Exploring Farmers' Groundwater Use Patterns with an Agent-based Modeling Approach Case study: Qazvin irrigation Network Area

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Abstract

Water resources scarcity is a major problem in arid and semi-arid countries like Iran. In such regions, groundwater resources play an important role to fill the gap between water demand and surface water resources deficiency when there is conjunctive use of surface and groundwater resources. Qazvin Irrigation Network Area (QINA) is an irrigation network system located in central part of Iran, where farmers have access both to surface and groundwater resources for irrigation. While farmers are dependent on groundwater resources, Qazvin plain has suffered from severe groundwater depletion and has been banned for further abstraction for years. In our study, continuous dropdown of groundwater resources in QINA, as a case study, has been studied with an agent-based modelling approach which enabled us to study heterogeneous farmers/ agents, with different resources and priorities. In this paper, groundwater use patterns where checked through different scenarios with regard to water pricing. The preliminary results show that low water cost is one of the main reasons for groundwater depletion in QINA so water pricing can be an effective policy to motivate farmers to extract less groundwater. At the end, suggestions for the policy makers to make this policy executable are presented.

Keywords: Qazvin Irrigation Network Area, Agent-based modelling, Policy making, Groundwater depletion.

1 Introduction

Iran is located in an arid and semi-arid region with growing population and though growing water demand in both municipal and agricultural sectors. Groundwater resources have been adversely affected by water scarcity issue in a way that many aquifers have been banned for further abstraction since many years ago but unfortunately continuous depletion of groundwater in many aquifers in Iran is still the main concern. This situation shows that an effective policy should be adopted by the government to not only stop groundwater resources dropdown but also recover groundwater storage. For this purpose, the policies should be adopted with regard to local situation and users behaviours and properties. As a result in this paper agent-based modelling approach has been used to explore policies in Qazvin irrigation Network Area (QINA) as a case study. There are plenty of researches on using agent-based models in the field of agricultural land use (Valbuena et al. 2010, Parker et al. 2003, Castella et al. 2005), water management (Berger et al. 2007, Schlüter et al. 2007, Ng et al. 2011) and specially policy making (van Oel et al. 2012, Mulligan et al. 2014, Giuliani and Castelletti 2013). With agent-based modelling approach, we will be able to explore policies, while considering agents/users behaviours and properties and find out how much each policy can be effective to save groundwater resources. In the next section, the case

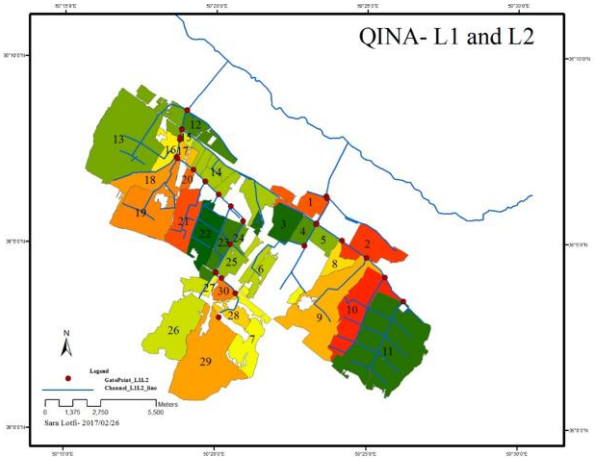

Figure 1: Case study area: QINA

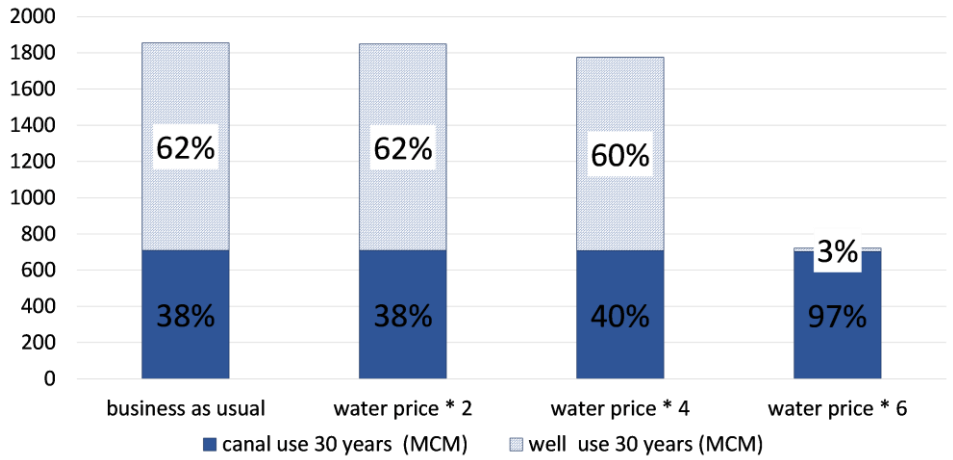

Figure 2: Water use by farmers in different scenarios

study is briefly introduced. After that, the developed agent-based model is described. Then the paper ends with the results and conclusion.

