# Applying economics to wicked problems: Protecting the Great Barrier Reef


AARES Presidential Address

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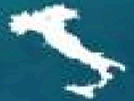
# Great Barrier Reef Marine Park


**AREA**
344,400 km$^2$

**LENGTH**
2300 km long

70 million
**football fields**

Roughly the same area as…



**ITALY**

**JAPAN**

**GERMANY**

**MALAYSIA**

3000 coral reefs

600 continental islands

1625 types of fish

133 varieties of sharks and rays

600 types of soft and hard corals

# But GBR is under pressure

- Most recent Outlook report (GBRMPA) lists key threats as:
  - Climate change
    - Very high impact & risk, ineffective measures
  - Coastal Development
    - High impact & risk, but good measures in place
  - Land-based runoff
    - High impact & risk, but very good measures in place


| | Influencing factors | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Direct use | | | | | | | | |
| | Climate change | Coastal development | Land-based run-off | All (overview of all direct use activity) | Commercial marine tourism | Defence activities | Fishing | Ports | Recreation (not including fishing) | Research and educational activities | Shipping | Traditional use of marine resources |
| **Activity** | Green-house gas emissions | Agriculture; mining; urban, industrial, port and island development | | | | | | | | | | |
| **Origin** | Global | Great Barrier Reef Catchment | | Great Barrier Reef Region | | | | | | | | |
| **Impact** | | | | | | | | | | | | |
| **Effectiveness of existing measures** | | | | | | | | | | | | |
| **Risk** | | | | | | | | | | | | |

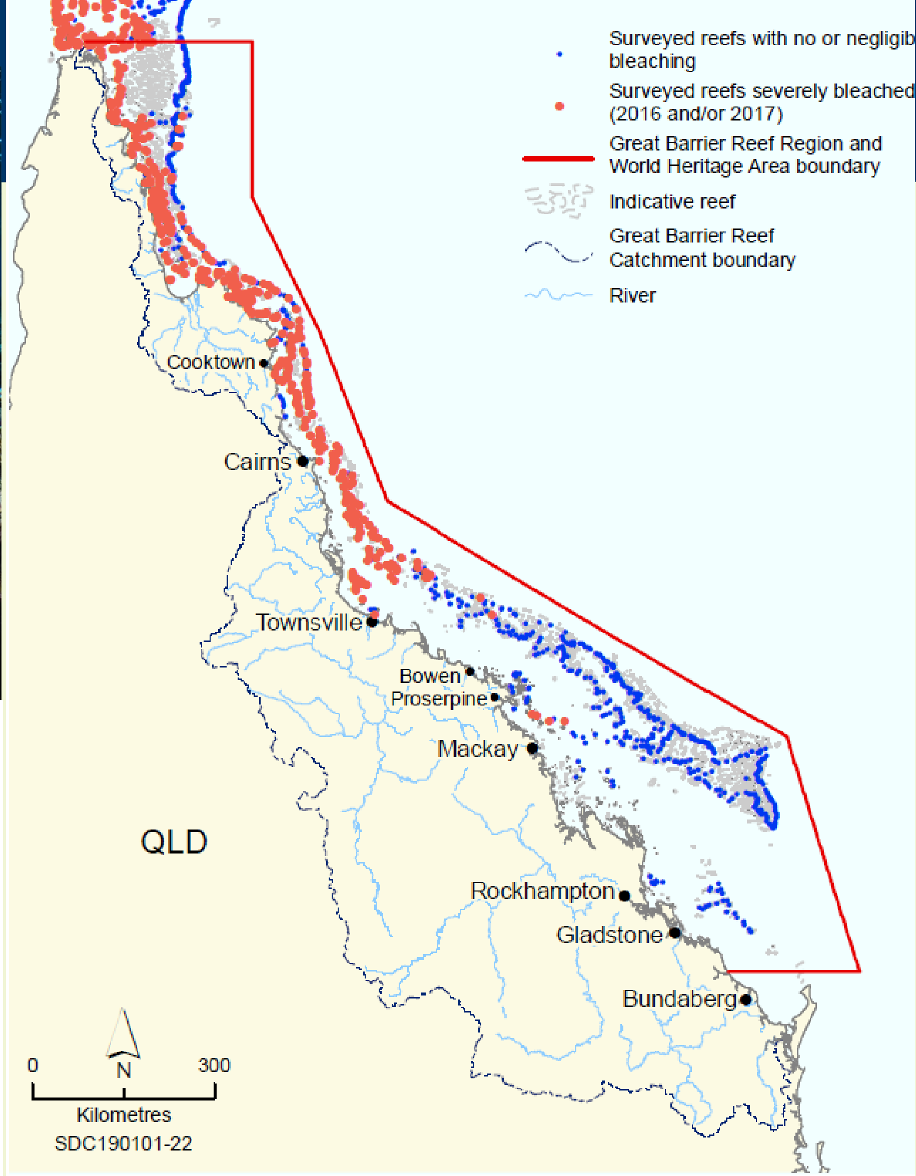
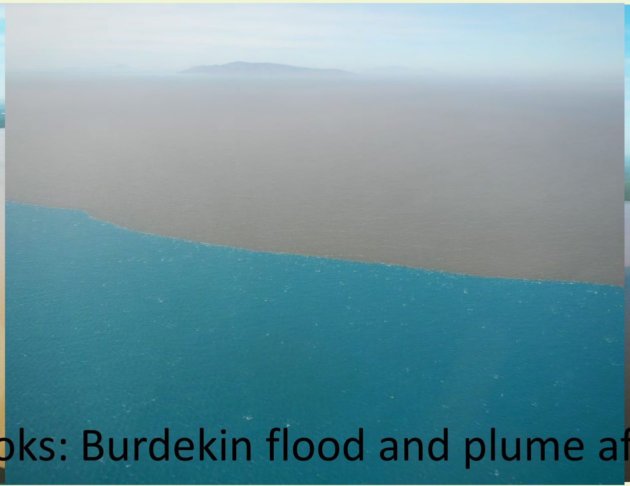



**Figure 2.6 Cumulative footprint of coral bleaching in the Great Barrier Reef during the summers of 2016 and 2017**
*Dots indicate: (red) surveyed reefs where >60 per cent of corals were bleached; and (blue) reefs that were surveyed but had no or negligible bleaching.* Source: ARC Centre of Excellence for Coral Reef Studies[94]

# Sediments from grazing and nutrients from farming lands are major issues

- Sources of sediment include degraded lands, gullies and stream banks
  - High rates of erosion in major rainfall events
- Sources of nutrients (and pesticides) are largely from sugar and bananas
  - Move through both surface water and groundwater
  - Overapplication or inferior application methods typically raised as underpinning causes

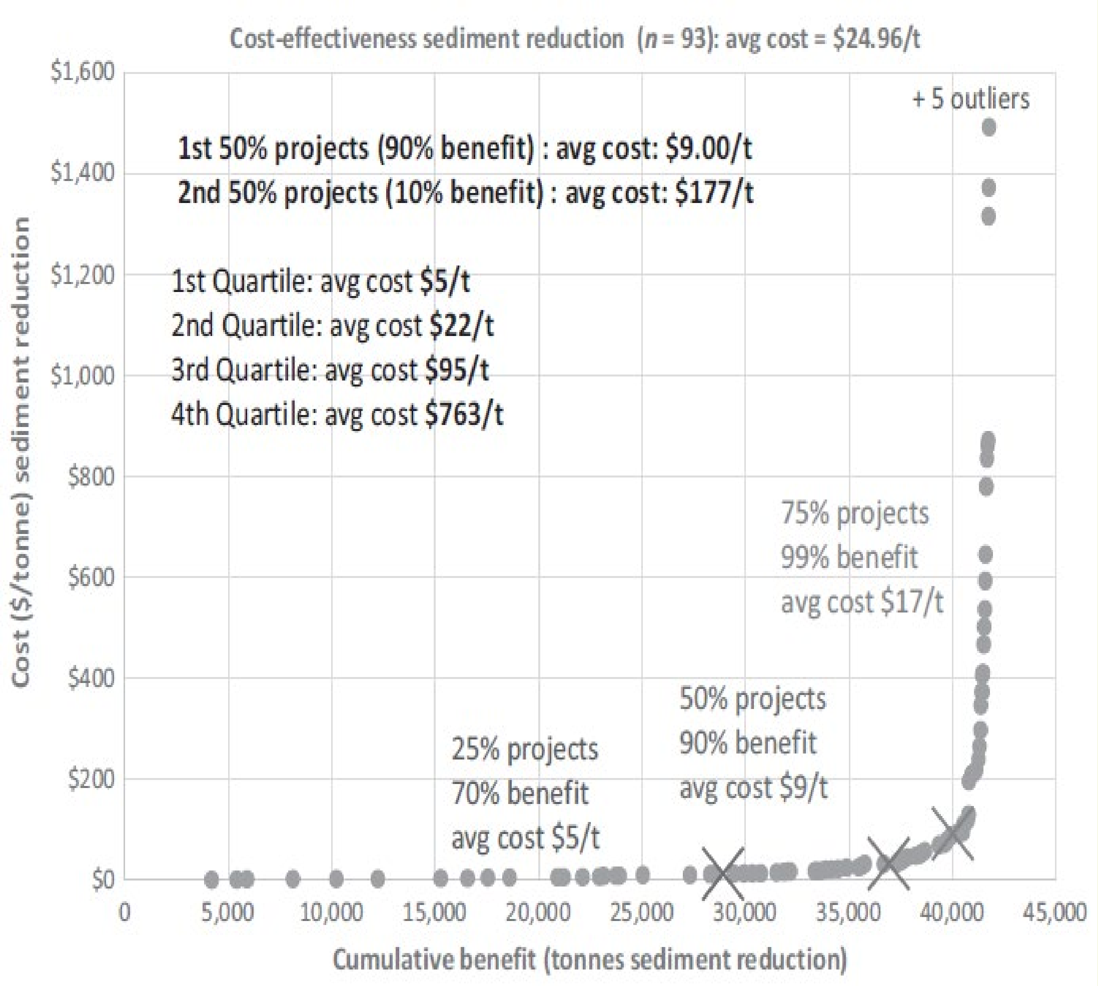


Photos from Andrew Brooks: Burdekin flood and plume after Cyclone Debbie March 2017

# So that should be simple to fix …or not

- Causes and effects very complex
  - Many lands produce very little pollutants
  - Impact of pollutants on reef condition difficult to judge
  - Intermittent plumes typically flow north close to the coast
- Selection of targets and policies has been evolving
  - Targets have changed over time
  - Large variations in programs and policies
- Effectiveness of policies has been debatable
  - Reducing erosion is slow and difficult to address
  - Nutrients are invisible, hard to estimate
  - The targets for pollutant reductions seem unrealistic
  - Adoption rates for better practices slow
- Difficult to generate agreement
  - Many farmers unconvinced about pollutant's impact
  - Science is becoming more contested
    - Peter Ridd argues science is flawed
    - Current Parliamentary inquiry into evidence base for water quality impacts on the Great Barrier Reef



# Characteristics of wicked problems

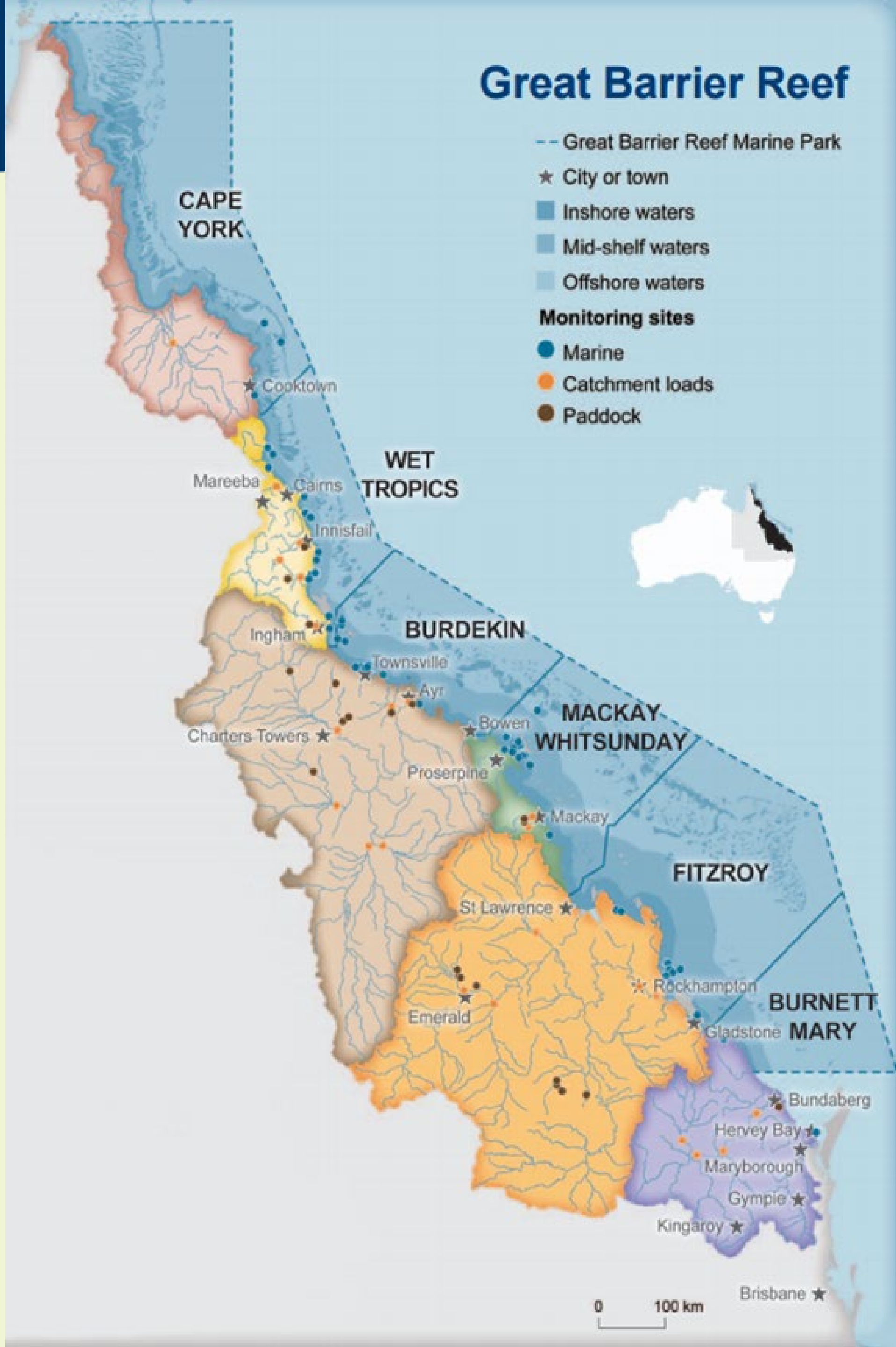
- Wicked problems are dynamically complex, ill-structured, public problems (Rittel and Webber 1973).
- Some of the characteristics of wicked problems (APSC 2007)
  - *Wicked problems are difficult to clearly define*
  - *Wicked problems have many interdependencies and are often multi-causal*
  - *Attempts to address wicked problems often lead to unforeseen consequences.*
  - *Wicked problems are often not stable.*
  - *Wicked problems usually have no clear solution*
  - *Wicked problems are socially complex.*
  - *Wicked problems hardly ever sit conveniently within the responsibility of any one organisation.*

# The focus of this talk

- GBR is typical of a wicked problem
  - Environmental asset impacted by agriculture practices and other pressures
  - Substantial investment by Australian and Qld Governments in programs and funds
  - Very difficult to solve issue
- But use of economics very limited to date
  - Perhaps typical of wicked problems
- Therefore how can we structure economic analysis to be helpful?
  - Can the standard three-step framework that we use for standard resource issues be applied to wicked problems?
  - What could improve the usefulness of economic analysis to GBR issues ?

