The 2006-07 drought in Australia: analysis in a water enhanced version of TERM

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Climate Change and Water

- **With growing population and incomes, water is getting scarcer.**
- **We need to use less fossil energy, but ….**
- **This can conflict with using less water, eg**
  - **desalination: guzzles energy**
  - **bio-fuels: guzzle water**
- **Climate change may reduce rainfall in some places**
- **We *think* a warmer climate may reduce SW Australian rainfall.**

THIS PAPER

- **What is the economic cost of drought in Australia, and how far may water trading alleviate that cost ?**

Australia and Drought

Like elsewhere

- Agriculture is 90% of the problem:
- Farmers want a great deal of water at little or no cost.
- Not much data about the contribution of water to farm output, or the possible response of farmers to volume water charging.

Special to Australia

- Agriculture pays its way.
- A recurring drought cycle provides data about effect on farm output of water shortages.
- Beginnings of a water trading system.
- Around 10 years of attempts to model water use with CGE models.

Irrigation, Drought, and Warming

- Irrigation important for several crops.
- Irrigation water comes from the river.
- Only river water might be charged for.
- River inflow = Rainfall - Evaporation
- 10% less rain means >>10% reduction in river
- Moreover, warming has increased evaporation.
- Farmers have been motivated to adopt practices which reduce runoff
  - tree planting
  - building own dams
- Some very low-hanging fruit
  - rice, cotton, unplugged artesian wells
- A problem of jurisdictions (States Rights)

Some Water Modelling Problems

- **Water usage behaviour varies by crop, region, season, but**
- **Typical CGE model deals with annual values for broad national sectors**
- **How does water enter into the agricultural production function?**
  - **Not much helpful econometrics**
  - **Crop switching is an alternative to water-saving**
  - **unpriced inputs pose some special problems**

Simplest modeling approach

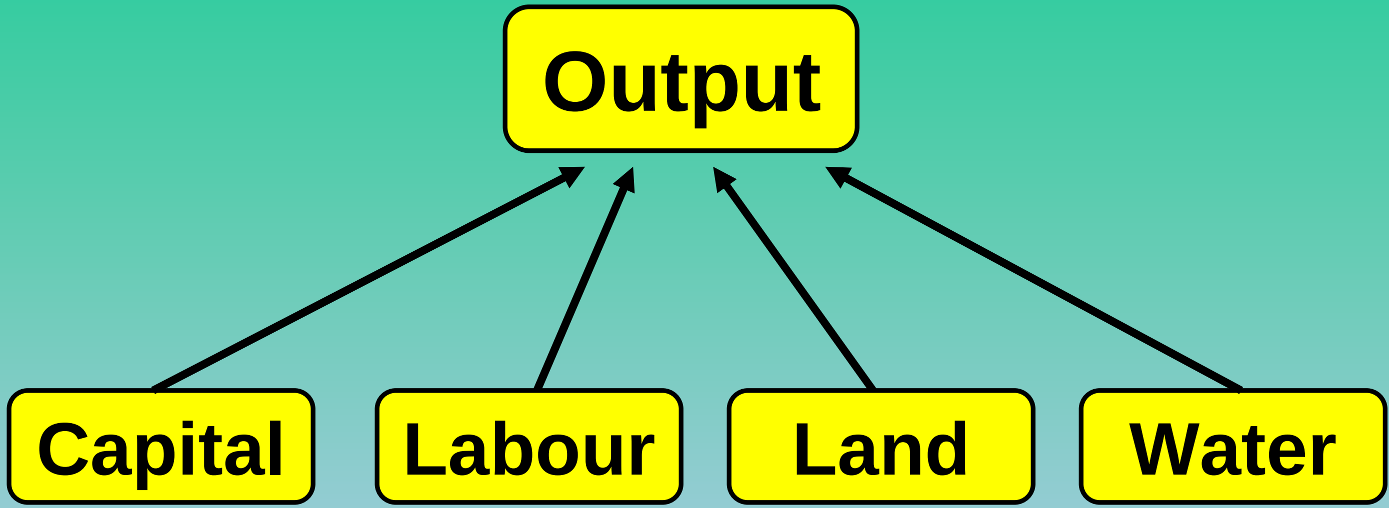
- **Leontief:**
  - **Within each sector/region, water use proportional to output.**
  - **Optionally, water pricing (like a tax on output]**

- **No direct way for water scarcity [prices] to lead to greater water efficiency.**
- **But indirect ways:**
  - **eat less vegetables**
  - **virtual water trade**

