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Zeitschrift für Bewässerungswirtschaft, 37. Jahrg., Heft 2 /2002, ISSN 0049-8602 **Seiten 199 - 218**

Irrigation management in the Jordan Valley – The neglected issue of "Principal-Agent"problems

Bewässerungsmanagement im Jordantal – Der vernachlässigte Aspekt der „Principal-Agent"-Problematik

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Stichworte
Governance, Wassermanagement, Bewässerung, Institutionen, Jordanien
Keywords
Governance, water management, irrigation, institutions, Jordan

Zusammenfassung
Wenn die erneuerbaren Wasserressourcen eines Landes oder einer Region den Wert von etwa 1000 m^3 pro Kopf und Jahr unterschreiten, werden die sozialen, wirtschaftlichen und ökologischen Potenziale für eine nachhaltige Entwicklung in der Regel erheblich eingeschränkt. Jordanien verfügt mit 209 m^3 pro Kopf und Jahr nicht einmal über 21% dieses Schwellenwerts (IWMI 1998). Angesichts solcher Gegebenheiten versucht die „Jordan Valley Authority" (JVA), Möglichkeiten zu finden, wie sie die ökonomische und technische Effizienz ihres Wassermanagements im Jordantal verbessern kann. Es ist deshalb bereits seit Jahren im Gespräch, einen institutionellen Reformprozess in die Wege zu leiten, der die erforderlichen Rahmenbedingungen für solche Verbesserungen schafft.

Der Artikel, der auf Diskussionen mit der JVA im Jahre 1998 zurückgreift, beabsichtigt nicht, die aktuelle Situation und den gegenwärtigen Stand der Veränderungsdiskussion zu reflektieren. Seine Absicht ist es vielmehr, an der Situation von 1998 aufzuzeigen, dass Reformbemühungen, wie immer sie orientiert sind, einen Aspekt aufgreifen müssen, dem in der Regel wenig Beachtung zukommt: der Principal-Agent-Problematik. Das Papier nimmt Bezug zu den allgemeinen Ausführungen des voranstehenden Artikels und zeigt die Anfälligkeiten der bestehenden Managementstruktur der JVA für Principal-Agent-Probleme im Bewässerungssektor auf. Das Fehlen oder die unzureichende Ausgestaltung interner Mechanismen zur Steuerung von Leistungsbeziehungen – der Artikel spricht diesbezüglich von „governance mechanisms" – öffnet Principal-Agent-Problemen die Tür und resultiert in Anreizdefiziten für die involvierten Personengruppen, potenziell in Korruption und damit letztlich in Effizienzproblemen, die auch durch strukturelle Reformen nicht ohne weiteres zu beseitigen sind.

Abstract
When the internal renewable water resources in a country or region are less than 1000 m^3 per capita/year, water availability is considered to be a severe constraint on socio-economic development and environmental protection. With 209 m^3 per capita/year, Jordan does not even dispose of 21% of this amount (IWMI 1998). Under these circumstances, the Jordan Valley Authority (JVA) is looking for

ways to improve the economic and technical efficiency of its water service. Moreover, JVA is trying to modify the institutional arrangements for this service, so as to solve the above-mentioned problems.

This paper, which draws on discussions with JVA in 1998, does not aim at reflecting the actual situation of JVA. Instead, referring to the situation of 1998, it seeks to illustrate how concepts of "Principal-Agent theory", as described in the previous paper, may be applied in practical cases. The paper analyses the institutions for water allocation, water delivery and maintenance in the Jordan Valley irrigation system and explicitly points to specific areas where potential principal-agent problems may deserve attention.

The artiele refers to the governance debate in the papers of this journal, and shows that in most cases the governance mechanisms for water allocation, water delivery and maintenance in the Jordan Valley irrigation were either deficient or altogether non-existent. Hence, unsurprisingly, the main actors, JVA staff and farmers, had little incentive to change the rules of the game – indeed, it may actually be in their best interests to maintain the system's existing inefficiencies.

