Decision Making Under Uncertainty Catastrophic Climate Change Risk

- Limits to Decision Making
  - Complex Systems
  - Godel
  - Our Brain
- Decisions About Uncertain Catastrophic Risks
  - Chichilnisky Approach to Catastrophic Risk
  - Bayesain Evaluation of Knowledge
  - Technological Approach to Control Climate Risk

Limits to Decision Making

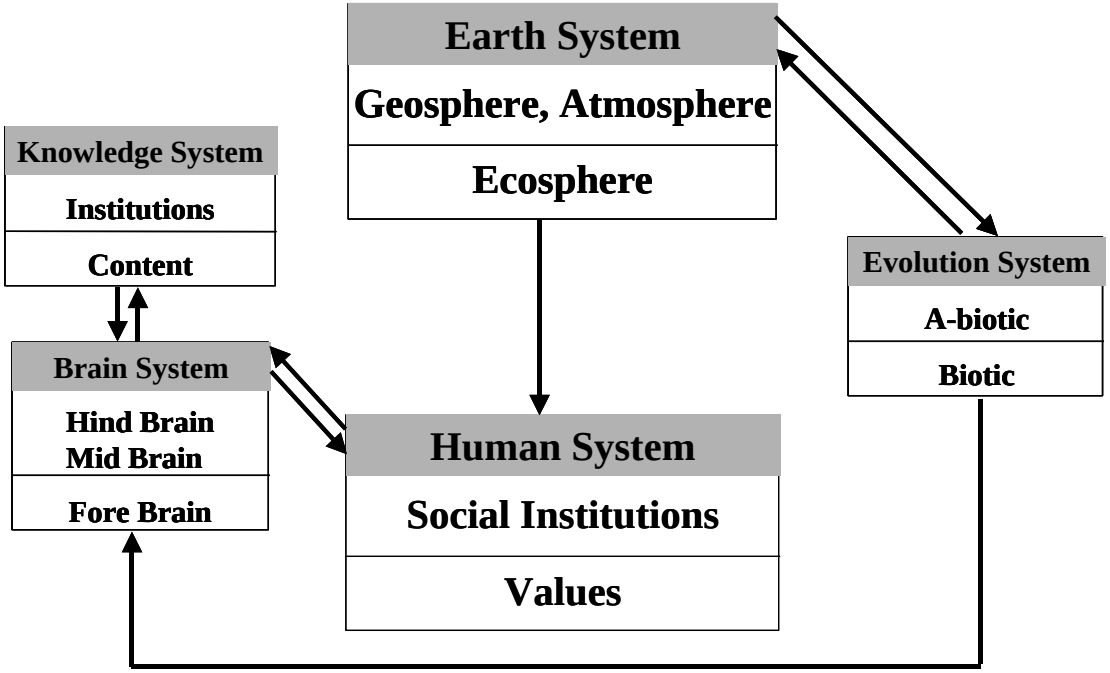
- Complex Systems
  - Limit to Predicting Future State of a System
    - Non-linear Dynamics/ Butterfly Effect
- Godel
  - Limit to Questions One Can Answer
    - Self Referential / Reference Frame Dependent
- Human Uncertainty Principle
  - Brain/ Constrains Evaluations
    - Reference Frame/Einstein Effect
    - Complexity and Emotions

Complex Systems

- Two identical systems at T=0 exponentially diverge over time
  - Non-linear feedbacks
  - Emergence
  - Non-reversible
  - Formally discontinous between different chaotic attractors
- New Emergent State can be a Catastrophic
  - Valued in old system

- **How to make decisions about the future of a complex system within the limits of knowledge and our brain(s)**

THE EARTH HUMAN COMPLEX SYSTEM
Before Human Dominance



OUR EVOLUTIONARY HISTORY

- HOMO GENUS EVOLVED FOR ~ 7,000,000 YEARS- SURVIVAL OF THE FITTEST(SOF)
- HOMO SAPIENS FOR~200,000 YEARS- 95% IN SOF FRAMEWORK
  - + LIMITED HUNTER GATHERER SOCIAL ORGANIZATION
  - + NO KNOWLEDGE AT GLOBAL SCALE OR OF BRAIN'S WORKINGS
  - + NO CAPABILITY TO ALTER NATURE GLOBALLY
- SINCE LAST ICE AGE (~13000 YA)- TOOLS/CHANGING SOCIAL ORGANIZATIONS

