

Agricultural Adaptation to Climate Risks: issues of productivity and resilience

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Agricultural Adaptation

- Crop adaptation – sole basis of agriculture*
 - The relationships between the environmental factors and the growth response of plants
 - Matters of ecology, with elements of geography, physiology, genetics, meteorology, and agronomy
- Climate risks include issues beyond farm
 - Linked through markets and trade, and social imperatives such as food security and poverty

*Wilsie, CP & Shaw, RH 1954, 'Crop Adaptation and Climate', in AG Norman (ed.), *Advances in Agronomy*, Academic Press, vol. Volume 6, pp. 199-252.

Climate risks

- Increasing uncertainty
 - Affects the set of available options
 - And the nature of outcomes of decisions
- Potential payoffs are dictated by knowledge and endowment

Faced with the prospect of learning, increasing uncertainty leads to a preference for more *flexible strategies*

How to find the set of *flexible and efficient* strategies when the distribution of the states of nature is widening

Flexibility and Uncertainty

- Preserving flexibility
 - Would it be an efficient strategy?
 - Uncertainty reflects the inability to reliably predict states of nature
 - Choices recognise that the pay-offs may be different as the beliefs that govern the choices may change, as more information comes to hand.
- *the more variable are a decision-maker's beliefs, the more flexible is the position chosen* (Jones and Ostroy 1984)
 - This has certain efficiency implications. “The way flexibility is used to exploit forthcoming information may be dictated by attitudes toward risk; but flexible positions are attractive not because they are safe stores of value, but because they are good stores of options “.

Jones, RA & Ostroy, JM 1984, 'Flexibility and Uncertainty', *The Review of Economic Studies*, vol. 51, pp. 13-32.

Flexibility and Pay-offs

- Flexibility is a property of initial positions.
 - It refers to the possible pay-offs in moving to various second period positions.
 - The net benefits need to account for switching costs
 - Greater switching costs imply inflexible strategies
 - As decisions are taken sequentially, first period decision is only impacted by prior beliefs, including the prospect of learning and subsequent positions will be influenced by progressive learning that increases flexibility
 - Increasing opportunity costs of learning increases the relative value of flexible positions , discouraging some investments.
 - This could, however, increase exposure to cumulative impacts of externalities, thus undermining the resilience.