Variation

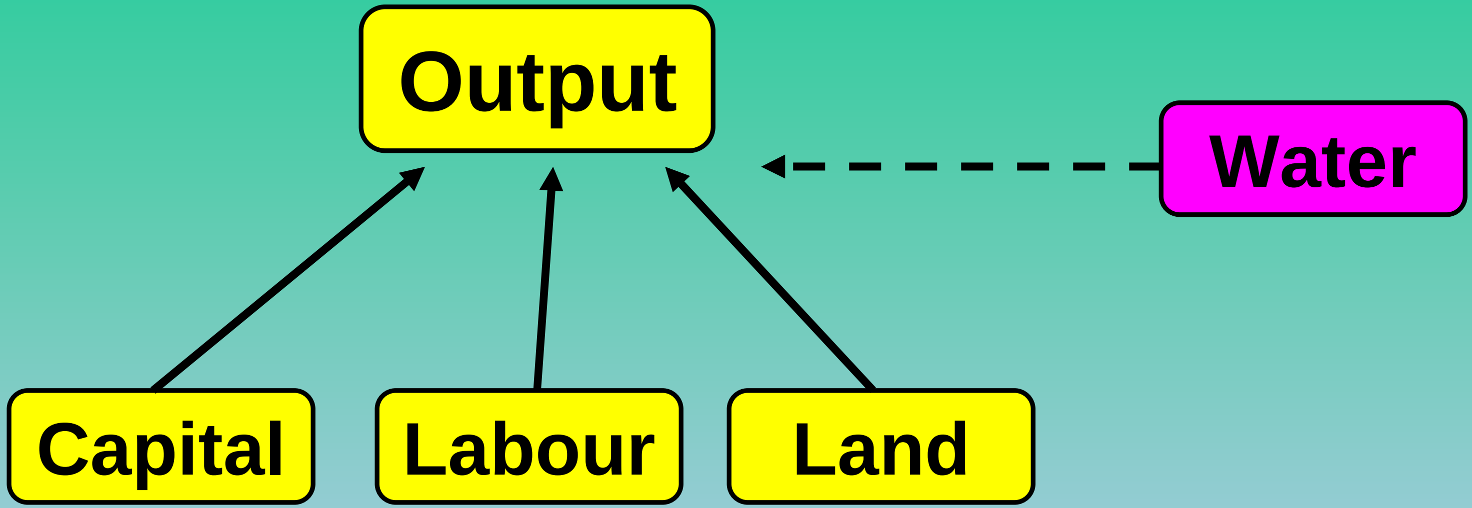
- **[water use/output] an arbitary function of water price**
  - **compatible with cost-minimizing behaviour ?**

CES production function
workhorse of CGE modeling



- Assumes water cost proportional to use, and:
- Water expenditure = contribution to output value of water input
  - Poor assumption with cheap or unpriced water
- Physical not monetary units
- Often water price AND quantity are perceived to be exogenous

Another method



- **Water supply exogenous: it affects efficiency with which other inputs are used.**
- **Con: Water price rise does not automatically lead to water saving**

Our strategy

- Lacking firm evidence, we hope to tell a plausible story.
- That plausibility standard -- the comparison with experience -- requires good sectoral and regional detail:
- eg, we must speak not of water use in Agriculture but of Rice in Northern Victoria.

- Our vehicle…. A detailed regional CGE model

TERM: a 'Bottom-Up' regional CGE model

The
Enormous
Regional
Model

- A series of separate standard CGE models, linked by trade and factor movements.
- Computationally efficient:

  [Nsectors x Nregions] up to 3000
- Data strategy: construct master database with more sector and region detail than can be used: then aggregate for specific problem.
- First Australian version developed 2002
  - database has 169 sectors and 56 regions
- Very useful where:
  - smaller regions are needed to track natural features such as climatic zones or river watersheds.
  - Supply-side constraints are specific to small regions (water shortage).

This version of TERM

- 35 industries (17 agricultural);
- 28 commodities (10 agricultural);
- Agricultural output mix varies by region;
- 18 regions inside Australia
  - clustered around Murray-Darling Basin;

- additions and modifications to better model farm water use and trading.

Simulation Regions

- NorthernNSW NorthWestNSW
- CentrlWstNSW MrmbidgeeNSW
- MurrayNSW FarWestNSW RoNSW

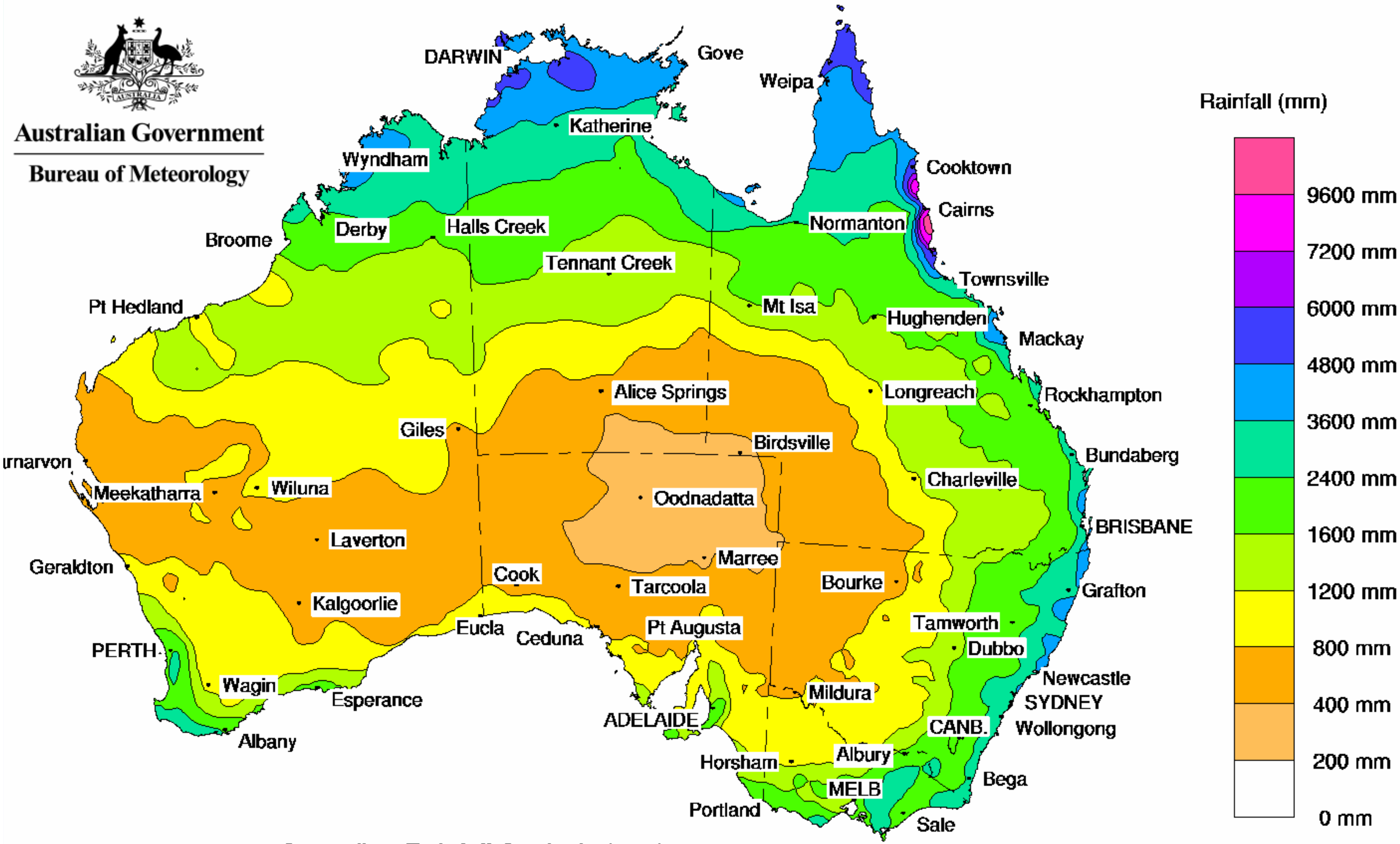
- WimmeraVIC MalleeVIC
- LoddonCmpVIC GoulbournVIC
- OvensMrryVIC RoVIC