1. Irrigation and water use in the Jordan Valley

Irrigation in Jordan accounts for more than 70 percent of all water use. Individual farms in the highlands are irrigated by groundwater from private wells. The publicly managed 36,000 ha surface irrigation system in the Jordan Valley uses mostly surface water and recycled waste-water. Irrigation in the highlands expanded from 3,000 ha in 1976 to about 33,000 ha in 1997 and accounts for about 60% of groundwater use (The Hashemite Kingdom of Jordan 1997). An additional 5,000 ha is irrigated by fossil groundwater in the Disi area, mostly by center-pivot irrigation for relatively low-value cereal crops. Because of over-abstraction, new licenses for pumping groundwater for agriculture have been officially restricted in the recent years (cf. The Hashemite Kingdom of Jordan 1997). The quantity pumped from existing wells is presently not regulated, but the Government has begun a program to reassert control over the resource. Doubts exist whether or not this control will be implemented more rigorously than has been the case so far.

Three public agencies are vested with responsibility for the water sector of Jordan: the Ministry of Water and Irrigation, the Water Authority of Jordan and the Jordan Valley Authority (JVA).

JVA's responsibilities within this area include:

- development of water resources (irrigation, domestic, industrial and municipal);
- development of towns and villages;
- design and construction of road networks, domestic water supply, electricity, and telecommunications networks;
- and the provision of tourist facilities.

The Law describes the Authority as "an autonomous corporate body" with "full authority" to determine the allocation and usage of all surface and groundwater, as

well as to establish water charges. In reality, however, JVA is a standard government agency lacking key aspects of autonomy. It lacks the power to hire and fire staff under its own conditions - at present civil service rules and pay scales apply. It also lacks financial autonomy, and has no freedom to set its own budget and to retain its revenues. In the following we only consider the irrigation part of JVA's portfolio.

To meet peak water demand during the summer, which coincides with a surface water shortage, a considerable hydraulic development program has been carried out in the Jordan Valley over the last forty years. It comprises storage, transport and water distribution structures.

The overall system includes the following levels:

1) Dams
2) Main Conveyance System
3) Secondary System
   a) Pumping Stations
   b) Secondary Canals and Pipes (to the farm turnouts)
4) On-Farm System (responsibility of farmers)
5) Drainage System

The King Talal Dam, situated on the Zarqa River, is the main water storage structure. Its current capacity is estimated at 75 MCM. Other storage structures are the Wadi Arab reservoir (20 MCM), the Wadi Ziglab reservoir (4 MCM), the Wadi Shueib reservoir (2.5 MCM), the Wadi Kafrein/Hisban reservoir (13 MCM) and the Karameh reservoir (55 MCM) (Soer 1998). The King Abdullah Canal (KAC) forms the backbone of the scheme along the Jordan River for a leugth of 110 km. It is the main water conveyance structure in the Jordan Valley. It is supplied from the North by the Yarmouk River, the Mukheibeh wells, and more recently (July 1995), by the KAC North Conveyor. The canal head capacity is 20 m^3/s.

The water distribution system was built as open channel networks and was later converted into high and low pressure networks. Today, the entire network consists of pressurized systems. These networks can be supplied either directly from the KAC, from one of the reservoirs or from a river offtake.

The dominant form of land use in the Jordan Valley is irrigated agriculture, which has undergone dynamic transformations, partly as a result of integrated social and economic development programs in the valley.

In the Jordan Valley irrigation system a broad range of farm types exists. There are large and small size farms that are efficiently organized and productive, and are located beside large numbers of smaller farms, which barely manage to produce enough for the families to survive. A large number of the first group uses modern technology in a highly productive way, although its further expansion is limited through scarce water resources. Capital-intensive agriculture uses drip irrigation

mainly for the production of vegetables (e.g. tomato, cucumber, aubergine, etc.). Vegetables and fruit (mainly bananas) are produced mainly for the domestic market and for Saudi Arabia and the Gulf states. The EU market is not very important for Jordan at present.

While vegetable cultivation occupies approx. 50% of the cultivated area, field crops account for ca. 20% and fruit trees for ca. 30% of the total (SOER, 1998).