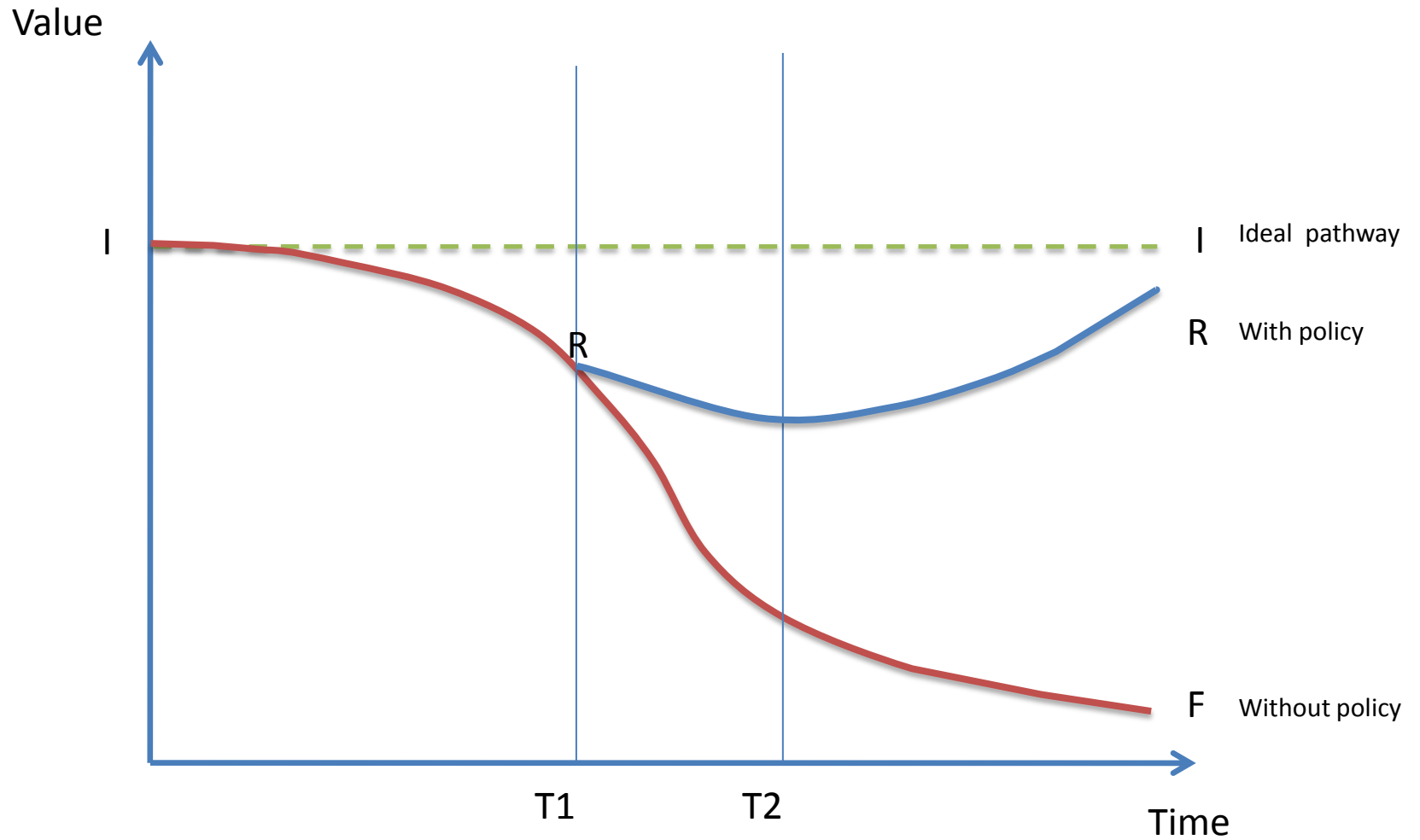
Resilience

- Resilience has been conceptualised as a measure of sustainable development
 - it concerns ecosystem properties such as thresholds, functions, and value of attributes,
 - or a pathway of recovery of a system after disturbance.
 - For example, structures built to facilitate development may provide resilience to shocks
 - Barrages along river Murray – allow salinity and water regulation
 - Dams offer increase resilience to drought
- When states of nature exposes these structures to conditions outside design parameters, a state of fragility may result.
- Some (Mäler et al 2008) view it as a form of ‘buffer’ or a form of capital that reduces the probability of a change in regimes.
- It is also known as ‘inclusive wealth’ (Walker et al 2010)

Resilience

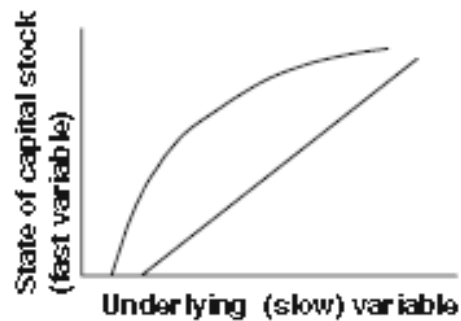
- For policy purposes resilience may be viewed as *the opposed concept of 'fragility'*.
 - *A resilient system is one which, following disturbances, returns to an equilibrium that is qualitatively similar to its initial state, and continues to deliver valued services.*

Resilience



Exploring resilience

(a) No threshold effect



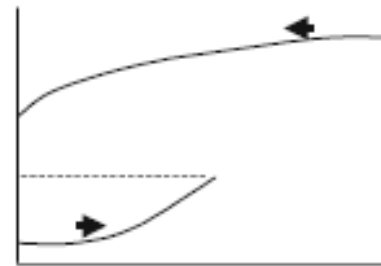
(b) threshold, no alternate attractors (no feedback changes)