INDUSTRIAL REVOLUTION INITIATES A MAJOR TRANSFORMATION

- ENERGY TO DO WORK
- IMPROVED TRANSPORTATION/COMMUNICATIONS/CONNECTIVITY
- RAPID GROWTH IN KNOWLEDGE

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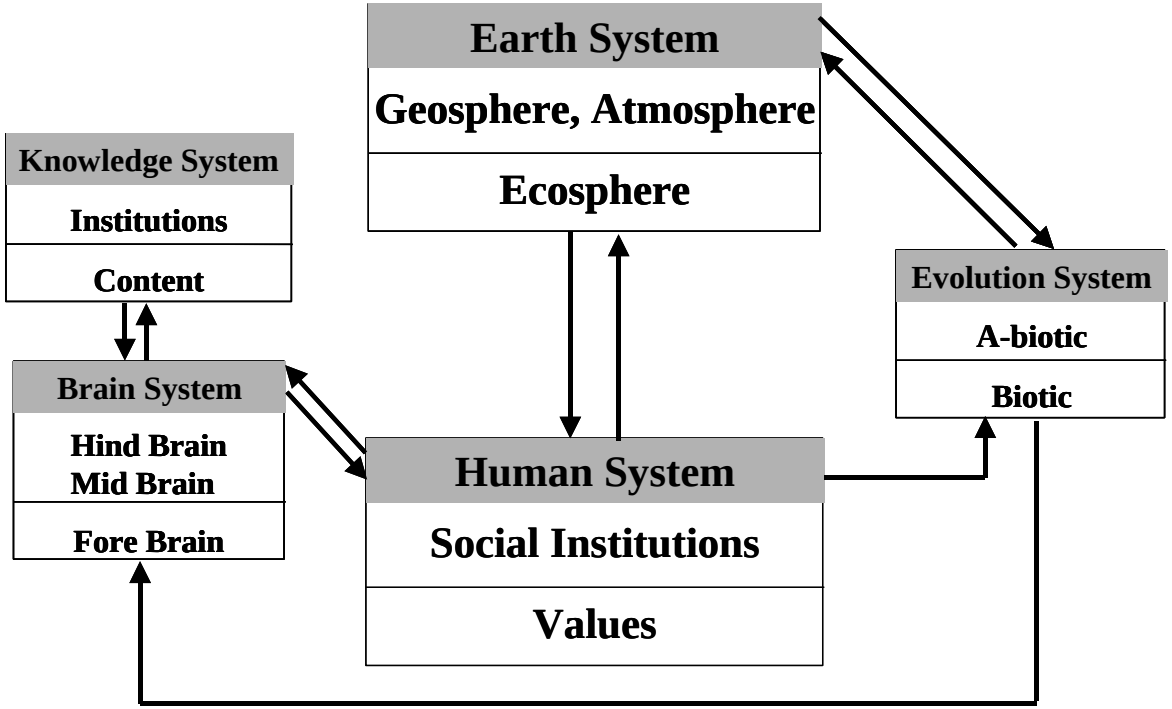
After Human Dominance



WE ARE A VERY SUCCESSFUL SPECIES/ WE ARE A GLOBAL FORCE
- POULATION HAS INCREASED GREATLY/LIFESPAN BY ABOUT 3
- OUR USE OF KNOWLEDGE ENABLES US TO HAVE GLOBAL IMPACTS
- WE CAN CHANGE THE COURSE OF FUTURE EVOLUTION

YET WE ARE STILL AT RISK FROM A CHANGING PLANET
- OUR KNOWLEDGE HAS IDENTIFIED GLOBLAL THREATS TO LIFE

WE ARE SUCCESSFUL BUT WE NEED TO CHANGE (AGAIN)
- TO ADDRESS THE GLOBAL THREATS LIFE FACES
- TO MAKE SURE WE ARE NOT A GLOBAL THREAT OURSELVES