# If Economics was useful ….

- At the GBR level
  - Select targets and policies by comparing the benefits of improvements against the costs
    - So that investments generate the most improvements to reef health
- At the paddock level
  - Select projects and actions that delivered best reef outcomes at lowest cost (CBA)
- Quickly adaptable to changing information
- Complementary to other disciplines
- Useful in changing people’s behaviour



# How to analyse resource economics issues

Adapting the approach of David Pearce (UK economist 1941 – 2005) to use three key steps:

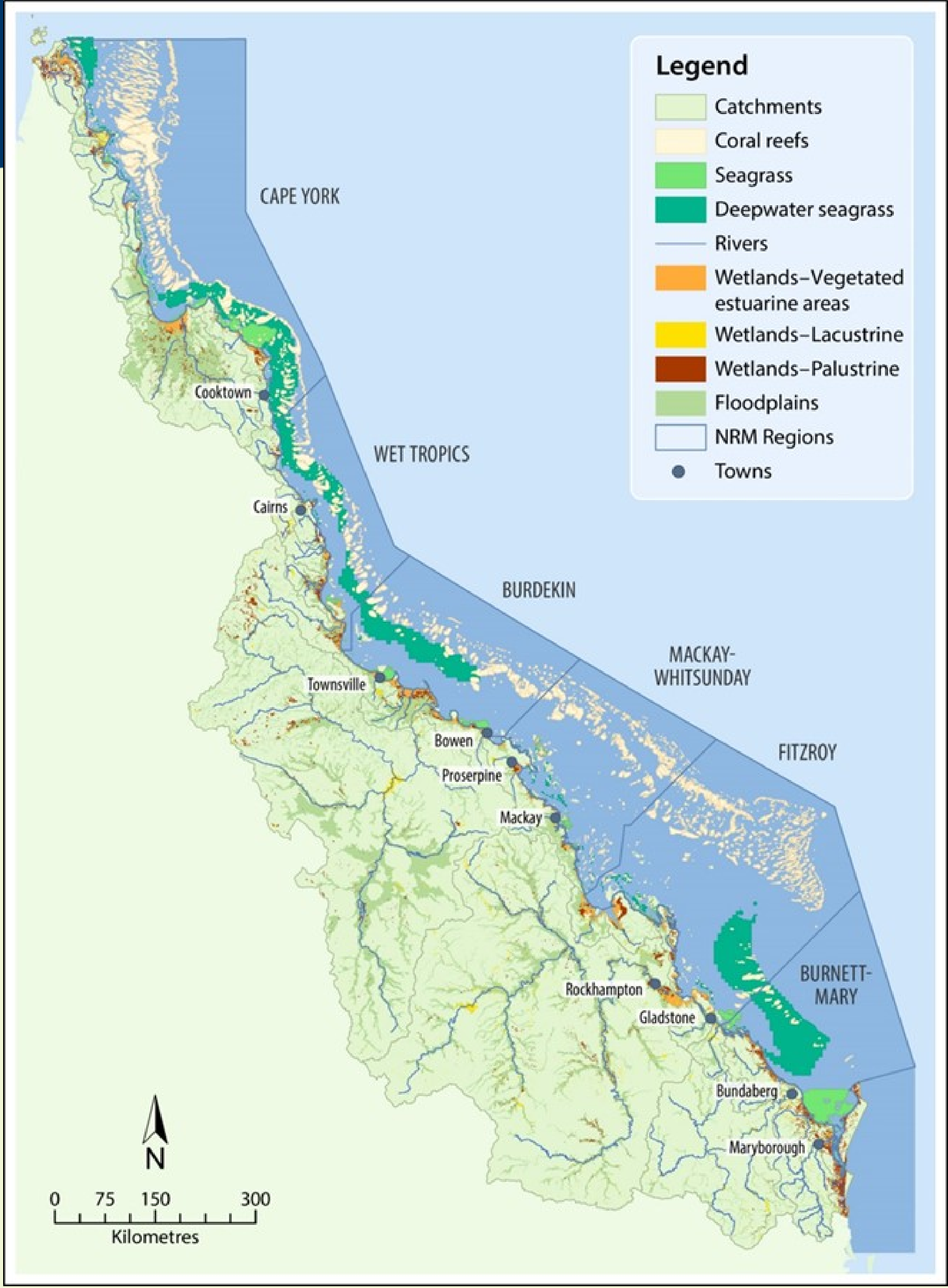
- **Identify what causes the problem**
- **Is it worth fixing ?**
- **Identify solutions and mechanisms**

Cost benefit analysis commonly applied to the 2nd question

- Identify the benefits of improvements and compare them to the costs
- Grounded in welfare economics
- Different valuation techniques needed for assessment

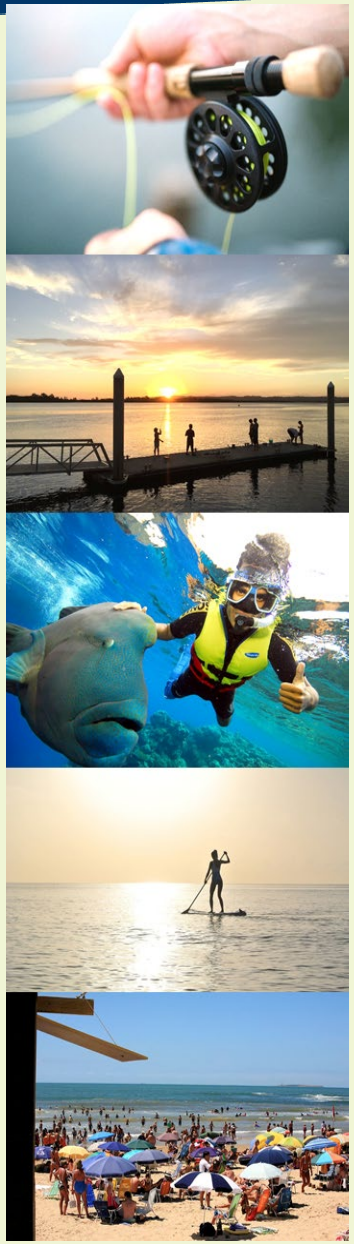
With environmental and other issues, not all impacts can be measured with market data

- Specialist techniques needed to value these



# Three stage approach is straightforward for small, discrete problems

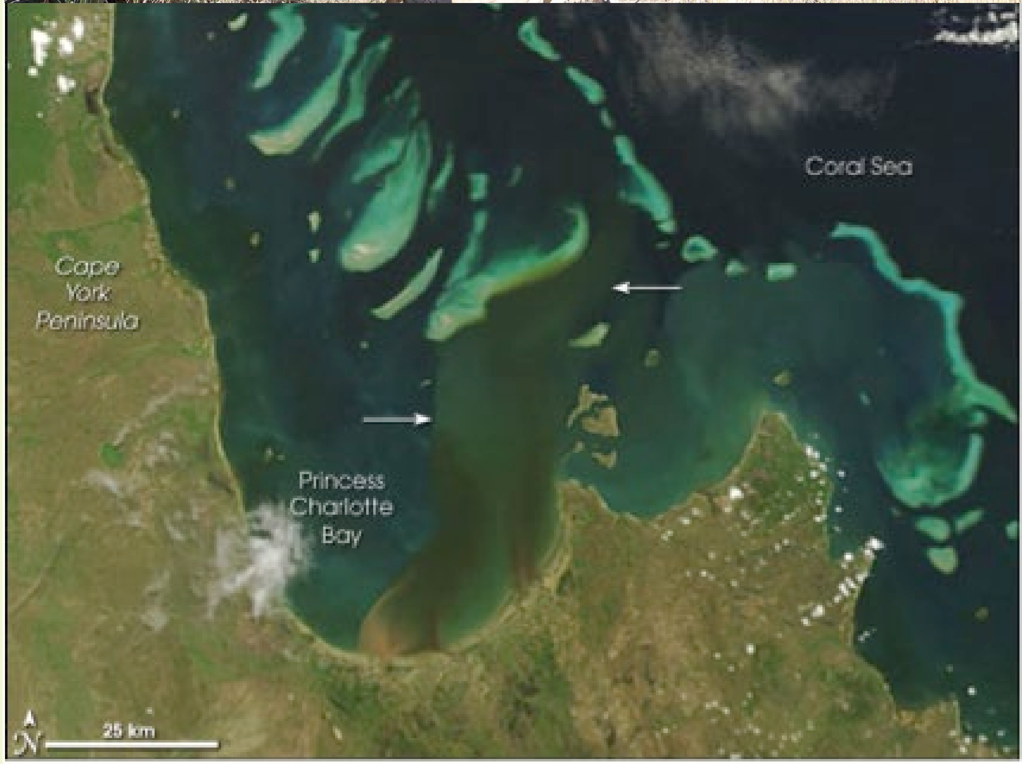
- *Overfishing*
  - Step 1: problem is a tragedy of the commons
  - Step 2: apply CBA to assess whether the benefits of maintaining fish stocks outweigh the costs of solution
  - Step 3: If CBA positive, recommend solutions, such as ITQs or better regulation



- *Bushland versus Agric*
  - Step 1: problem is a public good issue (biodiversity) vs clearing for agric. production
  - Step 2: apply CBA to assess whether the benefits of extra ag production outweigh the benefits of retaining the forest
  - Step 3: If CBA negative, recommend solutions, such as offsets, changes in property rights, or better regulation

# But not so easy for wicked problems

- Stage 1 – Identify the problem
  - *Wicked problems are difficult to clearly define*
  - *Wicked problems have many interdependencies and are often multi-causal*
  - *Wicked problems are often not stable.*
- Stage 2 – Evaluate whether to address it
  - .Benefits often difficult to assess
  - Solutions hard to cost
  - Time frames and discount rates
- Stage 3 – Identify solutions
  - *Wicked problems are socially complex*
  - *Wicked problems usually have no clear solution*
  - *Wicked problems hardly ever sit conveniently within the responsibility of any one organisation.*
  - *Attempts to address wicked problems often lead to unforeseen consequences.*



# Applying the three step process to the GBR

- Identify the problem

STEP 1

STEP 2

- Is it worth fixing ?

- Identify the solutions

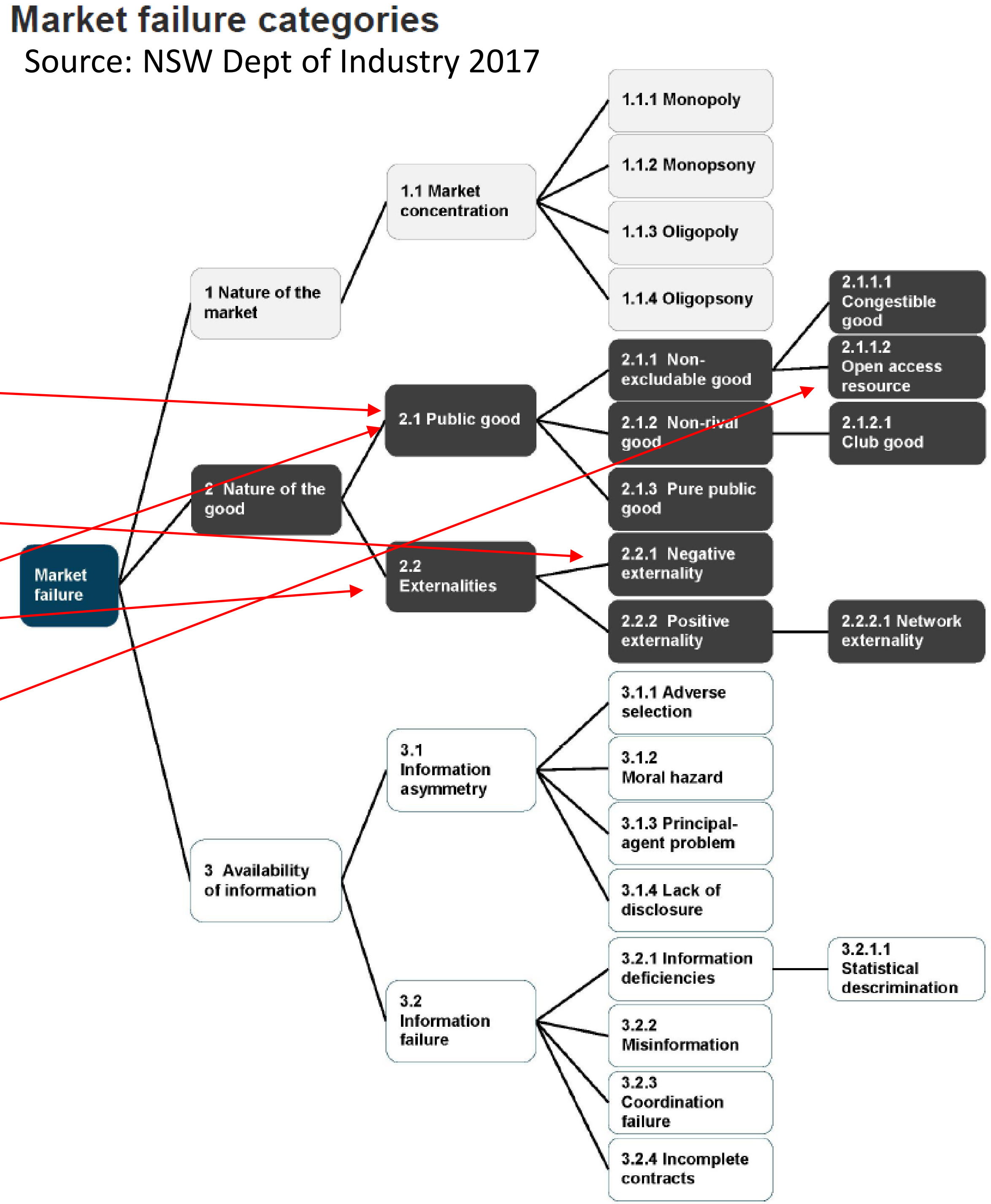
STEP 3

# Step 1: What causes the problem – Water quality into the GBR?

- Standard economic analysis
  - Negative externality (pollution) from diffuse sources affecting multiple parties
    - Multiple causes and effects makes it difficult to align costs and benefits of change
    - Multiple generating and receiving parties makes it difficult to negotiate solutions
- Other issues that have become apparent over time
  - Challenges in getting farmers to adopt better practices
  - Changing knowledge about science of the GBR
  - Limited knowledge about effectiveness of government programs and practices
  - Science and management interventions becoming much more contested

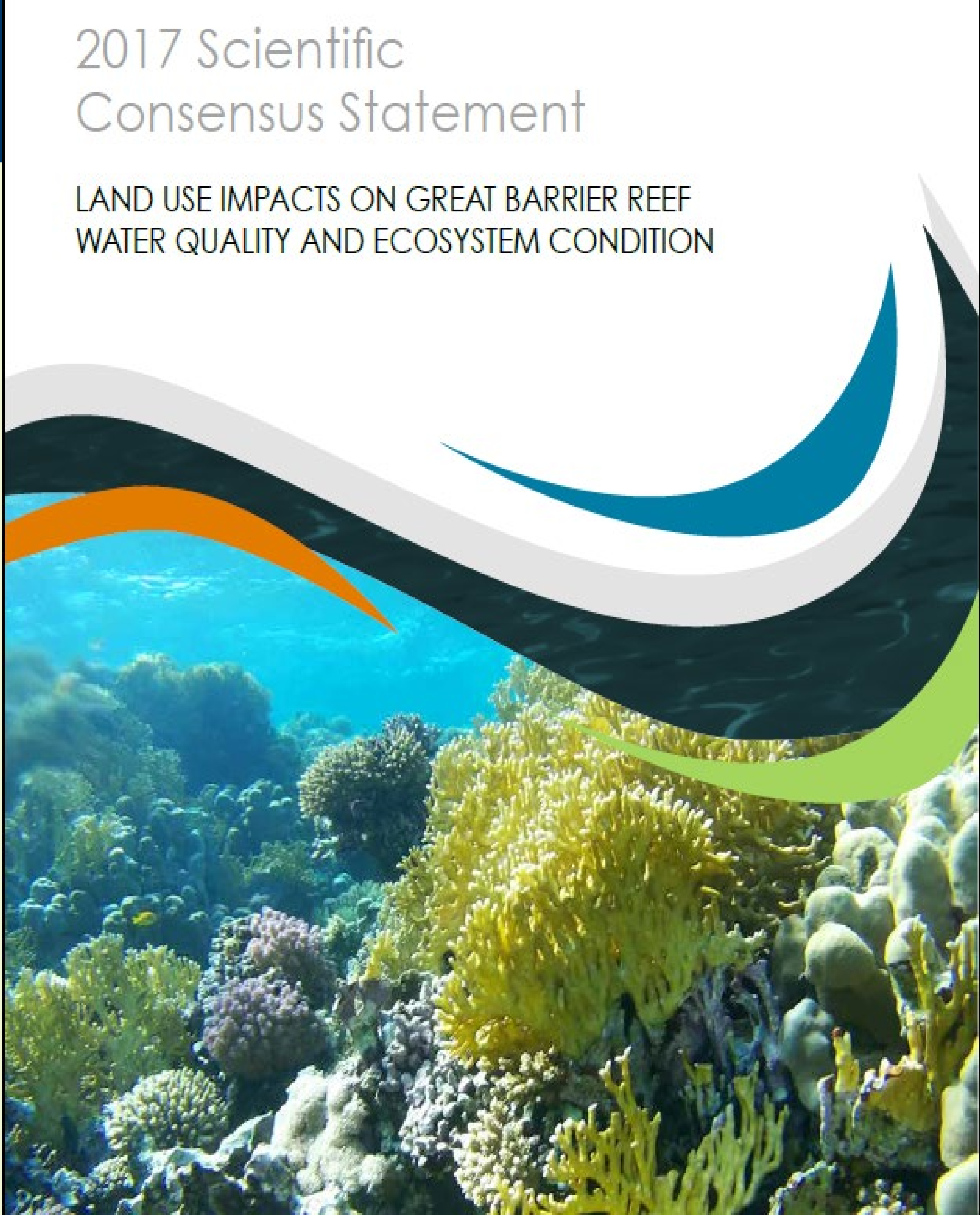

# Step 1 – Conceptualising the initial problem

- Reef protection
  - Public good issue
- Water pollution issues
  - Negative externality issues
- Climate change impacts
  - Negative externality + public good
- Fishing
  - Open access resource



# Challenges with Step 1 for wicked problems

- Science understanding evolves over time
  - Significant changes in understanding about the generation, delivery and impact of pollutants on GBR over the past two decades
    - Knowledge summed in GBR Scientific Consensus Statements (2008, 2013, 2017)
    - Aimed at consolidating and updating science information at points in time
  - This consolidation approach has potential application for economics
- Many causes and effects are interrelated
  - Economics identifies individual causes
  - But need to improve how we deal with combinations of causes