2. Operation and Maintenance

The overriding O&M problems in Jordan Valley Irrigation relate to the following three interconnected aspects of irrigation management:
a) Operation of water allocation
b) Physical condition of the secondary water delivery infrastructure (especially FTAs)
c) Water delivery to farms and water application in the fields.

a) Operation of water allocation
There are general difficulties in balancing out water distribution between the O&M Directorates in the valley and the municipality of Amman (served through the Deir Alla pumping station). The water supply for Amman has priority and its timing and amount is often unpredictable. Consequently, the resulting allocation of available water to the three O&M Directorates, i.e. to the three major irrigation areas, is characterized as unreliable and unpredictable. During times of water scarcity, an O&M Directorate cannot be sure about how much water to expect until a very short notice. This seriously impedes the programming of irrigation turns, undermines trust toward JVA as a reliable provider of water service and creates a constant source of conflict between water users. This also causes continuing disputes among the three O&M Directorates, and in various instances the Directorates tend to suspect that they may have been disadvantaged with respect to their 'fair share'.

b) Physical Condition of the Secondary Water Delivery Infrastructure
The major constraint here consists in the low level of functioning of the Farm Turnout Assemblies (FTA's). This has immediate repercussions with respect to amount, timing and reliability of water delivery. It also translates into substantial water losses.

Although the condition of the FTAs has improved following a large-scale renovation campaign, the condition of many of these crucial structures is still far from adequate.

The maintenance and repair of water meters seems to be a particularly 'hopeless' case. At the time of the discussions in the framework of this study, JVA had practically abandoned any effort to ensure maintenance and repair of water meters.

Another problem consists of the fact that clogged and broken pipes in the secondary water distribution system often are not maintained or repaired on time. This results in site-specific water delivery problems and corresponding inefficiencies.

As a general rule, preventive maintenance is not done. This holds true for the pumping stations and for the secondary conveyance system itself. It not only decreases the potential service time of the hydraulic infrastructure, but also increases repair frequency and hence interferes with operational efficiency.

c) Water Delivery to Farms and Water Application in the Fields
Water delivery in the Jordan Valley has been converted from surface irrigation to pressurized pipe systems. At present, most irrigation water application is done by drip irrigation. However, surprisingly, there is little difference in irrigation efficiency, compared to previous surface irrigation. Substantial water savings, which were expected to result from the conversion to pipe systems have not materialized so far.

The serious deficits in irrigation efficiency, especially for vegetable growing, most probably have their roots in the unreliability of water delivery that stems from deficits in water allocation and in maintenance, as described before (SOER, 1998).

Moreover, in many parts of the irrigation system, even after the conversion to pressurized pipes, farmers go on using the same amounts of water for leaching as they did before the introduction of drip irrigation. This drastically reduces field application efficiencies.

A large amount of the supplied water is actually "not accounted for" ("administrative losses"), meaning it is not billed to the farmers. These "losses" (i.e. part of this water that is probably used but not paid for) have gradually decreased during the last 5 years, from 20% in 1995 to 15% in 1998. Still, this amount is an indicator of serious management problems in the system (SOER, 1998).

3. The "Principal-Agent" perspective – looking at O&M from a different angle

Improvements in the above mentioned problem areas can only be achieved if the involved actors feel incentives to bring them about. However, this does not seem to be the case. Like many other irrigation systems, the Jordan Valley irrigation appears to be locked in an inefficiency trap. This trap is often due to the fact that inefficient water delivery and maintenance may provide sources for additional income or at least offer non-material advantages to the providing managers or technicians. In terms of the personal goals of income maximization and extension of socio-economic power that are pursued (not only) by most of the irrigation staff, such system inefficiencies may be highly efficient in terms of personal gain. More often than not they pave the way to rent-seeking activities and corruption.

Therefore, the common practice of searching for technical and / or economic / financial solutions to the O&M problem in irrigation is bound to fail in many cases. While this will often be the case in state-administered systems, farmer-managed irrigation systems are by no means immune to such incentive distortions.