Planar Double Pendulum Dominating Linear Dynamics

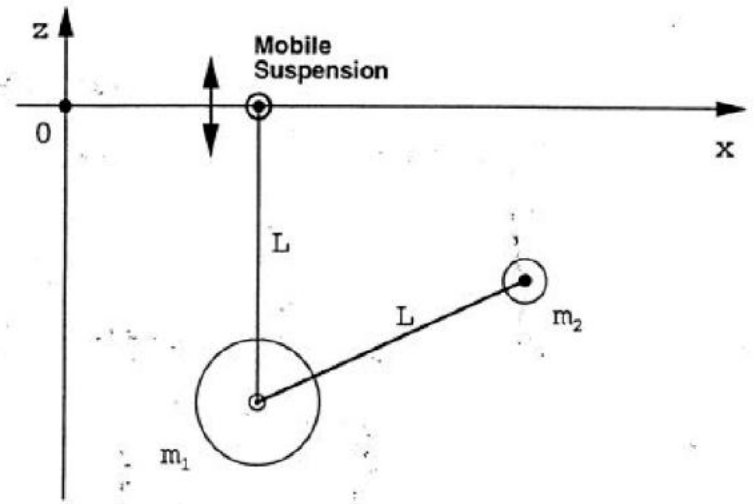


Figure 2. Planar double pendulum, moving under the combined influence of the gravitational forces $\mathbf{F}_i = -m_i g\hat{z}, i = 1, 2$, and a temporal modulation of the pivotal suspension. g denotes the constant acceleration due to the Earth's gravitational field, the two rigid links have identical length L. We initially assume that the first mass is clearly dominating the dynamics, i.e., $m_1/m_2 \gg 1$.

Phase Space Portrait 1

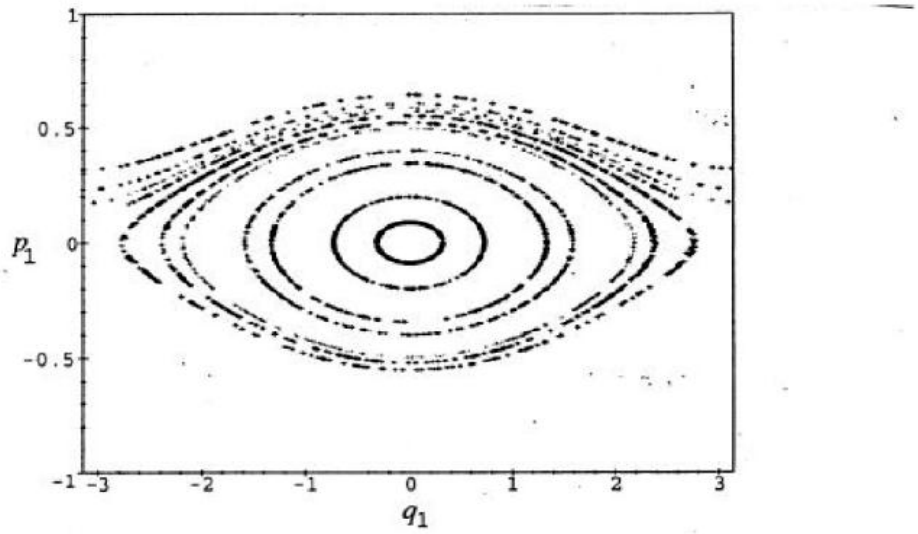


Figure 3. Phase space portrait for the motion of the (almost) unperturbed dominating mass in the double pendulum system depicted in Fig. 2. Each contour corresponds to a given (practically conserved) initial energy of the system component considered. The analyticity of the graph indicates the perfect regularity of the dynamic behaviour observed.