- DarlSWQld RoQLD
- MurrayLndsSA RoSA

- RoA

Australian Government

Bureau of Meteorology

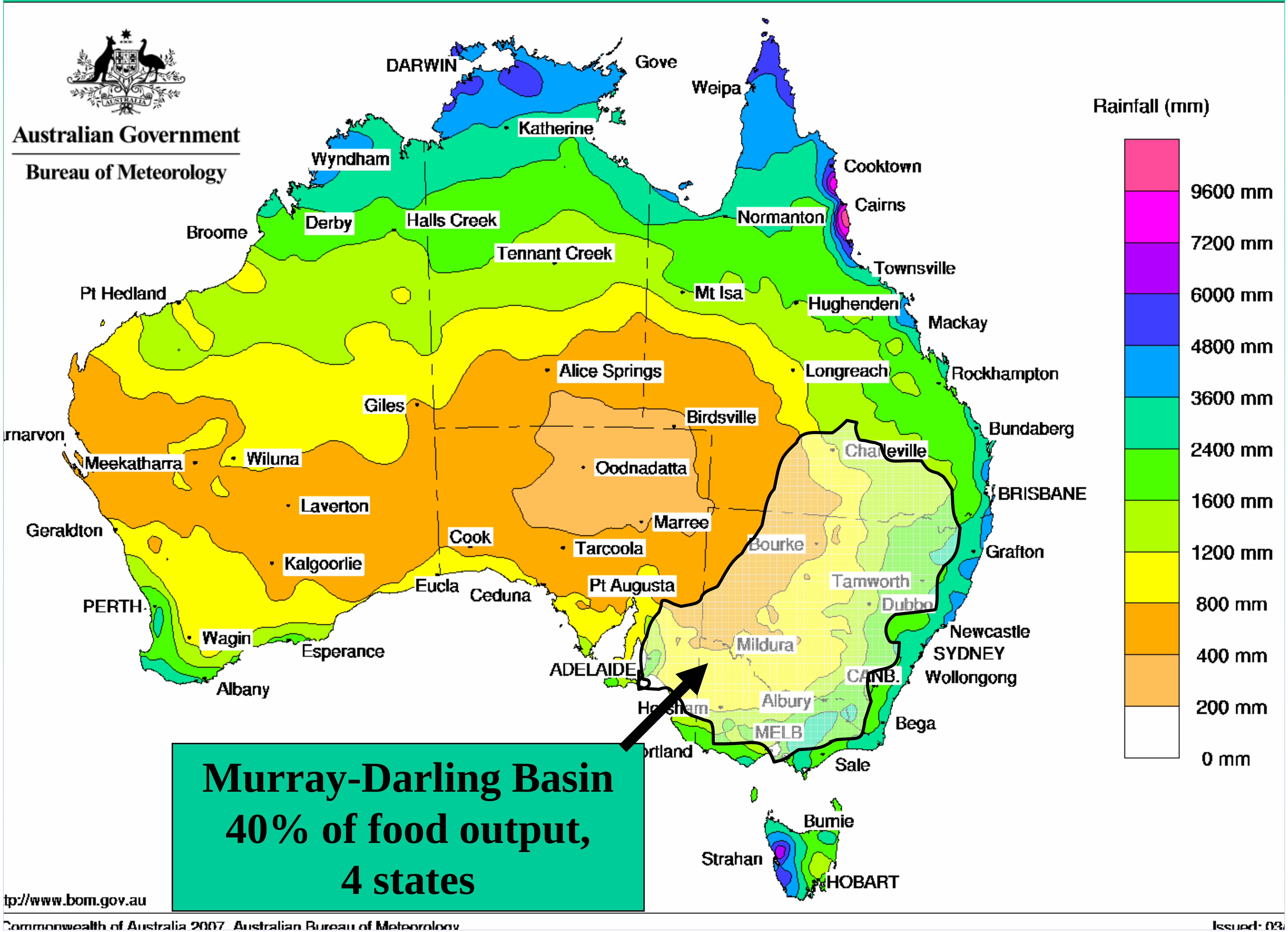


Australian Rainfall Analysis (mm)

