Optimal policies for terrestrial and coastal ecosystems

Sittidaj Pongkijvorasin
Faculty of Economics
Chulalongkorn University
จุฬาลงกรณ์มหาวิทยาลัย
Pillar of the Kingdom

Sustainability Science for Food, Forests, and Floods: Integrating Climate Adaptation and Pro-Poor Resource Management
Asia Room, Hawai'i Imin International Conference Center, Honolulu, Hawai'i, May 27-28, 2010

Resource Management

- Resource use has external impacts on other resources, for example, fossil fuels-GHGs, groundwater-nearshore resource, deforestation-downstream sediment.
- Managing one resource ignoring the external impacts is suboptimal.
- Terrestrial and coastal ecosystems are both interlinked and closely-related to human activity. Therefore suitable prototype for sustainability science.

Complicated resource-externality

Type of externality / Source of externality	Fund externality	Stock externality
Resource extraction/flow	**Extraction-to-fund** Canonical externality problem (pollution, apple-bee) (e.g. Meade 1952; Pearce and Markandya 1989)	**Extraction-to-stock** Climate change (e.g. Nordhaus 1991; Sinclair 1994; Ulph, and Ulph 1994; Perman et al. 2003)
Resource stock	**Stock-to-fund** Forest-amenity value (e.g. Berck 1981)	**Stock-to-stock** Aquifer→marine resource (limu) Wetland development→ offshore fishery Deforestation→ downstream sedimentation

Sustainability Science of RM

- To manage resource efficiently, we need to know scientific relationships among resources.
- Transdisciplinare study is necessary.
- Possible objectives

  - to decide how many resource we should extract,

  - to evaluate different policy choices,

  - to compare various institutional arrangements,

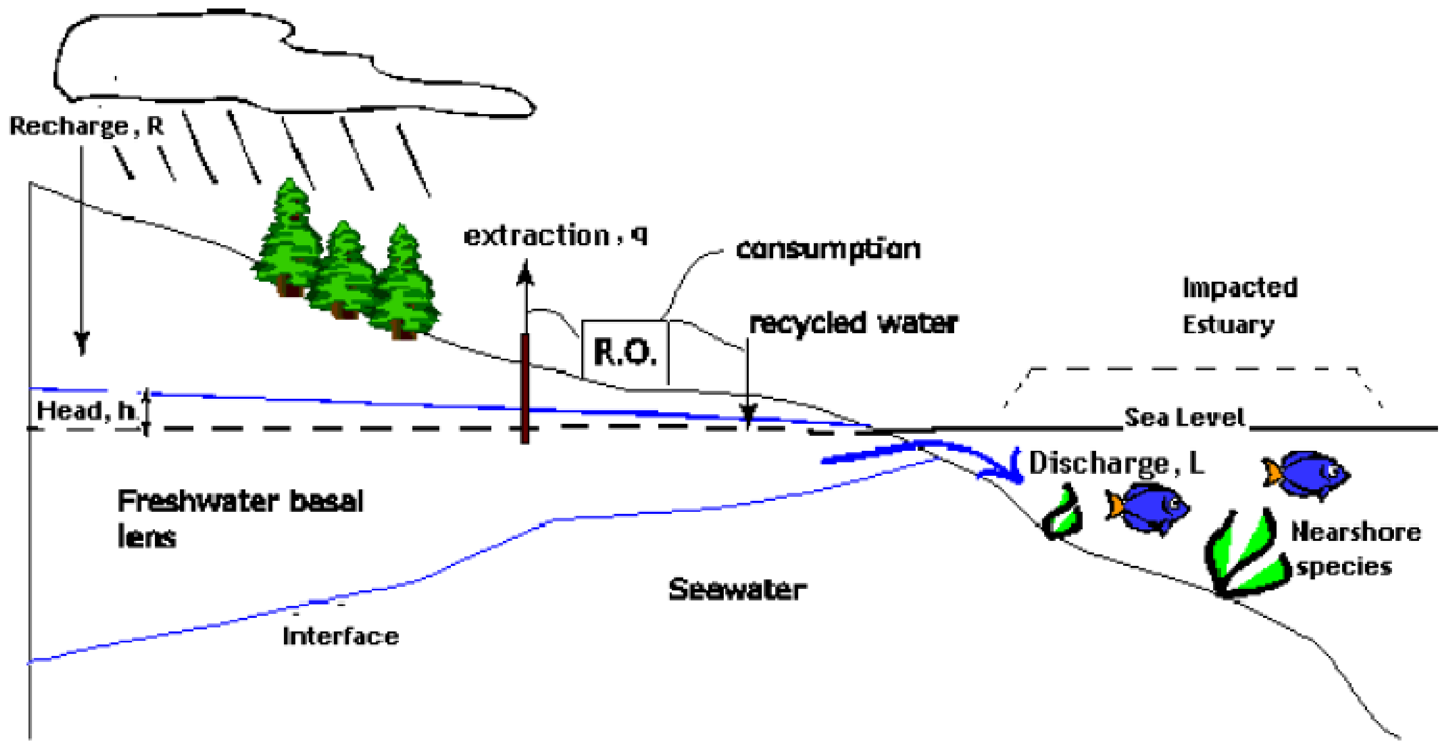
  - to design proper corrective instruments for environmental problems

