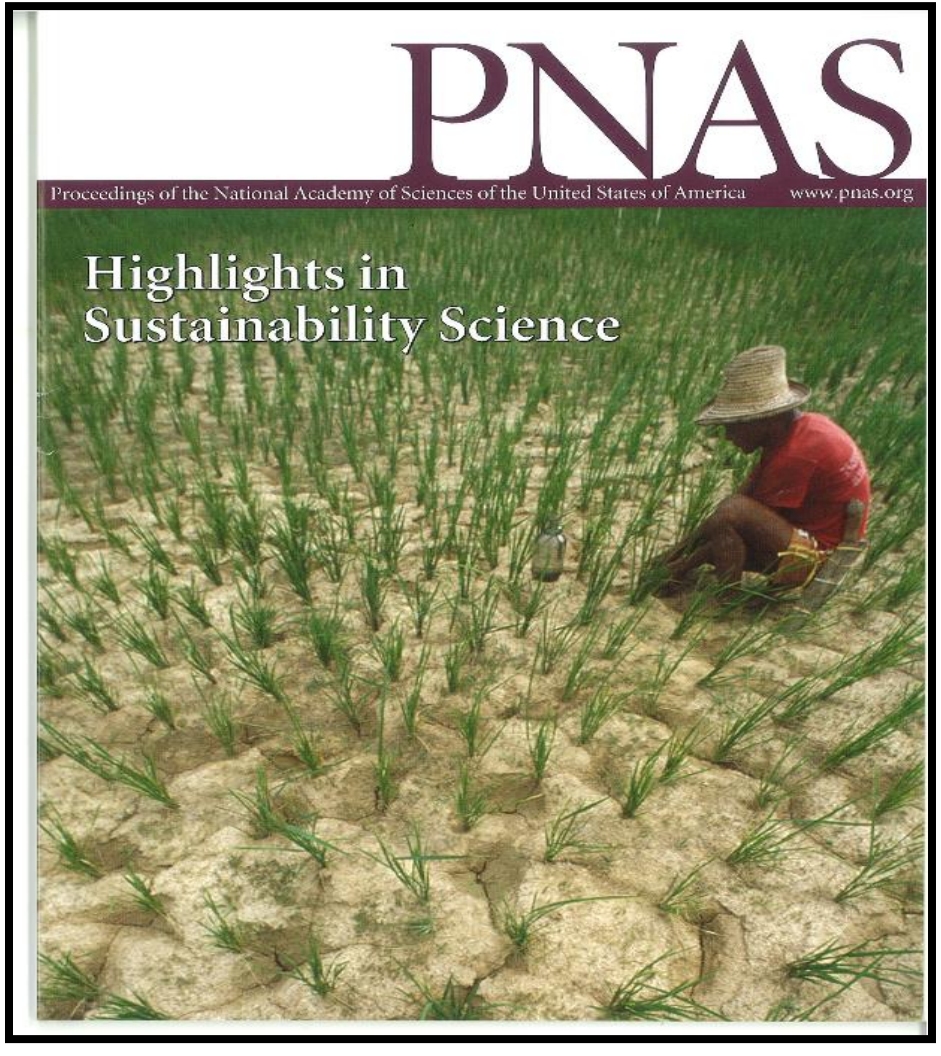
Clark, W.D. 2008. Sustainability Science: a room of its own. PNAS 104:1737

Matson, PA. 2009. The sustainability transition. Issues in Science and Technology

Clark, W.C. and S.A. Levin. 2010. Toward a Science of Sustainability. Report of the Airlie Center Workshop.

Kates, R.W. 2011. What kind of science is sustainability science?

A new scientific field: “Sustainability Science”



“Use-inspired fundamental research ”

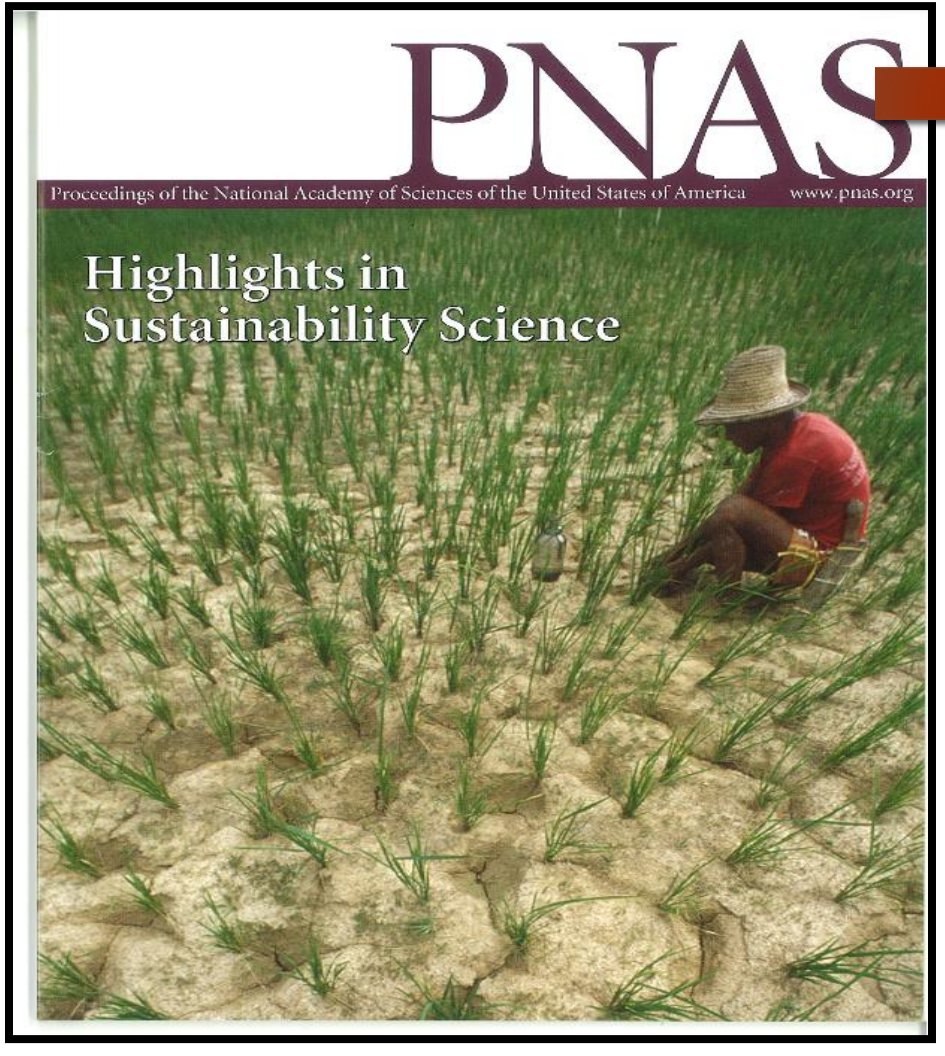
“Interdisciplinary”

“Focused on coupled social-environmental systems”

“Recognizes complexity of interactions, feedbacks, thresholds and potential for unintended consequences”

“Links Knowledge to Action”

A new scientific field: “Sustainability Science”



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‘Pasteur’s Quadrant’ Model of Scientific Research

Research inspired by...

Considerations of use?

Quest for fundamental understanding?	No	Yes
No		Pure applied research (Edison)
Yes	Pure basic research (Bohr)	*Use-inspired basic research (Pasteur)*

(redrawn from Stokes, 1997)

