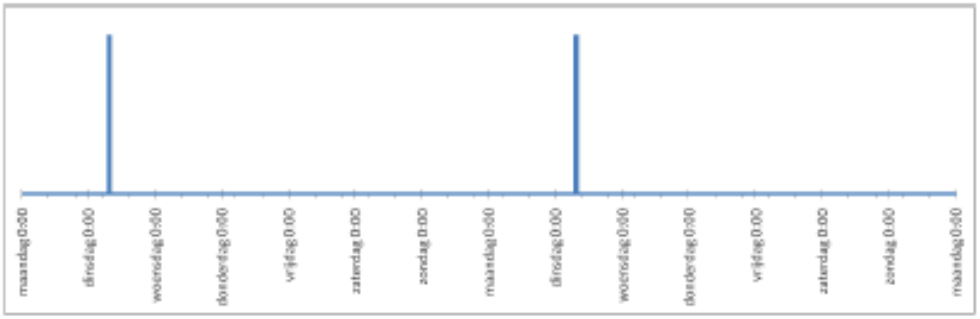
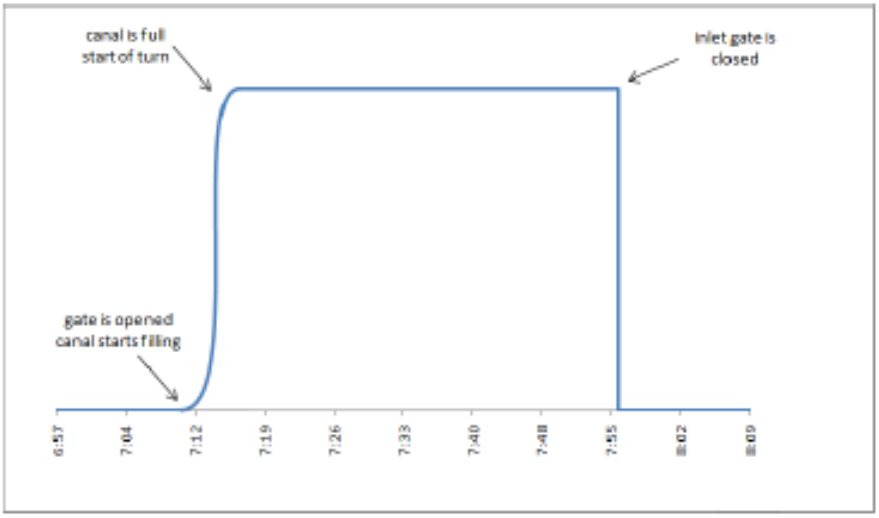
1. **Overview of delivery schedule**



Close up of one turn



2. We agree that the definition of water rights is an advantage on paper, not like the situation here in the warabandi system is outlined. In its present form the allocation of the water is too simplistic. Several factors should have a role to play in the definition of water rights. Waste of water and excessive irrigation are indeed great disadvantages because of unreliable supply, random and frequent occurrence of maintenance and a faulty distribution of water rights.

   We therefore agree with both, but we are more convinced of the fact that the disadvantage mentioned in the paper is the main disadvantage and not fully convinced of the fact that the advantage mentioned in the survey is the main advantage . To fully agree on the fact that the advantage in the paper is really the main benefit we would need several factors to establish a clear definition of water rights such as the paper also concludes.

   They relate because every farmer now gets his water rights allocated on the size of his farm, on the amount of hectares. There will be a waste of water or over irrigation when not all of the land is being used for growing crops, or when the farmer grows crops that do not have a demand for the big amount that will be delivered.

3. According to table 1 and 3, the survey includes many factors, including water rights, quality, price and shortage, farm size and location, education level, profit and whether the farmers have other types of income.
   However, the value of *personal investments* has not been taken into account.
   The profit of a farmer is not only determined by the water he gets and the amount of land he tills, but also by the amount of labour he contributes to tending to his crops and the use of products such as high quality seeds, herb- and pesticides, fertilisers etc. Applying these products and labour will increase the yield of the farm, but also cost the farmer either money or time.
   The paper slightly hints at, but does not take into account, the invested labour with *'Farmers having no income other than from agriculture'*, as having a side job means that they spend less time at their field than those who do not. The paper states that those with another income could use this to buy *'crop inputs'* (fertilisers etc), thus increasing their profit, completely ignoring the input of labour.

