The feasibility of rainwater harvesting in the rural areas of Beijing

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Beijing rural area and water source for agriculture irrigation

Figure 1 The distribution of Beijing rural areas and location of the An project

Underground water is the main source for agricultural irrigation in the rural areas of Beijing, which accounts for around 75.6% of total agricultural water consumption in 2001(Beijing statistic year book, 2008).

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Decrease of underground water level

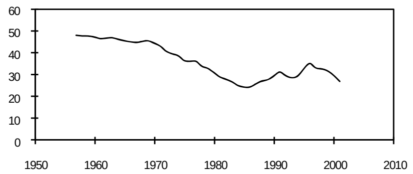

Figure 2 The groundwater level at Capital Normal University in Beijing urban area (Adapted from Beijing Geological Institute)

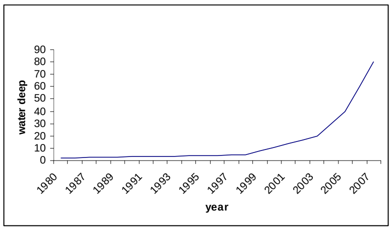

Figure 3 The change of water depth of a well in Beijing rural area
(Sourced from interview with An project manager)

New water source

- Rainwater harvesting is a cheap and easy way to replace underground water for agricultural irrigation.
- Recently around hundreds of rainwater harvesting tanks have been constructed by the government. The capacity of these rainwater harvesting tanks mostly ranges from 50 to 1000 m3.
- Although rainwater harvesting tanks are built by the government, the remaining expenditures for the functioning of rainwater reuse systems have to be paid by the project managers.
- Normally the project managers of these rainwater reuse systems are local farmers who have no experiences and knowledge of the technology for rainwater reuse.
- Compared with using underground water, using rainwater for agricultural irrigation is a “new thing” to the local farmers.

Objective of the study

- If the rainwater reuse system is not financially attractive, the local farmers would reject the "new thing" and continue to use the underground water for agricultural irrigation.
- The objective of this study is to evaluate whether the rainwater harvesting and reuse projects in Beijing are financially attractive.
- The "financially attractive" means that the "new" system is better than the "original" one.
- The existing papers concentrate on evaluating the economic feasibility of rainwater harvesting and reuse systems. The economic feasibility only indicates that the new system is economically feasible to be constructed, which does not reflect the "new system" is more attractive than the "original system".

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The studied case

Table 1 The information related to the studied case

Item	**Value**
Capacity of storage tank	500m^3
Harvested water amount	700m^3/year
Reuse for irrigation	450m^3/year
Irrigating area	640 m^2

• Firstly, the technique used in the An project is very similar to that of other projects in Beijing rural areas.

•Secondly, the crops planted in the An project are all the common crops in Beijing's rural areas.

•Thirdly, the financing sources are similar between the An project and other projects in Beijing's rural areas.

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Methodology--Comparison

- Different financing models are compared in order to find which model is financially more attractive.
- The hypothesis is that all required irrigating water is supplied by rainwater and the incomes for crops do not change in the evaluation period.

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Methodology--Comparison

- Option 1: without the rainwater reuse system. There is not initial investment for a rainwater harvesting and reuse system. The irrigated water is all pumped from the well, and the underground water is charged. This option represents the status of “no change”.
- Option 2: with a rainwater reuse system. In this option, all irrigated water comes from rainwater. The storage tank is subsidized by the government, but other cost for the initial investment should be paid by the project manager. The storage tank is only used for rainwater harvesting.
- Option 3: with a rainwater reuse system and an increased subsidy. All irrigated water comes from rainwater. Two third of the initial investment is subsidized, including the cost of the storage tank and other water reuse facilities. The storage tank is only used for rainwater harvesting.
- Option 4: with a rainwater reuse system and using storage tank for different purposes. Since the rainfall in Beijing is concentrated in the period from March to September, the storage tank will be idle during other periods. We suppose that the tank is used for mushroom planting when it is not used for water storage. So the income for crops in option 4 is larger than that in other options. All irrigated water is from rainwater. The storage tank is subsidized by the government, and other cost is paid by the project manager.