In this presentation

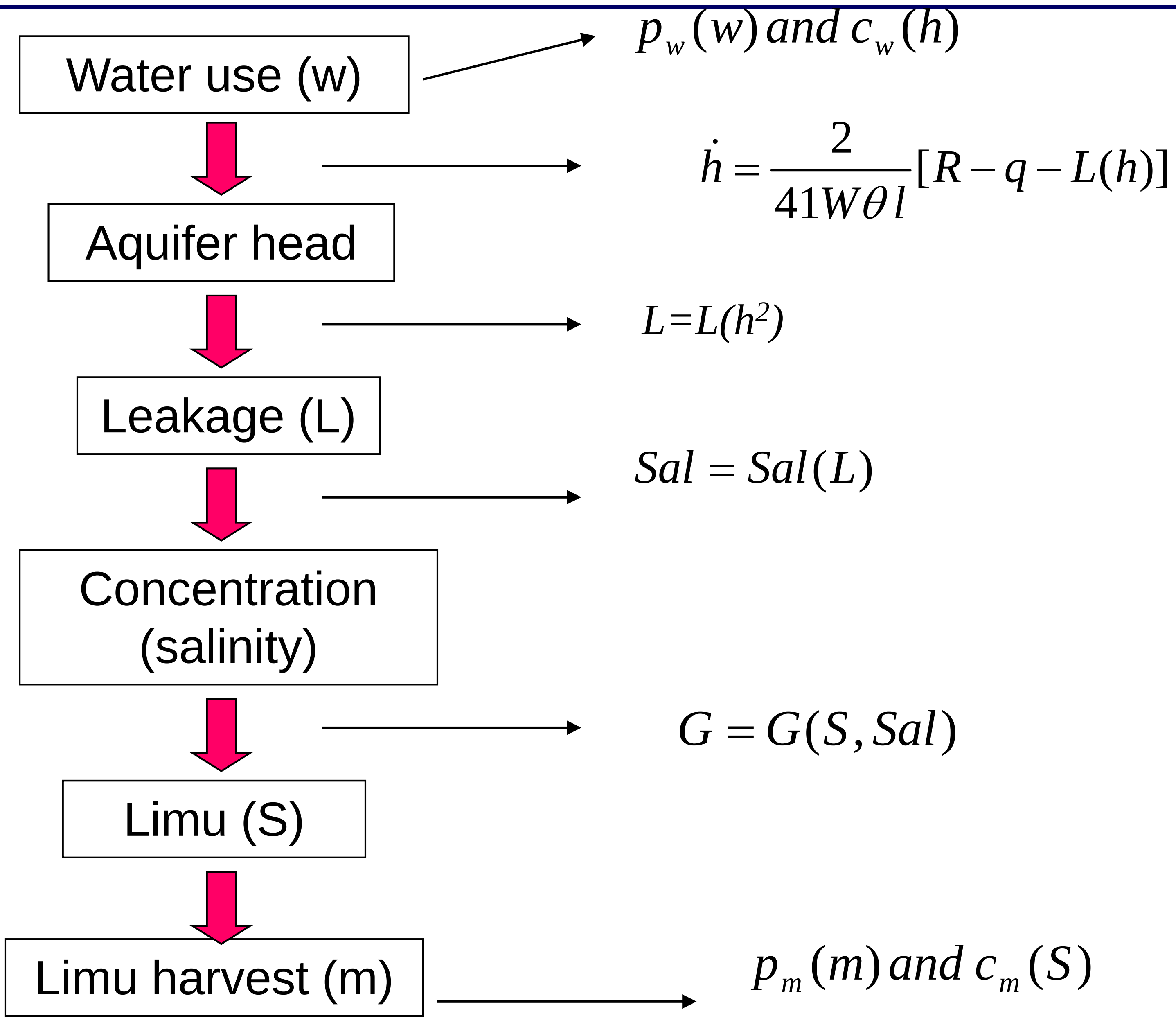
- Optimal use of resource with stock-to-stock interaction: groundwater vs. limu problem in Hawaii
- Valuating benefits from resource use under different institutions: Land use (Mangrove vs. Shrimp farm) and the external impacts on offshore fishery sector in Thailand.
- Further research topic in SS for resource management in developing countries (Thailand).

Groundwater – Limu

- Groundwater aquifer → nearshore water quality → limu
- Integrated framework for water management and estuary conservation by Economic-Hydrology-Ecology model



The Framework



The model

$$\max_{q_t, b_t} \int_0^{\infty} e^{-rt} [\int_0^{q_t + b_t} p(x)dx - c(h_t)q_t - \bar{p}b_t + \int_0^{m_t} p_m(y)dy - c_m(S_t)m_t]dt$$

$$s.t. \quad \dot{h}_t = a[R - l(h_t) - q_t] \qquad \dot{S}_t = g(S_t, h_t) - m_t \qquad p_m(m) = c_m(S)$$

Where:

p: water price

b: desalinated water

h: head level

a: conversion factor from volume to height

q: water extraction

c: extraction cost

$\bar{p}$: desalination cost

p_m: limu price

c_m: limu harvesting cost

R: water recharge

S: limu stock

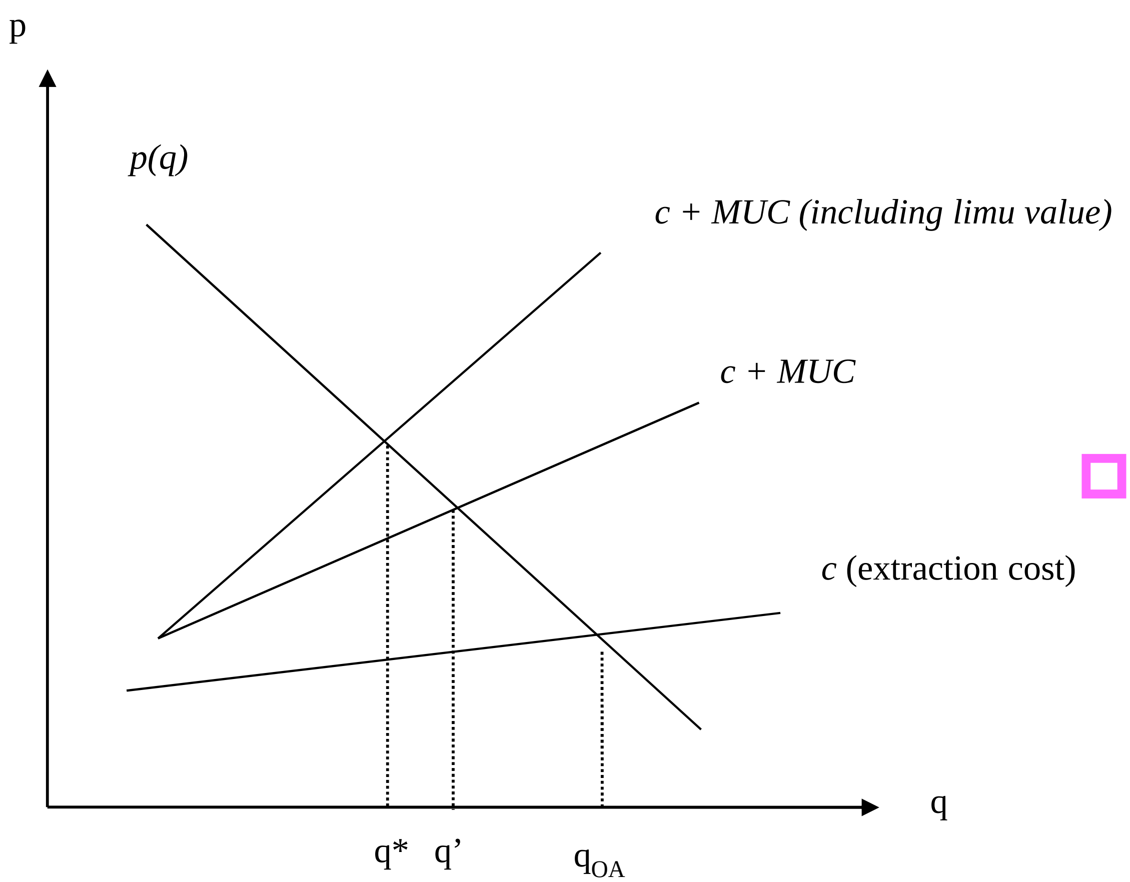
m: limu harvesting

l: leakage

g: limu growth

F.O.C. $$p = c(h) + \frac{\dot{p} - a(R - l(h))c'(h)}{r + al'(h)} + \frac{ag_h(S, h)\theta}{r + al'(h)}$$ MUC

Pearce equation



- Analytical result: Incorporating MUC in total marginal cost decreases the optimal extraction rate of resource
- However, we don't know low much less.

Results: Kukio, Big Island

- First, we compare the optimal extraction between the case considering benefit of water only with the case when benefits of water and limu are taken into account mutually.
- With limu value, optimal extraction rate is only <u>slightly</u> lower than the case without limu value. This is because the market value of limu is relatively insignificant compared to the high value of water

Minimum constraints on limu stock

- Market value of limu may not represent other values, e.g. ecological or cultural value.
- Impose minimum level of limu stock
- Correspond to "Safe minimum standard", and "Irreversibility" concepts
- What if limu stock cannot be depleted by more than 90%, 75%, and 50%?
- The constraint composed will increase the MUC because the scarcity value of water increases.
- As a result, the extraction rate should be even lower.

GW extraction rate

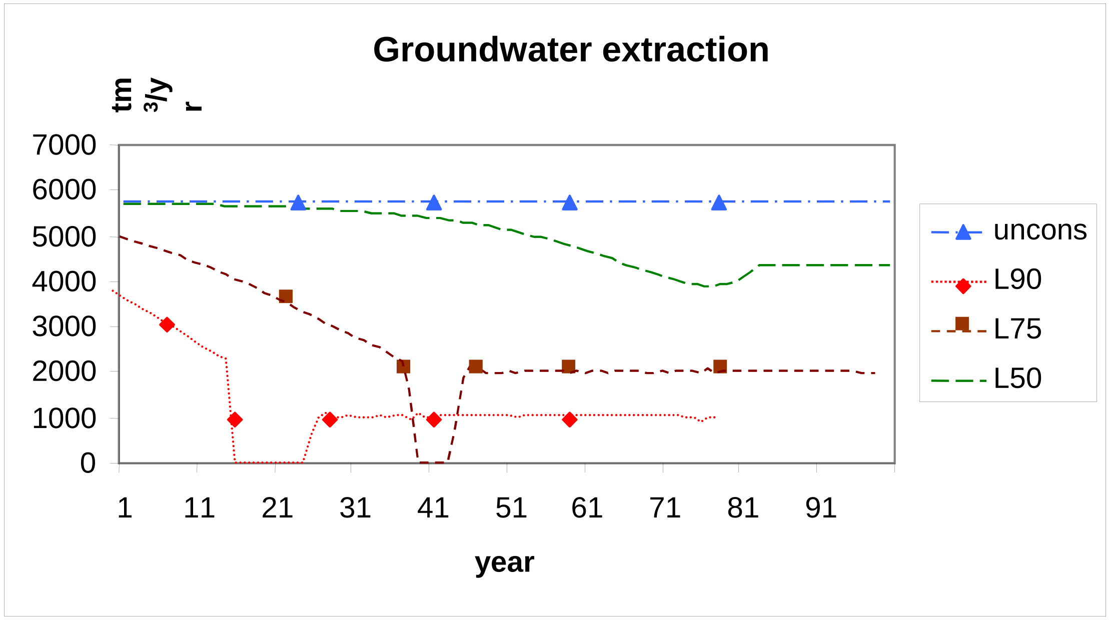


Fig. 2 Optimal paths of groundwater extraction with different marine algae stock constraints.