   A factor for the invested time and costs could be derived by comparing the size, the net income of the farms and the water applied to the fields.

   Note that the management and control of the system is also an influence, but as the paper considers the inflow of water at farm level, not at system level, these factors are included in the water shortages, regardless of whether they are caused by poor management, losses within the system or simply low water supply at the intake.

4. Performance of the main system under warabandi arrangements does not potentially differ much from other types of arrangement in other main systems, because the systems themselves do not differ much. The main and secondary levels of the warabandi system consist of canals discharging a constant water flow. This is the case in most large-scale irrigation systems.

   The difference between the warabandi system and other irrigation systems becomes clear when the distribution system in the lower levels is considered. The proportional distribution to the watercourses and tertiary units is a problem in the warabandi system. Water rights are still granted on the basis of landholdings, despite socio-economic changes in the last decades. Water allocation on the basis of one criterion never proves to be a success. Also, farmers do not have control over the irrigation interval, amount and its distribution. When an external party with limited information and knowledge about a particular field has to decide, wrong choices can and will be made. This introduces an additional source for potential differences with other irrigation systems. Productivity depends on a lot of factors, such as e.g. irrigation requirement, soil type and the crop that is grown. Other systems might function in more effective ways when these factors *are* taken into consideration.

5. If more water is assigned to them, farmers will be more careless with the implementation of that water. However, some farms can be effective in their water use. This can be seen when we look at 3L-G. In the game investments were also included, such as seeds. This affected the profit and effectiveness of the yield per unit water. Unfortunately, the game did also not include labour investments. In the game we also did not have to pay for water rights and

also did not pay anything per unit water (that was delivered by the manager). This affects the net income majorly. Another difference is that in the game, we were allowed to ask for a certain amount of water, while in the Warabandi system farmers are assigned water based on the size of their farm.

A similarity is, that during a water shortage, people divert to their neighbors who have water. Whether groundwater in Pakistan, or units of water in the game, people ask exorbitant prices for additional units of water.

In short, the more water is supplied to one farm, the lower the effectiveness with which the farmer handles the water. Because they are becoming 'too spoiled', farmers at the end of the tails will do anything to get extra water.

6. The paper shows three graphs relating data to the position of the farms in the system: the water right, water shortages and farm income per hectare.

Figure 4

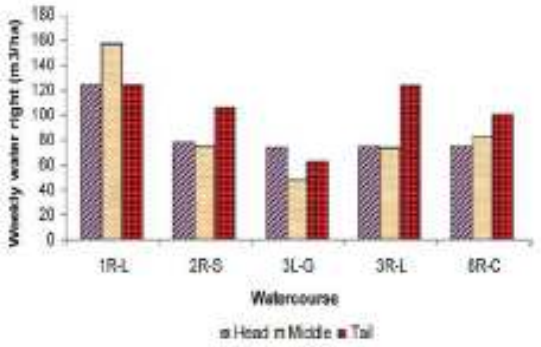


Figure 4, on water rights, does not really depend on the farm location as much, as also crop type, soil conditions, groundwater supply etc affect it. The graph does not show any clear head-tail pattern, but this not say anything about the behaviour of the system.

Figure 6

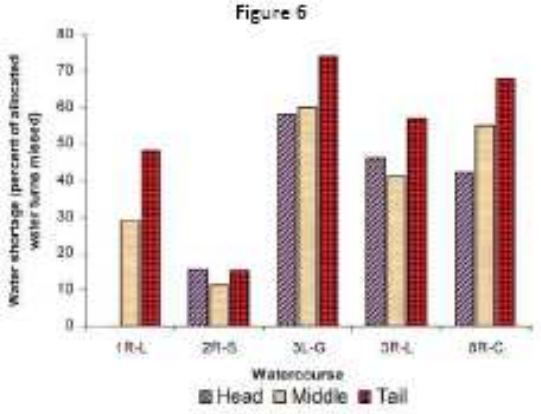


Figure 6, on shortages, should show a relation for the farm location. In a head-tail system, one would expect the farms at the tail end to have more problems with water shortages,

caused by seepage and leaking canals, thieving upstream farmers, and a higher chance of being affected by maintenance closures. (as maintenance in a lower end of the canal does not affect the water supply of upstream farmers)
The graph does show increased shortages for farms further downstream.
2R-S and 3R-L do not show the typical pattern. This may be caused by the stochastic nature of the maintenance in the Warabandi system.