It is therefore imperative to give more space to principal-agent-analysis in irrigation management as it has been introduced in the previous article by Huppert and Wolff. Relating to that paper, we intend to illustrate how concepts of "Principal-Agent theory" may be applied in a practical case taking the Jordan Valley irrigation as an example. Since we draw on discussions with JVA in 1998, we do not aim at reflecting the actual situation of JVA. Instead, our intention is to use this example to show how a fresh look at problems in irrigation management from the point of view of principal-agent theory can unveil hidden root-causes for deadlocks in improvements of irrigation operation and maintenance. The paper analyses the institutions for water allocation, water delivery and maintenance in the Jordan Valley irrigation system and explicitely points to specific areas where potential principal-agent problems may deserve attention. Finally, some options for the solution of principal-agent problems in Jordan Valley irrigation are discussed.

3.1 Allocating water to irrigation and other uses

The Central O&M Directorate Dirar is the entity responsible for the overall operation of the Jordan Valley irrigation system. (In the following we refer to this Directorate as the Central Directorate). Figure 1 depicts the major services the Central Directorate supplies and receives. The services Sa and Sb refer to the allocation of water deliveries (to O&M – Directorates and to Deir Alla) and to water inflows into the system (from Israel and Syria). These services thus correspond to actual flows of water.

Figure 1 makes clear that one main objective of the Central Directorate is balancing out demand and supply between the different clients involved. On the demand side, the Central Directorate has to satisfy the water needs of irrigation put forward by the three O&M directorates in the Valley (to be satisfied by supply Sa). The Central Directorate has to respond to the municipal and industrial water demand of Amman (which is being served through the Deir Alla pumping station, which receives the supply Sb). This balancing out is a difficult task since the water supply available in the Jordan Valley not only depends on the runoff coming from the dams controlled by JVA (Sc) and the Yarmouk river (Se), but also on the water provided from Israel (Sd). The latter are regulated through the Joint Water Committee. There are also further sources of unpredictability, such as illegal connections in the valley and unpredictable withdrawals by individual O&M directorates.

The task of balancing out water supply and demand means that JVA has to manage a complex water delivery system and a complex water acquisition system. Supply

must match demand as closely as possible and water shortages supposed to be handled in a way that is acceptable to the various constituencies involved.

Finally, there are additional services that are necessary for the functioning of water allocation. The Central Workshop provides services in the technical operation of the irrigation system (Sf) and the Laboratory makes regular checks of water quality (Sg).

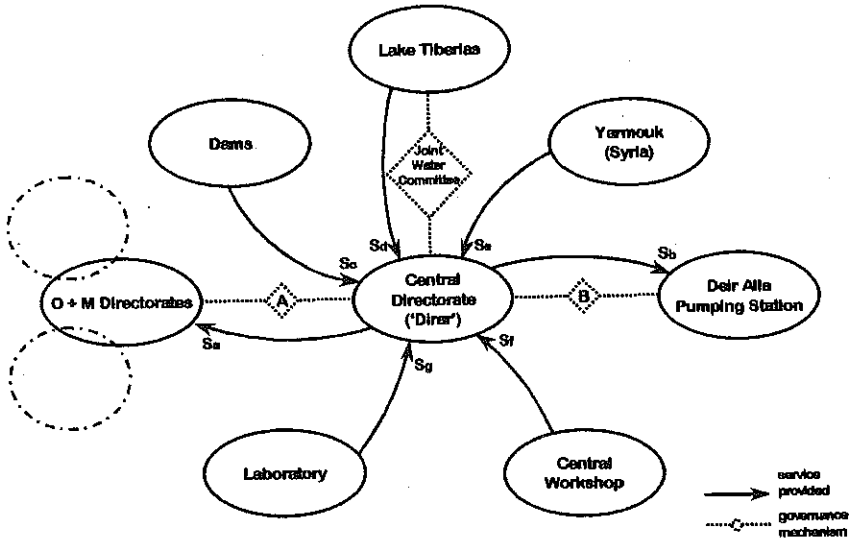

Figure 1: ***The Central Directorate as a Service Provider and Service Receiver***

The services Sa and Sb to be provided by the Central Directorate relate to the allocation of water to the regional O&M Directorates on the one hand and to the Deir Alla pumping station on the other hand, as stated before. To be able to provide these services, the Central Directorate is dependant on information provided by these two clients. This information is perceived as a return to these services.