Phase Space Portrait 2
Non-Linear Dynamics/Earth System

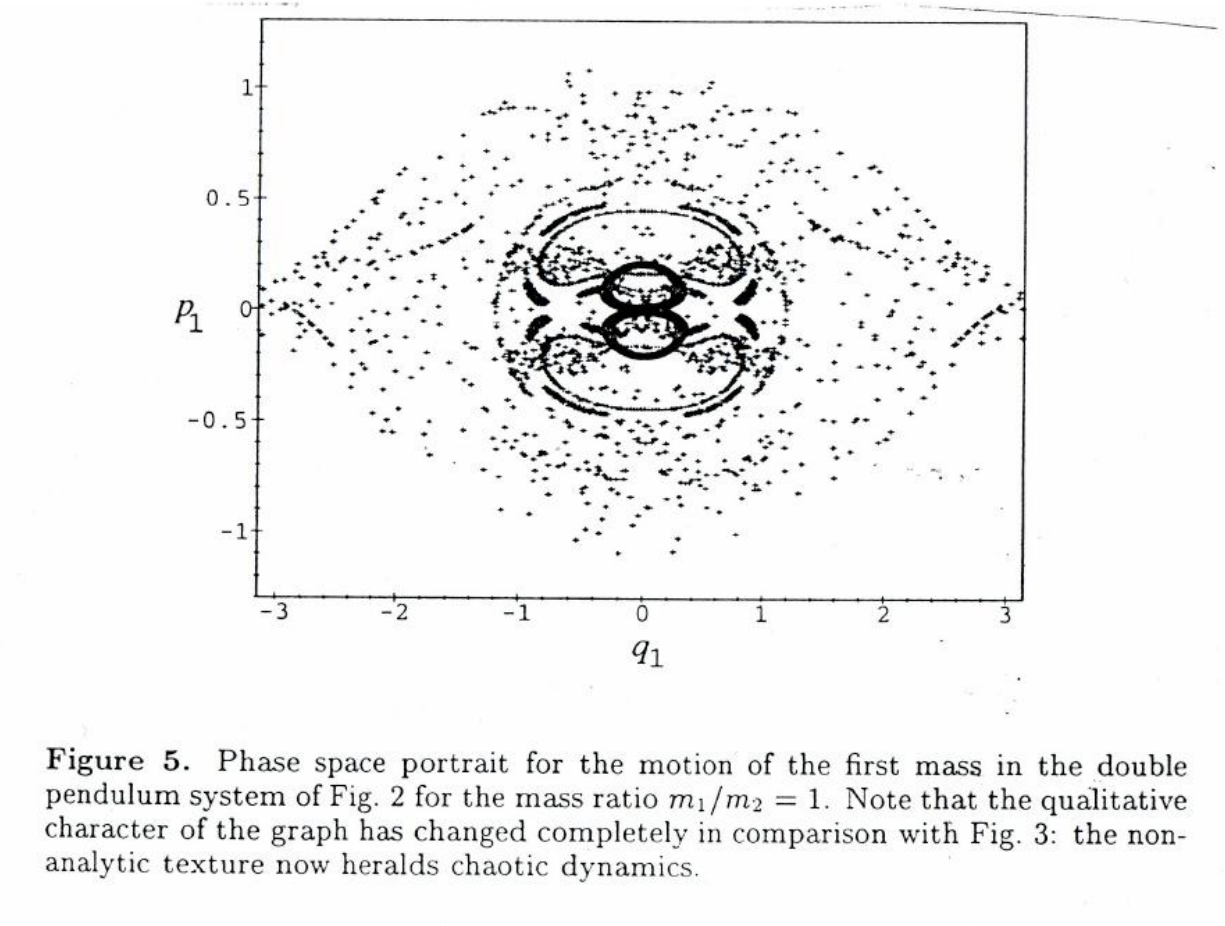
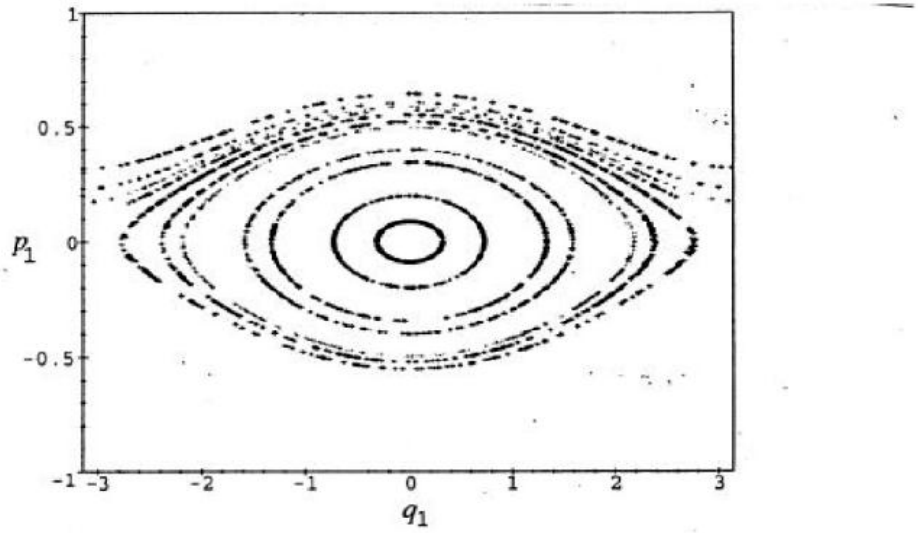