Figure 8

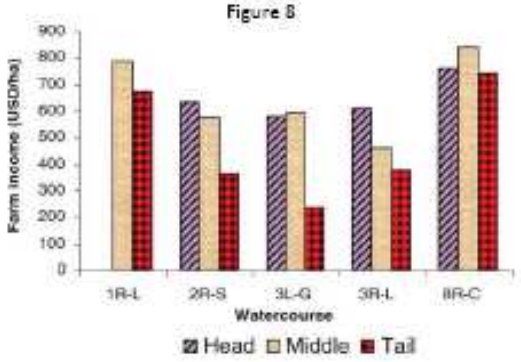


Figure 8, on income, should also show a pattern in a head-tail system. The downstream users make less money, as they are more likely to lose part of their crop due to drought and are less likely to invest in expensive seeds etc because of the more unreliable and overall less redundant water supply.
The graph indeed shows that the farmers upstream have more income than the farmers downstream.
8R-C does not show the typical pattern, and 3L-G almost shows it.
The income of the farms of 3L-G at the head and middle end are almost the same, and we saw in figure 6 that the water shortages were also almost equal.
8R-C however did show the typical head-tail pattern in the water shortages, but does not in the income. This could be caused by more *personal investments* (that were not included in the paper) as explained in question 3.

In short, the two graphs that we expected to show a certain pattern because of it being a typical head-tail system, show it. Therefore it is safe to assume the Warabandi is indeed a head-tail system.

7. The crucial difference between canal irrigation and groundwater irrigation is the reliability of the delivery of irrigation water. The very reason that the farmers have a willingness to invest in groundwater is the fact that the mentioned automatic relation does not exist. This is the opposite reasoning than the one suggested in the paper.

   The investment in groundwater will result in a better performance, because the investment will immediately yield a reliable flow of irrigation water. An investment in canal maintenance will not yield this immediate result, because of several reasons:

   - The actual maintenance is a large operation which ironically will cause losses of watering opportunities, because the canal must be closed for maintenance.

- There are external factors that can block a continuous canal discharge and extra payment cannot solve all these problems.
- The two reasons mentioned above indicate that even with extra investments, canal water is still unreliable. However, the reason farmers are willing to pay high prices for the groundwater is that they can call upon it when the supply of canal water fails: they are paying for its high reliability. This indicates that those farmers who have access to usable groundwater might not be willing to invest in the canal system, and to make maintenance economically possible, many farmers have to contribute.

On the short and medium term groundwater is a much more feasible solution, because there are fewer external influences that can hamper the flow and it is probably cheaper. On the long term a drop of the groundwater table may cause problems and will push the farmers in the direction of paying canal fees.

Therefore extra payment will not yield results.

8. The major problem in the warabandi system is the huge amount of water losses. This problem is obvious and clear and leaves little room for disagreement. To blame the warabandi concept is another question.

   As mentioned in the answer to question 4, the water rights are still granted on the basis of landholdings, despite socio-economic changes in the last decades and water allocation on the basis of one criterion never proves to be a success. The reform of the allocation of water rights is the most important step to improve water use efficiency. The factors that have to be taken into account are gross area on tertiary canal, sensitivity of growth stage, water shortage, crop value, efficiency in water use, water use efficiency of the crop itself, potential for loss etc. The current problems as stated here are the result of the warabandi system.

   Another important cause for losses is the canal system itself and the apparent lack of maintenance. As argued in the answer to question 7, an increment in the current canal water charges is not feasible, because it does not guarantee an increase in reliability of the irrigation water delivery. Therefore individual farmers have started pumping groundwater to close the gap between water demand and availability. This is implicitly considered a problem by the authors of the paper, because they suggest that maintenance, by means of higher water charges, can improve the reliability of the water flow. But farmers themselves are of course better investors. The choice to be made is as follows:

   1. Farmers pay higher water charges to the PID and the PID will conduct maintenance that will possibly result in an increased reliability of the irrigation water discharge, or;

   2. Farmers invest in groundwater pumping facilities and guarantee a more reliable water flow. The second choice seems the obvious one and will most probably happen in reality. Of course, this choice is not a sustainable one. In the long run, the groundwater table will drop and a new problem arises. Then farmers will in the end still opt for the first choice, as led by Smith's invisible hand.