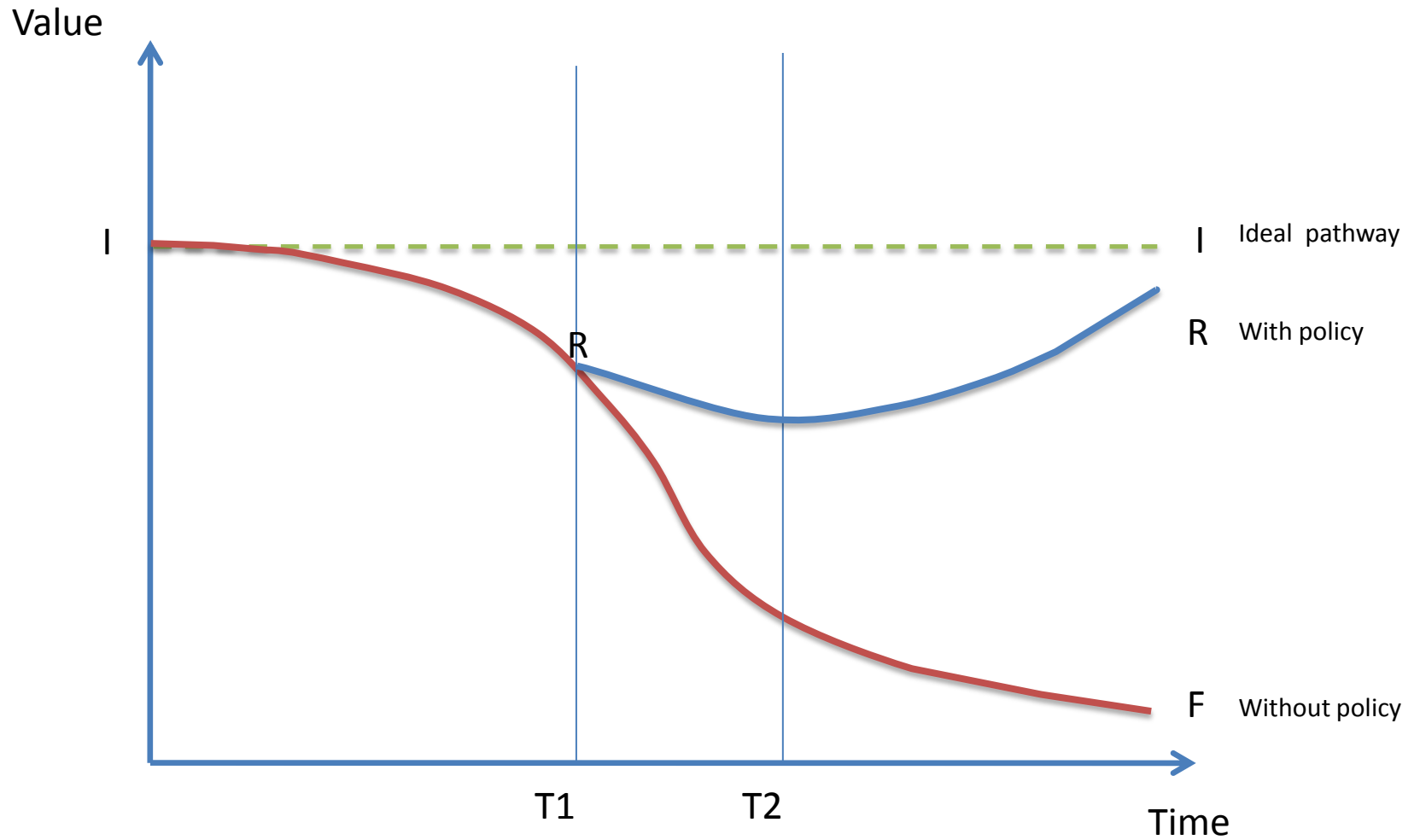
(c) threshold, alternate stable states



(d) irreversible threshold change



Resilience



Farm resilience

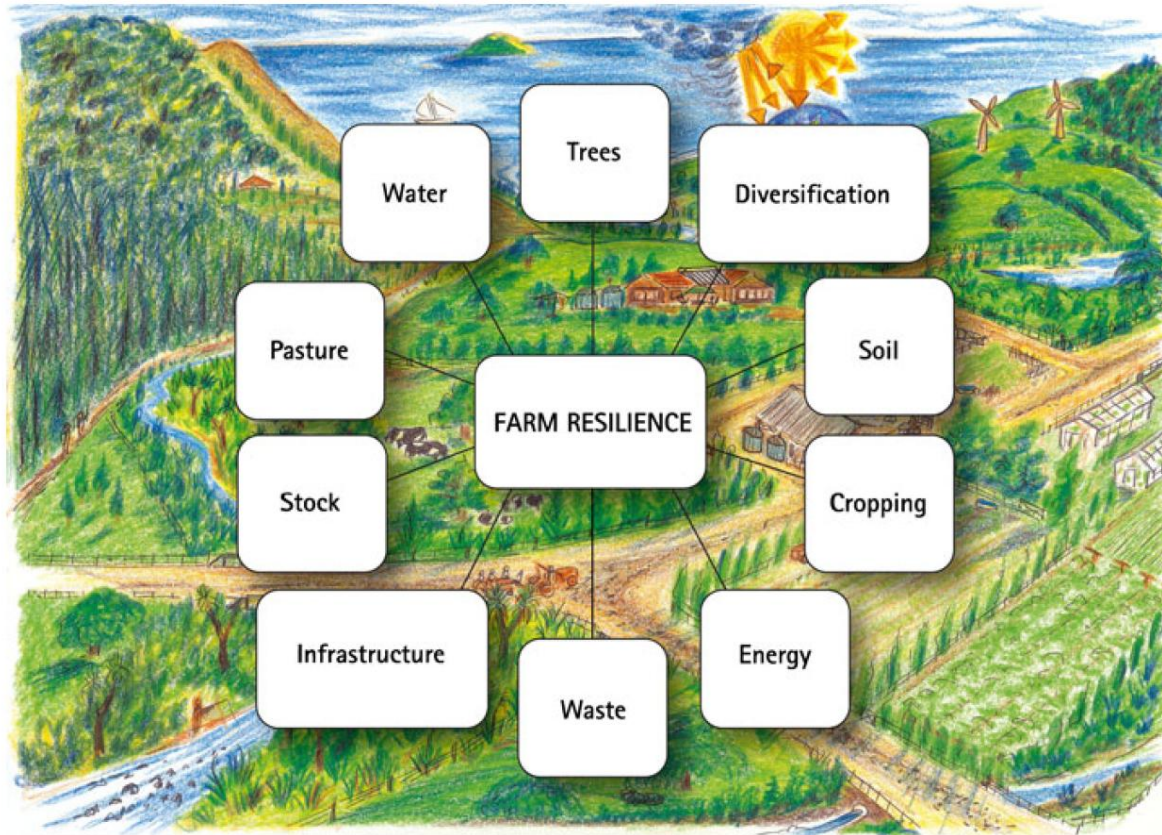
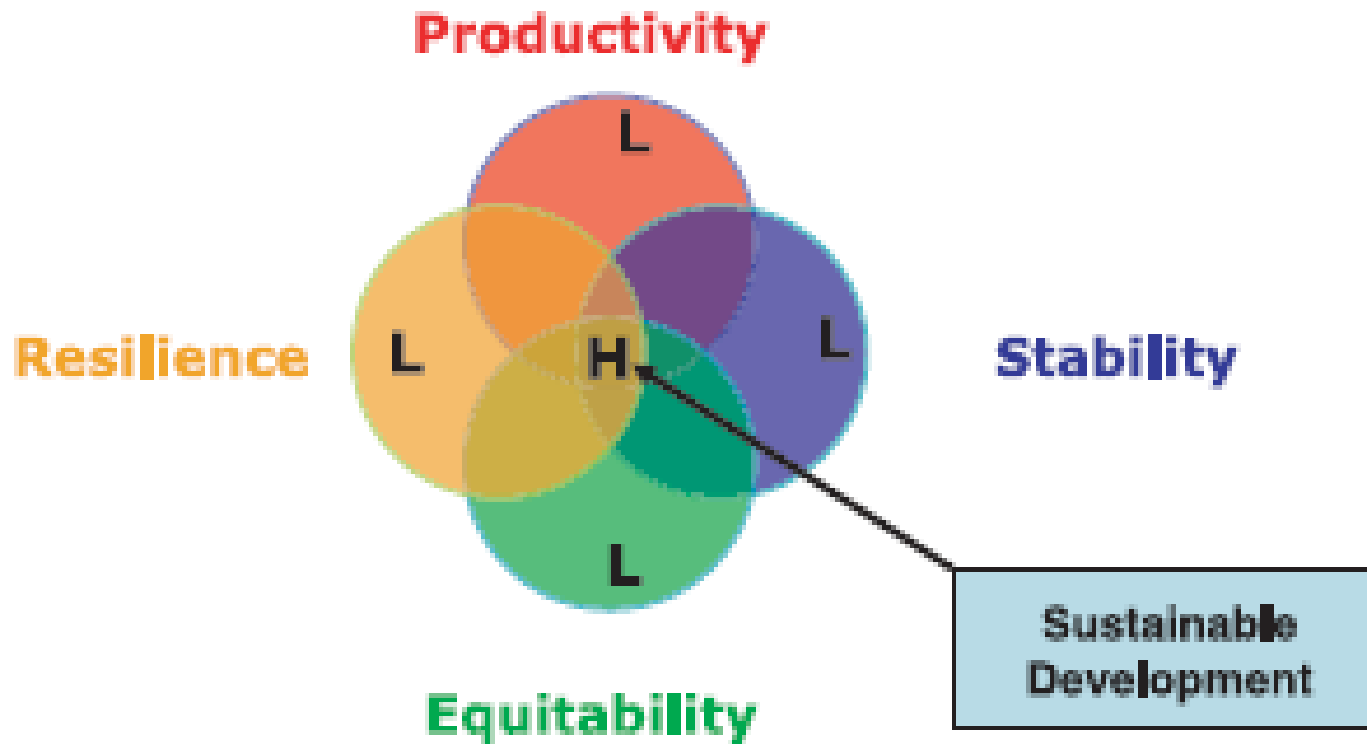


