Performance of a Demonstration Greenhouse RWHs and its Potential in Beijing

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Purpose

- To identify the feasibility of a demonstration RWH system to upscale it in Beijing.
- To estimate potential of greenhouse RWH

Water situation of Beijing

- Water shortage

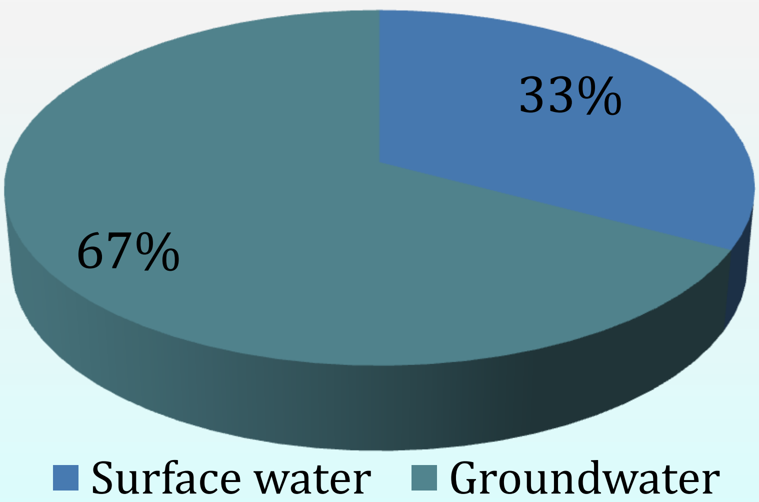
  Annual per capital local water resource is less than 300 m^3. In 2009, local water resources are 2.2 billions. And water consumption is 3.55 billions.

- Agriculture mostly use groundwater

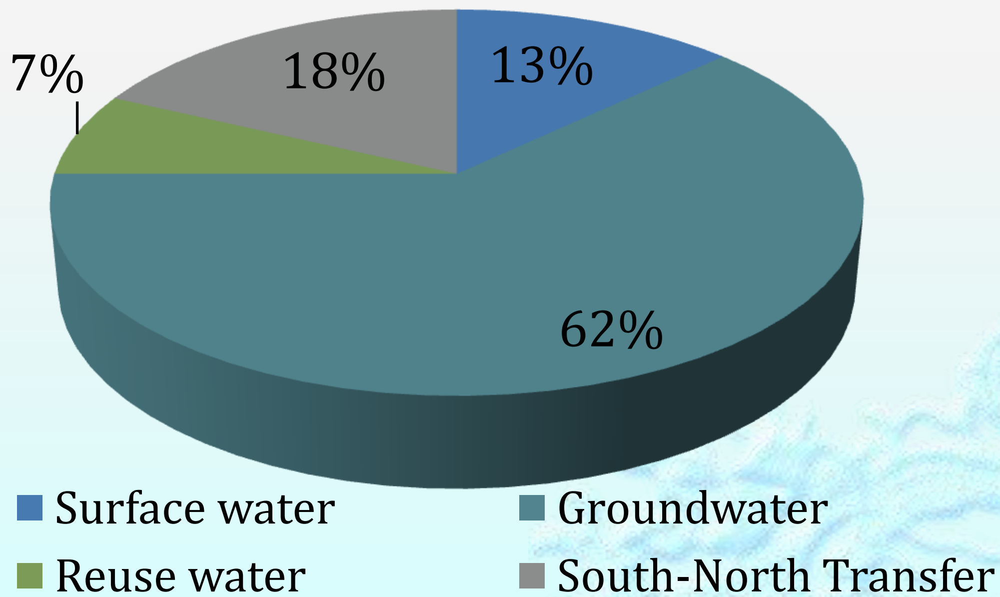
  About 90% is supplied by groundwater. Agriculture consumes more than 1 billion every year.

Changes

- Annual water consumption decreases from 4.04 billions in 2000 to 3.55 billions in 2009 (good?)
- Water supply becomes multi-sources



2000



2009

The Demonstration

- Farm Area: 13,340 m^2, including Greenhouse agriculture 3,335 m^2 (5 G)
- Production: tomato, cucumber, mushroom, onion…
- Water source: groundwater for irrigation (free of charge), tap water for drinking (about 3 RMB/m^3, 1 euro= 9 RMB)
- Water table: 35 meters
- Rainfall: about 600 mm annually, 80-90% April to Sep.

1

3

2

4

System Performance

- RWHE = RWH / Total rainfall (%)
- Rv = reliability of rainwater supply over demand (%)
- Two ways evaluate performance

  1) Simulation by long term of historical rainfall data

  2) And analysis of 2008-2010 operation could be used to testify simulation results.