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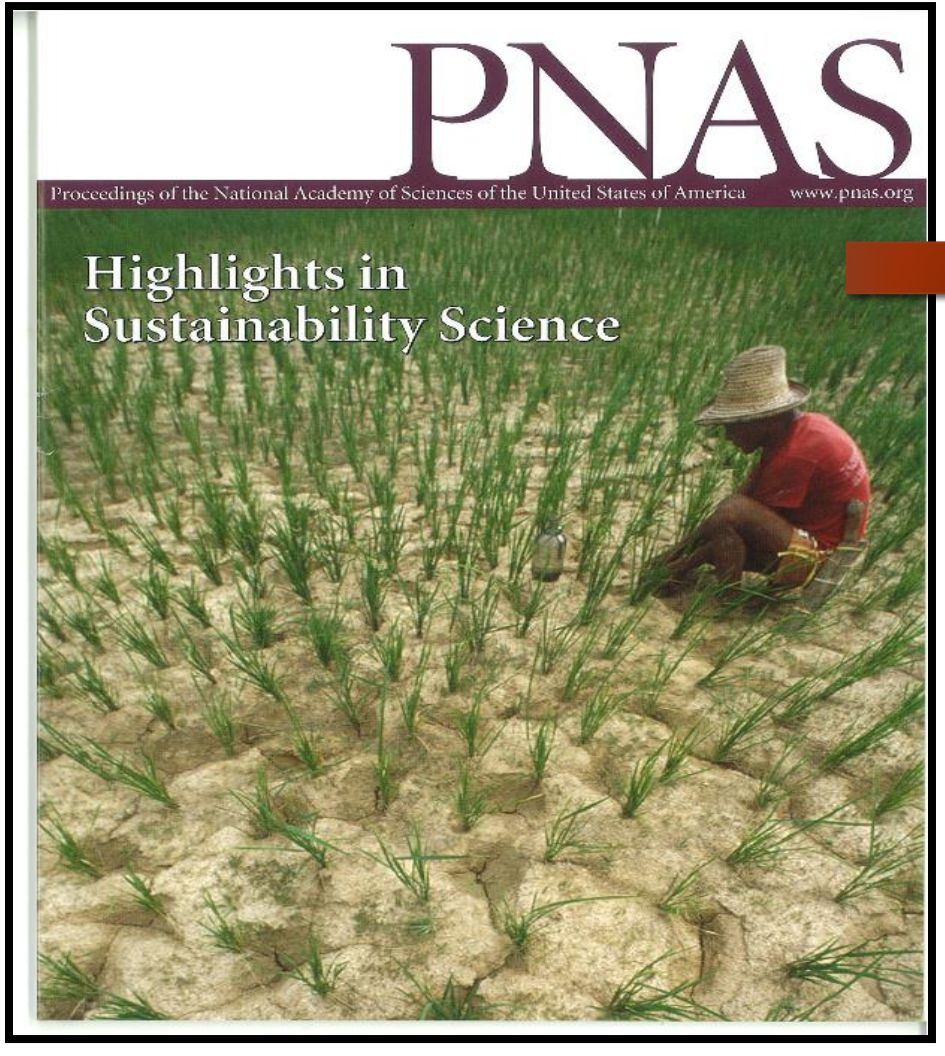

“Use-inspired fundamental research ”

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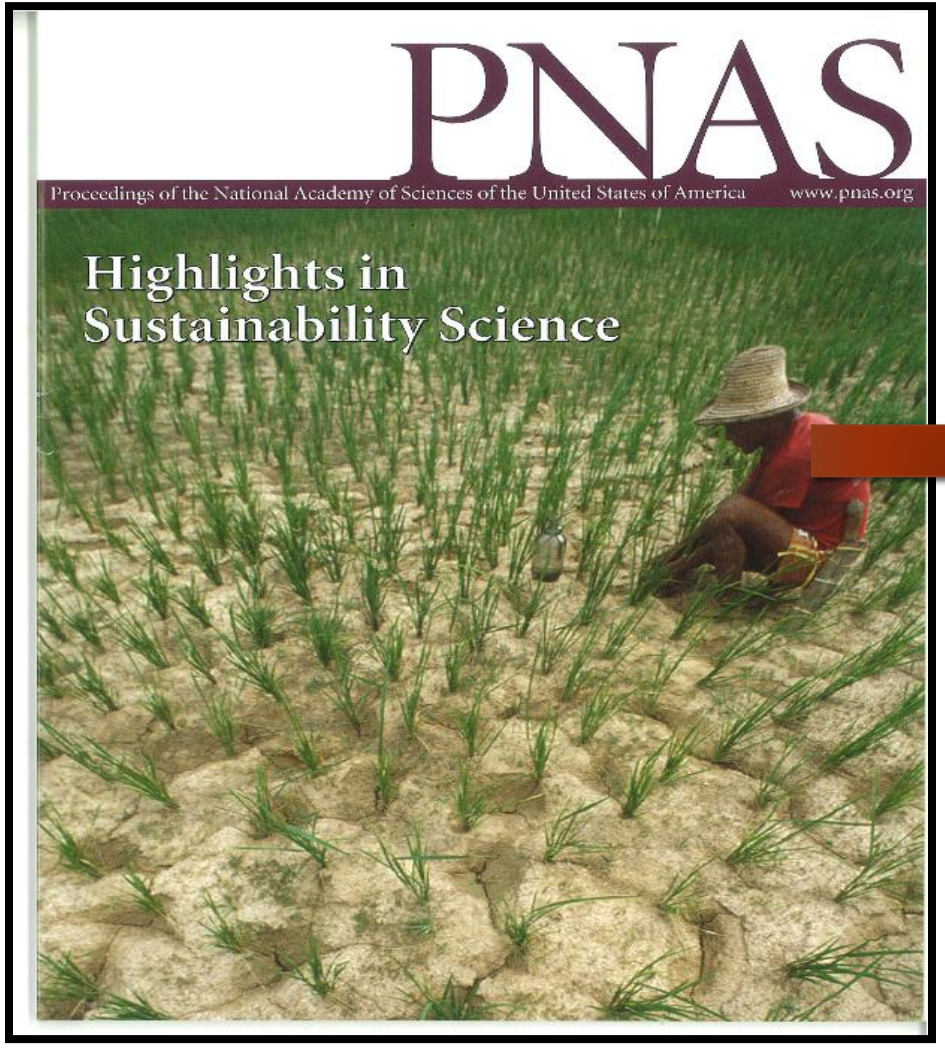
Interdisciplinary, integrative research

These challenges are too complex to be solved by any one discipline working alone…

A diversity of knowledge and perspectives is needed, from many different disciplines, cultures, perspectives.

A new scientific field: “Sustainability Science and Technology”



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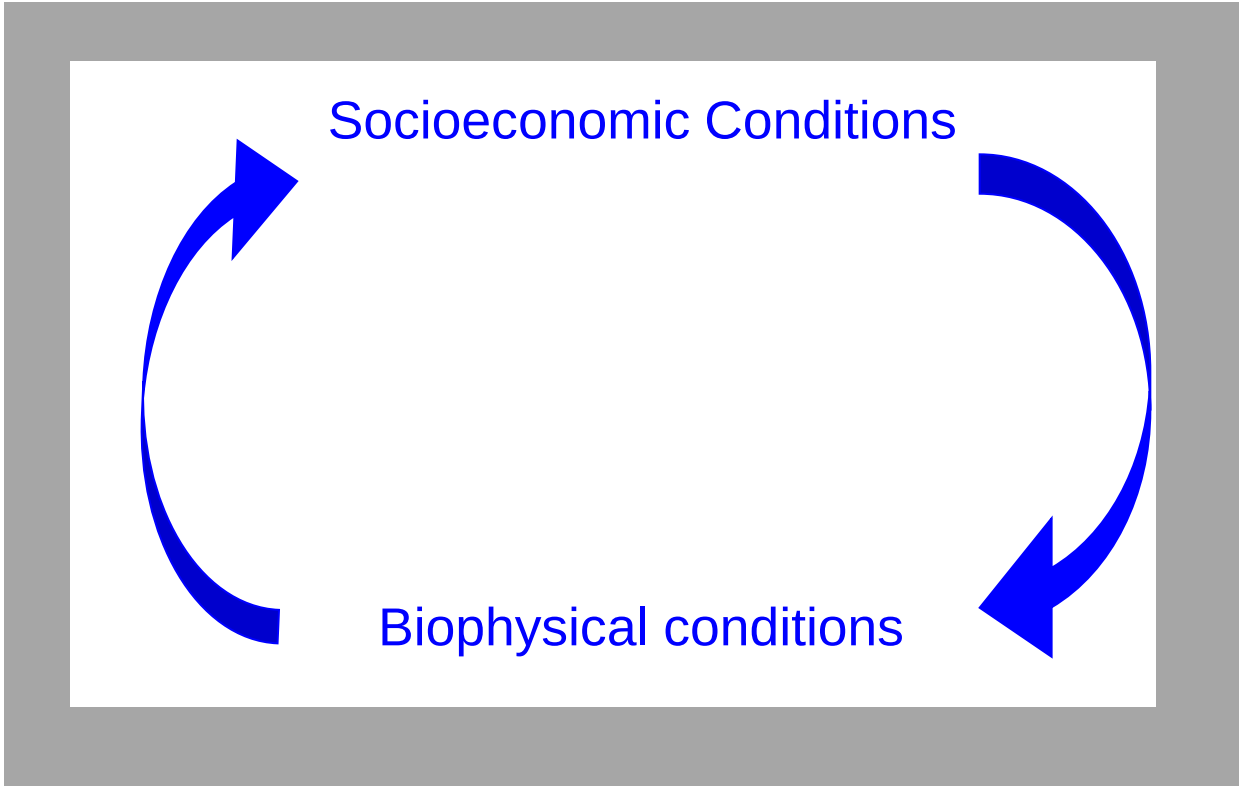
focus on **Coupled Social-Environment Systems**