1 September 2004 to 31 August 2007

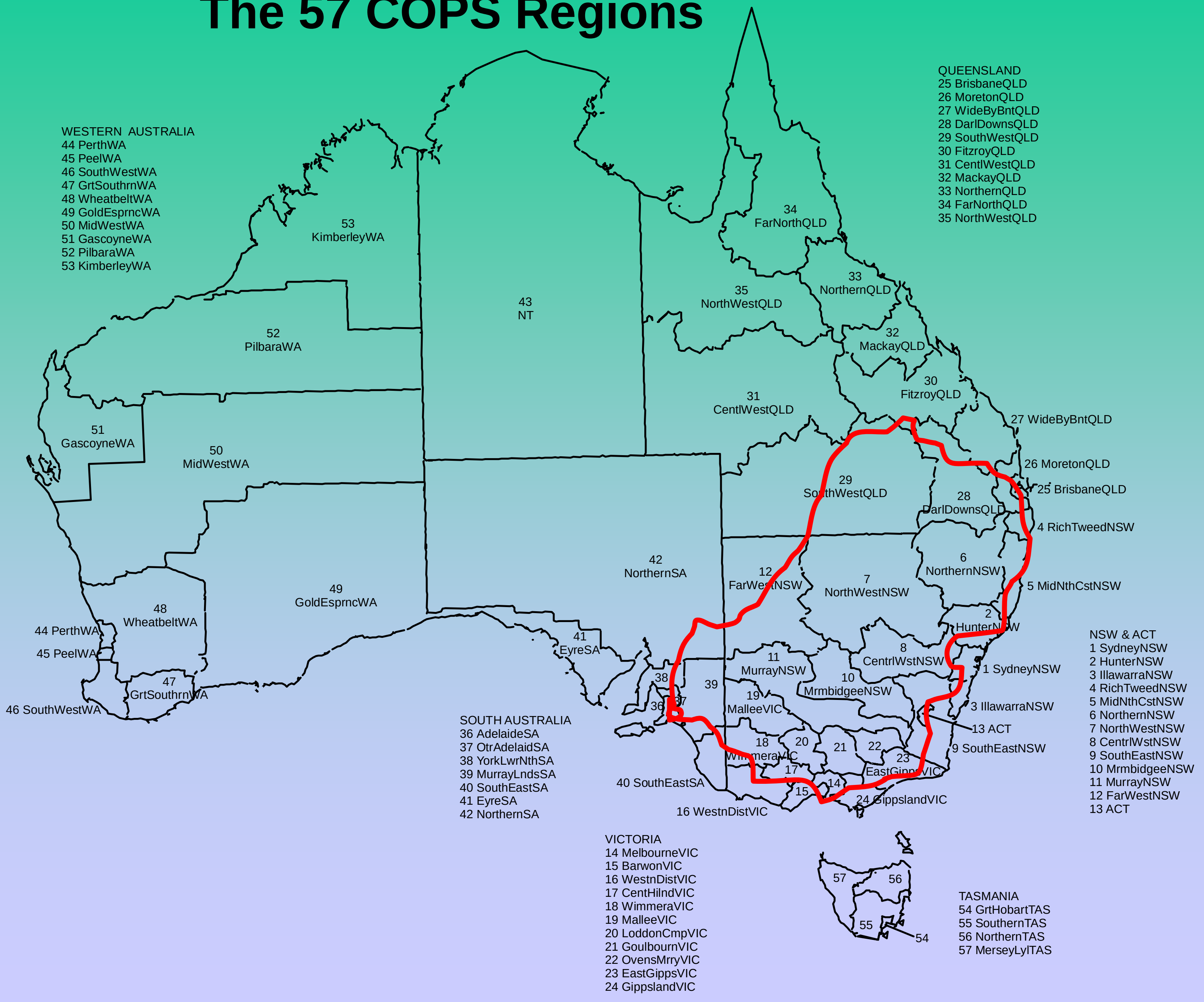
Product of the National Climate Centre

tp://www.bom.gov.au



Murray-Darling Basin
40% of food output,
4 states

The 57 COPS Regions



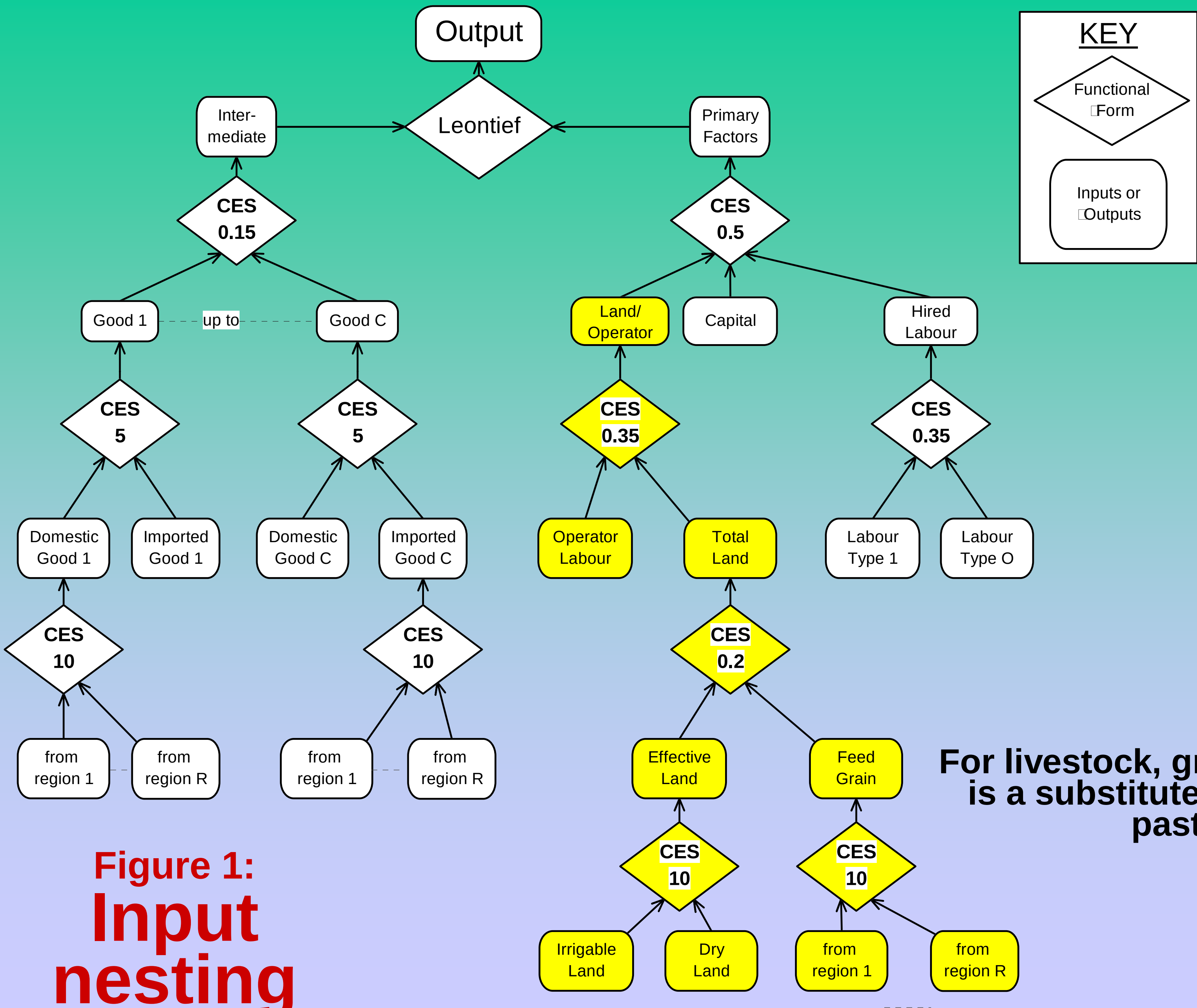
The 17 Agricultural Industries

DRY LAND	IRRIGATED
CerealDryL	CerealIrig
Rice	
DairyCatDryL	DairyCatIrig
OthLivstoDry	OthLivstoIrg
CottonDryL	CottonIrig
Grapes	
Vegetables	
FruitDryL	FruitIrig
SugarCanDryL	SugarCanIrig
OthAgriDry	OthAgriIrig