Figure 5. Phase space portrait for the motion of the first mass in the double pendulum system of Fig. 2 for the mass ratio $m_1/m_2 = 1$. Note that the qualitative character of the graph has changed completely in comparison with Fig. 3: the non-analytic texture now heralds chaotic dynamics.

Phase Space Portrait
Humans Manage The Planet



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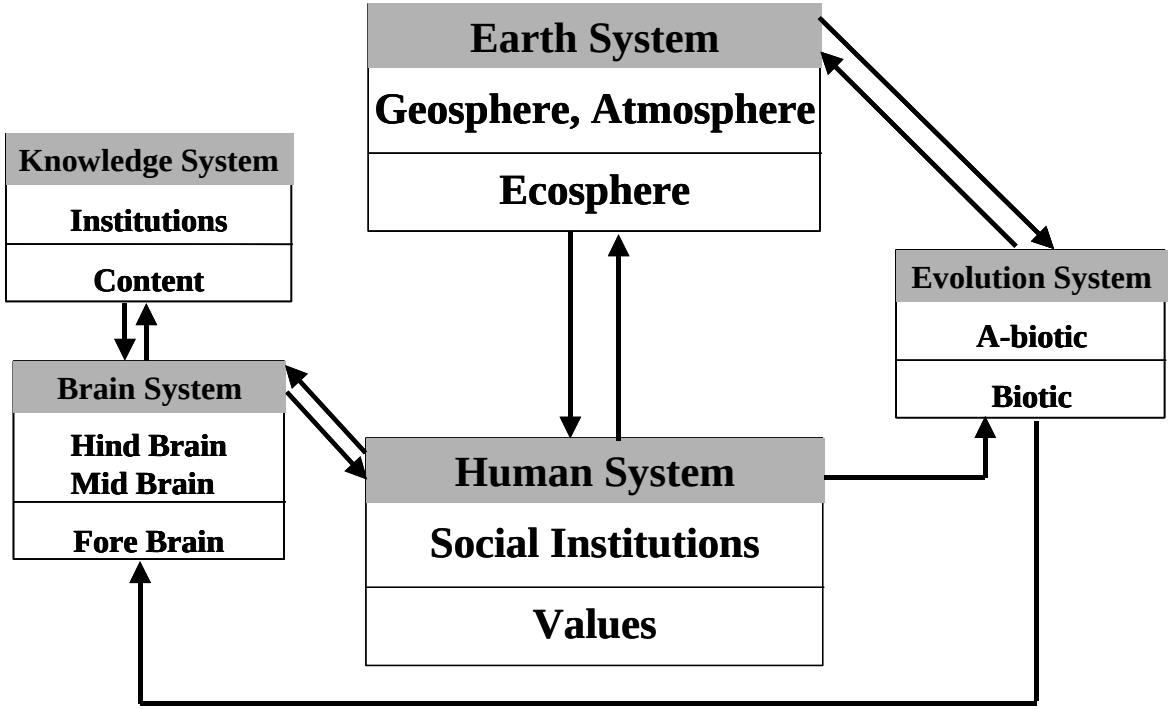
Can Humans Impose Linear Dynamics/ Prevent Growth of Non-linear Feedbacks ?