With emphasis on place-based analysis

Place based perspectives, and attention to scale

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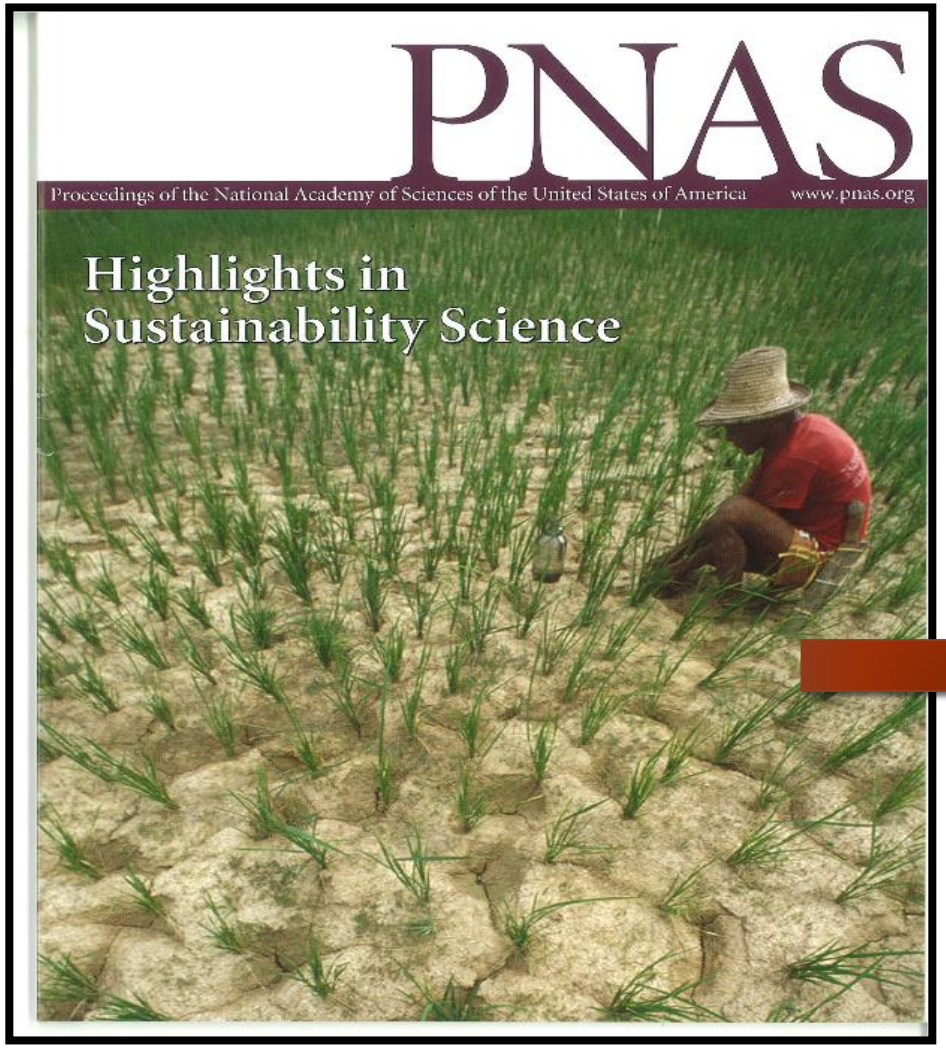

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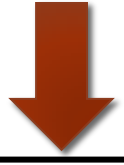
human needs

food					
energy 					
water					
health and safety					
	Air quality	Water systems	Climate 	Species, ecosystems	

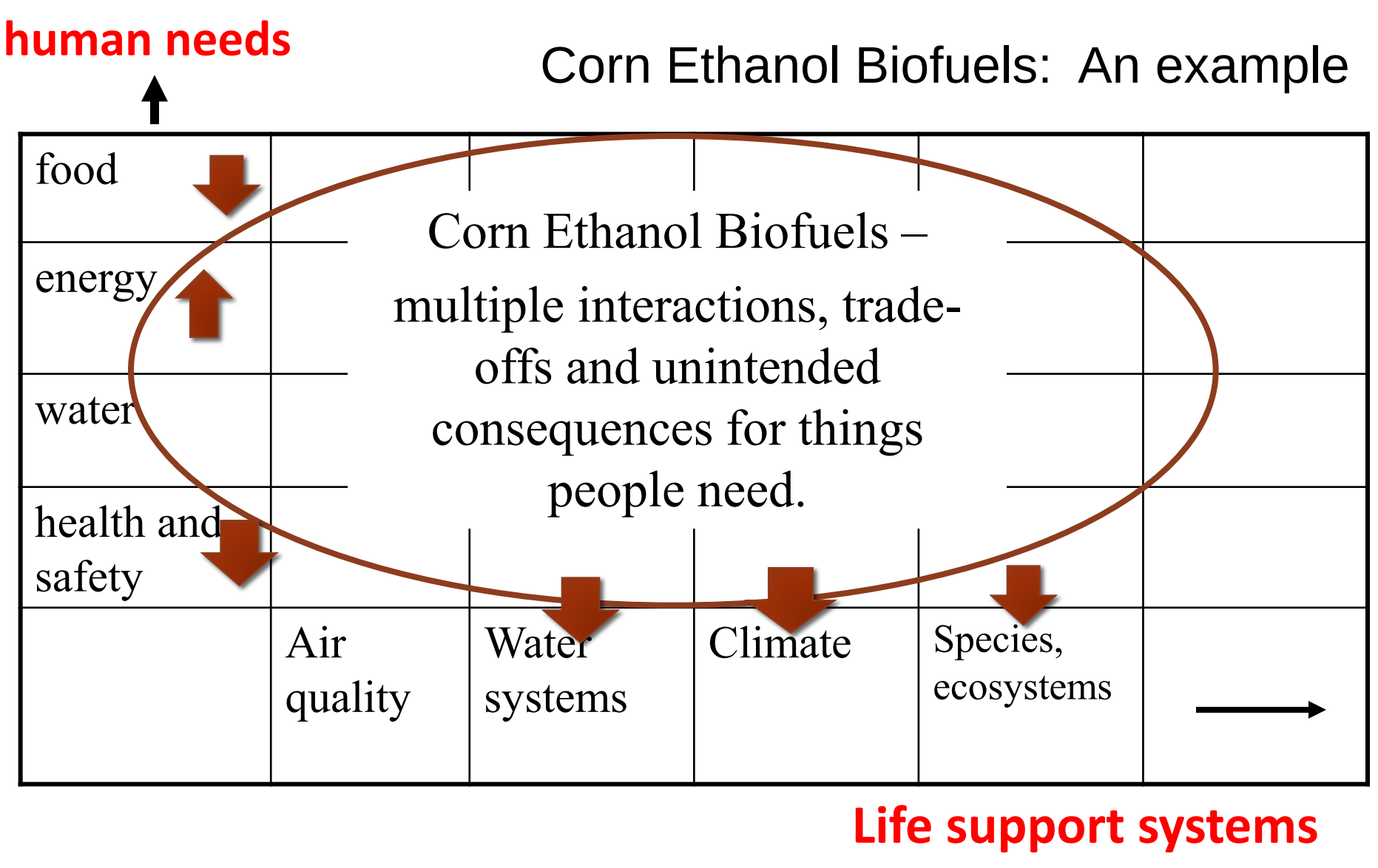
Life support systems

human needs

Corn Ethanol Biofuels: An example

food					
energy			biofuels		
water					
health and safety					
	Air quality	Water systems	Climate	Species, ecosystems	

Life support systems


human needs
Corn Ethanol Biofuels: An example
food
energy
water
health and safety
Corn Ethanol Biofuels – multiple interactions, trade-offs and unintended consequences for things people need.
Air quality
Water systems
Climate
Species, ecosystems
Life support systems