- It is optimal to extract groundwater heavily in the beginning, following by the conservation period.
- Desalination will be used in only some cases where water price exceeds desalination cost.

Head level

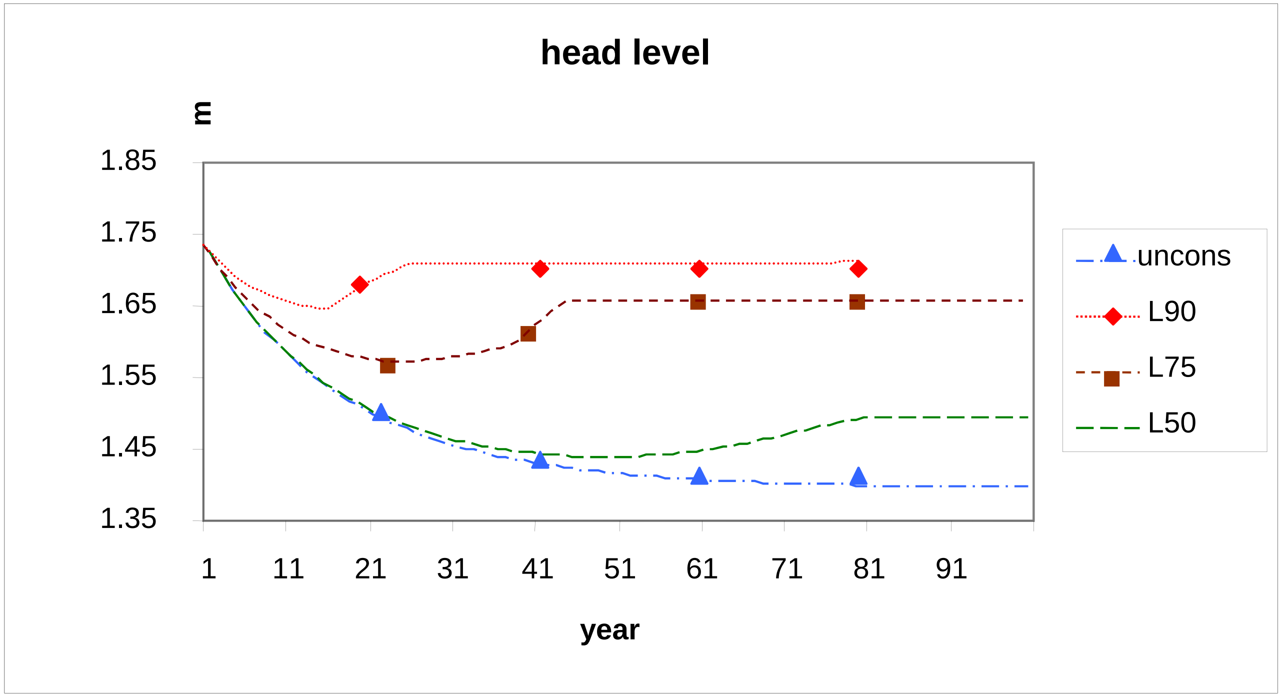


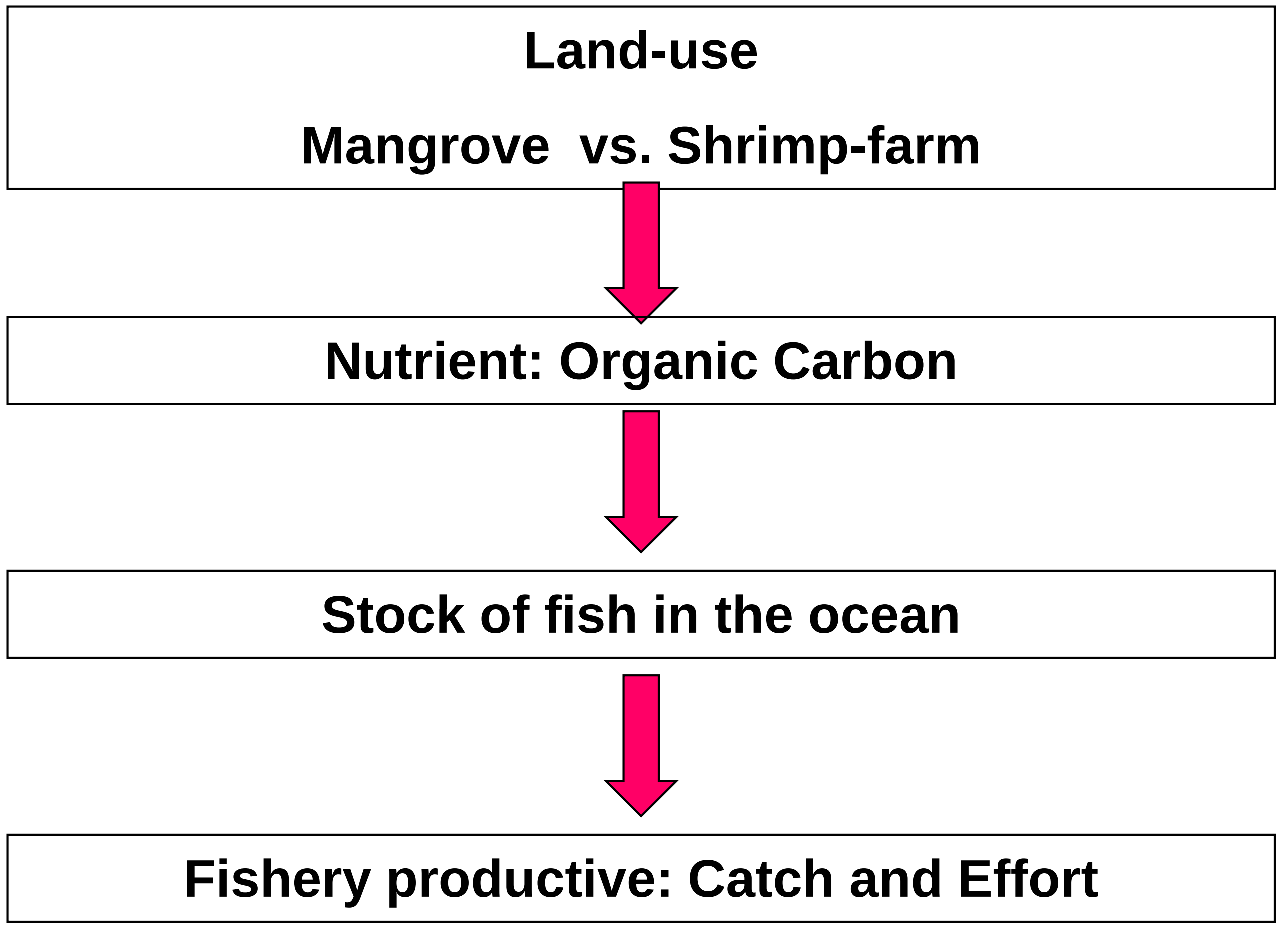
Fig. 1 Optimal paths of head level with different marine algae stock. constraints

- Optimal paths of groundwater extraction, head level are not monotonic.

Mangrove vs. Offshore Fishery