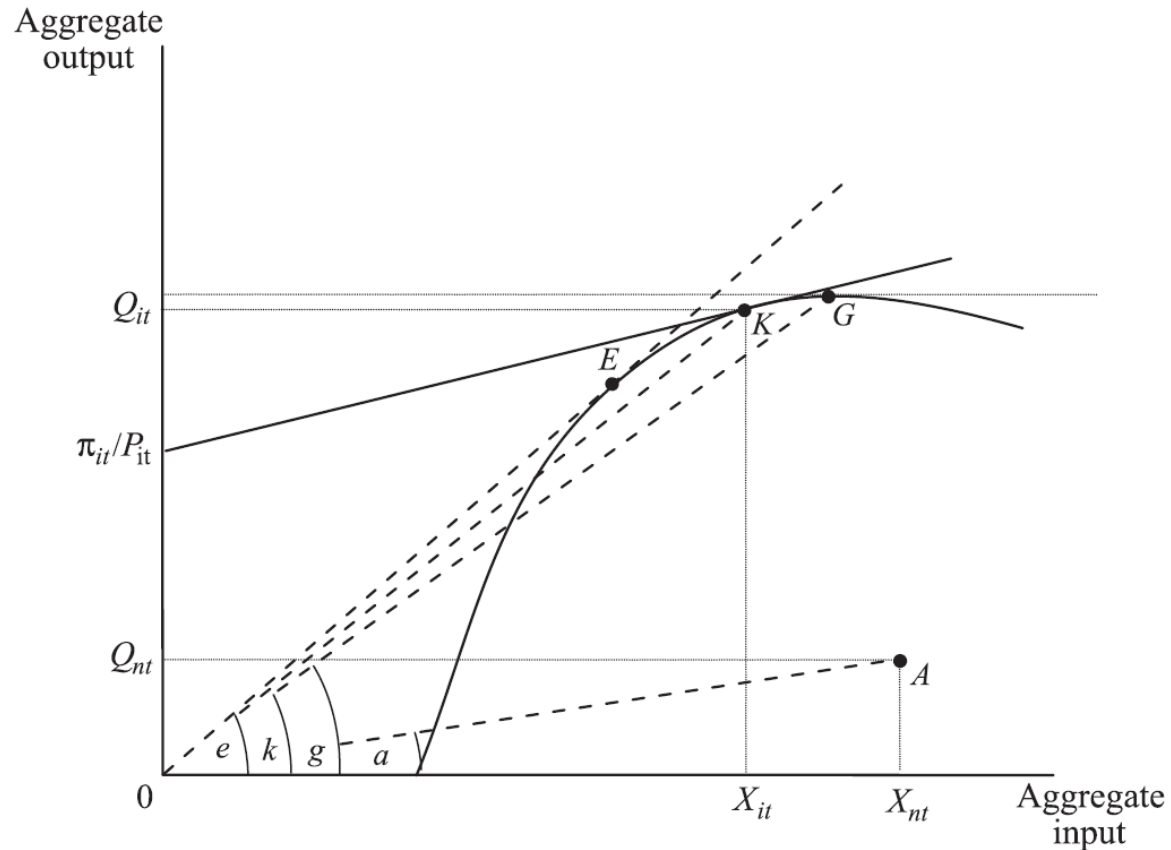
Fig. 1 The farm resilience picture (from Kenny 2005 with original art work by Fred Robertson)