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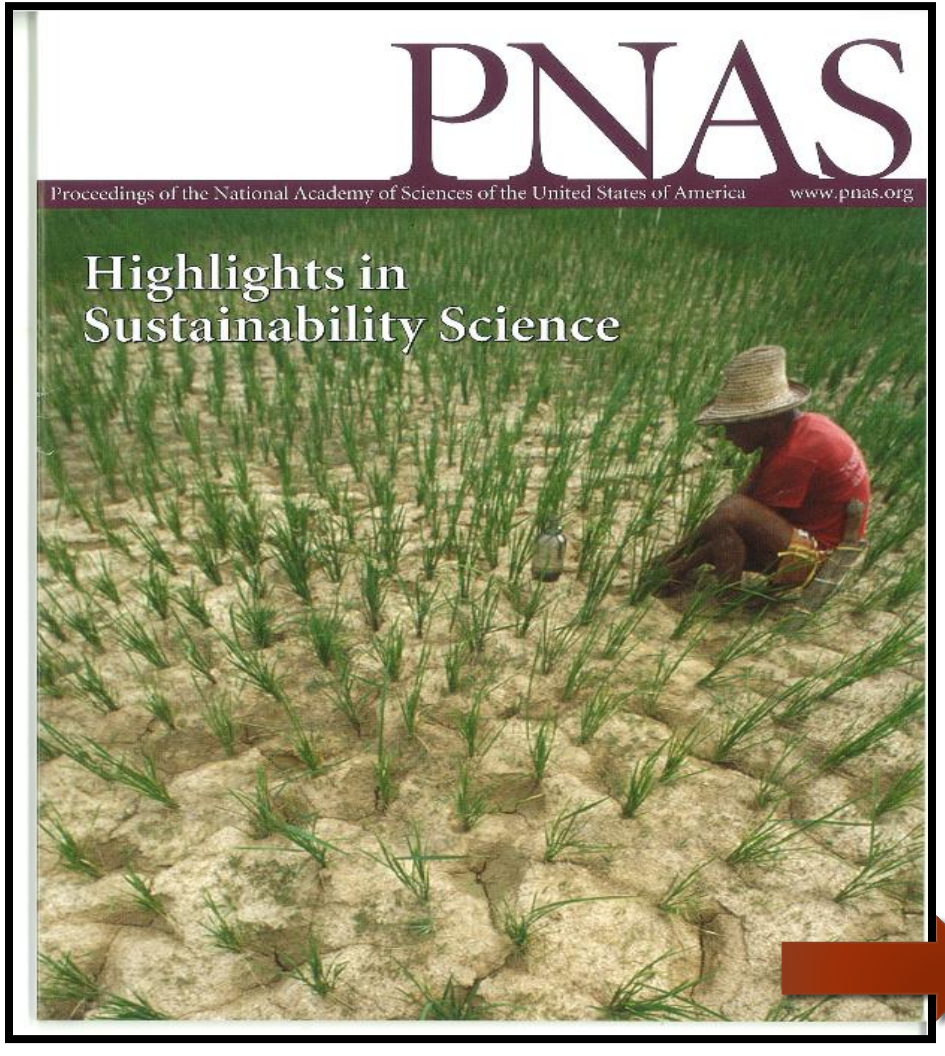

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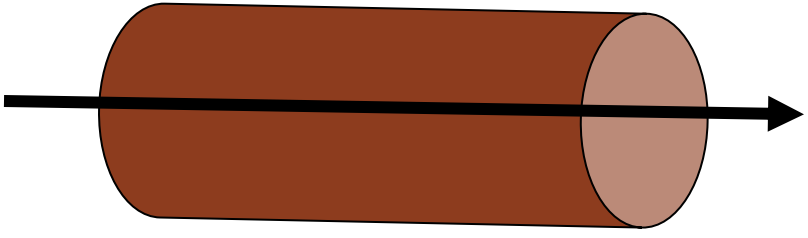
“Toward More Usable Knowledge”

The “pipeline” model of knowledge and technology transfer rarely works….

Knowledge producers

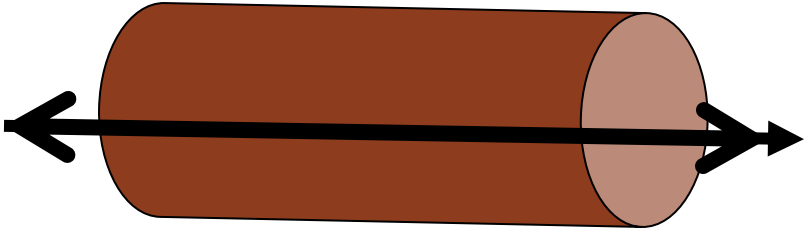


Knowledge users (decision makers)

NRC. 1999. OUR COMMON JOURNEY

Reject the "pipeline" model of knowledge and technology transfer

Knowledge producers



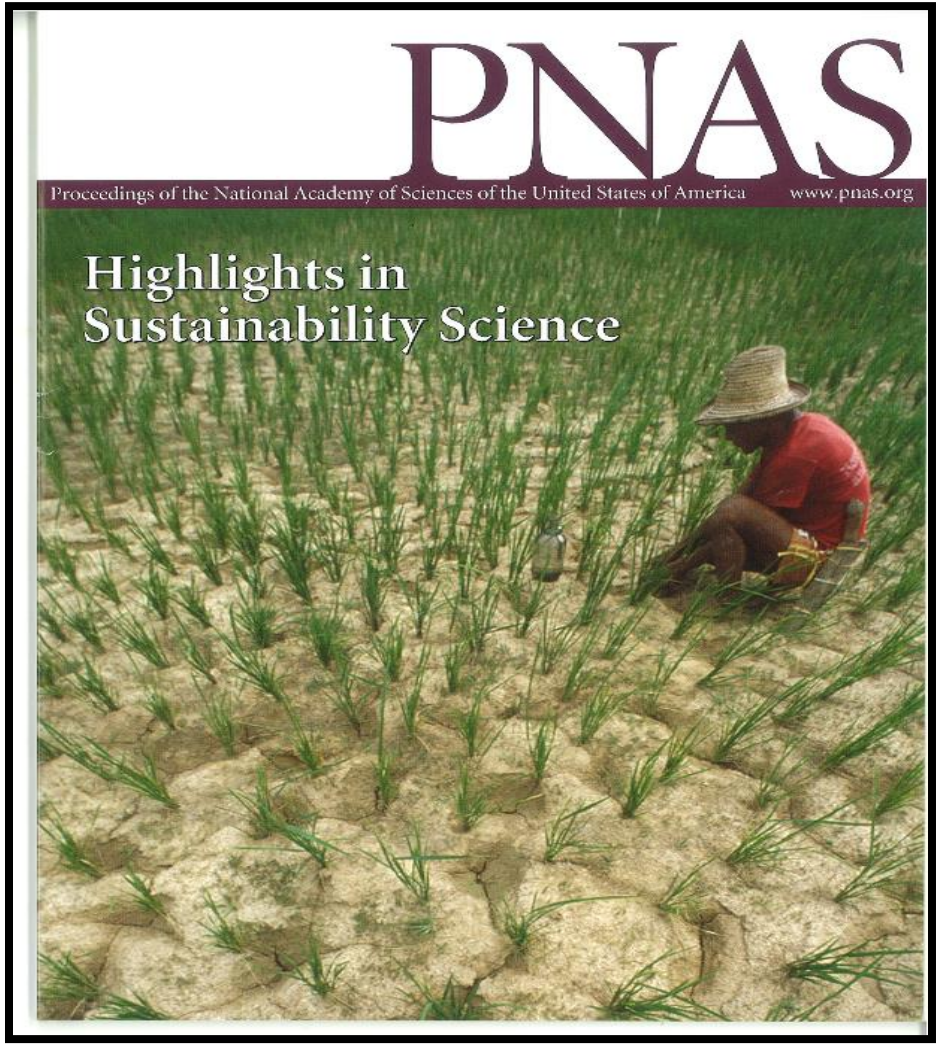
Knowledge Users

Design research programs and systems to:

- Promote *collaborative production* of trusted knowledge
- Engage stakeholders in its creation

And create S&T systems with funding to do this….

A new scientific field: “Sustainability Science”



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So, how are we doing?

Tremendous progress in many of the areas that were identified, but also much more to be done.

In Pam's opinion…and interviews with
Louis Lebel, Editor
Global Environmental Change
Arun Argrawal, Editor
Global Development
Billie Turner, Editor
PNAS Sustainability Science
William Clark, Editor
PNAS Sustainability Science
Nancy Dickson
Osvaldo Sala
And other friends

1) Tremendous progress in the reorientation of research so that science can better address the needs of decision makers.