- Valuate the impacts of land-use change on off-shore fishery
- Ecological services of mangrove forest
- Nutrient recycling
- Offshore fishery productive
- Mangrove conversion (to shrimp farm) in Thailand
- Instead of optimizing resource use, we can also use SS to evaluate a discrete change or institutional change

Framework

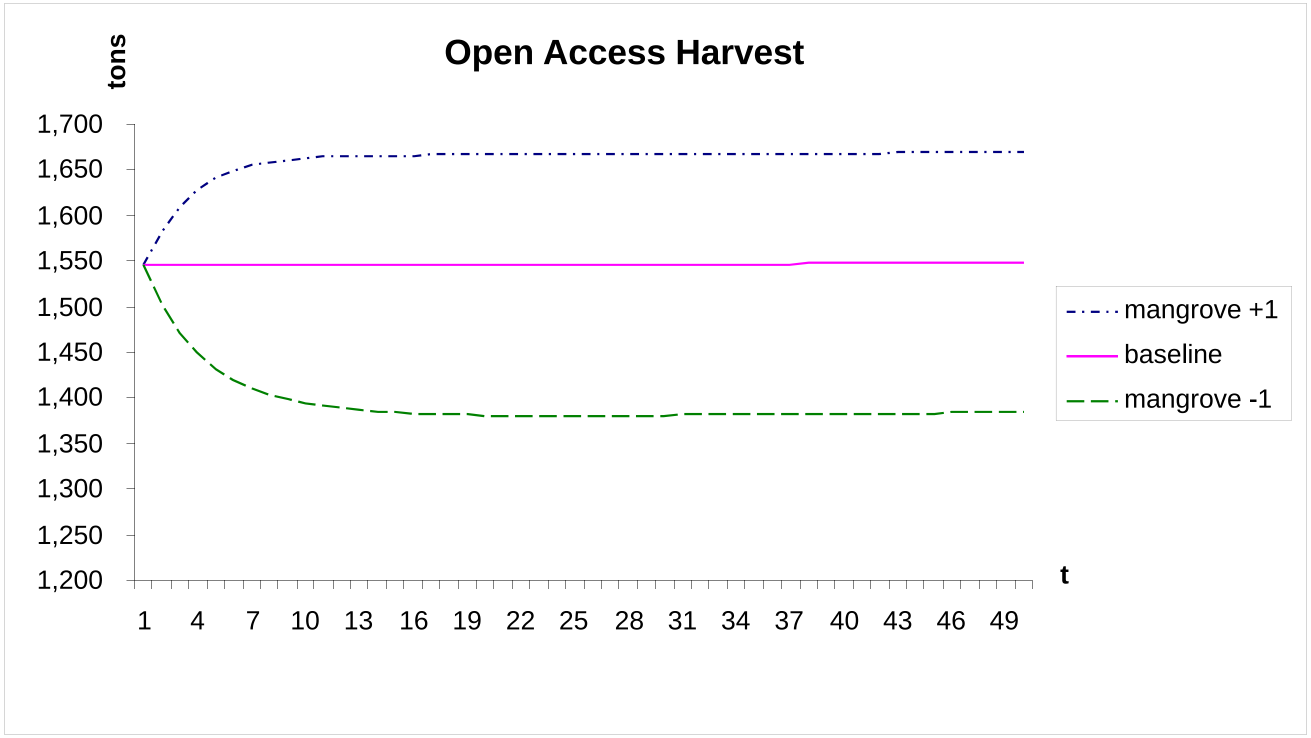

Land-use
Mangrove vs. Shrimp-farm
Nutrient: Organic Carbon
Stock of fish in the ocean
Fishery productive: Catch and Effort

We can then calculate..