Trade-offs

Minimising the Trade-Offs

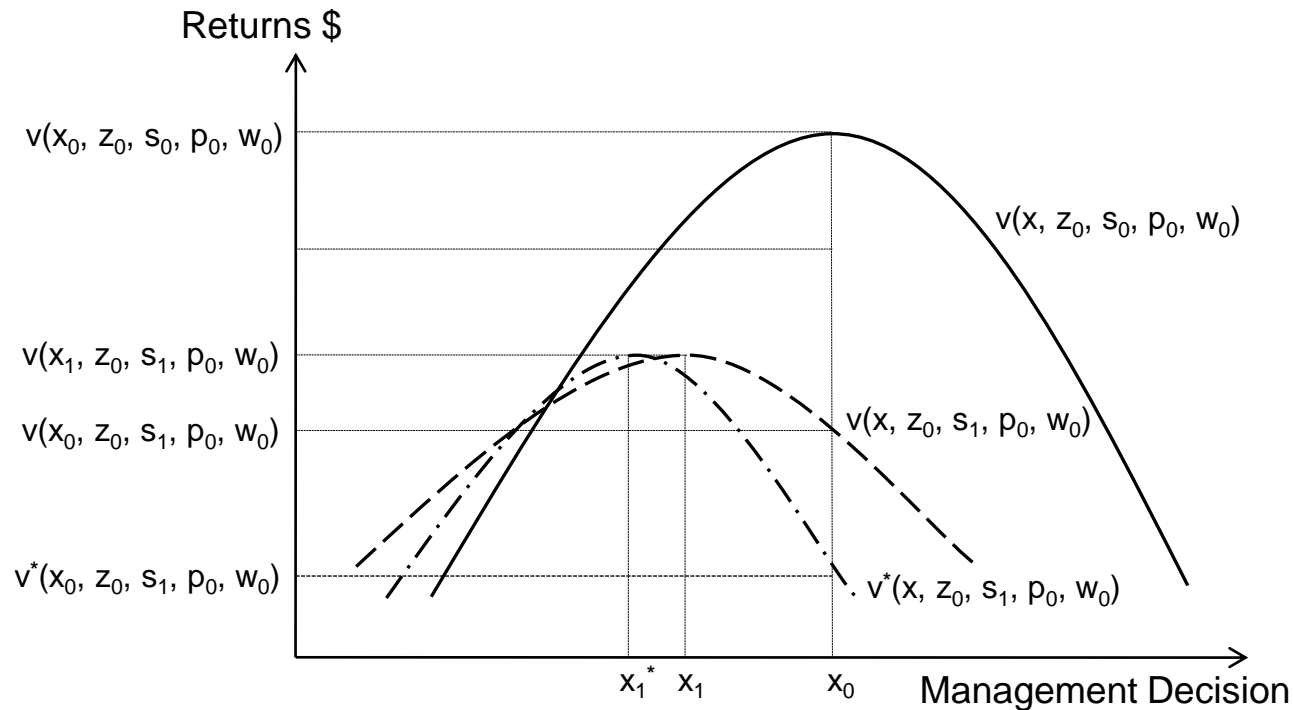


Productivity



Productivity, profitability and the terms of trade.