The Industries

- Distinguish the main water users in the study area
- Are in pairs (Irrigated and Dry-Land), representing 2 ways of growing the same commodity.
- Irrigated crops use water in fixed proportion.
- During water shortage, land may shift from irrigated to dry-land use.

- Water trading, when allowed, allows water to flow between irrigated technogies within a group of regions.



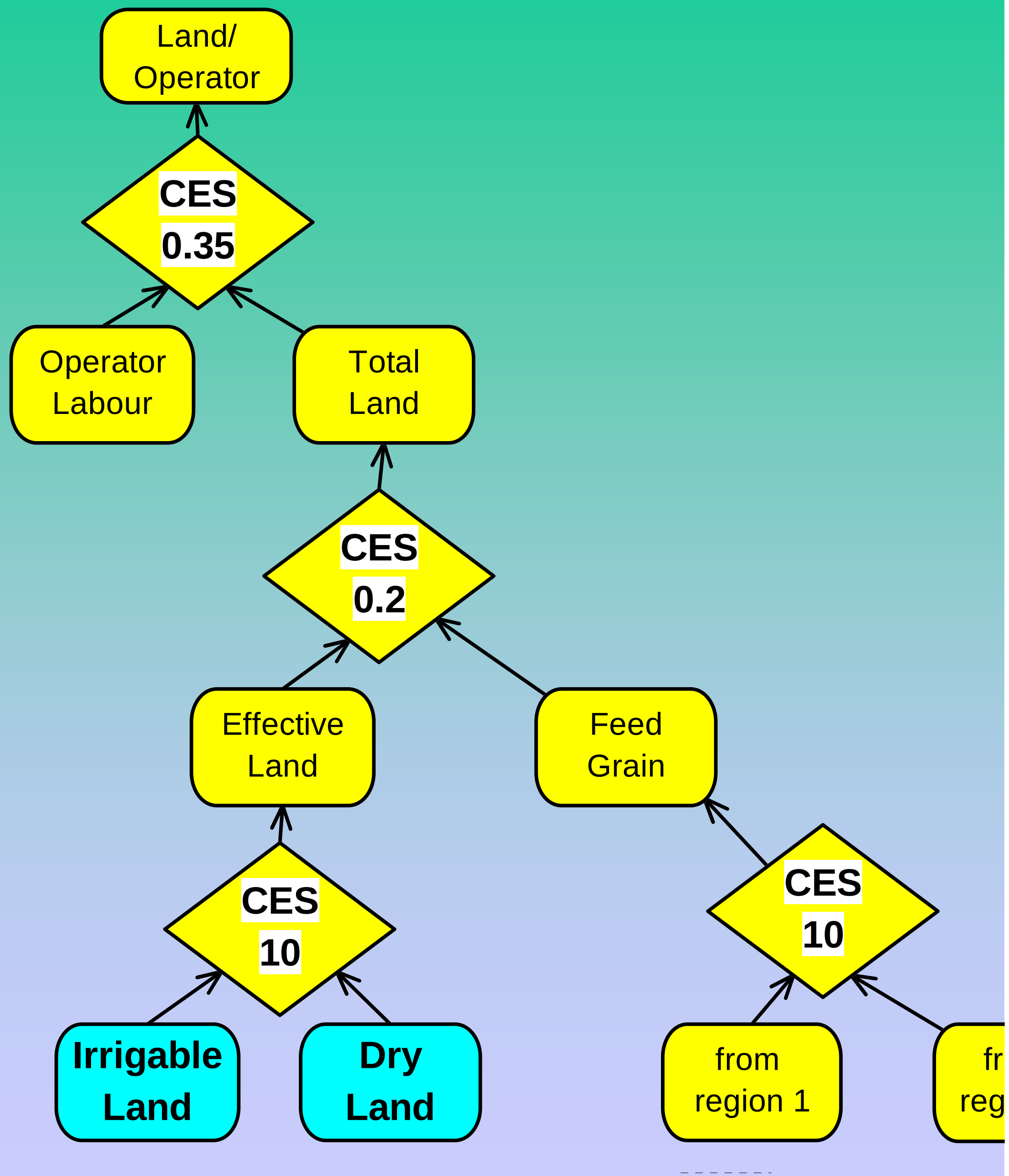
For livestock, grain is a substitute for pasture