# Applying the three step process to the GBR

- Identify the problem

STEP 1

STEP 2

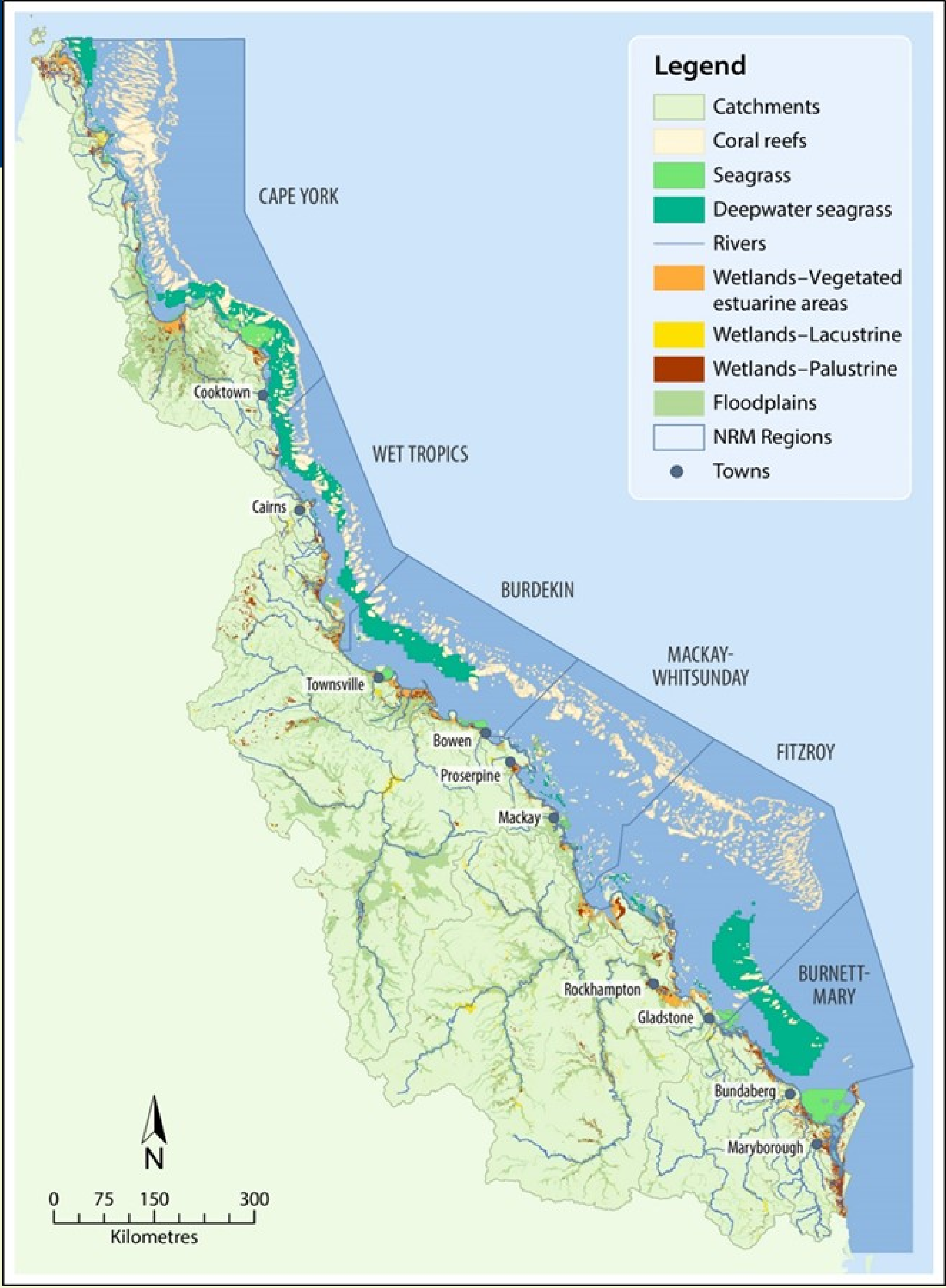
- Is it worth fixing ?

- Identify the solutions

STEP 3

# Stage 2 – Assessing the costs and benefits to protect GBR

- The power of economics
  - Weighing up the tradeoffs (so as to prioritise)
  - Using marginal analysis, rather than just total costs
  - Standard workhorse is cost benefit analysis
- Involves assessing the benefits of pollutant reductions and comparing them to the costs of management changes
  - Use dollar values as a standard measurement unit
  - Discount all values to a common time period
- Can do primary studies
- Or reuse values in benefit transfer process



# How do other disciplines make decisions?

Paraphrasing the approach of the ecologists

- **Quantify the size of the asset**
- **Identify condition and trends**
- **Fix the biggest problems / Give some nature trump status**

Different set of implicit assumptions

- Natural systems are ideal state to aim for
- Causation relationships often too difficult to prove
- Removal of pressures is a key objective

An underlying assumption is often that the precautionary principle should apply

- Changes burden of proof to the threat
- Simplifies the case for preservation

**Very different to the marginal analysis mindset of economists**





# Adapting to wicked problems

- Challenges in wicked problems
  - Measuring costs & benefits
    - More complexity to deal with
      - Can address with better modelling and techniques
  - Reconciling measurements
    - Different approaches to measurement generate inconsistent cost and value estimates
  - Need to make values understandable and accessible for policy purposes
    - Extrapolation and modelling of costs
    - Benefit transfer functions

- Often very difficult to measure and align costs and benefits
    - Cost effectiveness often used instead

# Dealing with long time horizons

- A standard CBA analysis will choose discount rates consistent with project assessment (4-7%)
  - But discount rate in wicked problems often different because time horizons are longer
    - Perhaps the most contentious issue in the Stern Report about the economics of climate change
- Weitzman (2001): appropriate social discount rate depends on the time period of the analysis
    - Use around 2% for time horizons of 26-75 years
    - Use around 1% for time horizons of 75-300 years
    - Use around 0% for time horizons > 300 years

# Applying the three step process to the GBR

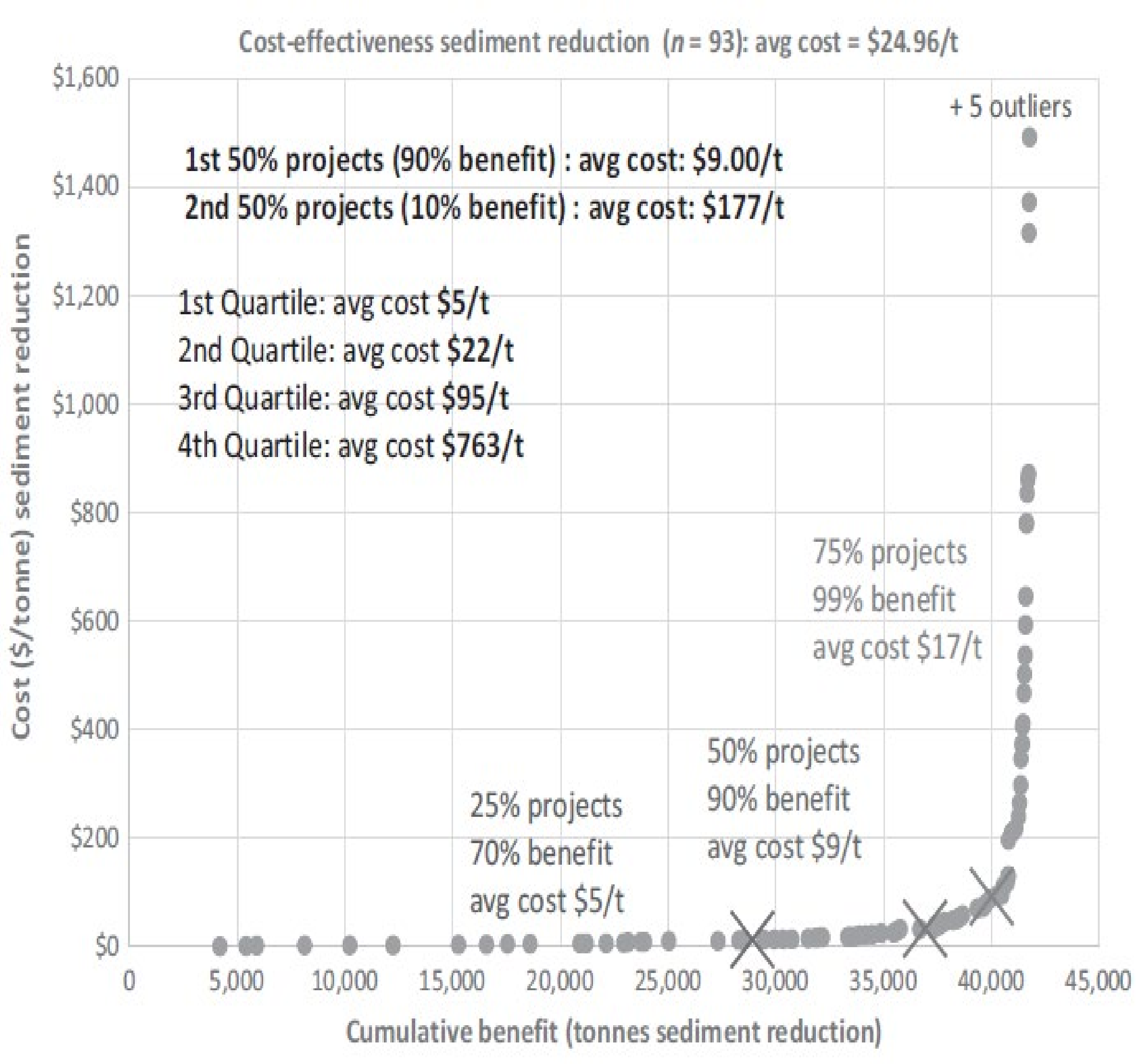
**STEP 1**
- Identify the problem

**STEP 2**
- Is it worth fixing ?
  - Costs

**STEP 3**
- Identify the solutions

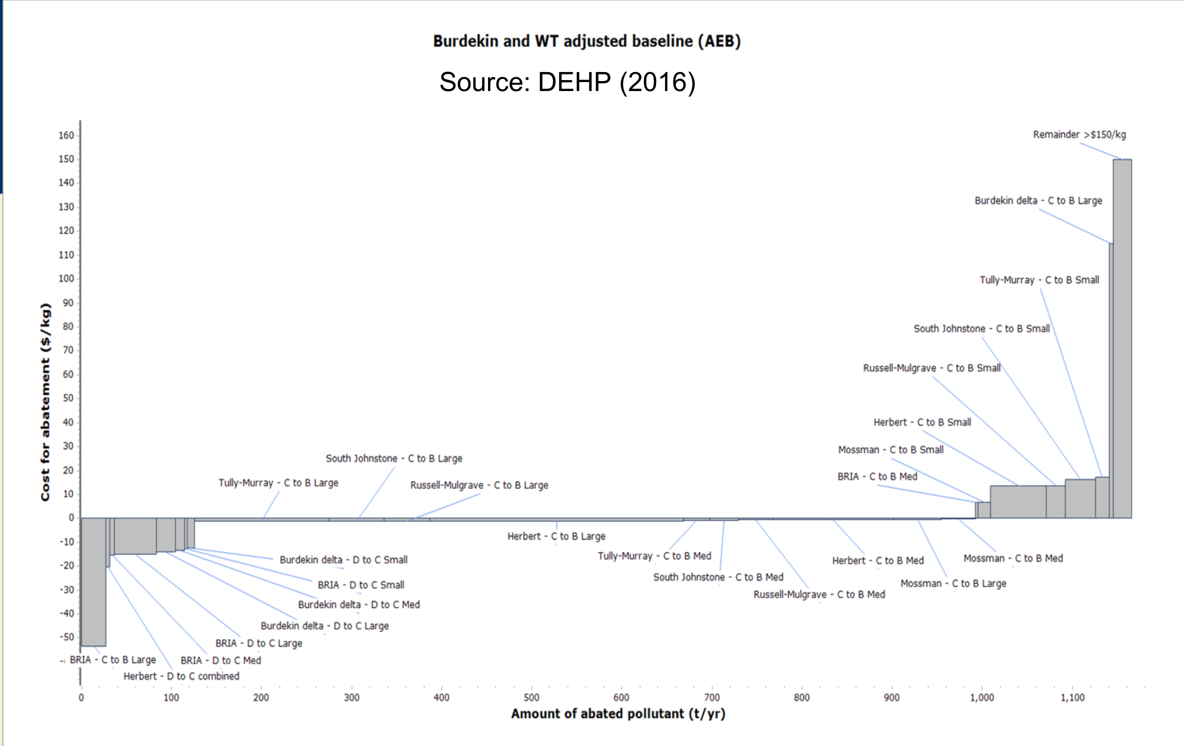
# Evaluation of cost effectiveness shows that prioritisation is important

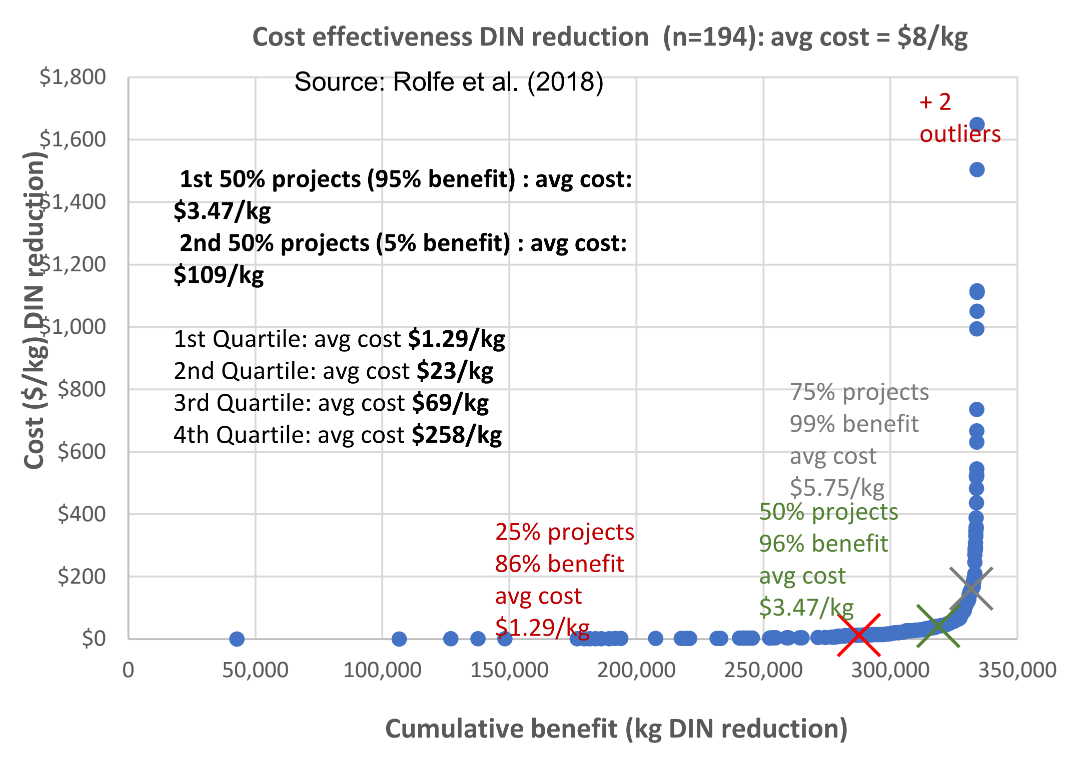
- Evaluated data from one major program (Reef Rescue)
- Identified amounts paid to farmers for individual grants
- Matched that to modelling of benefits to calculate cost effectiveness
  - Identified large variations
- Results support growing attention on improving effectiveness of funding
- In contrast to earlier approaches that focused more on equity and engagement issue
- Increasing evidence about variation in cost-effectiveness generating more focus on prioritisation

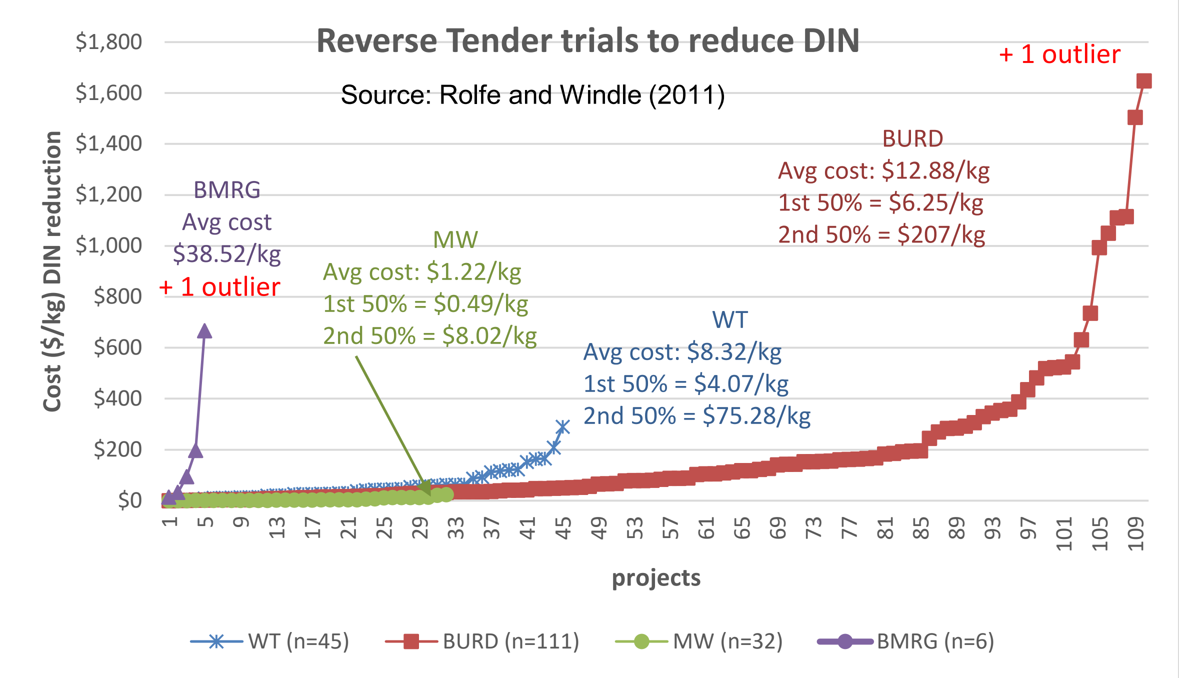


# Consistency

- Estimates vary widely between models, field experiments and analysis
    - Field experiments for 5 years of reduction, others for annual
    - Demonstrates the case for prioritising
    - Using tenders about 2.5 times more cost effective than grants