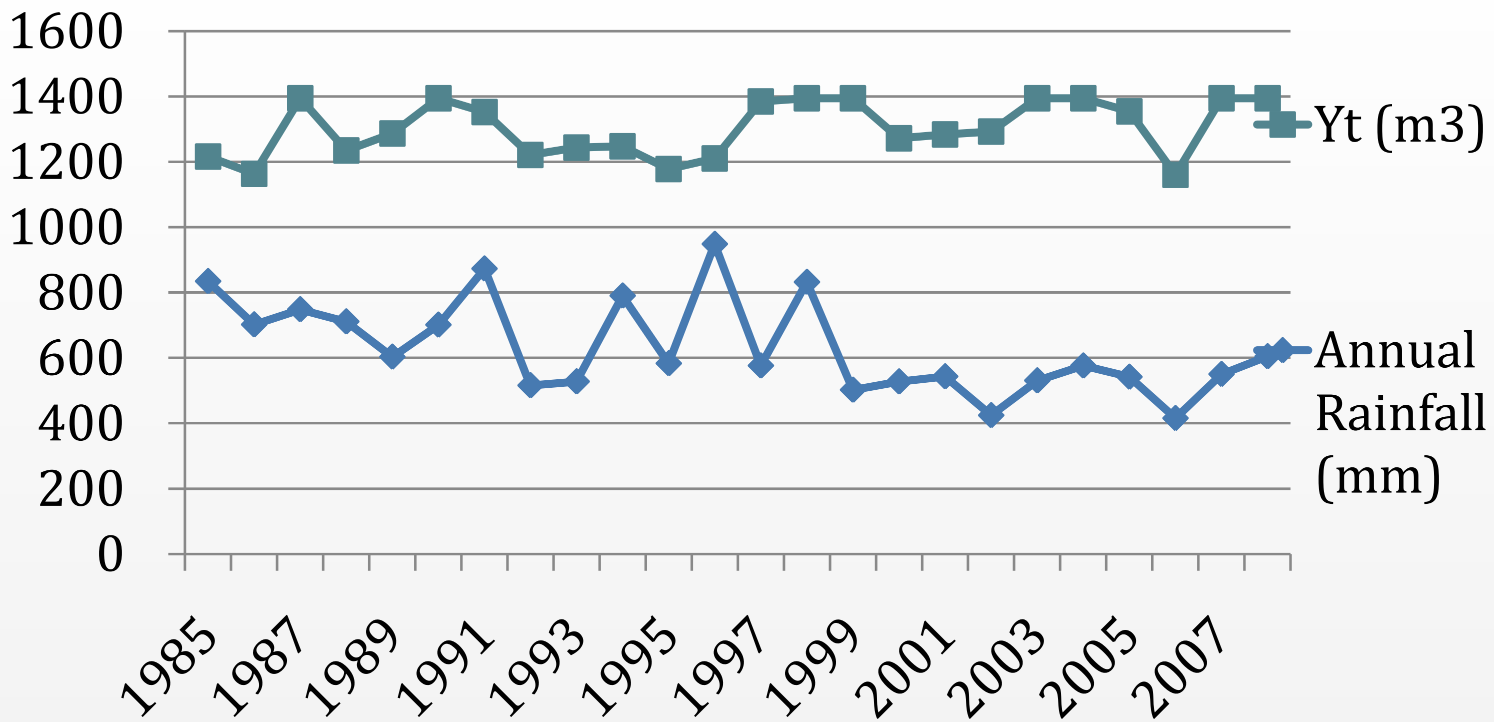
Performance-simulation

- The YBS (Yield before spillage) algorithm (time step: 10days)

$$Y_t = \min\begin{cases} D_t \\ S_{t-1} + Q_t \end{cases}$$

$$S_t = \min\begin{cases} S_{t-1} + Q_t - Y_t \\ V \end{cases}$$

- Y_t = yield from the tank in t^{th} time period (m^3); D_t = water demand at time t (m^3); S_t = storage at the beginning of the t^{th} time period (m^3); Q_t = inflow during the t^{th} time period (m^3); V = storage capacity (m^3).