In order to operate the system, the Central Directorate relies on a highly sophisticated computerized system. Based on estimated runoffs and water supplies on one hand side and the expected demand on the other (calculated on the basis of the water requirements of crops and area requested to be planted by farmers), water delivery is simulated in advance for the whole year.

3.2 Discovering potential Principal-Agent problems

As the discussions with JVA have shown, there is no clearly established governance mechanism underlying the service relationship between the Central Directorate and

the Deir Alla pumping station, which supplies water to Amman for municipal and industrial (M&I) uses. Actual demands may be issued on an ad-hoc basis and no clear rules of information exchange have been established between the Central Directorate and the Deir Alla pumping station so far (1998). This means that the governance mechanism <B> in Fig. 2, i.e. the rules and procedures that are supposed to govern the relationship between the Central Directorate and Deir Alla, is practically inexistent. In practice, M&I water demands for Amman have priority over agriculture in the Jordan Valley. However, a formal regulation on the distribution between irrigation and M&I requirements does not exist. Arrangements are made on an ad-hoc basis through informal coordination between the Central Directorate and Deir Alla. From the viewpoint of the Central Directorate this requires frequent and difficult on-the-spot decision making and speedy adjustments in supply schedules for irrigation. With other words: the Central Directorate is subject to external influences that are beyond its control. This is an important aspect when we look at principal agent problems that may arise in the relationship between the Central Directorate and the O&M-Directorates, as we will see in the following.

Service provision by the Central Directorate to the O&M Directorates

The discussions with JVA brought to the fore that the existing service relationship contains serious information asymmetries among the actors. It is important to realize that such asymmetries may lead to so-called 'moral hazard' problems as described in the previous article of this volume by HUPPERT and WOLFF. Such problems are frequently encountered in employer-employee and employer-contractor relationships. They are also common in service relationships between clients and service providers.

A moral hazard problem arises in service relationships where the customer cannot be informed about every action taken by the service provider and so cannot control everything the provider does. The particular circumstances mentioned refer to situations where information asymmetries occur when actions of the provider are subject to various unpredictable external influences which cannot fully be perceived or appreciated by the client. Unless well functioning governance mechanisms are in place (e.g. particular contract agreements, special control mechanism, mutual trust etc.) the client faces certain risks: the service provider may exploit this difference in available information in order to pursue personal interests that are not in line with the agreement about the service to be provided. Because of such opportunistic behavior by the service provider, benefits from the service may fall well below the level expected by the client (on the basis of the initial agreement). However, the service provider cannot be held accountable for this by the client (see previous article).

Using these concepts, the information asymmetry contained in the service relationship between the Central Directorate and the O&M Directorates, and its consequences, can be described as follows.

We consider the O&M Directorates to be the clients (or the Principals) which expect the service of water allocation to be provided by the Central Directorate (or the Agent). In this case the discussions with JVA pointed to particular information asymmetries that exist between the Central Directorate and the O&M Directorates.

First, it is only the Central Directorate that has detailed knowledge about the supply to be expected from various sources. This includes the supply from Israel, which is based on the decisions of the Joint Water Committee. These supplies are highly variable, depending on external influences such as rainfall-runoff conditions, demands on the Israeli side, and so on.

Secondly, it is almost exclusively the Central Directorate that is informed about short-term requirements for the water supply to Amman, which has clear priority. These demands on the Deir Alla Pumping Station, that pumps water to Amman, are highly unpredictable, as noted above. Thus, the amount of water to be drawn by Deir Alla can vary substantially with only short notice to the Central Directorate.

Under such conditions the individual O&M Directorates face the risk that the Central Directorate may act in an opportunistic way and use the information intransparency to give preferential treatment to a particular region and O&M Directorate. The supply service for the other O&M Directorates will then be below their expectations. This can occur without a risk for the Central Directorate being held accountable. Hence, the above-mentioned Moral Hazard problem applies. Circumstances are so complex and unpredictable that it is impossible for the O&M Directorates to find out in a particular case whether or not supply shortages announced by the Central Directorate correspond to reality or are the result of information manipulation by the Central Directorate. According to Principal-Agent theory, rent-seeking behavior can be a basic driving force for such tactics.