- The value of Mangrove under open-access fishery (fishery revenue = $200,000/year/km^2)
- The value of Mangrove under optimal fishery (fishery net revenue = $32,000/year/km^2)
- The impacts of changing fishery regulation, from OA to optimal

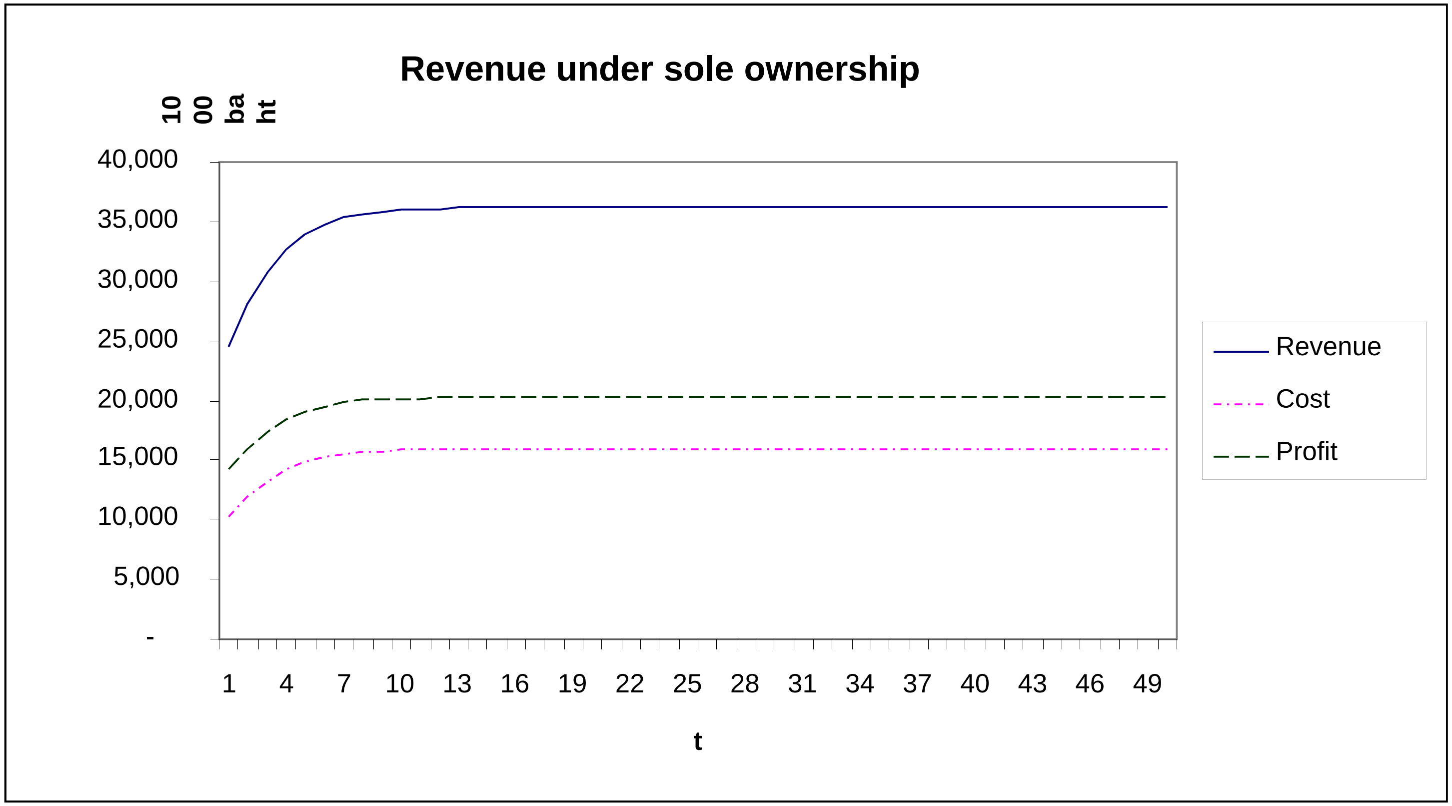
  (fishery net revenue = $650,000/year)