YBS simulation results

Irrigation (m^3)		Rv (%)	TR (m^3)	RWHE (%)
Demand	Supply			
1 395	1 296	92.90	2 106	61.54

Records of 2008 - 2010

Year	Rainfall (mm)	Irrigation (m^3)		Rv (%)	TR (m^3)	RWH (m^3)	RWHE (%)
		Demand	Supply				
2008	583	1 050	1 050	100.00	1 944	1 233	63.42
2009	534	1 430	1 190	83.22	1 781	1 190	66.82
2010	542	1 390	1 120	80.58	1 808	1 120	61.96

Simulation results are close to three years records

Benefit/Cost

- Benefit

  for farmer: lower energy consumption, higher production income

  for the city: lower GW overexploitation

- Cost

  for farmer: high initial investment, low running cost

  for the city: high initial investment

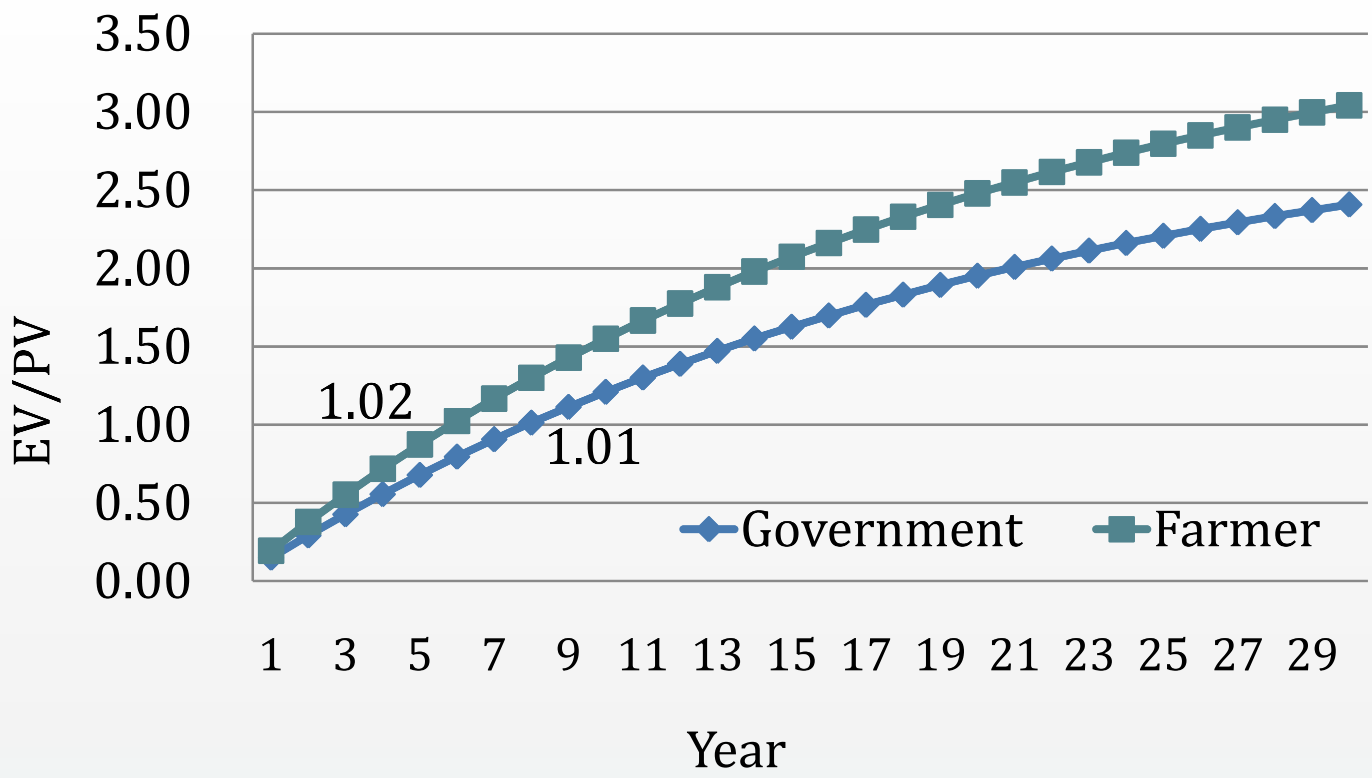
α ≥ 1?

$$EV = B \times \frac{(1+i)^n - 1}{i(1+i)^n}$$

$$\alpha = \frac{EV}{PV}$$

$$PV = I + C \times \frac{(1+i)^n - 1}{i(1+i)^n}$$

EV = present value of total benefits (in RMB);
PV = present value of total cost (in RMB).
B = average annual benefits (in RMB/y).
i = discount rate (5%).
n = service life of system (30 years). I = fixed investment (in RMB). C = annual running cost



Payback time: 8 and 6 years

EV/PV: 2.41 and 3.04

Comments: it could be an economic feasibility project.