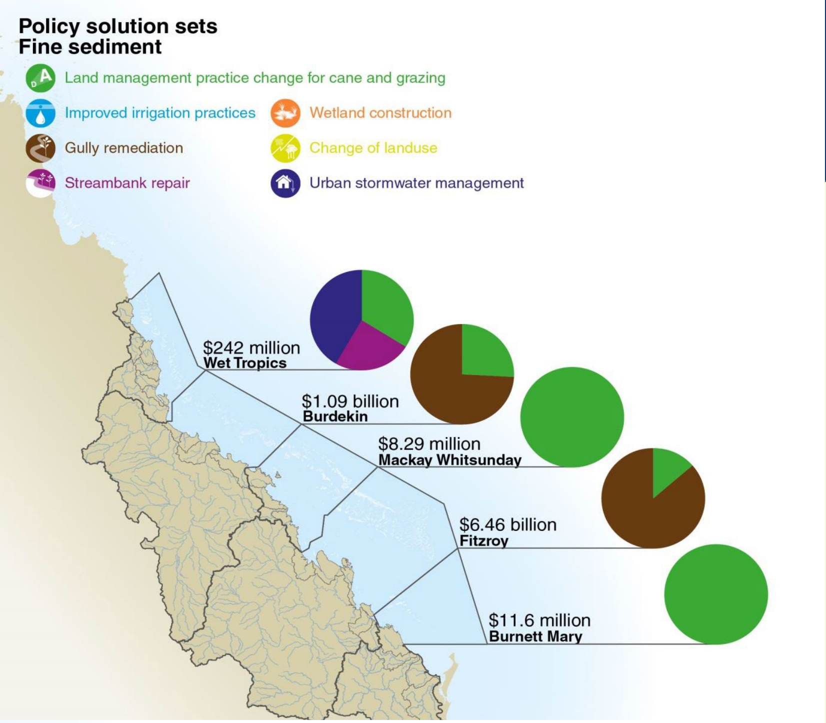


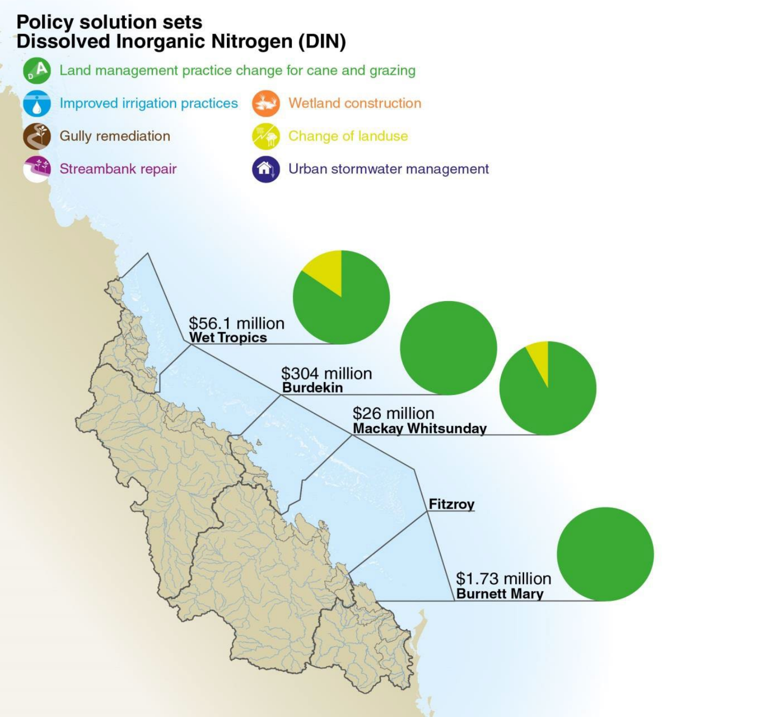



# The difficulties of estimating costs

- The complexity problem
  - 3 main pollutants x 3 main industries x multiple catchments x multiple practices x multiple conditions = Very large prediction set
- The component problem
  - Assessment of costs include different components of private and public costs
- The scale problem – costs needed for
  - The farm level for individual projects
  - Cost effectiveness at the program level
  - Cost effectiveness at the GBR level
- The stochastic elements problem
  - Returns vary with climate, weather, prices etc
  - Need to estimate the average return over time



# Defining Cost-effectiveness

- Cost associated with an Ag management change to achieve pollutant reductions

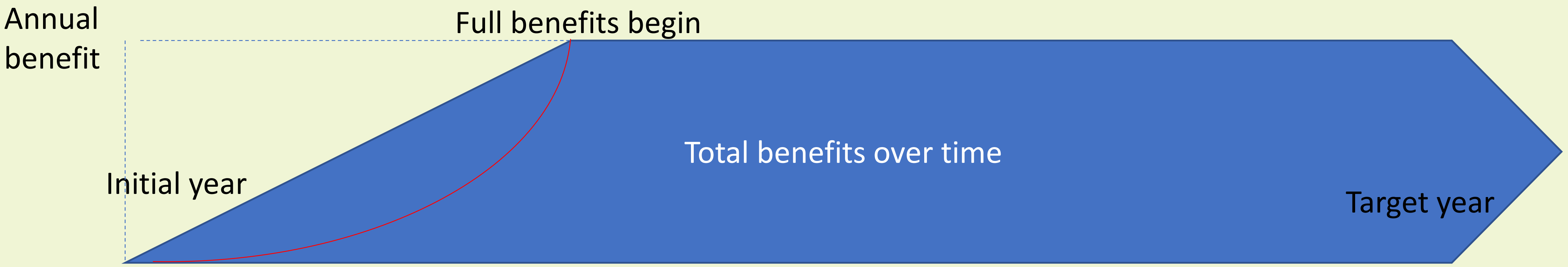
  $/Tonnes reduced

- Powerful way of assessing, comparing and benchmarking projects

- Numerator issues (costs)
  - Different components of costs can be included
- Denominator issues (pollutants)
  - Identify if costs are compared to (a) **total pollutant reduction** or (b) **annual pollutant reduct**ions
  - Allow for efficiency, risk, adoption, time lags (expected reductions)

# Example issue: Treatment of time lags to benefits

- Many sediment projects involve time lags to achieve full effect
  - Can take 10 – 30 years for some degraded areas to heal naturally
  - But modellers assume full benefits immediately from projects (t/year)
    - Simplification to make modelling, accounting and explanation simpler
    - Leads to large over-estimate of benefits
    - Effect is to penalise projects that generate more immediate benefits
    - Extent of over counting depends on shape of recovery function
  - We recommend it would be better to assess total reduction by a target year
    - Or discount annual estimates by time, similar to costs



# Recommendations for 4 main steps

1. Identify the **amount of pollutant reductions** expected each year from a project, and then subtract the transmission losses between the project and the target area for benefit.

2. Assess **effects** of time delays and **risks** the project will not deliver benefits because of technical failures or climate factors = expected reductions

3. Identify and sum the **costs** involved
   a. Capital, Opportunity, Maintenance, Transaction, Program
   b. Add relevant Public & private

4. **Discount** future pollutant reductions and costs back to a common time period, and then take the **ratio** of the sum of costs against the sum of pollutant reductions.

# Applying the three step process to the GBR

**STEP 1**

- Identify the problem

**STEP 2**

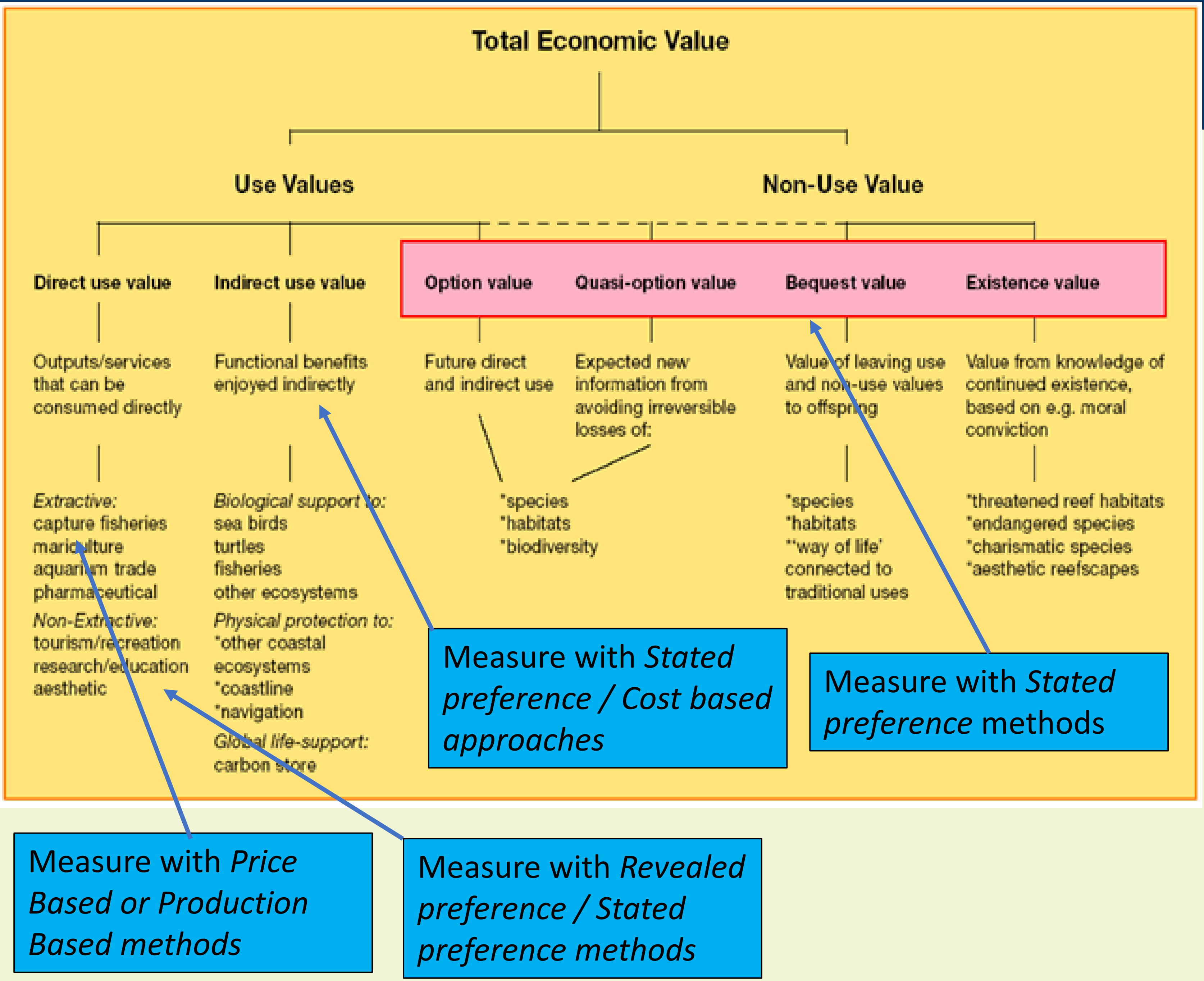
- Is it worth fixing ?
  - Benefits

**STEP 3**

- Identify the solutions

# Use of specialist framework is required

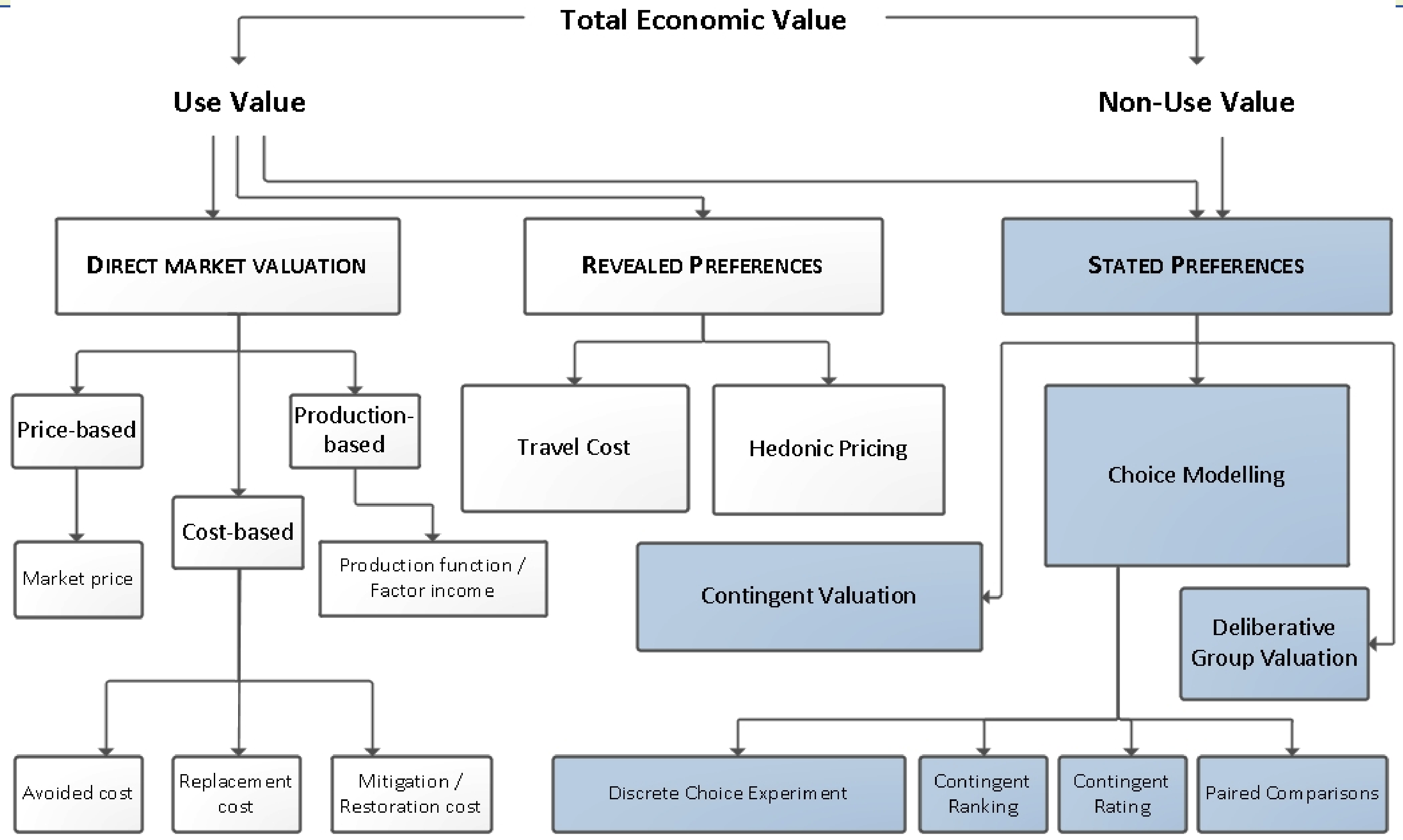
- Use Total Economic Value framework to classify
  - Direct extractive
    - Commercial Fishing
  - Direct non-extractive
    - Recreation
    - Tourism
  - Indirect
    - Coastal protection
    - Carbon
  - Non use
    - Option values
    - Existence values
- Measure either:
  - Producer surplus
  - Consumer surplus
- But not easy to communicate concepts to non-economists



# Different valuation studies and techniques

Reasonable number of valuation studies

- 33 GBR-wide studies since 1985 + many more localised ones
- + broader assessments (e.g. Deloitte Access Economics 2018)
  - *The Great Barrier Reef has a economic, social and icon asset value of $56 billion. It supports 64,000 jobs and contributes $6.4 billion to the Australian economy.*




adapted from TEEB (2010) and Pearce & Özdemiroglu (2002)

# Challenges

1. Accounting for indigenous values in TEV
2. Different frameworks to approach the issue – can be confusing
3. Difficult to differentiate between Total, Surplus and Marginal values
4. Science information not well aligned
5. Benefit transfer very difficult to apply

# 1. Accounting for indigenous values in Total Economic Value framework

But difficult to include Indigenous values in standard TEV framework

+

Indigenous values

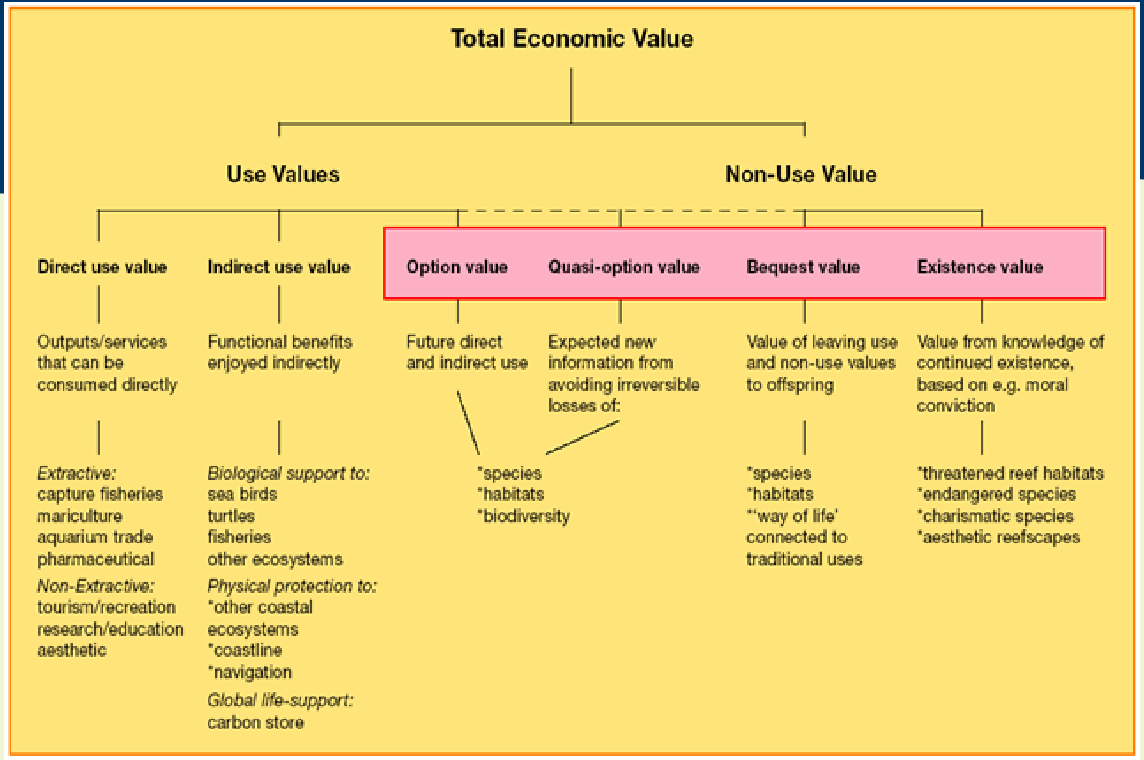
- Total Economic Value (TEV)
  - Use Values
    - Direct use Values
    - Indirect use values
    - Option Values
  - Non-Use Values
    - Existence Values
    - Bequest Values
    - Altruistic Values