Open access harvest



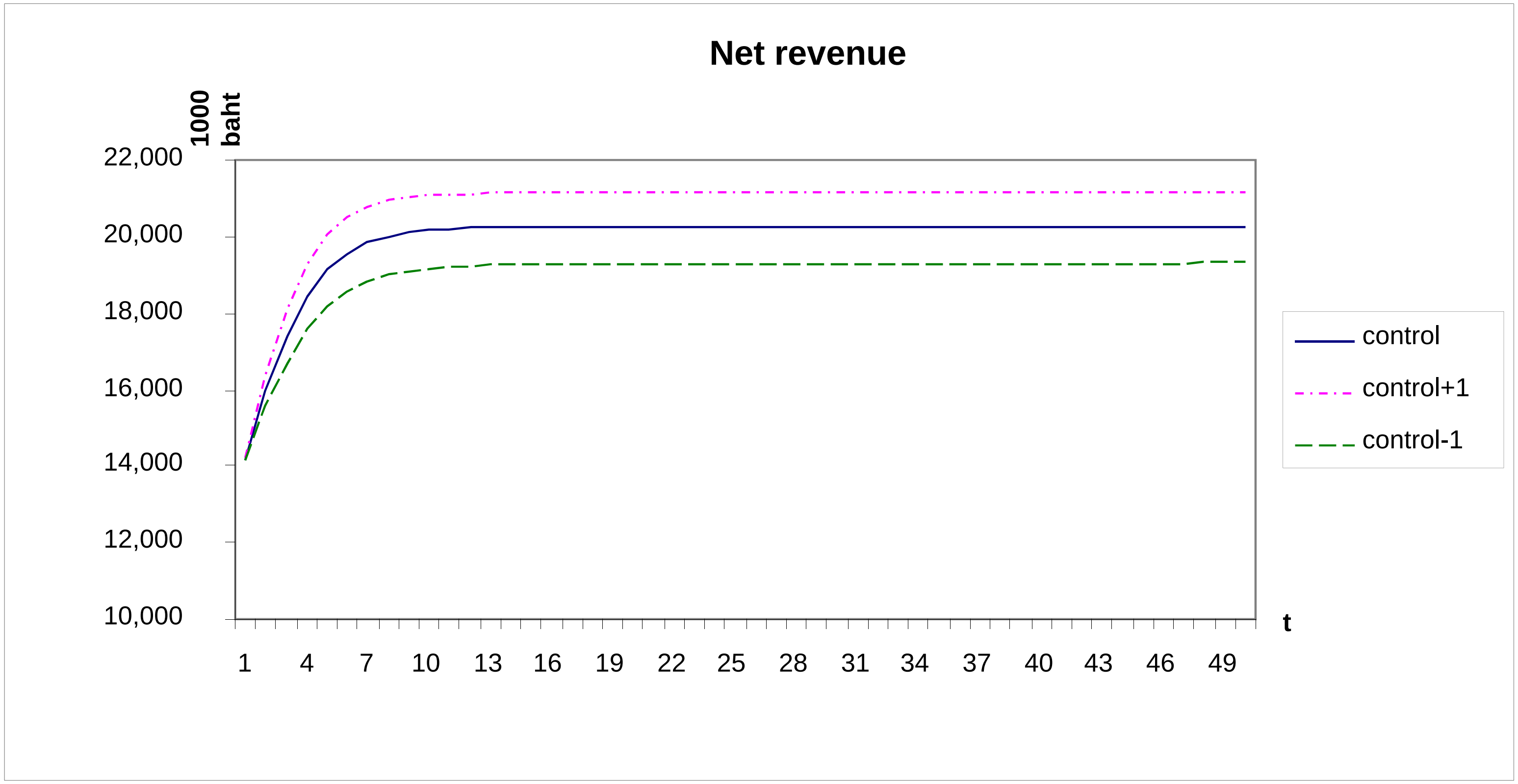
- 1 km^2 reduction in mangrove area will decrease steady state harvest 160 tons (10.44%) and revenue of around $200,000 per year

Sole ownership/ Institution comparison



- Net revenue increases from 14.17 million baht ($450,000) in the first year to 20.27 million baht ($650,000) in the long-run. Discounted net benefit over 50 years is calculated at 504.66 million baht ($16.28 million).

Change in net revenue under optimal catch



- A 1 km^2 depletion of mangrove area results in lower net revenue of almost 1 million baht ($32,000) annually, 22.65 million baht ($0.73 million) over 50 years.