‘Pasteur’s Quadrant’ Model of Scientific Research

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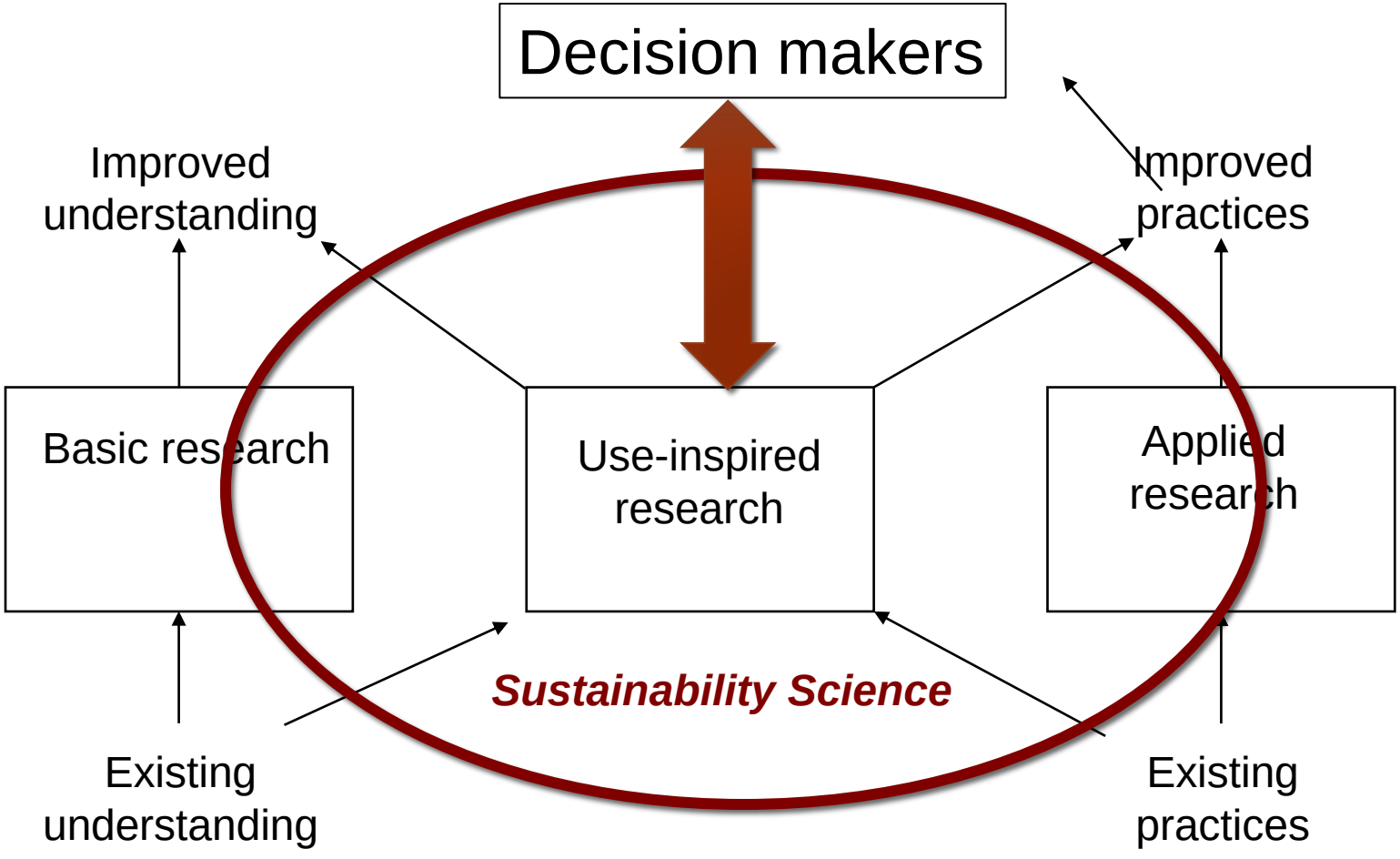


(redrawn from Stokes, 1997)

Lots of examples of
Use-Inspired, Solutions-Oriented Fundamental Research
for sustainability goals

Hazards and Resilience

Food Security

Climate Change, Impacts, Resilience

Natural Capital and Ecosystem Services

Sustainable Water and Health

Ocean Solutions

Global Health

Energy Choices

Influence of public and private governance on land use decisions

Commodity certification programs and response in the S-E system…

and feedback to Foundation and NGO ‘decision-makers’

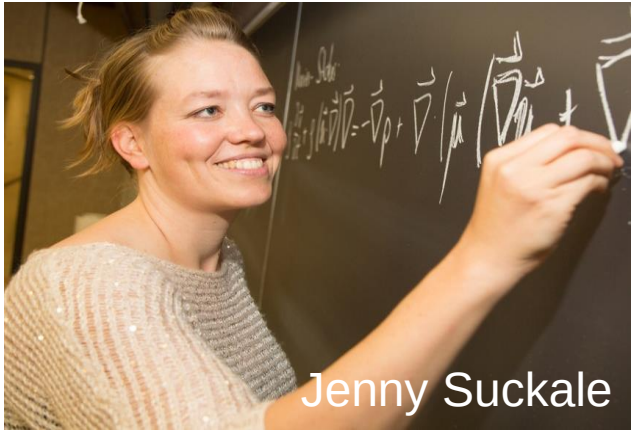
Eric Lambin

Reducing Disaster Risk

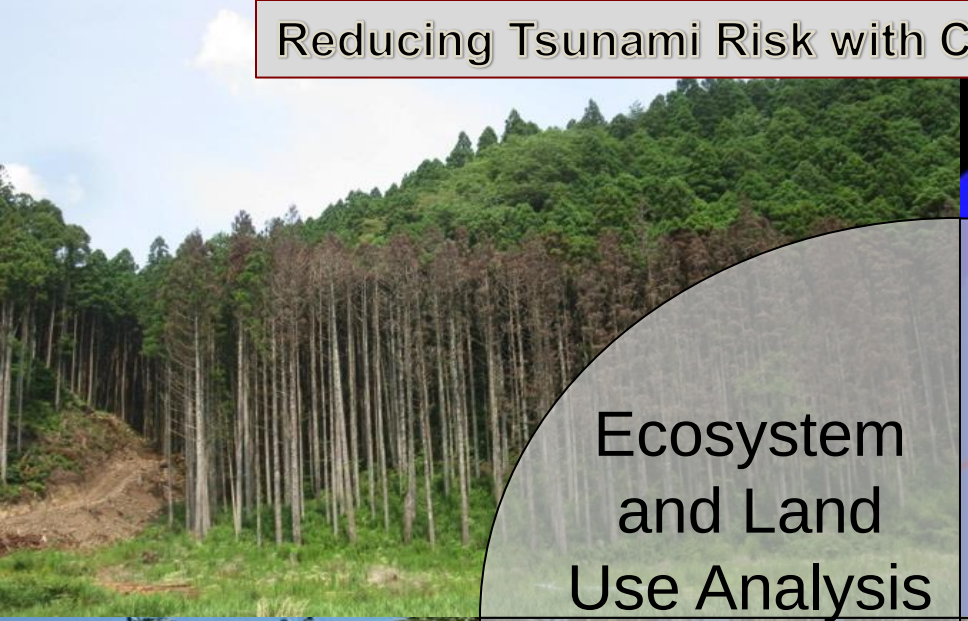
Fundamental fluid dynamics of heterogeneous flows…

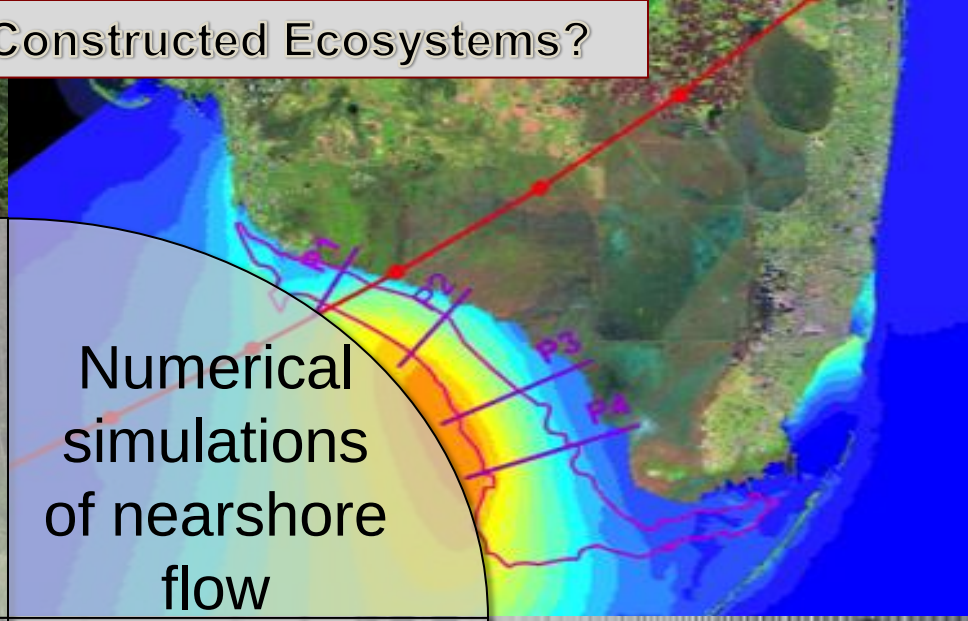
where and under what conditions ecosystems provide coastal protection…

working with in-country disaster planners



Reducing Tsunami Risk with Constructed Ecosystems?