While this does not imply that the O&M Directorates and the Central Directorate actually engage in such tactics, it is apparent that, in the absence of adequate governance mechanisms, information asymmetries are such that it will be difficult for actors involved to avoid being drawn into them.

4. Water Delivery and O&M of the Secondary System

4.1 Actors and services

The actors involved in the operation of the secondary system are (1) O&M Directorates, (2) "stage" offices, (3) ditch riders, (4) pumping operators and (5) farmers. The objective of service provision at this level is to ensure efficient water delivery through the secondary canals to farmers. The individual services required to reach this objective are the following:

S0: identify irrigable area and cropping pattern
(service provider: ditch riders, stage office),

S1: file irrigation orders (by farmers),
S2: aggregate irrigation orders and prepare irrigation schedule (service provider: stage office),
S3: approve of schedule and monitor all activities (service provider: O&M directorate),
S4: daily assignment of tasks to ditch riders (service provider: stage office),
S5:technical orders to pump operator, monitoring of the system, reports (service provider: O&M Directorate),
S6: information about timing of pump operation (service provider: stage office),
S7: operate pumps (service provider: pump operators),
S8: open and close gates and report back to the stage office on problems (service provider: ditch riders).

4.2 Potential Principal-Agent problems in the allocation and distribution of water within the O&M Directorates

Service S2 consists of the preparation of the irrigation schedule. Service S3 amounts to the approval of this schedule at the level of the relevant O&M Directorate.

The stage offices process the incoming water demand and develop irrigation scheduling options that try to match supply expectations with projections of water requirements. Such projections are supplied to the O&M Directorate on a monthly basis and are later refined with respect to the daily demand. On this basis daily allocation orders are issued by the Directorate.

The governance mechanism which is supposed to coordinate such service provisions (mechanism <1> in Fig. 2) consists only of the authority delegated to the O&M Directorate to take allocation decisions on the basis of given supply and demand projections and of the hierarchical rules and procedures between the O&M Directorate and the Stage Offices.

However, this mechanism is embedded in a serious "cloud" of information intransparency. On the demand side, accurate information is dependent on the filing of orders by farmers (service S1). However, JVA has practically no means to ensure that the users file orders in a proper way. Unofficially, some influential farmers have access to water whenever they short-circuit the official management entity and ask for water from higher political authorities. This means that the rules and procedures that are supposed to govern the relationship between the Stage office and the farmers, i.e. governance mechanism <4>, are ineffective. Actually, it should be in the collective interest of the farmers to comply, but if at least some of them have unlimited access to water, then they don't see the need to file orders for it.

The functioning of governance mechanism <1> depends firstly on accurate information about the water that can be expected to be allocated by the Central Directorate. As has been mentioned above, this type of information is likely to be inaccurate and may be subject to manipulation by the Central Directorate. Hence, the O&M Directorate can point to such unpredictable decisions of the Central Directorate and justify suboptimal allocation decisions to the Stage Office without being held accountable ('Moral Hazard' problem).