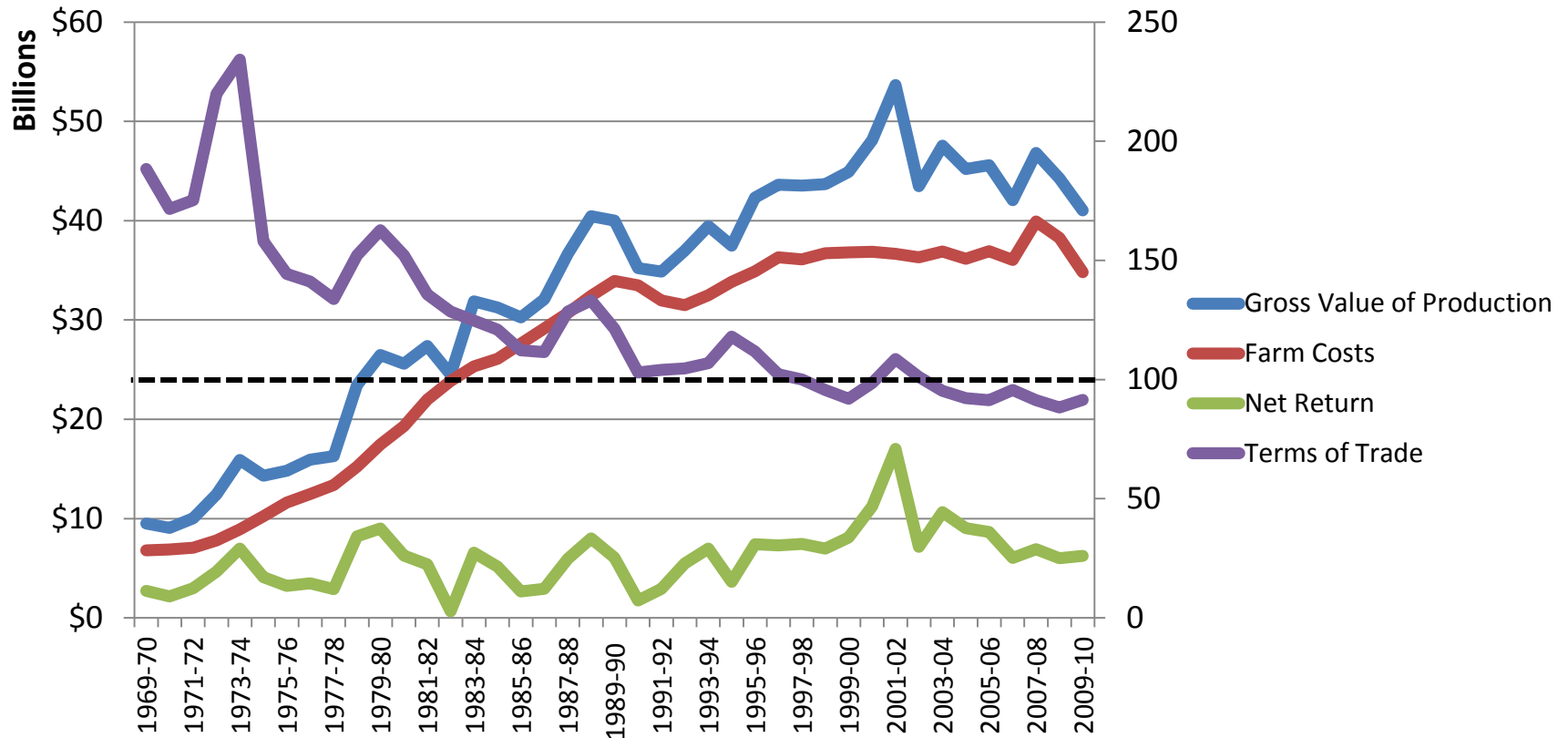
Economic analysis of adaptation to changing states



Antle, JM, Capalbo, SM, Elliott, ET & Paustian, KH 2004, 'Adaptation, Spatial Heterogeneity, and the Vulnerability of Agricultural Systems to Climate Change and CO₂ Fertilization: An Integrated Assessment Approach', *Climatic Change*, vol. 64, no. 3, pp. 289-315.