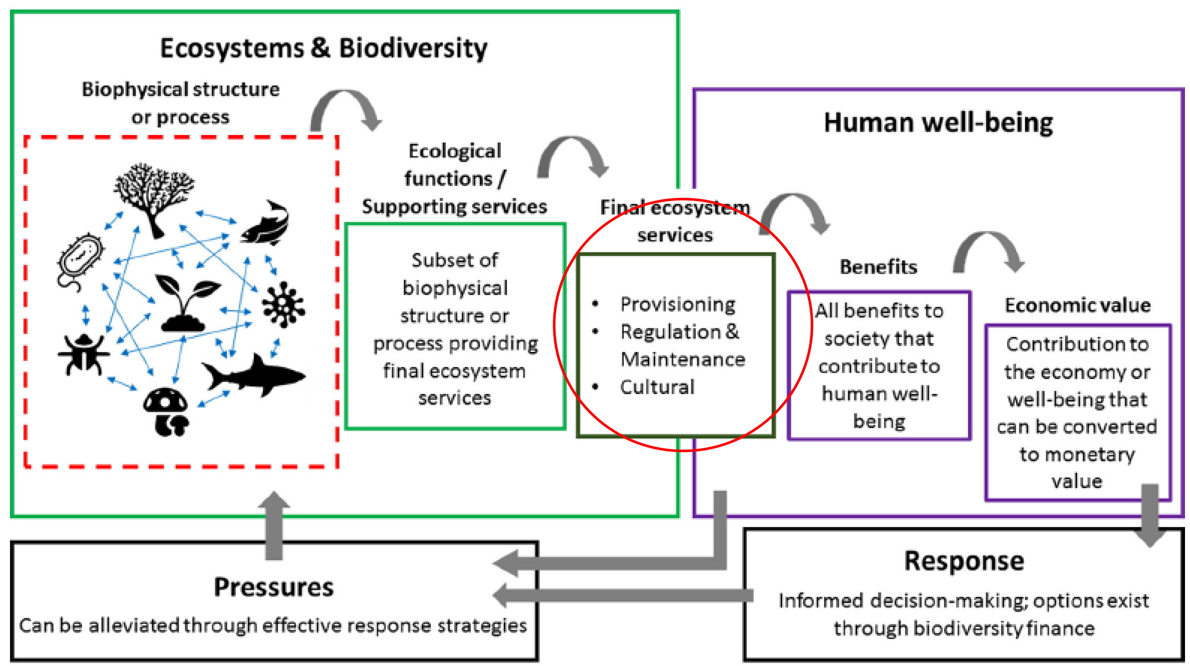



# 2. Use Environmental or Ecological Economic frameworks? (De Valck and Rolfe 2018)

- TEV is main focus in Environmental Economics
  - Assess Direct, Indirect and Non-Use values
  - Consumer surplus for most categories, plus Producer surplus for Direct Use industries
  - Tends to focus on marginal analysis




- Ecological Economics is an alternative but overlapping paradigm
  - Use the Ecosystem Service (ES) framework
  - More focus on systems analysis as compared to Environmental Economics
  - Easier to align with Science disciplines
  - Tends to focus on total values (e.g. total value provided by an ecosystem service)



# While others focus on Economic Accounting concepts

- Economic contribution
  - Measured Value Added and Employment generated by key industries
- Total Economic, social and icon value
  - Direct use values
    - Tourism $1.5B/yr = $29B total
  - Non use values (CV study)
    - $1.2B/yr to protect GBR) = $24B

Figure 1.1: Scope of the report

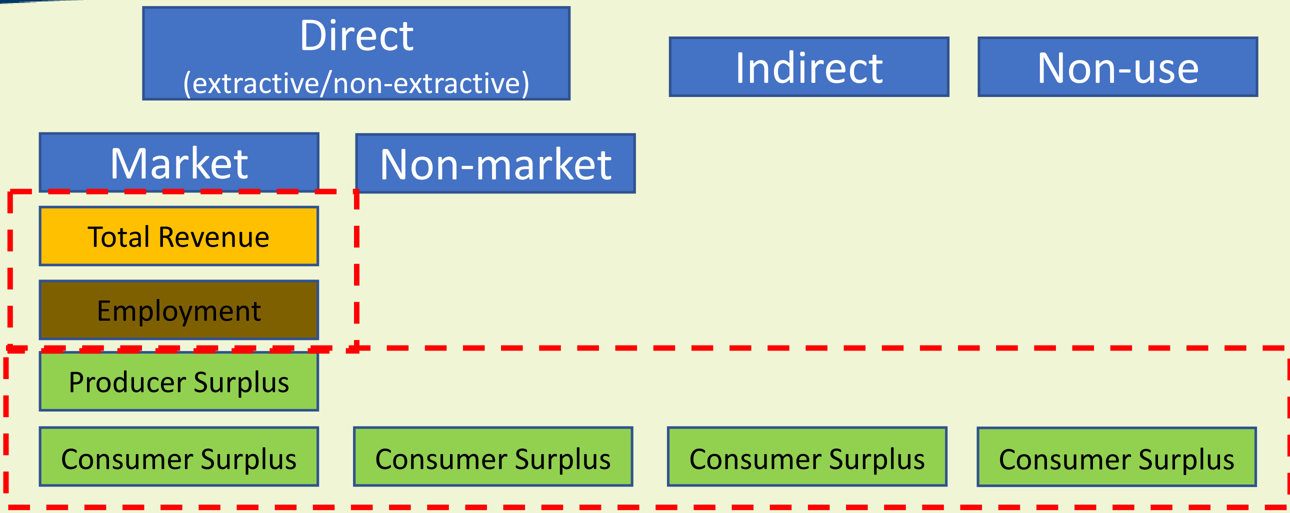
| | |
|---|---|
| Economic Contribution | • Value added to the economy<br>• Contribution to employment |
| Economic and Social Value | • Direct use value from tourism and recreation<br>• Broad non-use value to society |
| Traditional Owner Value | • Cultural heritage<br>• Spiritual and religious<br>• Educational<br>• Knowledge |
| Brand Value | • Differentiation<br>• Relevance<br>• Esteem<br>• Knowledge |

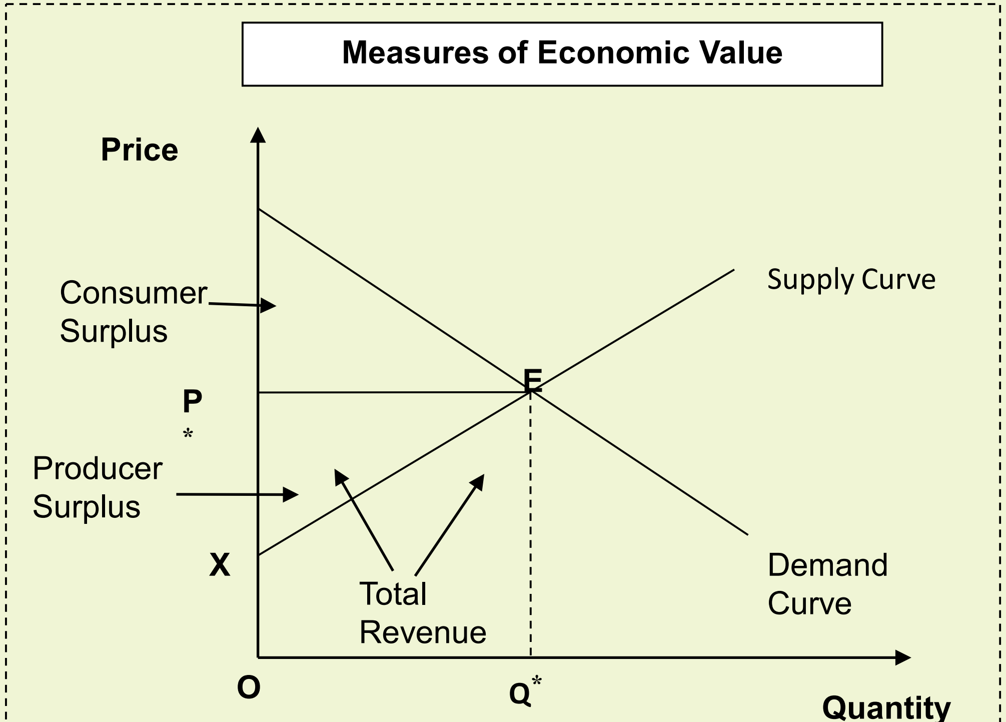
Table 2.9: Economic contribution of the GBR 2015–16

| | | GBR Regions | Queensland Total | Australia Total |
|---|---|---|---|---|
| Value added | Tourism ($billion) | $2.4 | $3.4 | $5.7 |
| | Fishing ($million) | $139 | $140 | $162 |
| | Recreation ($million) | $284 | $296 | $346 |
| | Scientific research ($million) | $155 | $161 | $182 |
| **Total value added ($billion)** | | **$2.9** | **$3.9** | **$6.4** |
| Employment (FTE) | Tourism | 19,855 | 28,768 | 58,980 |
| | Fishing | 680 | 690 | 814 |
| | Recreation | 2,889 | 2,964 | 3,281 |
| | Scientific research | 895 | 914 | 970 |
| **Total employment (FTE)** | | **24,319** | **33,336** | **64,044** |

# 3. Total and Surplus values

- Total revenue/employment important
  - But economic analysis should focus on surplus measures
  - Most useful to focus on marginal unit values
- Deloitte Access Economics 2017
  - Economic Contribution
    - Total Revenue / Employment
    - But counted all tourism to Fraser Island and north Qld as visitors to GBR
  - Economic Value
    - Tourism, Recreation, Non-use
  - Traditional Owner
    - Recognised but not assessed

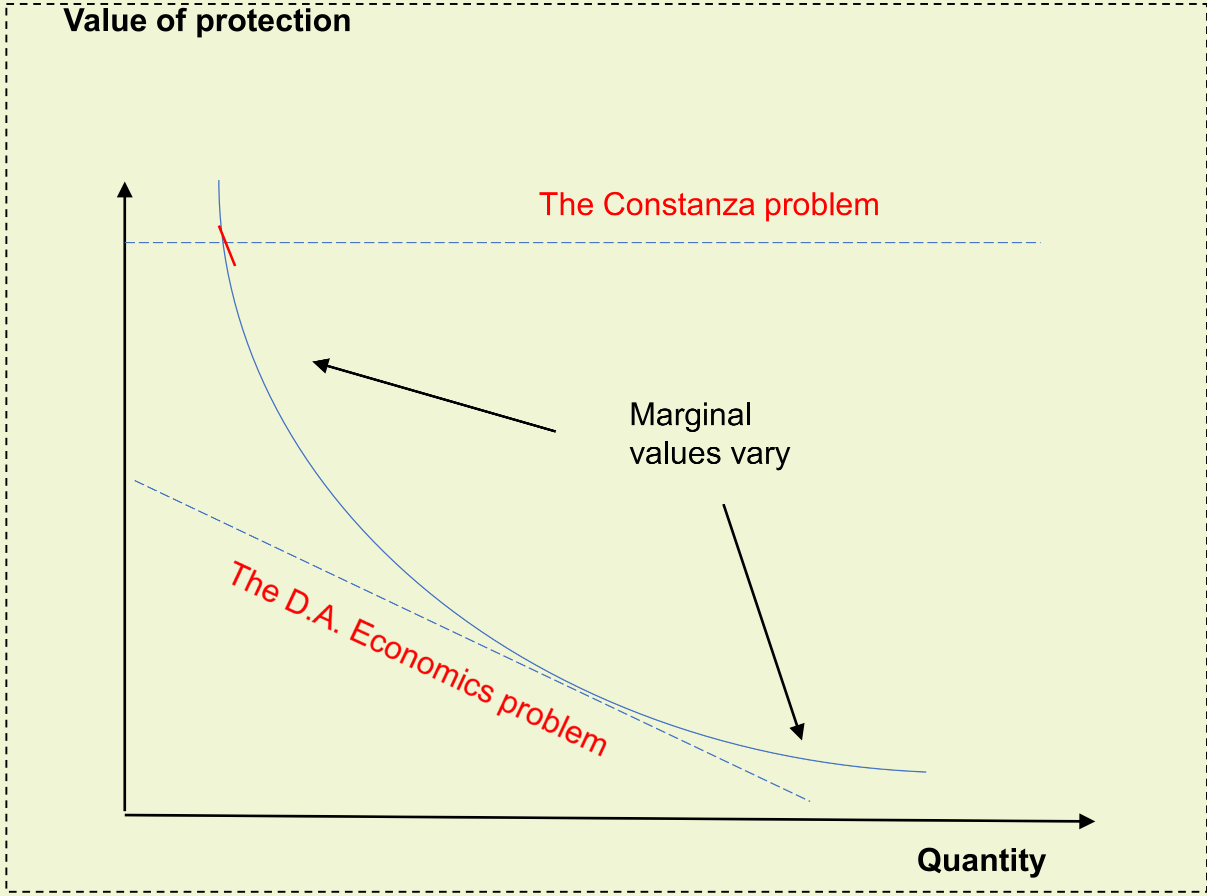


# 4. The Total Marginal problem

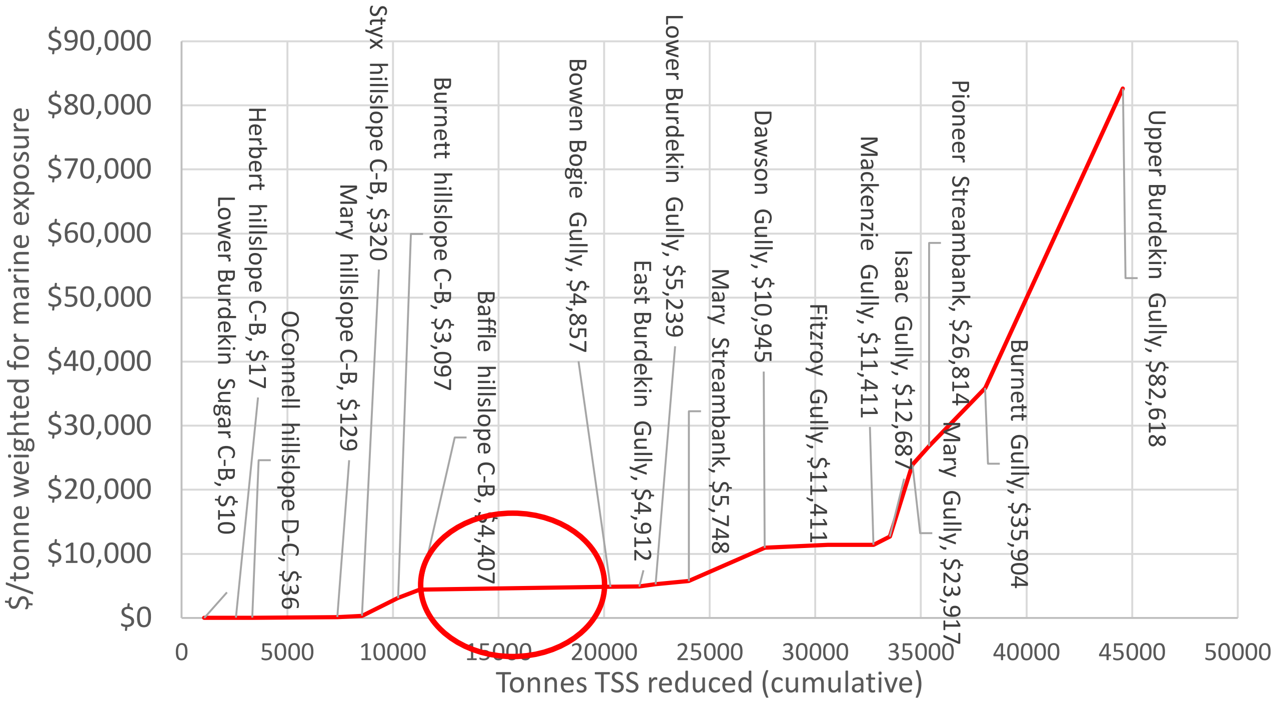
- Aggregation of marginal values is very problematic
    - Confounds marginal and absolute values
    - Does not allow for diminishing values with scale
    - Is not consistent with framing of marginal experiments
- The Constanza et al. (1997) approach
    - Aimed at estimating Total value of ecosystems
    - Multiplied marginal values by total areas
    - Did not allow for diminishing utility or variations in WTP with increasing scale
- Deloitte Access Economics (2017)
    - Aimed to measure Total Non-Use value
    - Single CV question asking for (weekly) WTP to protect the GBR
    - Did not allow for variations in WTP with diminishing resource
        - As well as other methodological issues

- How to get results noticed
    - Use the biggest numbers possible
        - Total lump sum values
    - But not very accurate or useful