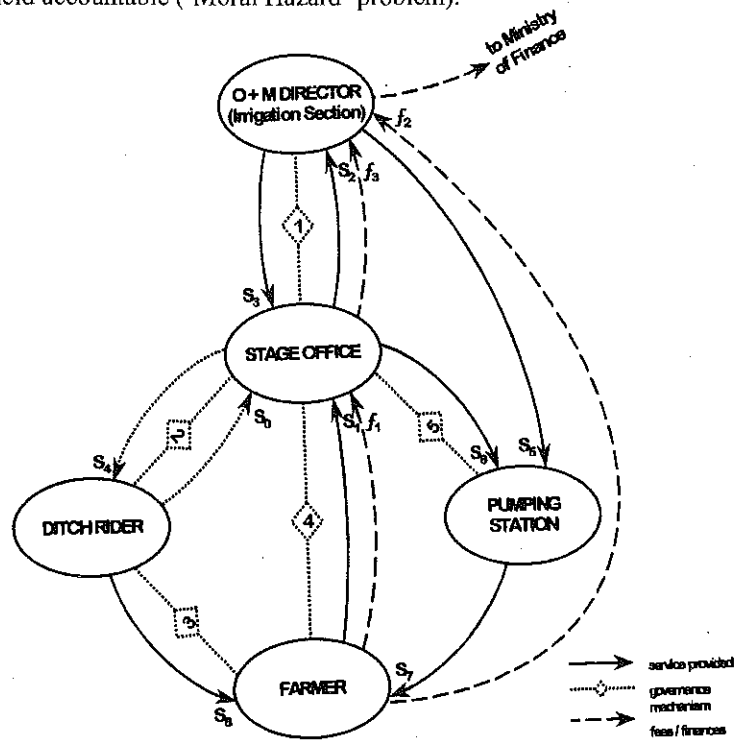

Figure 2: ***Internal Service Provision for Water Allocation and Distribution (secondary system)***

Secondly, governance mechanism <1> also depends on the identification of planned and actual irrigated area and cropping patterns. As has been explained before, this type of information is deficient due to the limited possibility of reliable data collection. Here again, information manipulation can be a problem. In fact, information asymmetries and related moral hazard problems may extend further down the hierarchy to the ditch-riders. Both the stage office and the ditch-riders face the temptation to use such hidden information to allocate water partially on a preferential

basis, in order to extract side-payments (or "rents"). While it is difficult to establish to what extent this really happens in Jordan Valley irrigation, one has to be aware that a multi-level hierarchical system of coordination as it exists in JVA is chronically prone to such rent-seeking efforts. Information asymmetries exist and the corresponding governance mechanisms (in this case weak control capacities and sanctioning powers) are deficient or non-existent.

Even though formally the JVA Directorates possess the authority to sanction default, it is rarely applied in practice. Some sanctioning arrangements have been established in the past (especially the establishment of monitoring groups) but they have proved to be ineffective.

4.3 Principal-Agent aspects when supplying water to farmers

Service S8, shown in Fig. 2, implies that the ditch riders are supposed to open and close the valves at the FTAs according to the approved schedule in order to deliver water to the different irrigation units.

The return, which farmers are supposed to provide, consists of reporting back on problems, filing of orders (S1), and the payment of water charges (f1, f2).

The governance mechanisms in this case are vague. Clear water rights (rights that can be sued for, with respect to amounts and timing of water delivery) do not exist. Hence the only official governance mechanism is the authority delegated by JVA to the stage office and its ditchriders to supply water according to the irrigation schedules approved by the respective O&M Directorate. This official governance mechanism reveals a specific deficiency that is quite common in service relationships. If a customer has already undertaken substantial investments in a service relationship with a certain provider prior to a particular service provision, there is a risk that the provider may use this dependence in an opportunistic way to its advantage. This risk will be particularly high if it is combined with pronounced information asymmetries between both parties. But it also exists in circumstances where such asymmetries are non-existent. Deficiencies of this kind are called "hold-up" problems in Principle-Agent theory (cf. previous paper of HUPPERT and WOLFF).

Farmers asking for water in the Jordan Valley face a 'hold-up' problem of a particular type. They have invested in the on-farm irrigation infrastructure and most recently many have installed drip irrigation equipment. Moreover, before the onset of an irrigation season, farmers invest money and labor into land preparation as well as in the purchase of seeds and fertilizer. Thus they are heavily dependent on the service of water delivery for fear that they might risk loosing part of these investments. This risk has even increased with the introduction of drip irrigation methods. Weekly intervals of water application were sufficient in most parts of the Jordan Valley when surface irrigation was used. However, drip irrigation requires that small amounts of water be applied with shorter intervals on a timely and reliable basis.

The stage offices and ditch-riders who are supposed to ensure this water delivery face considerable constraints in doing so. First, the diverse cropping patterns in the Jordan Valley imply that a very complicated scheduling for the opening and closing of the valves at the FTAs needs to be followed. This proves to be difficult to follow due to the restricted number of staff available. Further, the unpredictability of the water supply requires ad-hoc allocation decisions in order to distribute an unforeseen water scarcity in an optimal manner. The fact that farmers do not have access to the information related to such allocation decisions constitutes an information asymmetry and compounds the above-mentioned problem of dependence of farmers upon the water service provider. Many farmers who fear that they may loose their investments tend to suspect that the service provider intentionally withholds water delivery, so they try to take extra water whenever they need it. They destroy the FTAs and operate the valves at times when it is not their official turn.