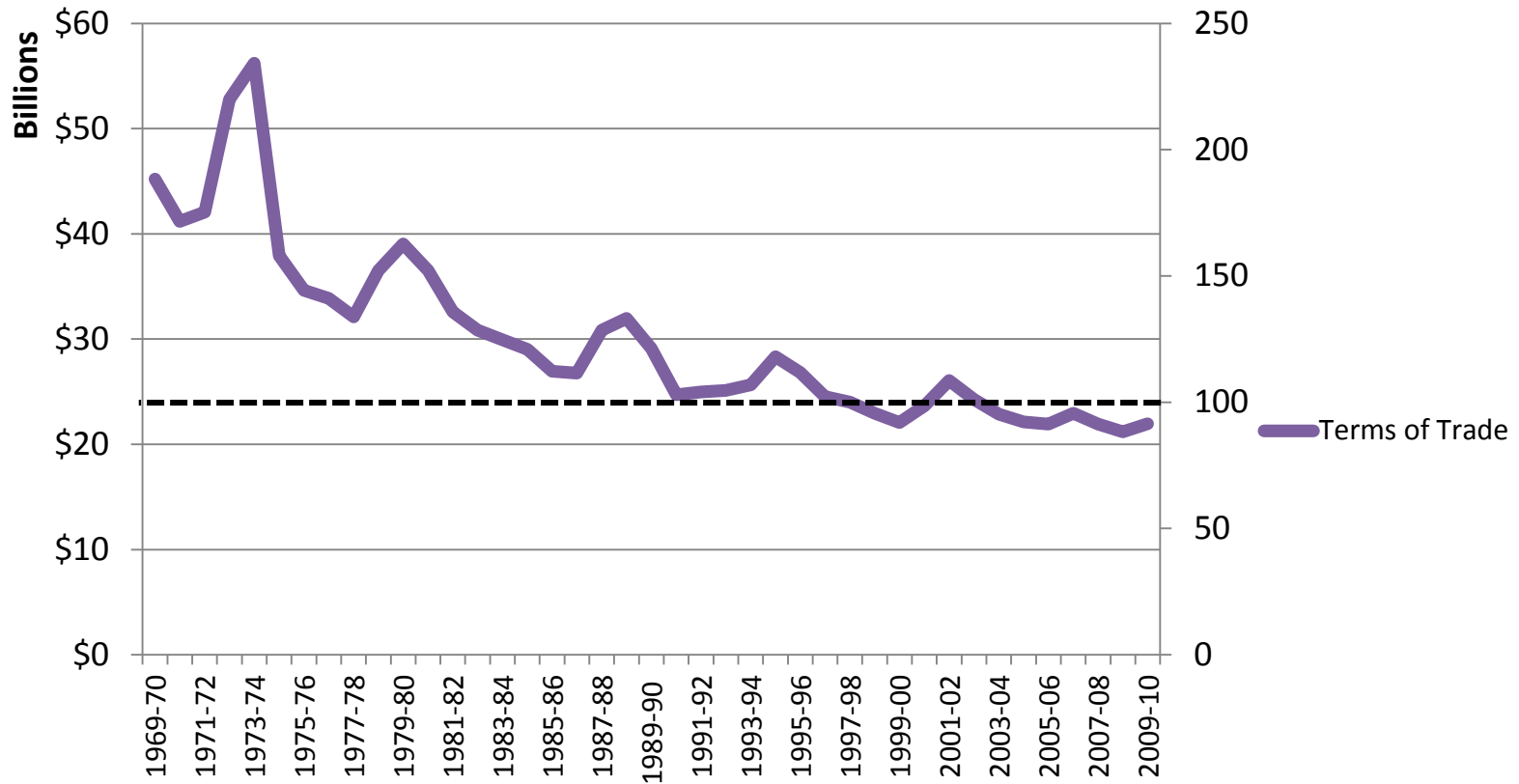
Farm sector performance

Agricultural Returns (2010 Values)



Source: ABARES

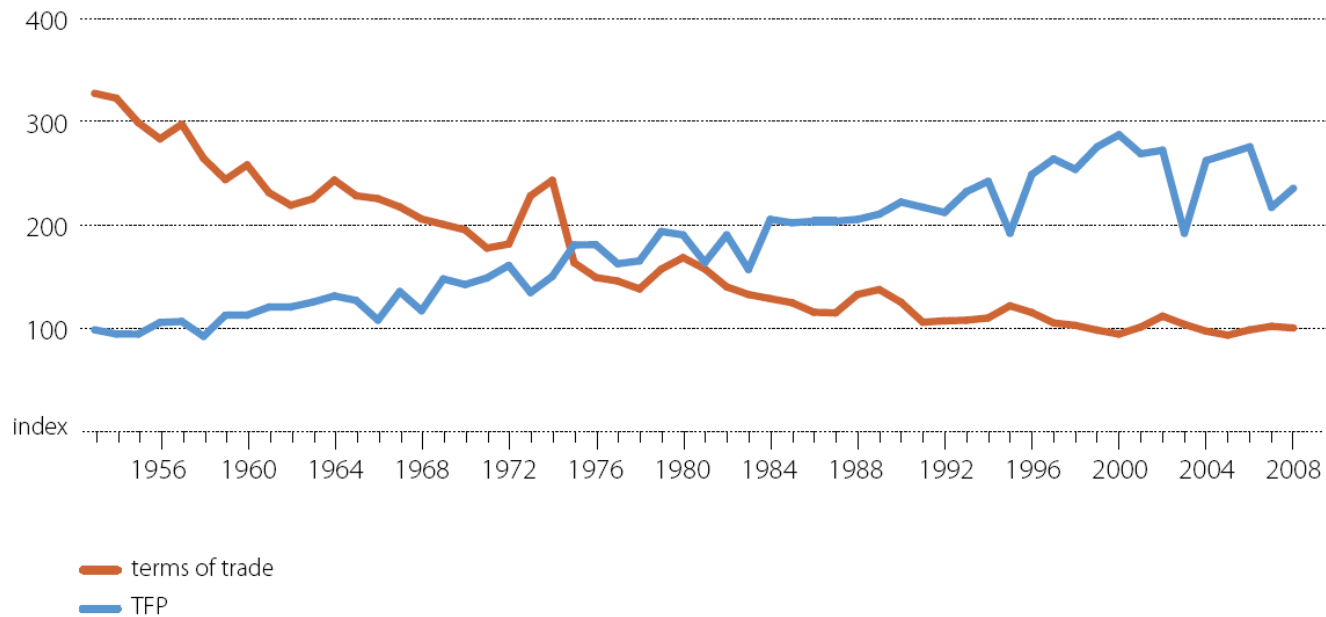
Farm TOT



Source: ABARES

TFP and TOT

2 Broadacre TFP and terms of trade in Australia, 1953–2007



Notes: The terms of trade is the ratio of an index of prices received by farmers to an index of prices paid by farmers (ABARE 2009). TFP is the ratio of a quantity index of aggregate output to a quantity index of aggregate input (Gray et al. 2010).