Ecosystem and Land Use Analysis

Numerical simulations of nearshore flow

Analysis of Governance Systems

Laboratory experiments of fluid-plant interactions

The Largest Mass Poisoning in History:

Arsenic in Groundwate
throughout Asia

Scott Fendorf

2) Progress in the focusing and framing the study and pursuit of sustainability

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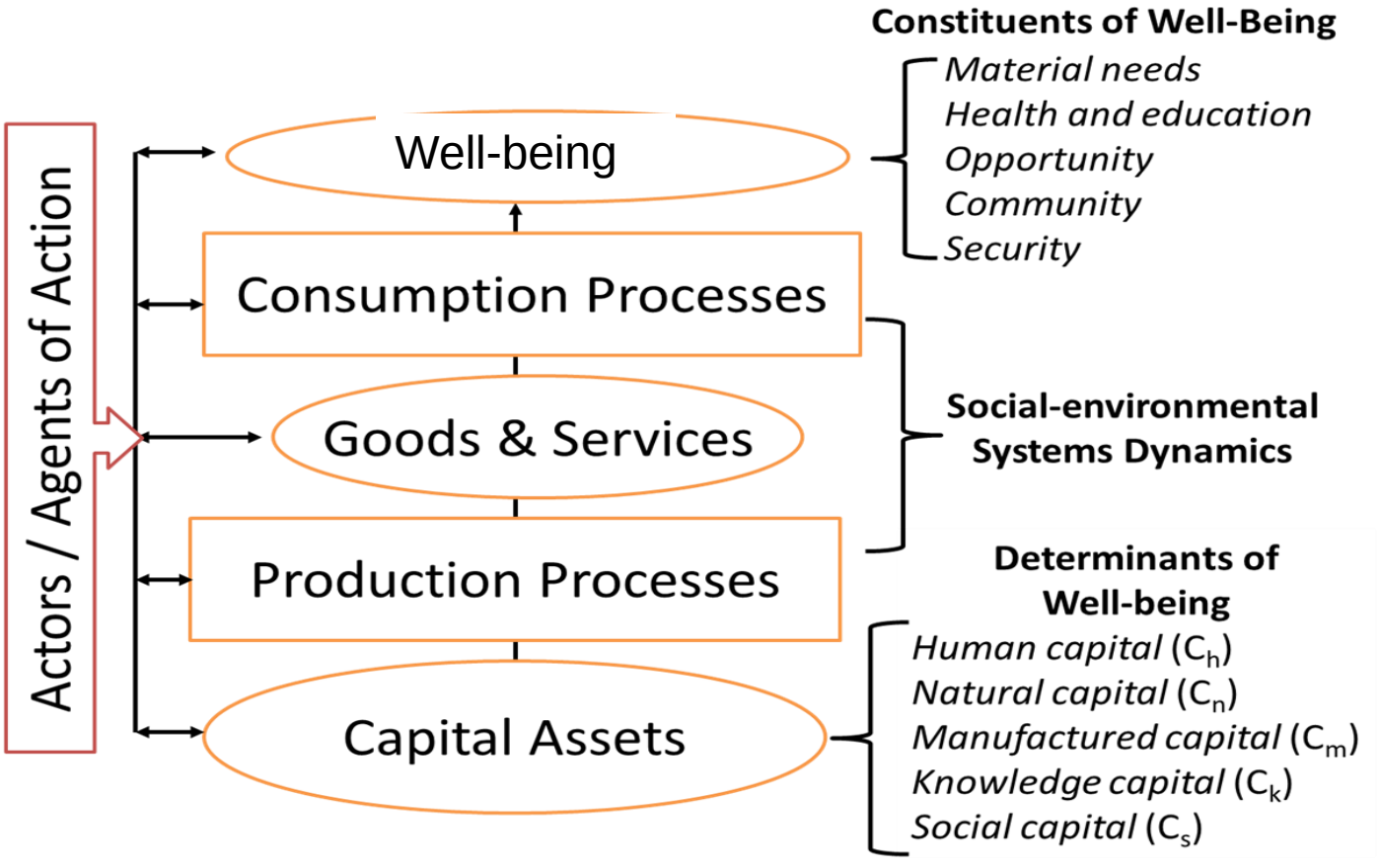
Can we move away from 'environmental sustainability,' 'social sustainability,' 'economic sustainability,' and so on….

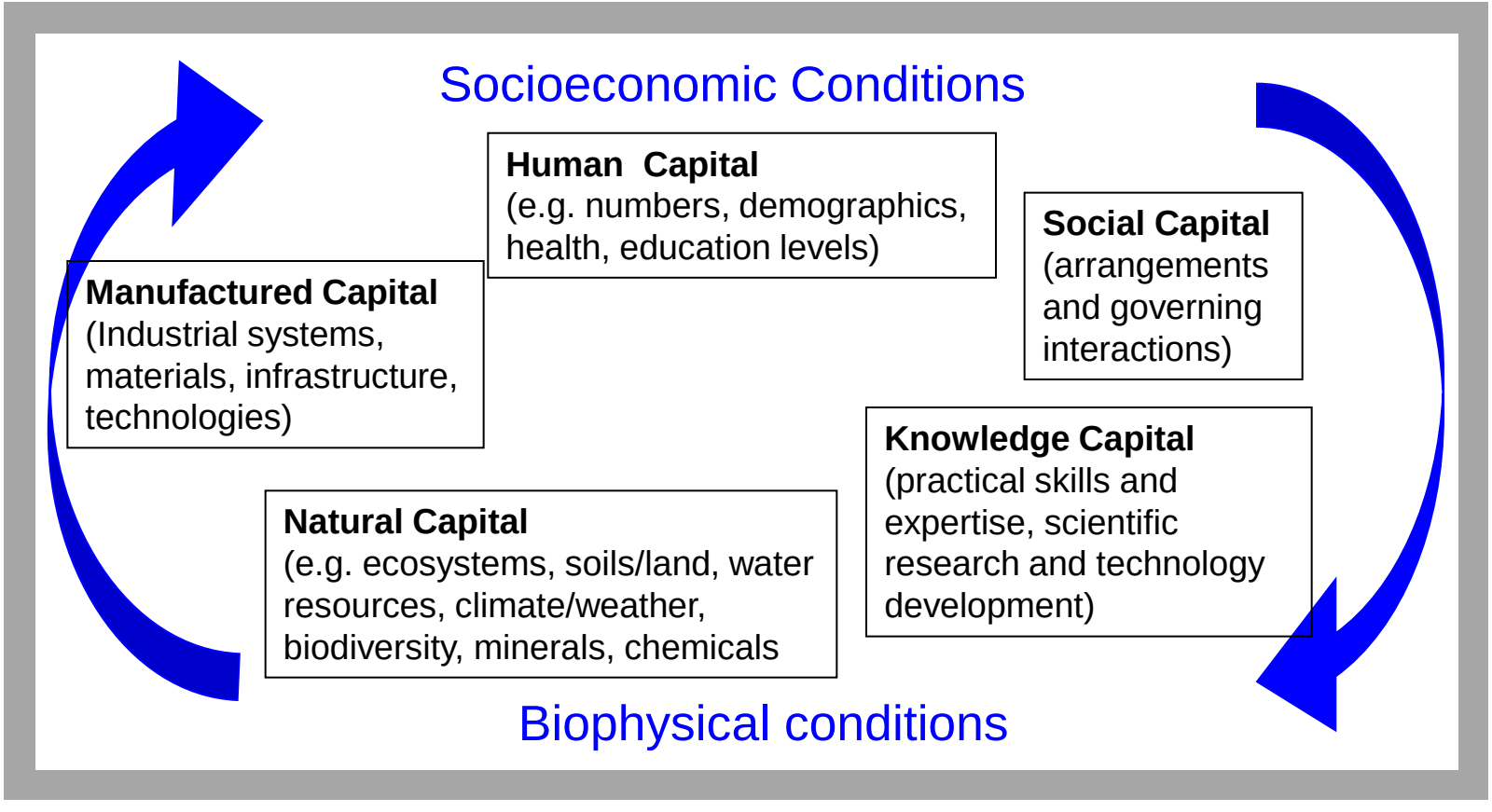
to

'Sustainability' ….with the goal of intergenerational social well-being??