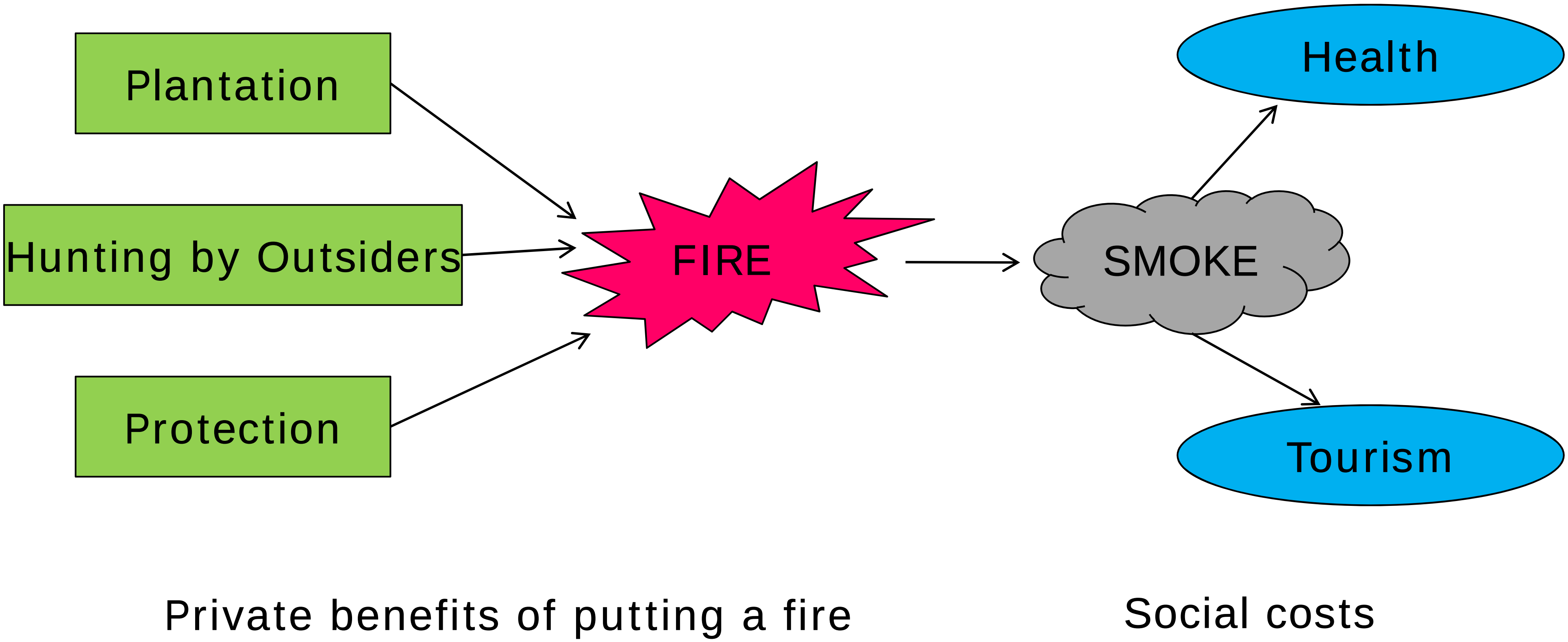
Forest fire problem in Thailand

- In the northern part of Thailand, farmers clear their harvest land (and sometimes forest) by putting a fire on their land in dry season.
- They claim that this will improve soil quality and the yield in the next season.

The impacts

- However, this causes a severe smoke problem all over the region.
- Externalities on health impact: more than 100,000 cases of respiratory disease during Jan-Mar 2010
- Externalities on tourism industry

Framework



Static problem, but emphasize on different instruments under different institutional setup and constraint

What can/should we do?

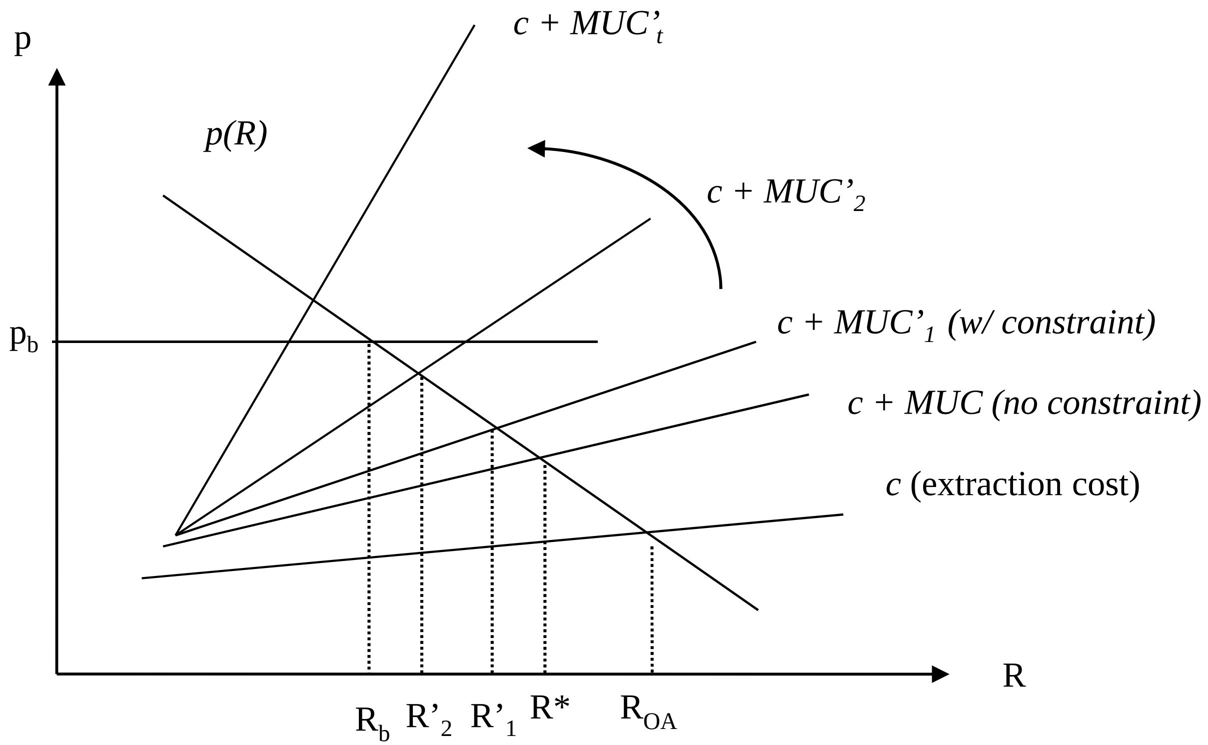
- Restriction.. One for all.. But it doesn't effective at all
- Why? Because government cannot monitor all area.
- We need a comprehensive policy studies in order to prevent each sources of fire.
- Different sources need different corrective instruments.
- For example, incentive scheme, institutional arrangement, community participatory, etc.
- But in order to accomplish this, we need the information on linkages between "fire-smoke" and the impacts of smoke on people.

Under Climate Change

- The problems will be more interesting and more difficult to tackle because of the higher uncertainty, for example,
- GW recharge will be more volatile
- Maybe higher risk to have fire
- Thus, need to improve the models to incorporate these concerns

Thank you very much

w/ constraint analysis



- w/ constraint, MUC is higher
- When head is decreasing, MUC is increasing
- Once the price is higher than p_b, desalination will be used