2 Case study

Qazvin plain is located in central of Iran in which groundwater depletion has been an issue since 35 years ago. Like many other basins in Iran, further groundwater depletion has been banned for years but groundwater level has been lowered more than 10 meters in last 15 years. Part of this plain is covered with Qazvin Irrigation Network Area (QINA) that is well-known as a modern irrigation system in Iran. In QINA, the farmers have access to surface water through canals and groundwater resources. The allocated surface water delivered to the farmers is from a dam that is also responsible to supply part of drinking water of Tehran, capital of Iran. With growing population of Tehran, more water is needed for Tehran city so the amount of water allocated to QINA is decreasing each year. First two sub-canals of this area (Figure 1) is the case study that is around 13000 ha. In this area, the farmers cultivate crops two times in a year: Wheat and corn are the main crops cultivated by the farmers in fall and spring, respectively.

Statistics show that irrigation accounts at most 30 per cent of the cultivation cost by the farmers. The price of one cubic meter of groundwater costs almost twice as much as one cubic meter of canal water so the farmers try to supply their irrigation demands from canal before wells. Unfair distribution of canal water rights with respect to the field area besides the decrease in surface water allocation to QINA has led the farmers to rely on groundwater resources (and even extract more that they are allowed) to supply their irrigation demand. Interviews with the farmers show weak monitoring system in the area is the main reason for over-tapping groundwater resources by users.

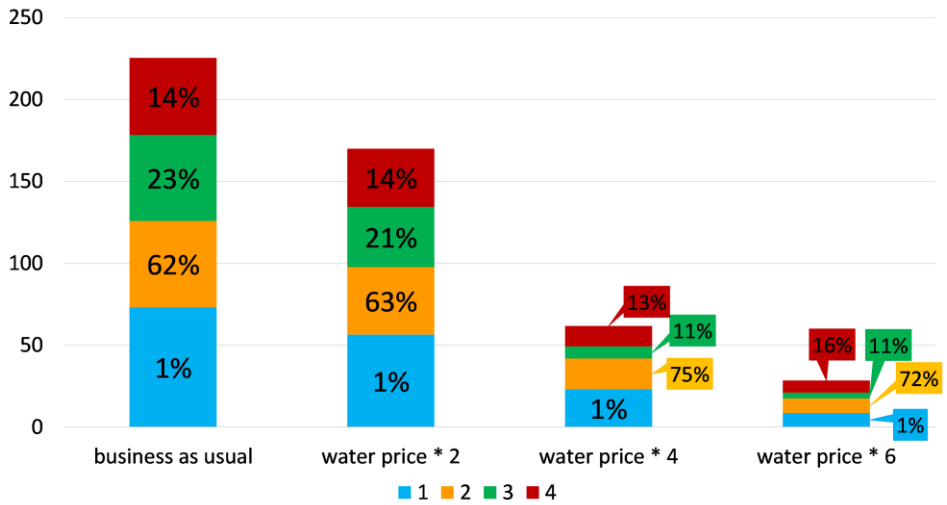

Figure 3: Profit gained per ha by four clusters of in different scenarios

3 Methods

In this study, an agent-based model is developed to explore the effectiveness of different policies in QINA to save groundwater resources by accounting farmers behaviours and properties.

The farmers/ agents are clustered into four main groups based on their access water resources:

Cluster 1: Farmers who have plenty of access to both surface and groundwater resources.

Cluster 2: Farmers who have plenty of access to canal but not groundwater.

Cluster 3: Farmers who have access to plenty of groundwater but not canal.

Cluster 4: Farmers who do not have plenty of access to canal and groundwater.

As mentioned before, Farmers cultivate crops two times a year in Fall and Spring. In each cultivation season the farmers decide about the area allocated to the crop they intend to cultivate while they do not allocate more than 30 percent of their field area to spring crops.

In this study, four different scenarios are compared with each other:

- 1-Business as usual
- 2- Twofold rise in water price
- 3- Fourfold rise in water price
- 4- Six fold rise in water price

4 Results

In figure 2, the results of four scenarios are compared with regard to water use. Each column shows the water use in each scenario while the percentage of surface and groundwater use is labeled on them.

The results show as the price of water increases the amount of water used for irrigation decreases. As surface water costs half of groundwater, the amount of surface water used by the farmers does not decrease. In the last scenario, with six-fold increase in water price, the amount of groundwater use decreases substantially.

Figure 3 shows the amount of fund that farmers will have in 30 years. It shows the farmers gain less profit as the price of water increases. In this figure, the share of each farmer from the fund gained in the study area is labelled on the figure in per cent, too. The results show with rise in groundwater price, the farmers will gain less profit while the share of different clusters of farmers, from the gained profit, changes.

5 Conclusion

The results showed that with an increase in water price, the amount of water used by farmers decreases while they gain less profit. As canal price is less than groundwater price, water pricing policy mostly affects groundwater use which is the main concern. Also this policy affects farmers who are more dependent on groundwater resources than surface water and thus their share from the profit decreases with rise in water price.

In conclusion, to execute water pricing policy it is recommended that policy makers take in account the below points:

1- Although this policy seems effective but there should be some other side-policies, like effective monitoring system, to make farmers follow this policy.

2- It is recommended that policy makers think of compensation polices to help farmers with their profit loss.

3- This policy may affect different clusters of farmers differently. The farmers who mainly rely on groundwater resources for irrigation are affected more than the others. As a result it is recommended that policy makers pay attention on diverse effect of this policy on different stakeholders.

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