Figure 1: Input nesting

Irrigated Sector needs Irrigated Land with water.

Irrigable Land, for which no water is now available, can be used by the Dry-Land sector.

Both land types can move between sectors (CET)



The Scenarios

Table 1: Drought means:

- **a reduction in irrigated land**
- **reduced efficiency for dry-land technologies**

Limited trading scenario

- **water trading within (not between) regions**
- **no water trades between crops and livestock sectors**

Water trading scenario

- **water trading within AND between regions**
- **water trading between irrigated crops and livestock sectors**

Rainfall deficiencies during 2006

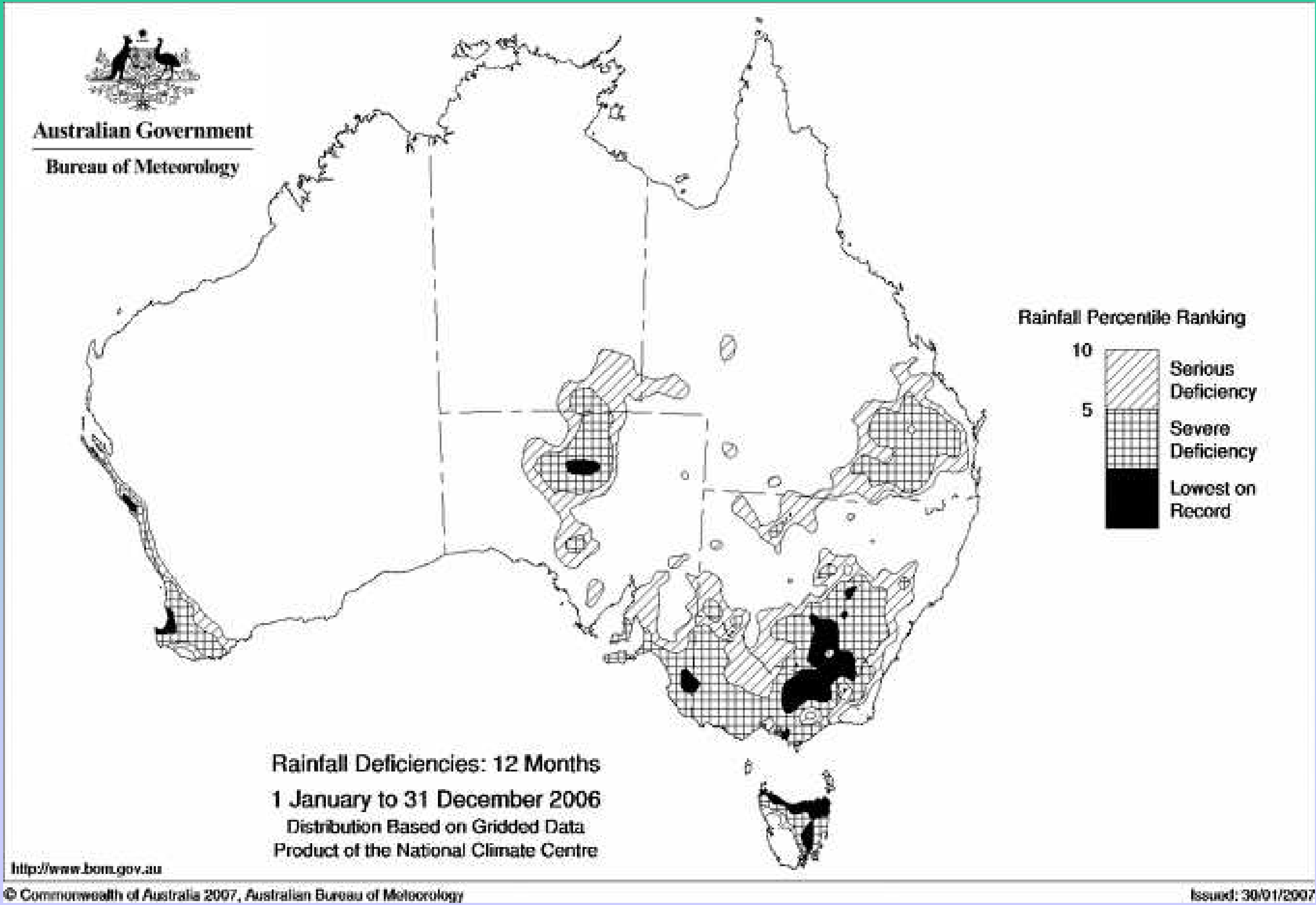


Table 1 Drought technology shocks

	Water	Cereal Dry-land	Dry-land pasture	Cotton Dry-land	Fruit Dry-land	Sugar Cane Dry-land	Other Agriculture Dry-land
RoNSW	80	66.7	0.0	-	76.9	76.9	66.7
NorthernNSW	80	40.0	83.3	71.4	71.4	-	50.0
CentrlWstNSW	60	50.0	66.7	50.0	50.0	-	50.0
MrmbidgeeNSW	30	40.0	57.0	40.0	40.0	-	40.0
……	..	..	..	..	..	..	..
RoVIC	40	50.0	77.0	-	50.0	-	50.0
WimmeraVIC	30	40.0	57.0	-	40.0	-	40.0
OvensMrryVIC	30	40.0	57.0	-	40.0	-	40.0
RoQLD	80	66.7	76.9	66.7	66.7	66.7	66.7
DarlSWQld	60	66.7	66.7	66.7	66.7	-	66.7
MurrayLndsSA	50	40.0	57.0	-	47.6	-	47.6
RoA	50	66.7	71.5	62.5	62.5	-	66.7

Water for irrigation

100 = normal

DryLand productivity

Table 3: Sectoral Effects of Trading

	Limited Trading		Water Trading	
National output	Output	Price	Output	Price
Cereals	-50.9	45.8	-49.9	44.0
Rice	-90.8	66.3	-93.9	70.8
DairyCattle	-2.8	12.2	-3.4	14.5
OtherLivestock	-5.3	6.5	-5.3	6.4
Cotton	-11.7	35.3	-10.1	28.2
Grapes	-12.4	64.7	-5.3	24.0
Vegetables	-6.5	20.1	-2.0	3.7
Fruit	-7.8	25.2	-3.3	9.5
Sugar cane	-9.8	54.2	-8.3	44.9
Other Agri	-10.3	45.9	-8.3	36.3

Table 3: Macro Outcomes

	Limited water trading	Water trading
Real Hou	-1.54	-1.32
Real Inv	-1.36	-1.18
Real Gov	0	0
Exp Vol	-1.81	-1.69
Real GDP	-1.43	-1.26
Agg Employ	-0.84	-0.68
Avg real wage	-0.86	-0.74
Agg Cap Stock	0.00	0.00