Dasgupta, Arrow, Maher, Hamilton, Ostrom, Kates, Bongaarts, Carpenter, Landegren, and many more
Matson, Clark and Andersson. 2016. *Pursuing Sustainability*

focus on **Coupled Social-Environment Systems**



Pursuing Sustainability. 2016
Matson, Clark and Anderssen

3) Significant progress in metrics and indicators:

“Indicators are becoming much more integrative”

“Novel uses of information technology to as indicator systems.”

“Metrics of institutions and governance issues are much stronger”

“For the first time, we have an inclusive and theoretically justified set of key indicators of sustainability – five, not five hundred!”

But…

“In some areas, the impulse seems to be to create new ones, not paying attention to how they relate to others. Instead of constantly collecting new data on new indicators, we need to map against on-going efforts and other indicators.”

“Very few studies actually carry out foundational research to test and validate metrics.”

“They don’t validate, and don’t show (or know) what happens with their use.”

“Going from theory to application is hard.”

4) Tremendous progress in development of models to support decision making:

“I’m seeing more rigorous and precise estimates from impact assessments.”

“Impressed with the use of robust IAM for decision making.”

“Clever extension of decision support models in a variety of areas.”

“Data rich, empirical models to support decision making (e.g., costs of pollution, land use, risk and vulnerability assessment) are improving.”

“Ecosystem services data and models are being used for strategic planning.”

But…

“Models are used in assessments, but how often are the assessments used by decision makers?”

“They assume that more rigorous and precise estimates of impacts will lead to better policy, but does better info lead to more effective decision making?”

“Do IAM work, or are they actually counterproductive and misleading?”

“Big, integrative models are “unverifiable.”

“Impact assessments tend to look at the effect of single interventions and they are not comparative.”

“Do IAM work, or are they actually counterproductive and misleading?”

“There are very strong grounds for arguing that they [IAMs] grossly underestimate the risks of climate change…
not simply because of limitations of climate and impacts models…but because of assumptions built into the economic models, which come close to assuming directly that the impacts and costs will be modest, and close to excluding the possibility of catastrophic outcomes.”

We’re underestimating risks, and “it is irresponsible to act as if the economic models currently dominating policy analysis represent a sensible central case.”

Nicolas Stern. 2013.The Structure of Economic Modeling of the Potential Impacts of Climate Change. J Econ Literautre 51(3), 838-859

But…

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And…(continued)

We don’t report back…

“Out of 1900 papers, maybe 2 of them are about how better information actually influenced decision making….”

“When you see a paper on this (the effect of assessment information on decision making) you get really excited.”

5) Great progress in efforts and opportunities to link knowledge to action

“Great advances in theory and actual efforts to engage stakeholders, run deliberative processes, and improve processes.”

“Great studies about boundary organizations and their function and role in the science-policy interface.”

“More and more individuals and organizations get that sustainability needs to be paid attention to, and are turning to us for help.”

But…

“Where knowledge is being used in decision making, research is not documenting outcomes for the most part.”

“We don’t know whether it’s successful or a failure.”

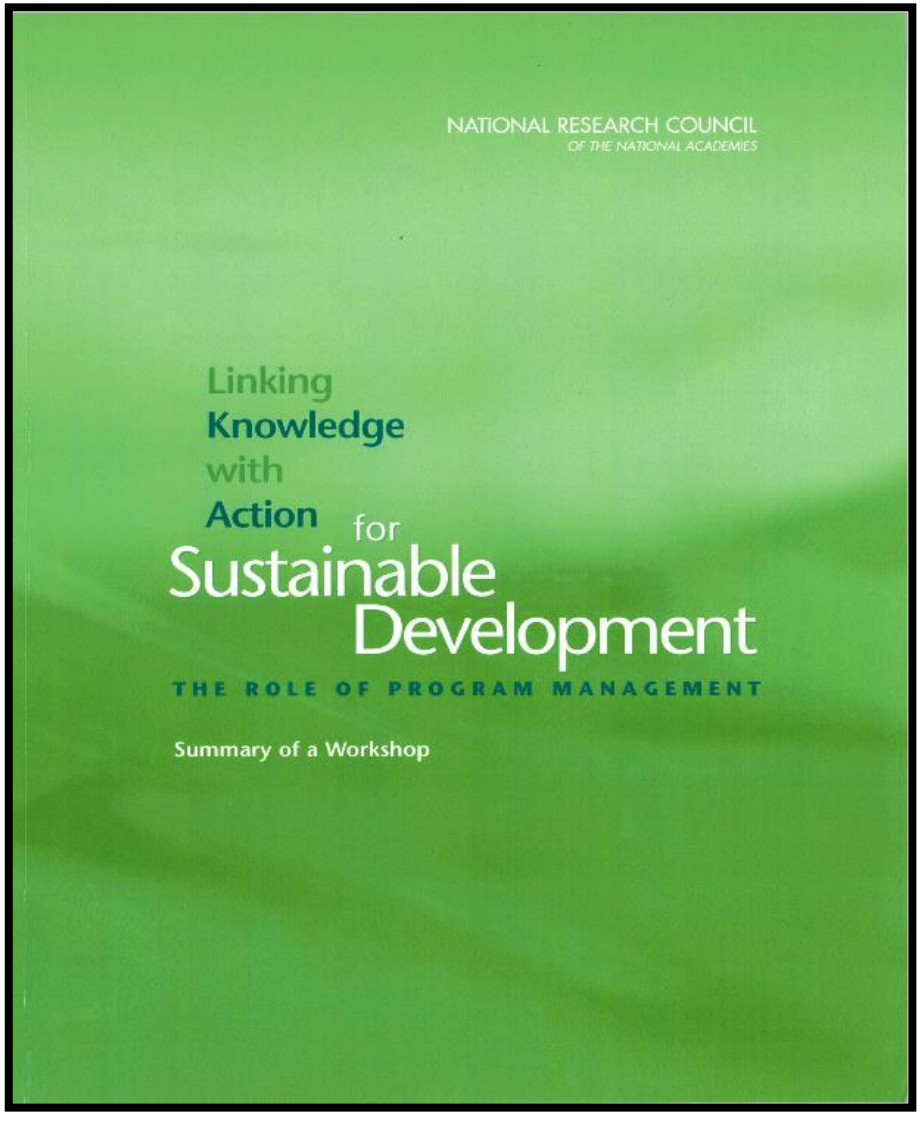
“Demand is there, but we are failing.”

“We’re working to understand the system, but not actually using that knowledge.”

“There’s a lack of capacity. Researchers are not being trained to do this.”

“A huge amount of expertise is being ignored.”

“Most opportunities to inform decision making are idiosyncratic, not systematic.”



How is knowledge and action linked effectively?

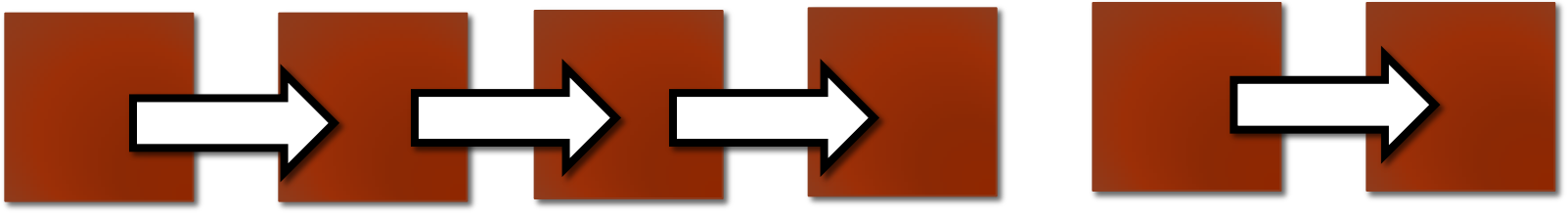
What works and why?