THE EARTH HUMAN SYSTEM
After Human Dominance



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- **TO ADDRESS THE GLOBAL THREATS LIFE FACES**
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THE BRAIN: NATURE AND NUTURE
BRAIN IMAGING REVEALS CONSTRAINTS/OPPORTUNITIES

EMOTIONAL CONSTRAINTS

- FEAR BLOCKS NEOCORTEX INPUT
- FLIGHT OR FIGHT REACTION

EMOTIONS ALSO PLAY AN IMPORTANT POSITIVE ROLE

- INFLUENCE VALUES
- FOCUS ATTENTION/INCREASES MEMORY
- LEARNING IS AN EMOTIONAL EXPERIENCE
- JOE LEDOUX DISTINCTION OF EMOTIONS
    + IMPLICIT EMOTIONS-BY PASSES CORTEX-FEAR/ANGER
    + EXPLICIT EMOTIONS- INVOLVES CORTEX- LEARNING
- IT MAKES US HAPPY/FULFILLED TO USE KNOWLEDGE SUCCESSFULLY
    + IMPLICIT EMOTIONS REINFORCES SUCCESSFUL HUNTING
    + EXPLICIT EMOTIONS REINFORCES SUCCESSFUL LEARNING

COMPLICATED ANALYSIS CONSTRAINT

- TUNE OUT CORTEX WHEN TOO COMPLICATED(KAHNEMANN)
- NEURAL OPTIMISM/BLINK
- MATHEMATICS NOT PART OF BRAINS ULTIMATE DESIGN

BRAIN'S ASSESTS FOR USING KNOWLEDGE

- USE OF KNOWLEDGE TO LEARN/PLAN FOR THE FUTURE
- INSIDE OUTSIDE AMBIQUITY/CAN PARTNER WITH MACHINES
- PLASTICITY

GENERAL OBSERVATIONS

NATURE AND NURTURE IMPACT ON OUR DECISIONS

- **INFERERENCES/RESPONSES ABOUT REALITY BUILT IN**
- **MANY BRAIN INFERENCES INCORRECT/KNOWLEDGE GAP THREAT**
- **OUR FRAME WORK CONSTRAINS OUR USE OF KNOWLEDGE/EINSTEIN**
- **BUT WE DO LEARN BASED UPON KNOWLEDGE/ SCIENTIFIC METHOD**
- **USING/DEVELOPING OUR EXPLICIT EMOTIONS VERY IMPORTANT**
- **PLASTICITY ENABLES US TO REDESIGN OUR BRAIN**

THE BRAIN/DECISIONS: SUMMARY OF CONCLUSIONS

IDEAL PERFORMANCE OF A BRAIN FOR DECISIONS

- EVALUATE BY REASON THE KNOWLEDGE AVAILABLE
- BE OPEN TO CHANGING REFERENCE FRAME/LEARN
- APPLY KNOWLEDGE BASED UPON EXPLICIT EMOTIONS/VALUES

WHAT IS A CONSTRAINT FOR MAKING BEST DECISION

- DECISION MAKING BASED ON ULTIMATE VERSUS PROXIMATE CAUSES
- DOMINANCE OF IMPLICIT VERSUS EXPLICIT EMOTIONS
- FAILURE TO BE ABLE TO EVALUATE KNOWLEDGE/COMPLEXITY

GLOBAL WARMING ISSUE(THREATS GENERALLY)