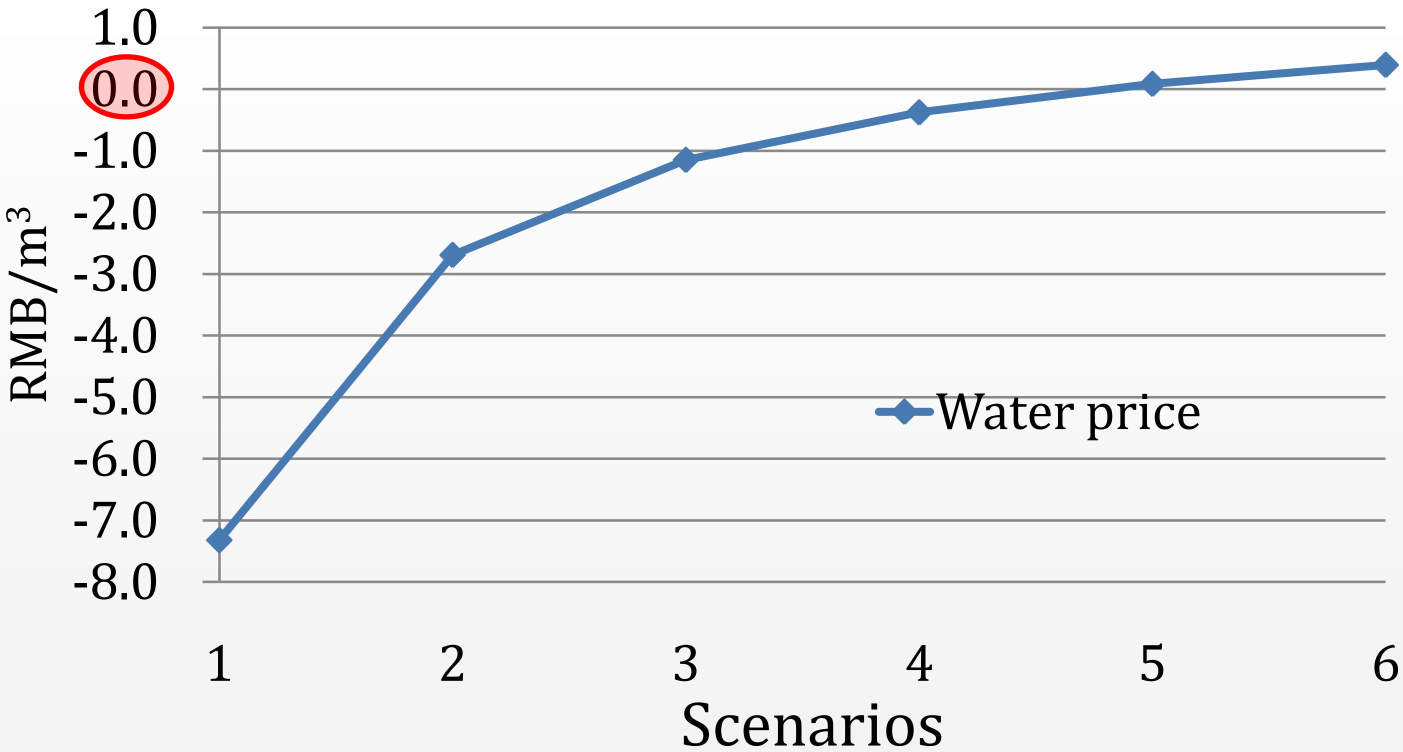
Water price

- To figure out how to set a water price (of GW) to promote farmers using RW instead of GW

- Cost of using GW $\boxed{\underset{\text{price}}{\overset{\text{Break-even}}{=}}}$ Cost of using RW

$$I_1 + n \times C_1 = I_2 + n \times C_2$$

- Water price ≥ Break-even price, then it's more economic to use RW.



1. Scenarios according to different service life of a tube-well, i.e. 5, 10, 15, 20, 25 and 30 years.
2. Service life less than 20, cost of using RW is lower than GW
3. Service life more than 25, we need to set a break-even price to promote RWH.

Potential estimation

Scenario 1	**Greenhouse agriculture develop and 30% with RWH**
Scenario 2	Greenhouse agriculture develop and 50% with RWH

$$P = G_a \times R_a \times 0.001 \times RWHE$$

P = RWH potential in 2020.

G_a = area of greenhouses developed

R_a = annual rainfall (in mm).

Table Potential estimation 2020

Scenario 1	**55 millions**	**1.6 %**
Scenario 2	91 millions	2.6%

Thanks ！