Difference = $A 1.2 billion

Future Research

Even more regional detail

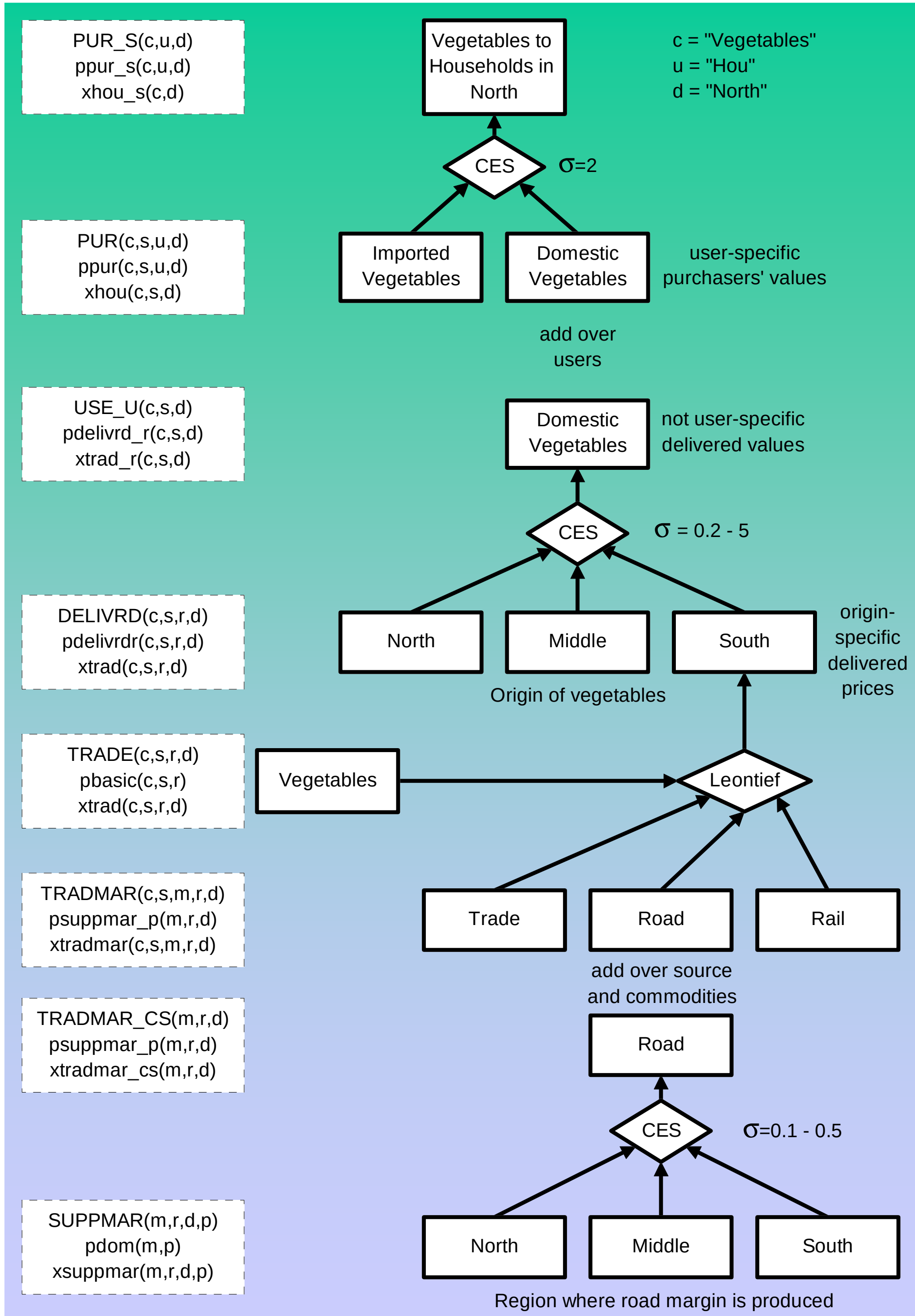
- **regions that match hydrology**

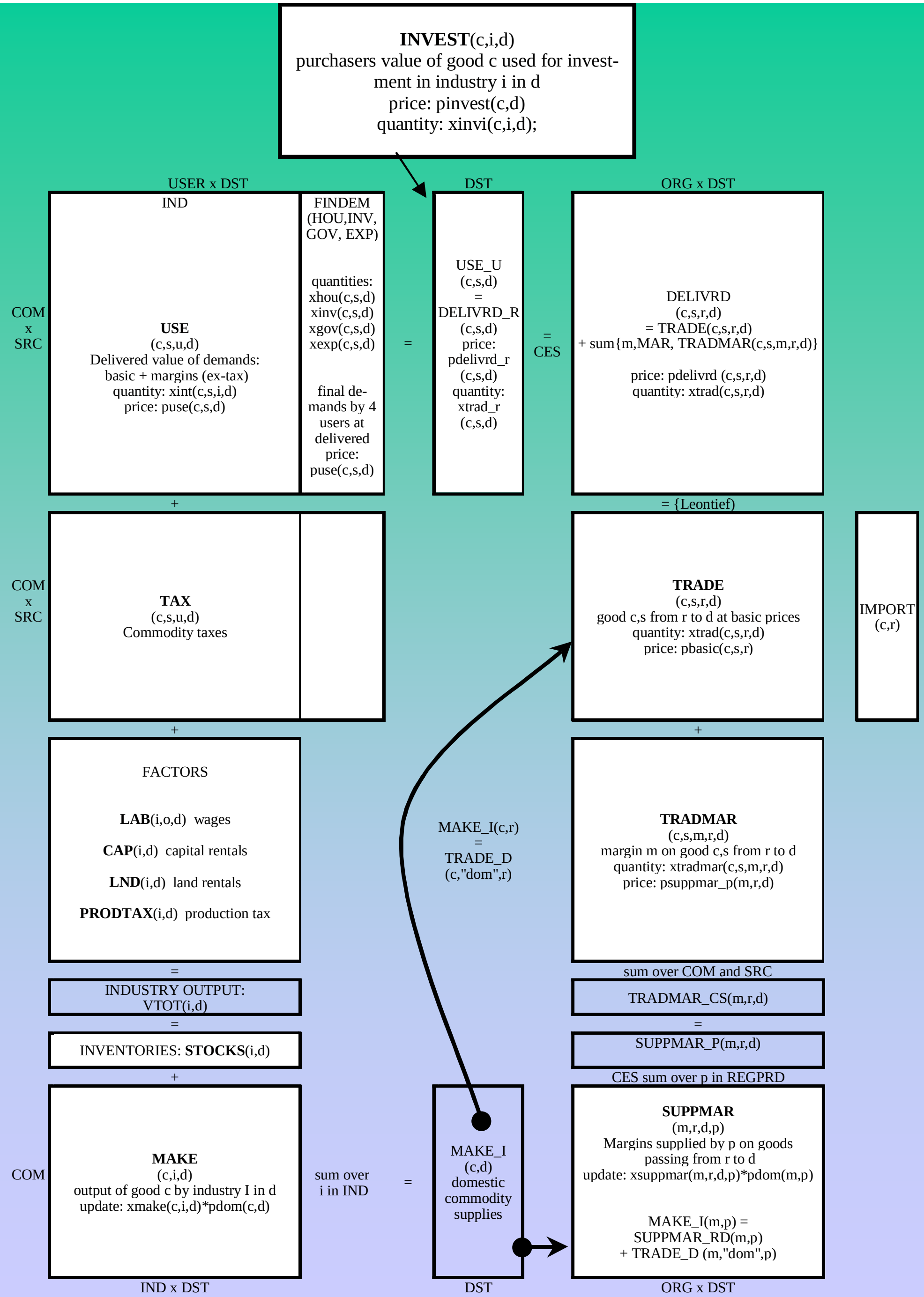
Timescale:

- **a year is too short to capture preservation behaviour (animals, vines)**
- **trading water between years**

End

TERM sourcing mechanisms





Index Set Description

c COM Commodities
s SRC Domestic or imported (ROW) sources
m MAR Margin commodities
r ORG Regions of origin
d DST Regions of use (destination)
p PRD Regions of margin production
f FINDEM Final demanders(HOU, INV,GOV, EXP)
i IND Industries
u USER Users = IND + FINDEM
o OCC Skills

TERM data diagram (see paper)

TERM/MMRF data process

- A sophisticated and standardized automatic process for creating a multi-regional database.
- Little additional data is needed:
  - National IO table
  - Region shares of industry outputs
  - Other regional data is optional
- Produces full regional IO tables and trade matrices
- Usually, gravity/distance formulae used to create inter-regional trade matrices
- Assumes similar technology in all regions
- The secret: many detailed sectors:
  - rice growing technology the same in all regions
  - "agriculture" technology NOT the same in all regions