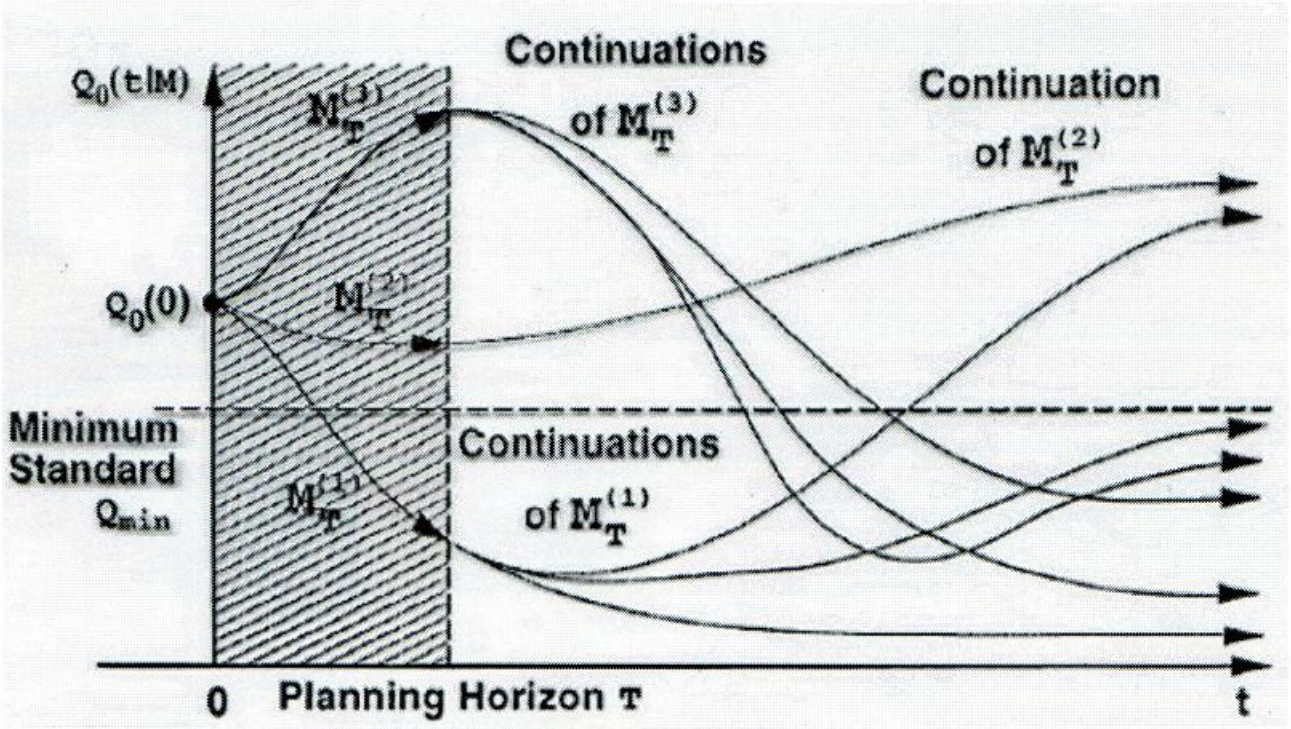
- RELATIONSHIP TO NATURE HAS STRONG ULTIMATE CAUSES
- MANY ARE NOT OPEN TO CHANGING THEIR BELIEFS/VALUES
  - \+ MANY GLOBAL WARMING/THREAT EXPERTS LIKE EINSTEIN
- ISSUE IS TOO COMPICATED FOR INDIVIDUALS TO EVALUATE

IMPACT OF CONSTRAINTS

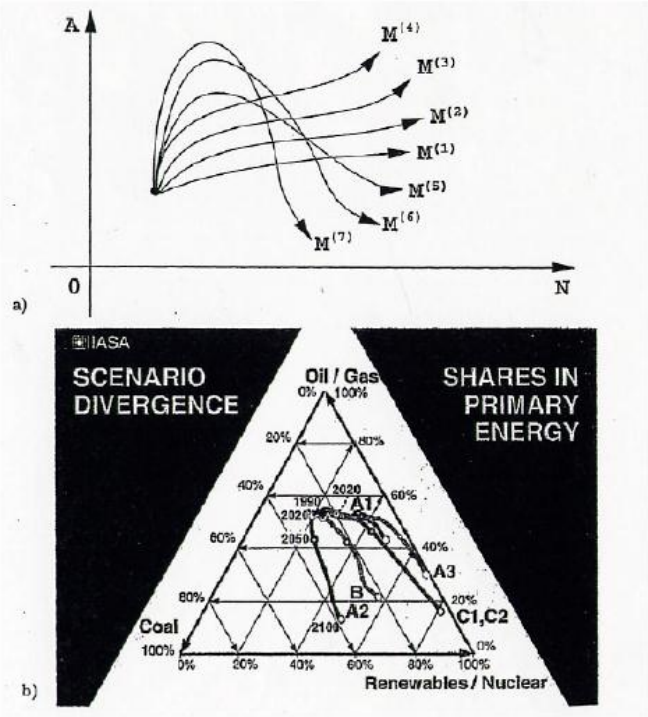
HUMAN UNCERTAINTY PRINCIPLE APPROACH TO DECISION MAKING

- WE ARE ALL TRAPPED BY OUR REFERENCE FRAME
- LEARNING CAN CHANGE REFERENCE FRAME
- PLASTICITY CAN ENABLE US TO IMPROVE DECISION MAKING