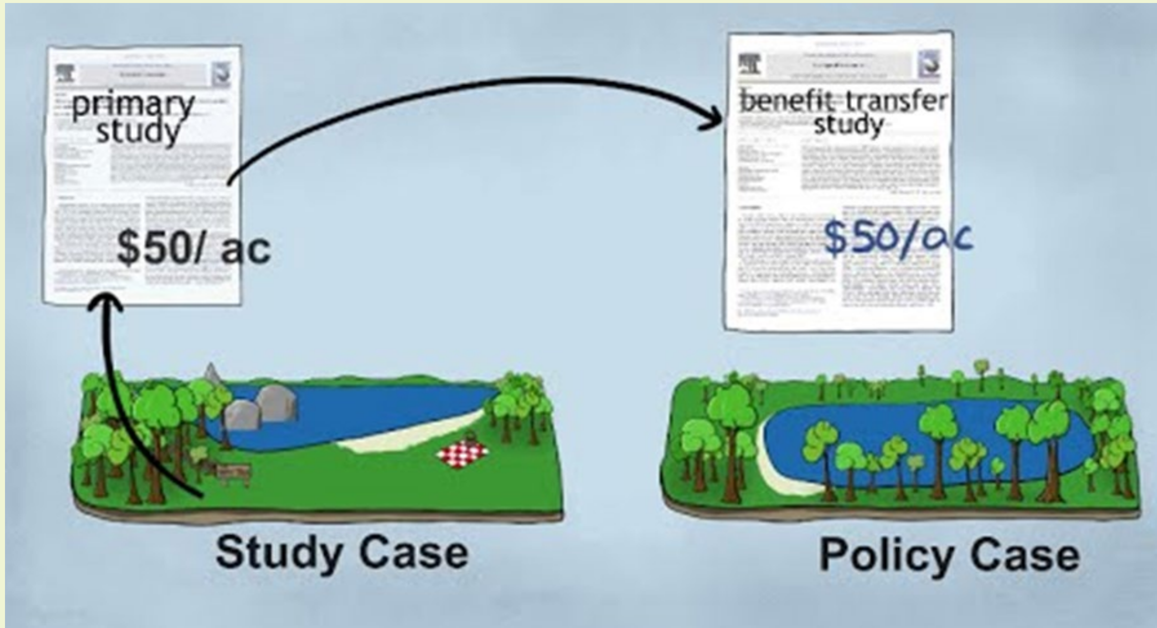
# 5. Science information is not well aligned to economics

- Ideally information about improvements in environmental management could be aligned with benefits to reef health
  - But pollutant changes are only tracked to end of catchment
  - No predictive function from science to predict marginal benefits in reef health from reductions in pollutants
- Instead there is a focus on identifying where problem is largest and setting targets for changes
  - Reflects a precautionary approach to issues rather than an evaluative approach
  - Difficult to compare benefits and costs of different targets



# 6. The benefit transfer problems

- Most evaluations require some application of benefit transfer, but
  - Limited understanding about the different types of values lead to invalid transfers
  - Limited pool of primary studies
  - Difficulties in accounting for scope differences (different assets included)
  - Difficulties in accounting for scale differences (i.e. measures with varying quantities of assets)



# Solutions to issues around benefits

1. Have clearer classification tools to explain framework and valuation differences
2. Discourage use of total marginal approaches
3. Explore ways to account for indigenous values in TEV
4. Engage more with science to promote marginal analysis
5. Develop a benefit transfer framework

# Applying the three step process to the GBR

- Identify the problem

STEP 1

STEP 2

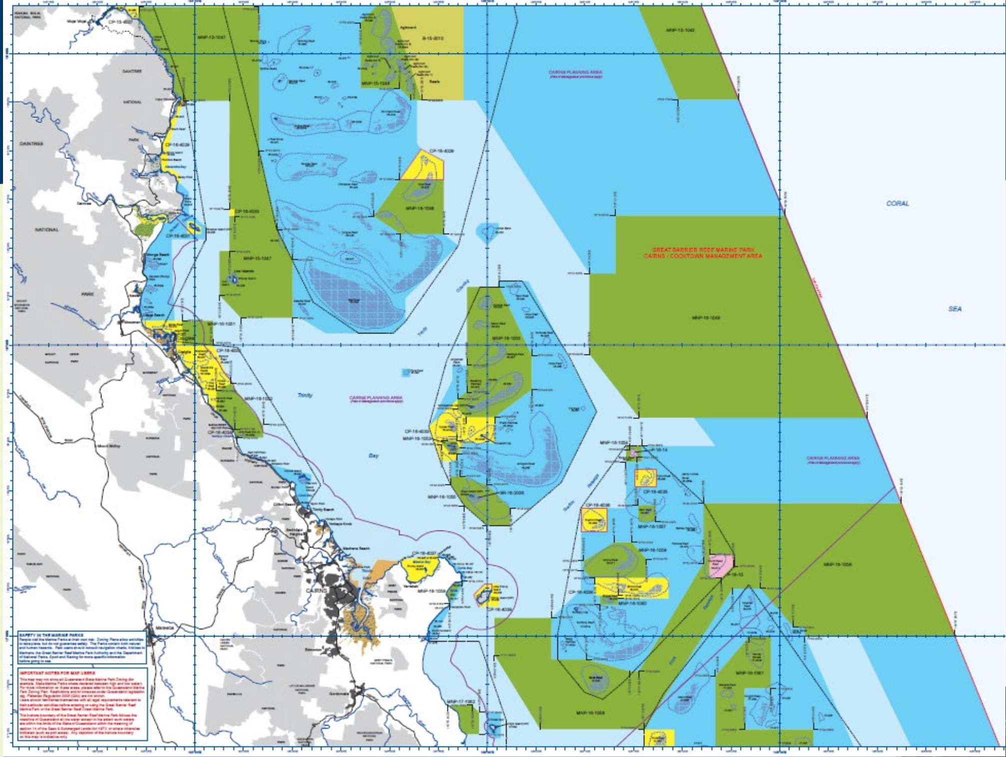
- Is it worth fixing ?

- Identify the solutions

STEP 3

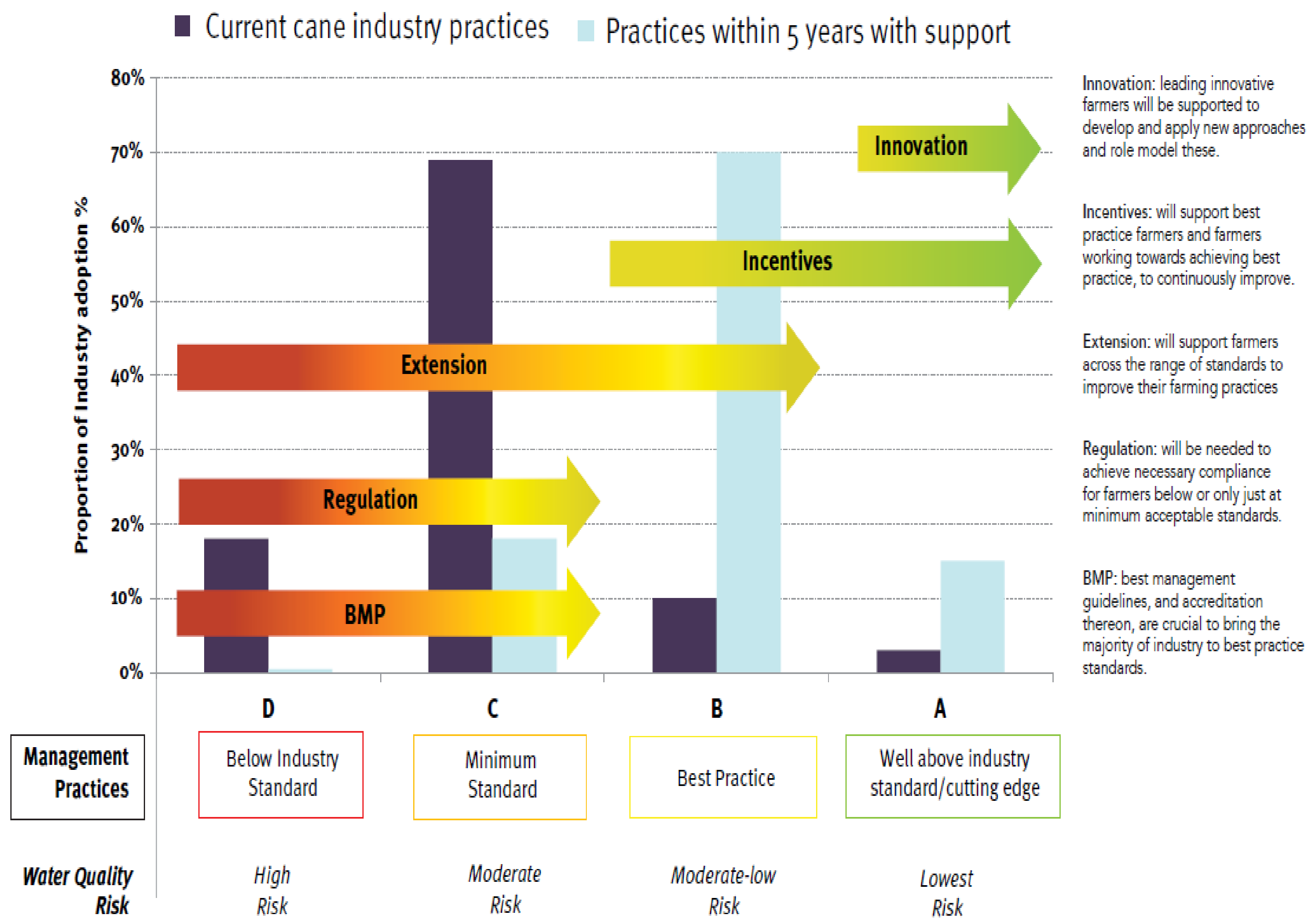
# Stage 3 – identifying solutions

- Range of tools available
  - Persuasion
  - Information
  - Extension
  - Direct incentives
  - Market based instruments
  - Regulation
- Each involve costs and benefits
- Most have been trialled in GBR
  - A number of grant programs – direct incentives
  - Natural Resource Management groups used to coordinate programs and provide information and encouragement
  - Number of extension programs
  - Trials of a reverse tender for nitrogen reduction



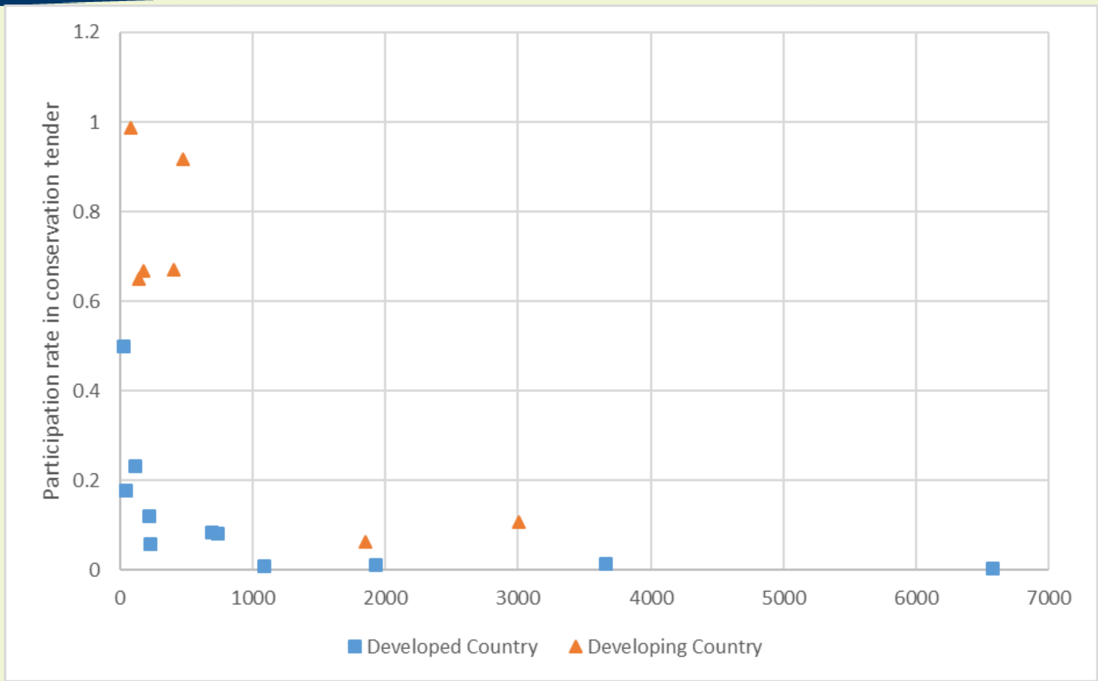

# One way of visualising the selection problem

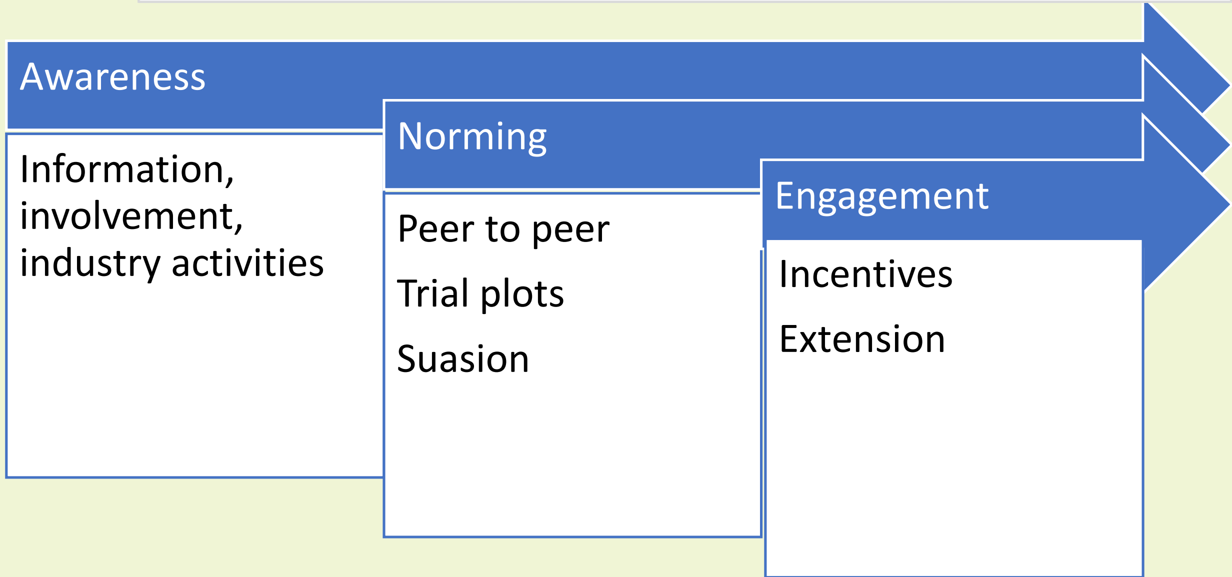
- GBR Water Science Taskforce 2016
- Related choice of instrument to required management practice change
- recommended that a more systematic analysis be undertaken to understand how different tools to achieve practice change fitted together
- But does not account for varying adoption or drivers



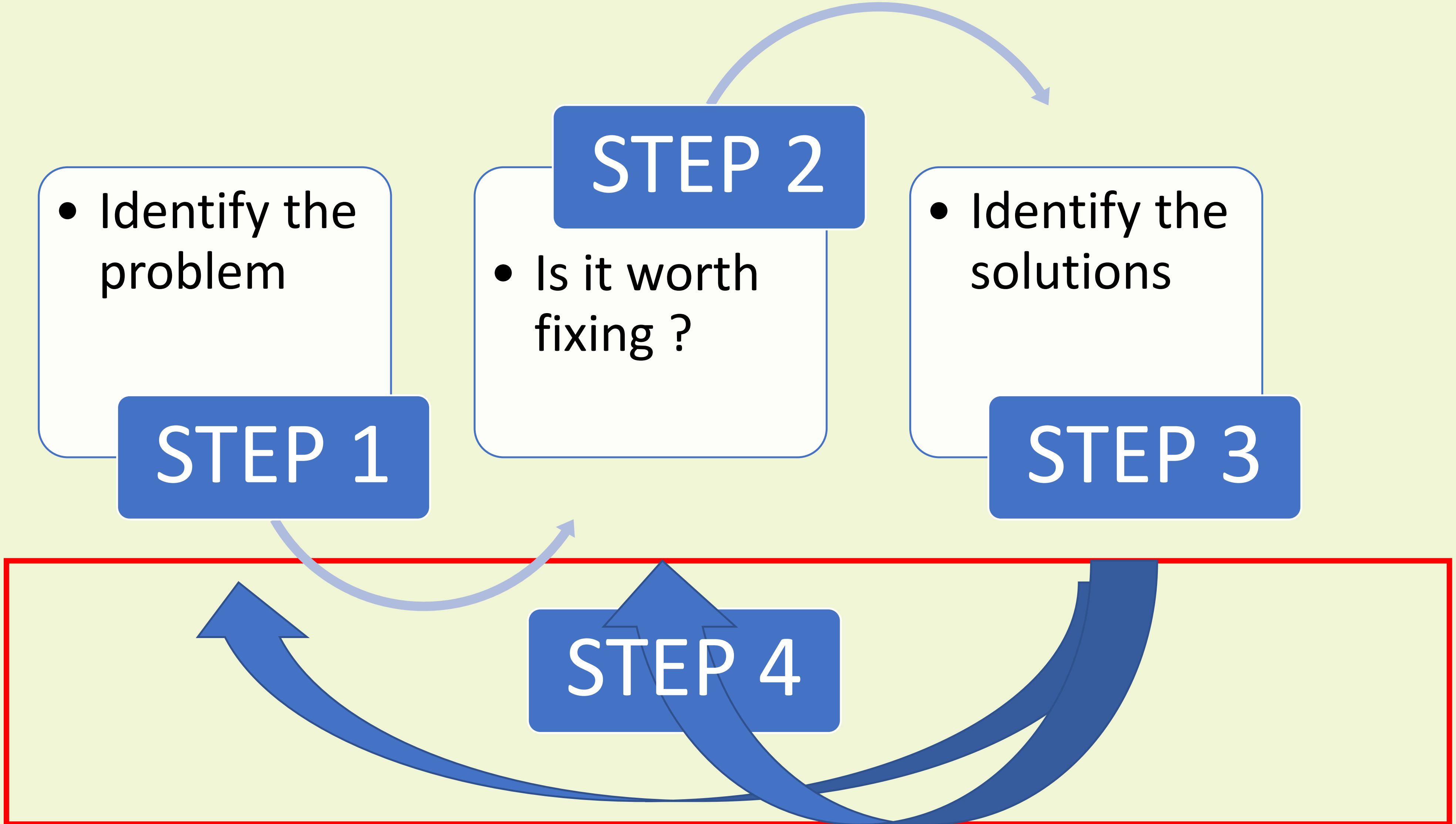
# Need to have more focus on progression and packaging of solutions