Source: Shen, Grey & Mullen (2010)

Uncertainty and information

- New information could reduce uncertainty
 - and offer new opportunities as flexibility may increase

“.. information is precisely the observation of a random variable, so that subsequent behavior should be and can be based on the distribution of the variables of interest *conditional* on the value of the observed variable.” – Arrow 2009.

Arrow, KJ 2009, 'Some Developments in Economic Theory Since 1940: An Eyewitness Account', *Annual Review of Economics*, vol. 1, no. 1, pp. 1-16.

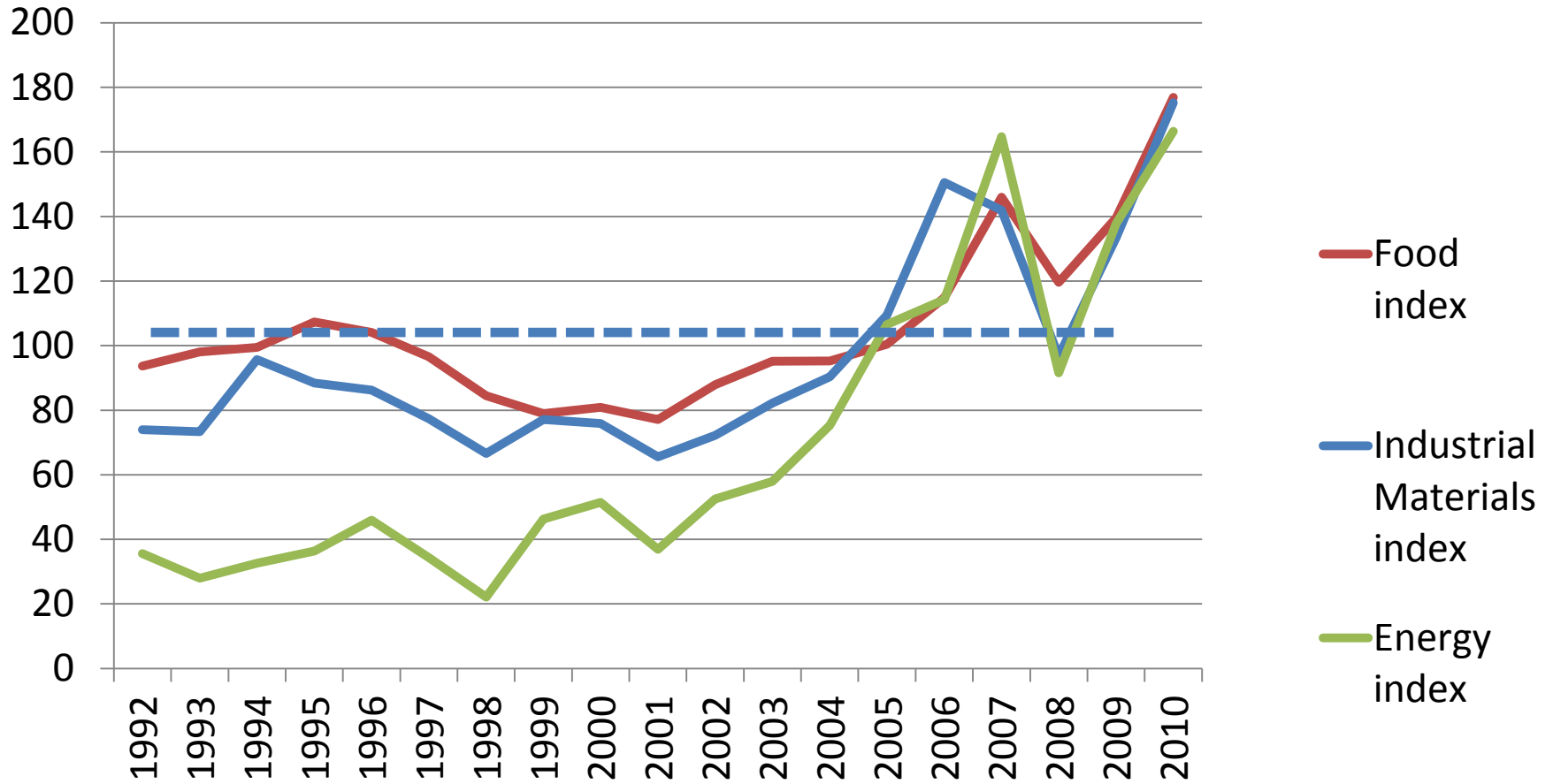
Flexibility and efficiency

- As uncertainty increases, choice problems becomes more complicated
 - While making a prediction, the DM uses the information acquired in previous periods.
- Similarity-based reasoning as a decision process
- infer unknown properties of an object from information about other objects
 - categorise information based on similarity
 - dynamically and endogenously adapt categories to observations

Summary

- Adaptation to climate risks for agriculture involves broader strategic and operational decisions.
- Increasing uncertainty highlights the need for continuous learning.
- The concept of resilience provides an alternative basis to assess adaptation responses.

Price trends



Source: IMF data