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Methodology—Financial cost and benefit

Table 2 The values of financial cost and benefits of four options

	Option 1	Option 2	Option 3	Option 4
Financial cost				
Initial investment (Yuan)	0	300000	300000	300000
O&M Cost (Yuan/year)	8000	1100	1100	1100
Production cost (Yuan/year)	7945	6280	6280	43780
Financial benefit				
Subsidies (Yuan)	0	100000	200000	100000
Income for crops (Yuan/year)	42000	42000	42000	110000

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Evaluation instruments

Two economic instruments are used in the financial evaluation: NPV (Net present value) and IRR (Internal Rate of Return).

$$B_n = \sum_{t=1}^{n} \frac{B_t}{(1+i)^t} \qquad C_n = \sum_{t=1}^{n} \frac{C_t}{(1+i)^t}$$

$$V_n = B_n - C_n \qquad \sum_{t=1}^{n} \frac{B_t - C_t}{(1+\lambda)^t} = 0$$

- Where, *Bn* is the present value of financial benefits in the evaluation period of *n*; *Bt* is the financial benefits occurring in year t, *i* is the discounting rate, *n* is the evaluation period (number of years), *Cn* is the present value of financial cost in the evaluation period of *n*, *Ct* is the financial costs occurring in year t, *Vn* is the net present value in the evaluation period of *n*, λ is the internal rate of return.

- i=0.08, n=1,2,3……20

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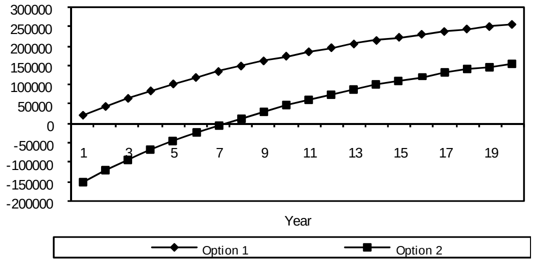
Results

Figure 4 The comparison of NPV between option 1 and option 2

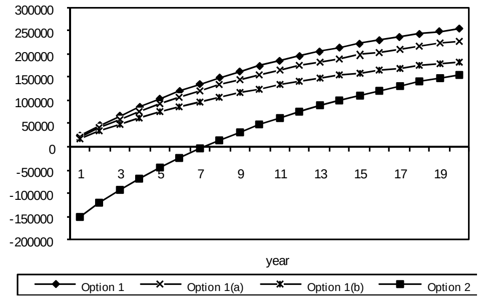


• option 2 is not financially more attractive than option .

• comparing rainwater and underground water, farmers would prefer to continue to use underground water even though the underground water is charged.

Results

Figure 5 The comparison of NPV between different options with alternative prices for sensitivity analysis



The financial situation of option 1 is not much sensitive to the price of underground water.

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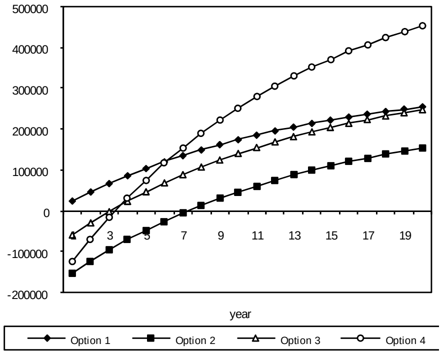
Results

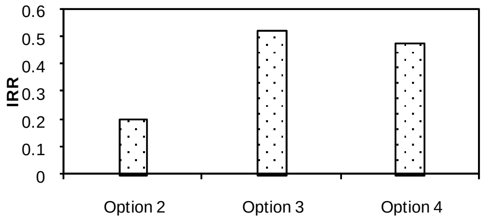
Figure 6 Comparison of NPV between four options



Increasing subsidies or increasing income from crops can improve the financial situations of rainwater reuse projects.

Results

Figure 7 Comparison of IRR within three options



- In option 3, the subsidy for the initial investment paid by the project manager is an acceptable amount to the farmer in Beijing and this option has a better internal rate of return. But its NPVs are lower than option1.
- In option 4, higher income generated by using the rainwater harvesting tank for different purposes results a higher NPV than option 1. But in option 4, the initial payment of the project manager is 200000 Yuan which is too high for most farmers.

Conclusions

- The results show that the rainwater reuse system in Beijing is financially feasible. However, the rainwater reuse system is not financially attractive to the farmer.
- Increasing subsidies or using the rainwater harvesting tank for different purposes is an option to make the rainwater reuse system financially more attractive.
- However, the option of increasing subsidies or increasing income for crops has its advantage and disadvantage.

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Thank You!

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