- Work with Schilizzi and others identified that participation in conservation tenders is very low
  - In developed countries large scale tenders may get only 1% participation
- Successful adoption in GBR requires a gradual build-up of farmer interest and capability - preconditioning
  - Range of awareness, information, encouragement mechanisms
  - Industry and peers generate norming
- Social sciences tends to focus more on pathways to change and packages of support that generate adoption



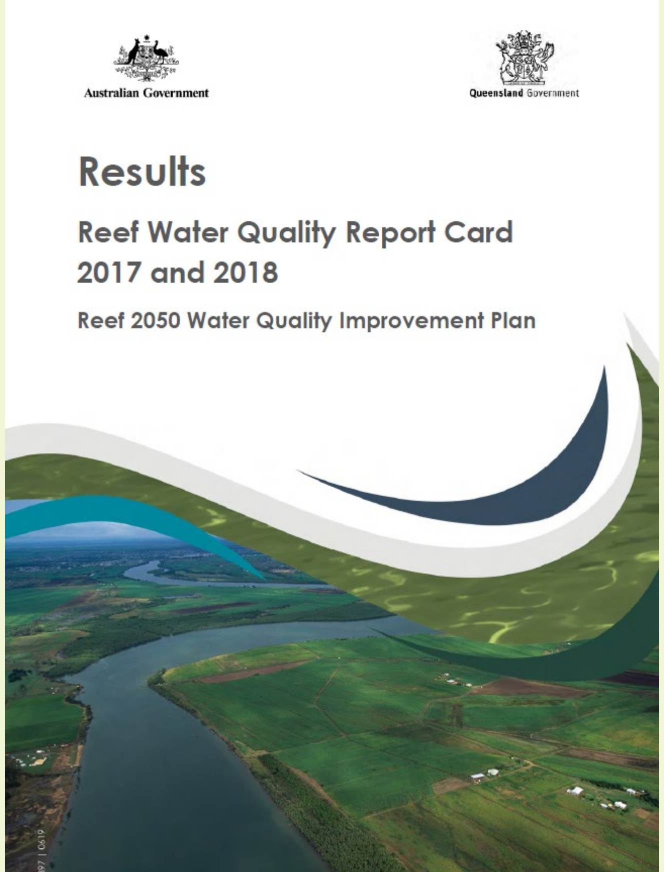



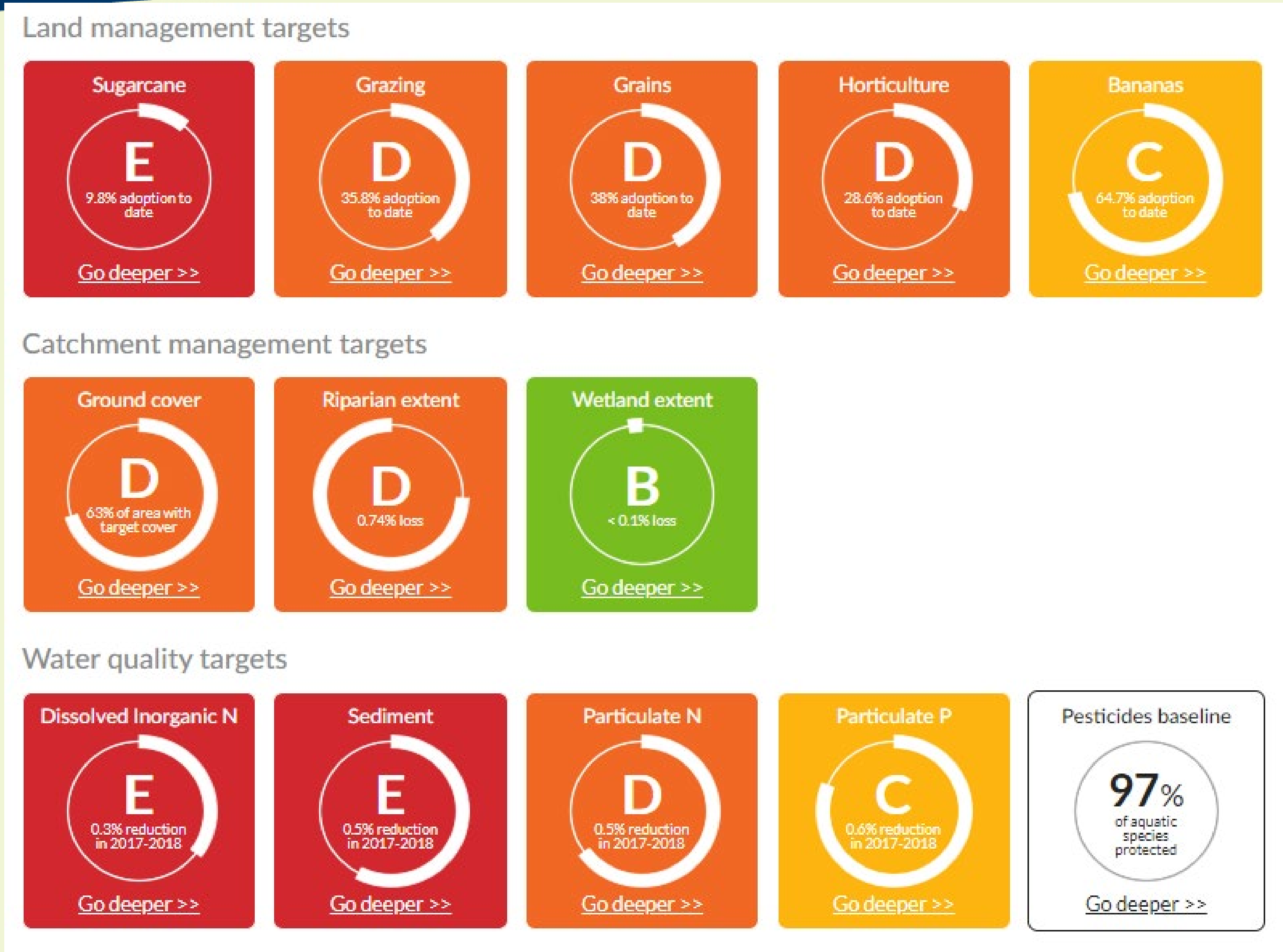
# Step 4: Making solutions work requires an iterative process



# The adoption problem in the GBR

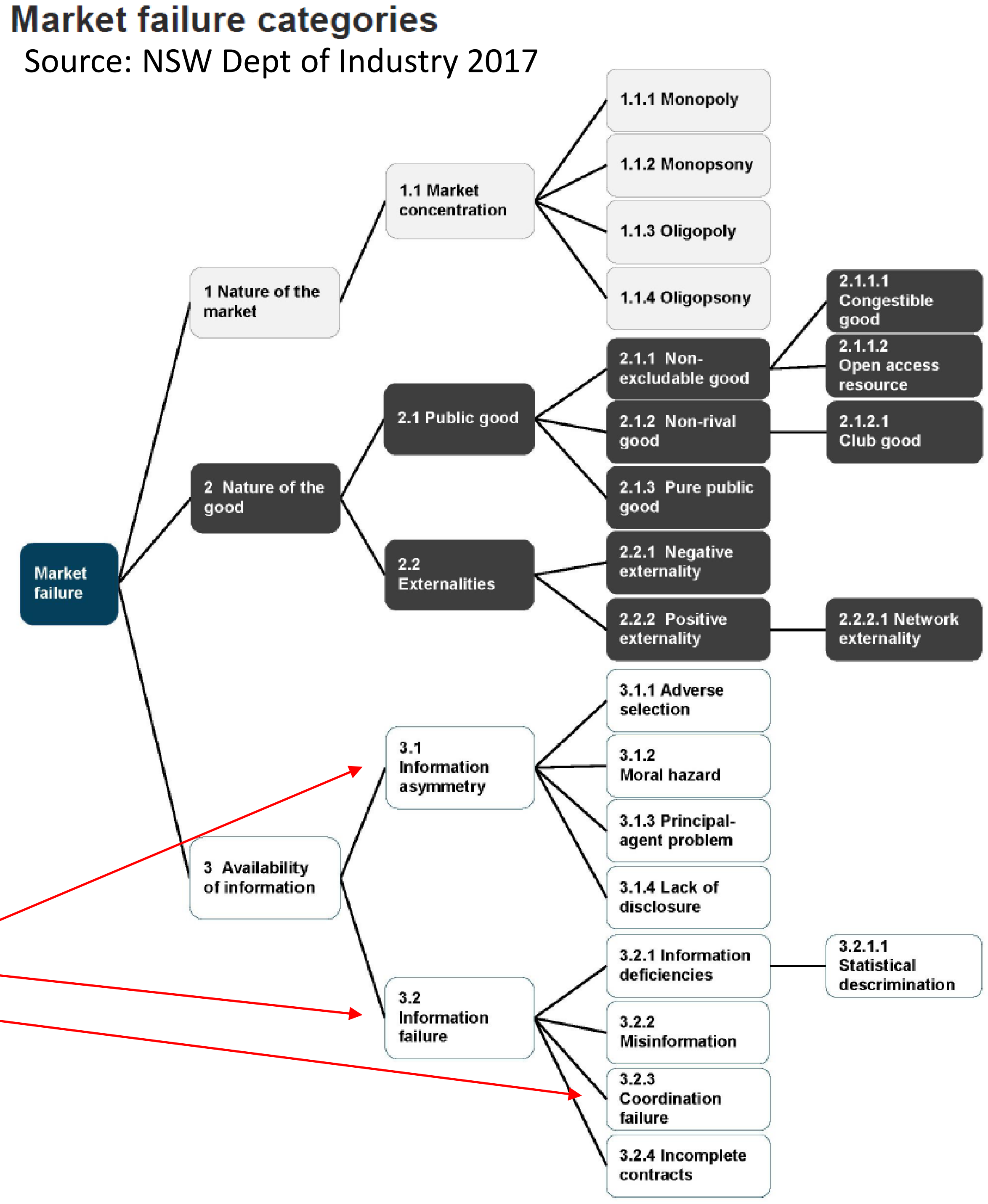
- Rates of adoption of better management practices / better condition much lower in GBR then expected



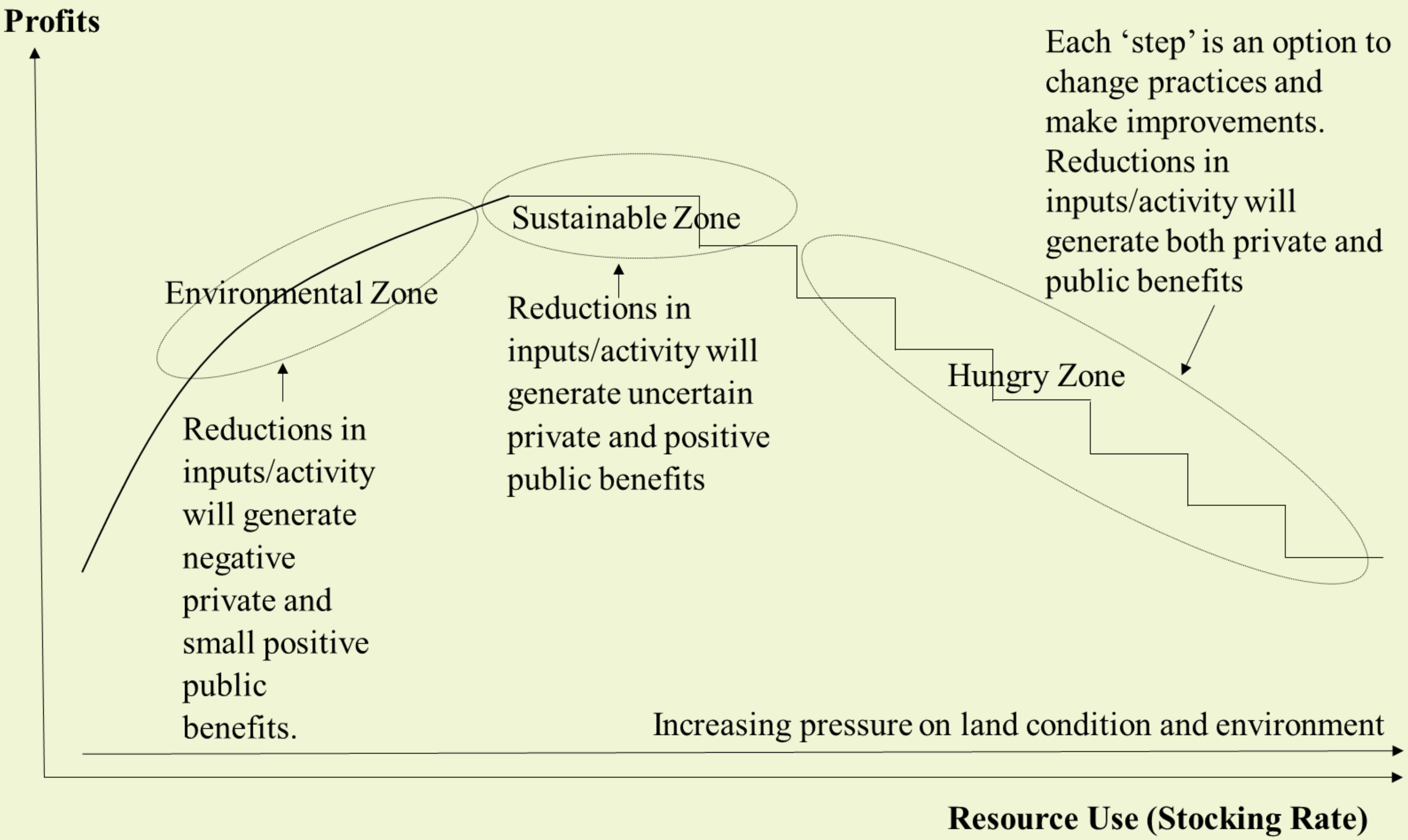
# Conceptualising the internality problem

- Reef protection
  - Public good issue
- Water pollution issues
  - Negative externality issues
- Climate change impacts
  - Negative externality + public good
- Fishing
  - Open access resource
- Farmers not optimising correctly
  - Information failure
  - Productivity / myopic issues
- Difficulties in coordination
  - Information asymmetry



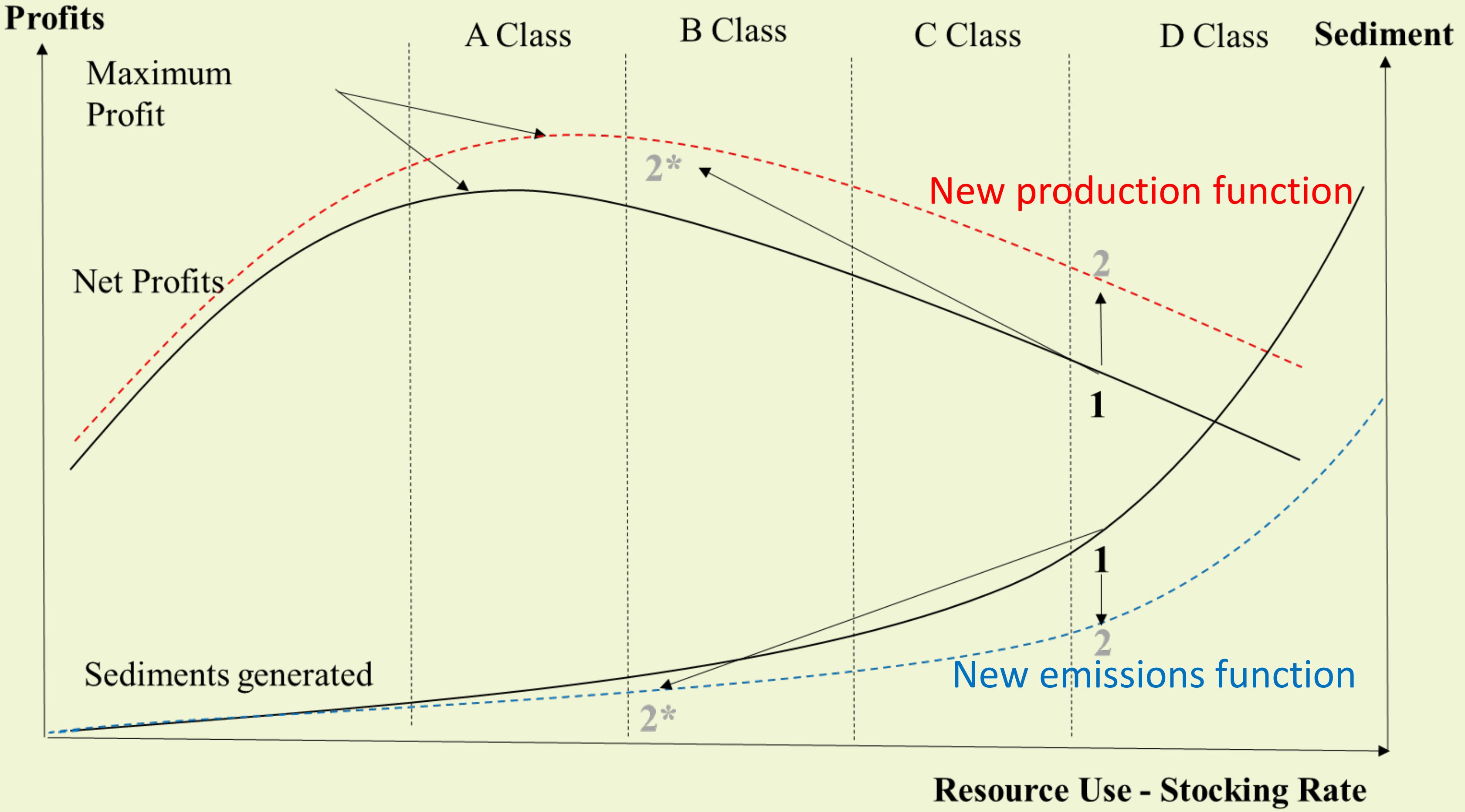
# Internalities mean producing in the Hungry Zone