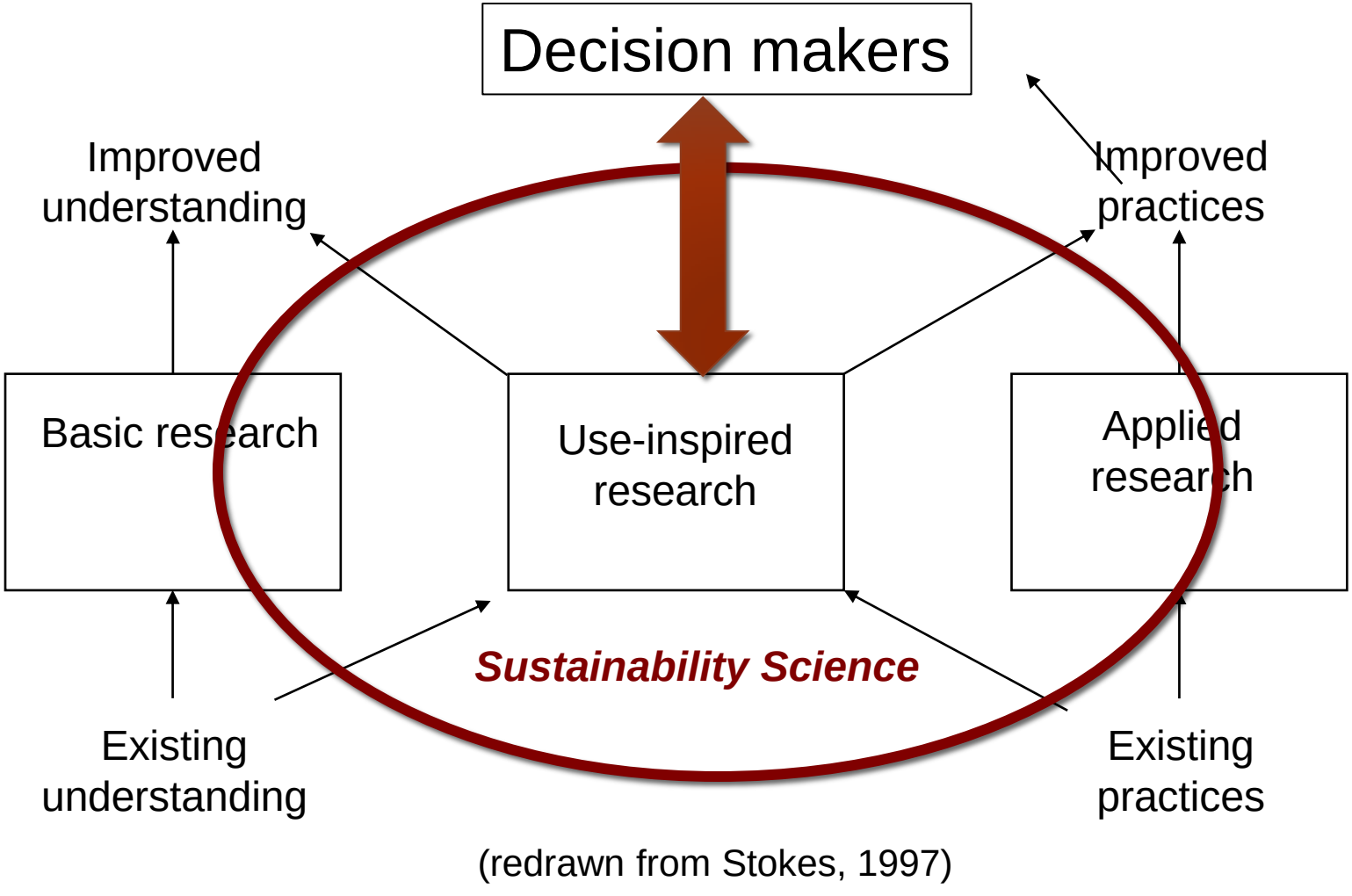
NRC Roundtable on Science and Technology for Sustainability
And other research…

Fragmentation

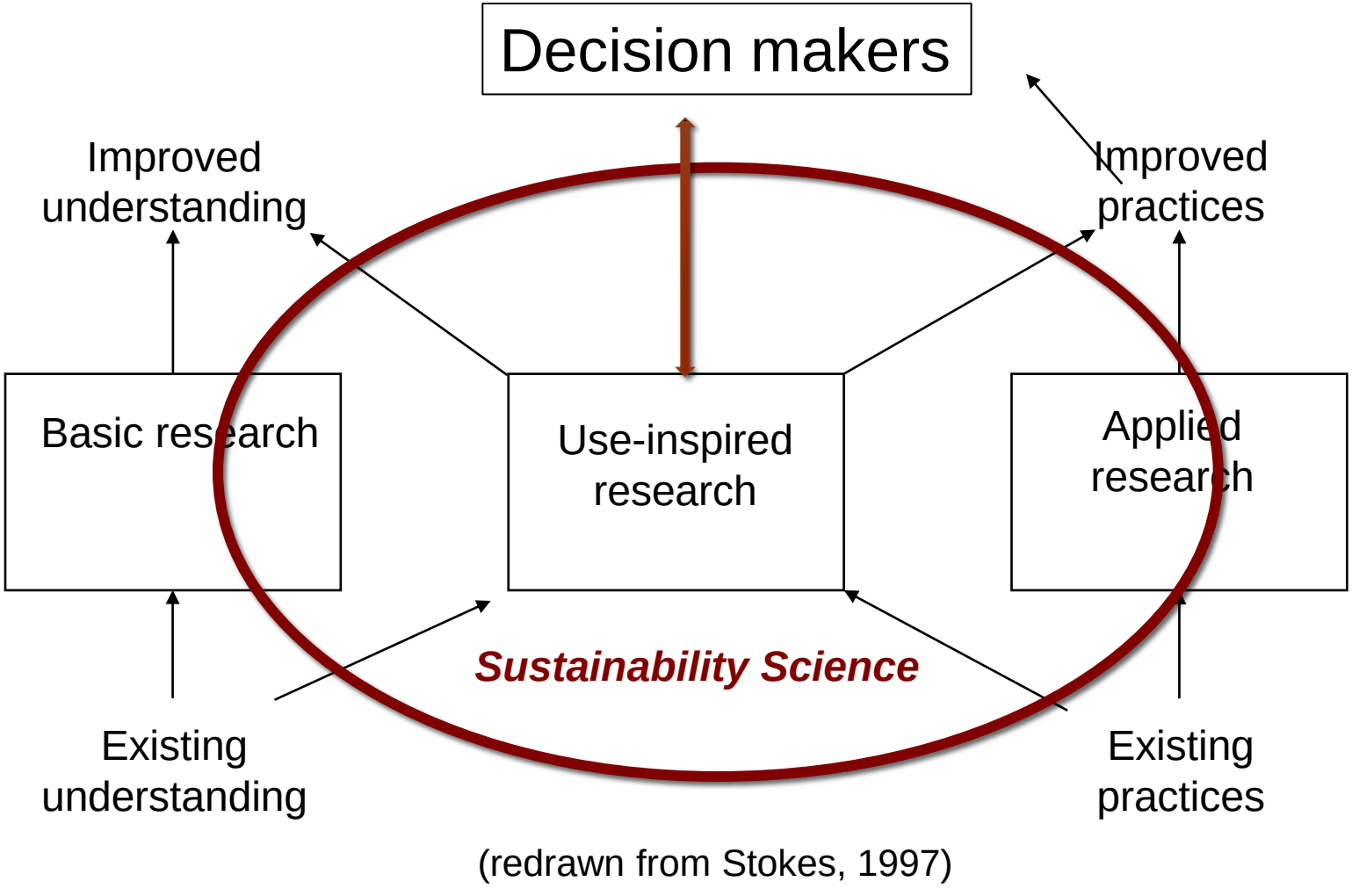
(knowledge system less than sum of its parts)

- Different organizations charged with different parts of the knowledge-action chain…
- In some situations, the incentives to complete the chain from basic research to adoption are weak
- Researcher desires may not match all the needs
- There are no incentives to complete the “supply chain”





(redrawn from Stokes, 1997)



(redrawn from Stokes, 1997)

So what can be done?

Create Opportunities

Create boundary capabilities and organizations to link researchers with decision makers and incentivize and oversee "supply chain"

Engage via partnerships with NGOs, corporations, governments

Develop new professional organizations and publication venues

Build Capacity

Create training programs in 'linking knowledge and action.'

Engage students and other researchers in (small) activities to learn by doing (e.g., Sustainability Clinics on the model of Law Clinics)

We are in the transition, but it needs to move much faster.

- Work harder to use the knowledge we are developing, and test its usefulness, and learn.

- Build-in knowledge-action functions.

- Design research efforts across the whole "supply chain."

- Focus on transformative innovations that can SCALE.

Thank you!