Decision Making To Manage
Earth/Human Complex System



Decision Making Involving
Complex System



Decision Making To Manage
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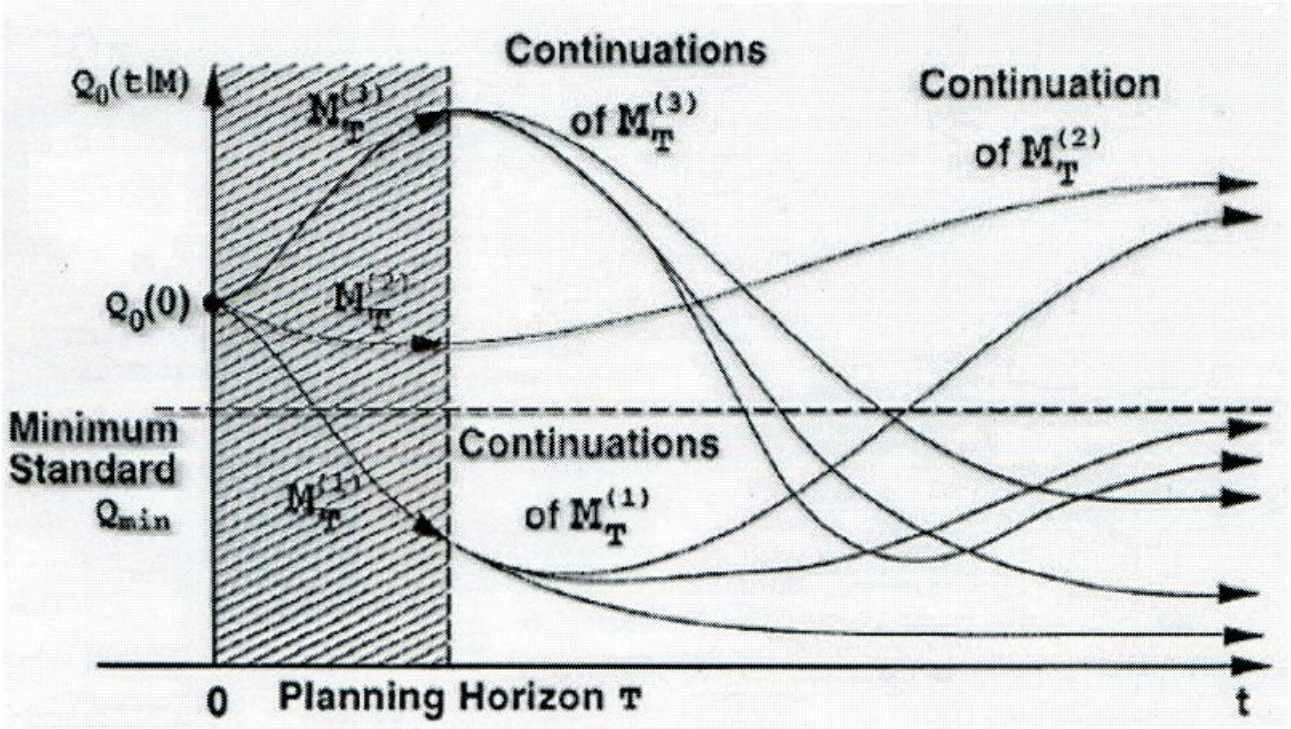

Climate Change Decisions

- Earth Human System is a Complex System
  - Cannot Predict the Future Climate
  - Cannot Carry out Reductionist Experiments
  - Catastrophic Risk Exists
    - Earth System with no Human Impact
      - Climate Change , asteroid impact, supervolcanoes
    - Human Dominace Adds Risk
      - Enhanced CO2 at Non –Geological Rates
- Choices
  - Do Nothing Different/
  - Minimize Impact
  - Manage the Planet- Impose Regular Dynamics

How to Address Climate Risk

- Assessment
  - Chichilnisky Approach
    - Explicitly addresses connection of present and future
    - Explicitly includes catastrophic risks
      - Low Probability in time
      - High catastrophic impact when it happens
  - Bayesian Approach
    - Acknowledges subjectivity/reference frame impact
    - Explicitly recognizes knowledge base used
- Technology to Manage the Climate
  - Designing the future better than predicting it
  - Closing the Carbon Cycle
  - Constrain Temperature Variations/ Global Thermostat

Earth Human Complex System