- Policy makers assume that problem producers are in Hungry Zone
  - Overstocking
  - Over-fertilising
- Industry argues they are in Sustainable zone
- Difficult to judge
  - Production functions vary each year with climate and prices
  - Farmers are optimising their position in the production function in an uncertain world



# Change to new production frontier

- But very difficult to convince farmers to just shift back along production frontier
  - Suasion, Information, Extension instruments
- Easier to use incentives to change to an improved enterprise that generates more production and less damages
  - E.g. new fertilizer splitter
  - Extra water points for stock
- Combination of mechanisms much more powerful than just extension or incentives

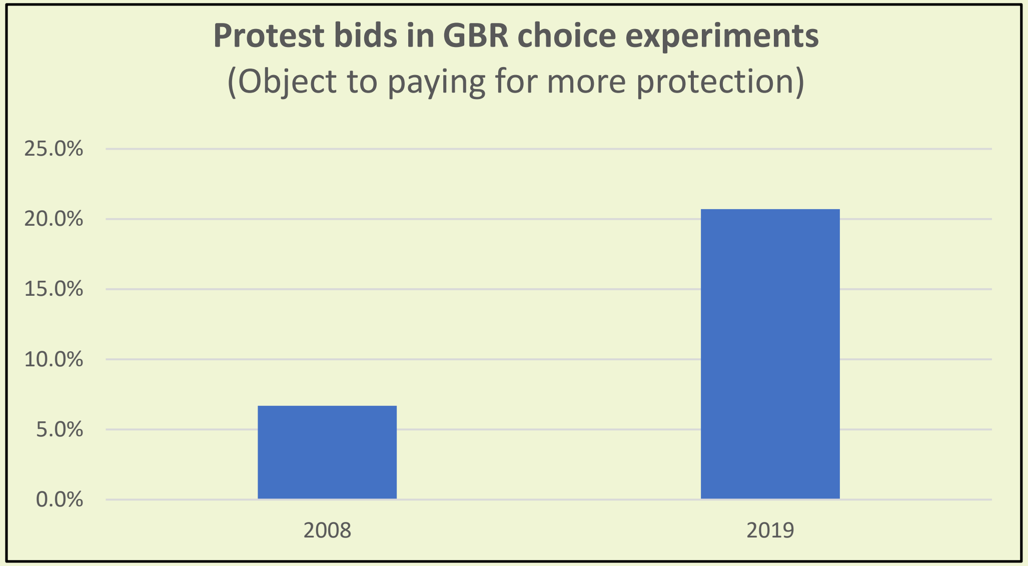


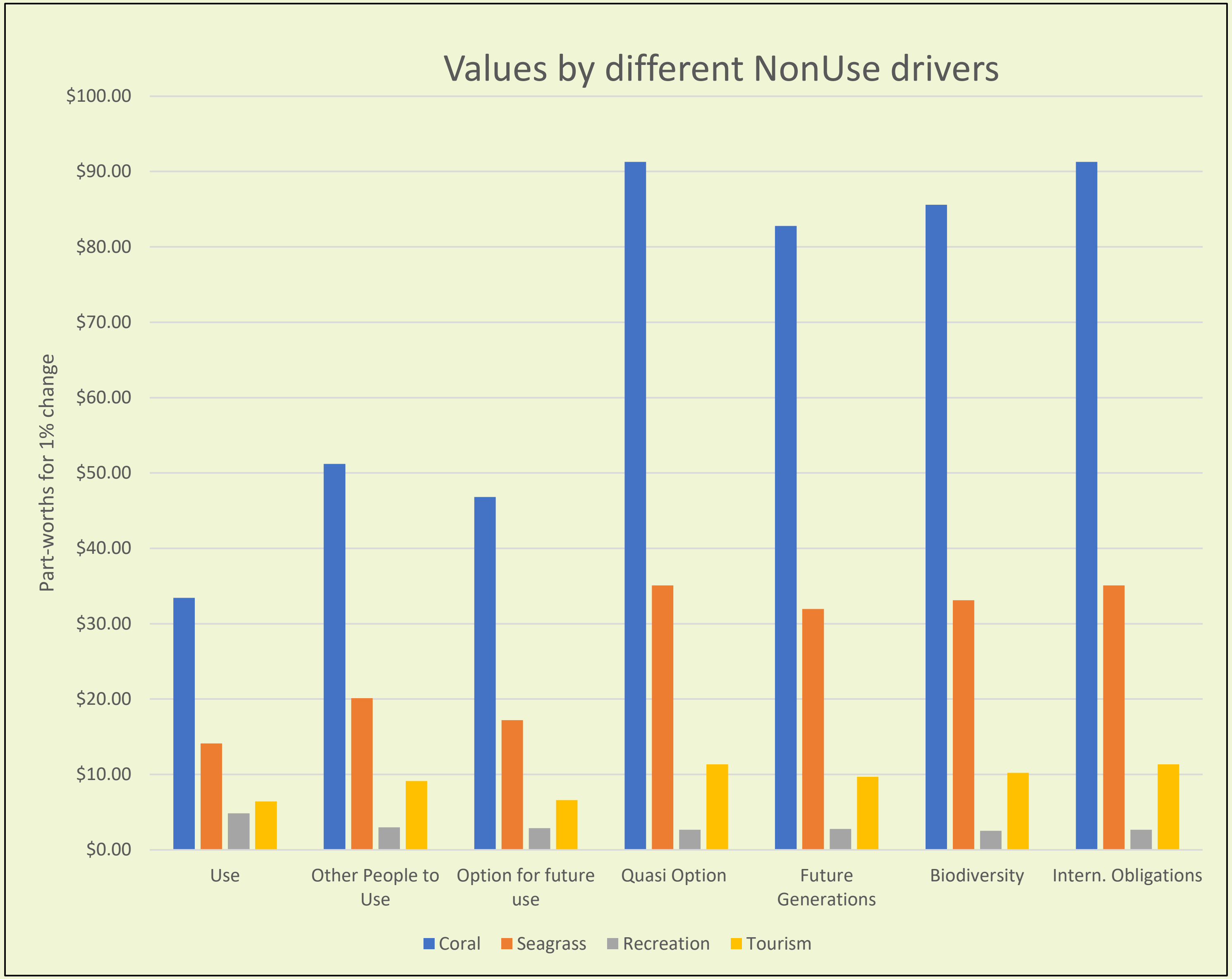
# Summary – what do we need to do?

- Large role for Economics to play
- For wicked problems, need to add feedback loops into the standard three–stage analysis
- More specific tasks
  - Need to address consistency and scale issues so costs and benefits can be more easily compared
  - Need to set up cost and benefit transfer frameworks
  - Need to ensure that policy and science are aligned with marginal frameworks
  - Need to put more work into analysing progression and packaging issues in instrument selection

# Getting economics right might help to maintain community support

- Results of recent experiment
  - Non-use values closely aligned with considerations of use
  - Including impacts on other sectors
  - Protests against paying more for GBR 3 times higher than 2008

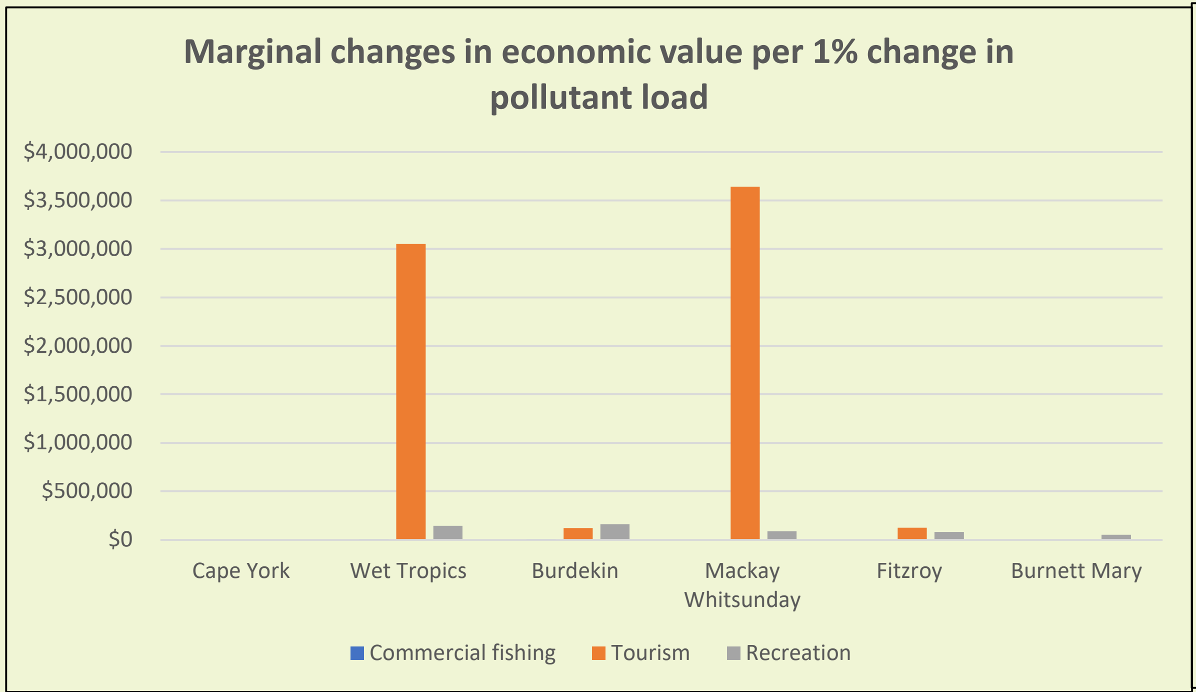


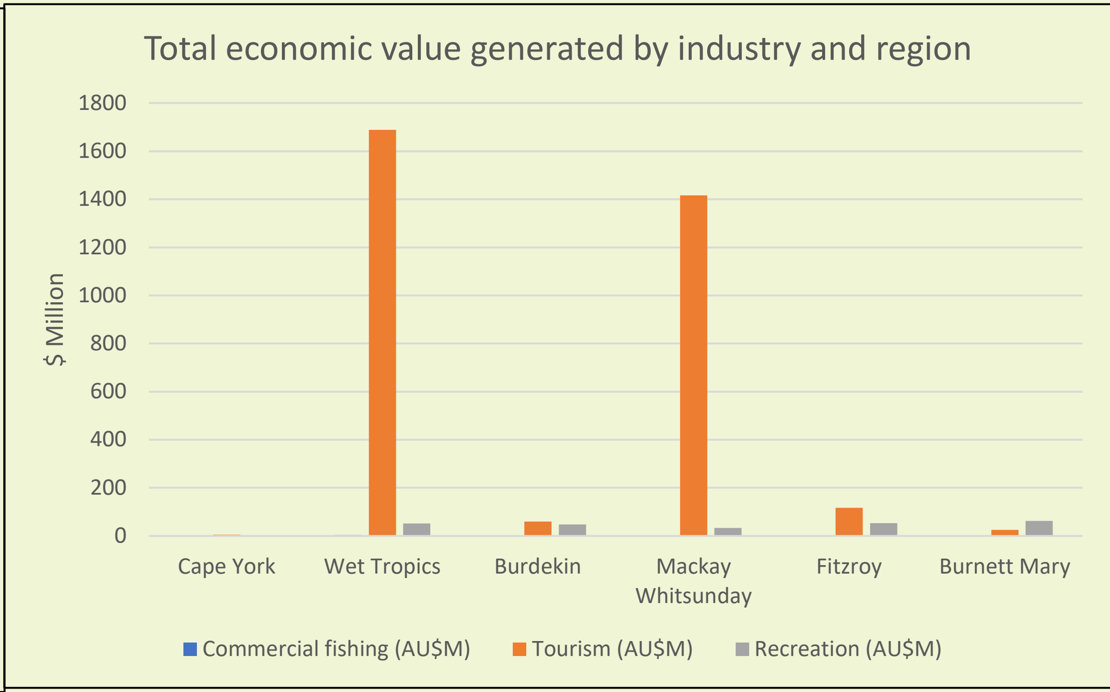



# Water quality targets, spending, and ecosystem services don't align

- Reef 2050 Plan has similar reduction target rates for each region
    - Underlying assumption of equivalent benefits
- But Direct Use values generated vary widely by region
    - De Valck and Rolfe (2018) *Marine Pollution Bulletin*
- Current investment priorities in Wet Tropics and Burdekin

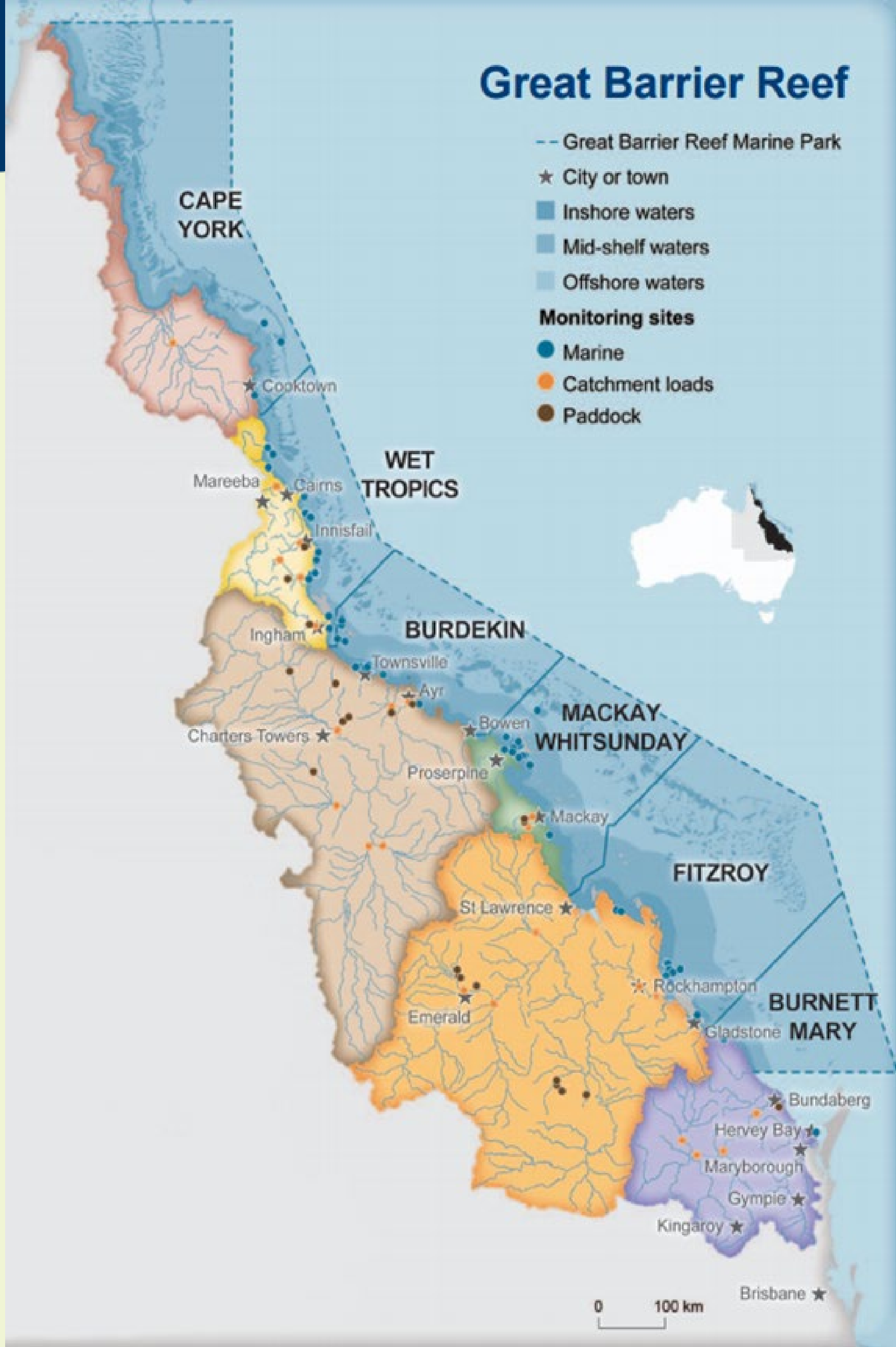
| Region | Dissolved inorganic nitrogen | | Fine sediment | |
|---|---|---|---|---|
| | tonnes | % reduction | kilotonnes | % reduction |
| Cape York | MCL | MCL | 23 | 5 |
| Wet Tropics | 1700 | 60 | 240 | 25 |
| Burdekin | 820 | 60 | 890 | 30 |
| Mackay Whitsunday | 630 | 70 | 130 | 20 |
| Fitzroy | MCL | MCL | 410 | 25 |
| Burnett Mary | 470 | 55 | 240 | 20 |



# If Economics was useful ….

- At the GBR level
  - We have some estimates of the benefits at GBR level
  - But science is missing to relate costs of pollutant reduction to changes in reef condition
- At the paddock level
  - We have estimates of the costs (needs improving)
  - But we don't have good ways of adjusting our benefit values from the GBR level down to the case study level
  - And the science to link paddock level changes to improvements in reef health is missing



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