The reaction of farmers to such situations (e.g. damaging of the FTAs) has serious consequences. Pressure distribution in the pipe system changes and when other farmers have their official turn for water withdrawal they cannot receive the water with the pressure needed to supply the intended discharge. This in turn undermines confidence in the reliability of the allocation system and introduces a dynamic that favors opportunistic behavior on both sides. Even though regulations exist to sanction water theft, the sanctioning powers are not strong enough. This is because some of those who break these regulations are politically too influential to abide by regulations set by JVA. Also, in view of a relatively insecure legal situation (see chapter 6), it would be quite unwise for a farmer to follow the legal process and go to court when he does not receive his fair share (especially if he is not very influential). This could mean that in the future he might be unofficially punished with minimum delivery of water.

On the other hand, farmers with strong political and/or economic influence may prefer this kind of situation to another situation with a more "efficient" water allocation between all farmers.

Under such circumstances, what is seen as a problem from the viewpoint of the functioning of the overall system may appear to be quite advantageous for some influential actors. Hence, it is likely that they will try to perpetuate this situation. In this way the problem (in this case the malfunctioning of the FTAs) is perpetuated because of malfunctioning service relationships and deficient governance mechanisms.

Once they become established, these kinds of principle-agent problems have the tendency to consolidate in a way that will be difficult to uproot. Since the key actors in such situations may benefit from profitable rent seeking opportunities, there may be little interest and commitment to change things in the general interest of improving the technical efficiency of water allocation. Hence, the information asymmetries

and lack of information transparency combine with deficient or insufficient governance mechanisms to jeopardize well-intentioned efforts to improve water service delivery in the Jordan Valley.

5. Financing Operation and Maintenance Services

Discussing governance mechanisms for water allocation, water delivery and maintenance of irrigation systems in the Jordan Valley means looking for ways to ensure efficient and sustainable exchange relationships in the multi-actor service delivery system. Financing of such services constitutes the key return and hence is the "engine" for adequate service provision.

Cost recovery for the supply of irrigation water in the Valley amounts to only about 50% of the O&M costs for irrigation. An increase of the water charge has been continuously demanded by various international organisations, but has been implemented only reluctantly, mainly apparently for political reasons.

The total cost for government of the irrigation system in the Jordan Valley, in terms of O&M plus capital costs, amounted in 1997 to approximately 10.4 million JD (SARA, 1998).

Water tariffs have been at a low level of 0.003 JD/m^3 till May 1990. Today they are at 0.015 JD/m^3. In order to achieve full cost recovery this level should be to be raised to 0.045 JD/m^3 (SOER, 1998).

The level of the water charge has been subject to constant debate in recent years, the hope being that increased levels of water charges will per se bring about increased efficiency of water use in the Jordan Valley. The institutional aspect of financing has been touched upon less frequently.

One of the basic principles of any sustainable or long lasting service relationship is that the relationship contains a closed feedback loop between services and returns (or finances) for each service. In case such a closed feedback loop does not exist (i.e. where services are provided but not compensated for) the chances that this service can be provided reliably in the long run are dim or will depend on external financial inputs to cover the costs for the service in question. This is why SMALL and CURRUTHERS make the important distinction between "irrigation financing" and "irrigation cost recovery". Irrigation financing "is the generation of funds that are specifically used to pay for the costs of providing irrigation services." Cost recovery, on the other hand, "refers to the funds that flow into public agencies as a result of irrigation, regardless of whether or not these funds are used to pay for the costs of providing the irrigation services." (SMALL and CURRUTHERS, 1991).

Taking into account this distinction, we conclude that some cost recovery exists in the Jordan Valley, but there is actually no financing of irrigation services. User

charges for the services provided go to the Ministry of Finance and into the general government revenues rather than being used as a 'quid pro quo' for services actually provided by JVA. Doing so, an important governance mechanism that could help to make the overall service delivery system function in an effective way is foregone. Since there is no direct connection between the services provided and the budget allocated, the incentive-creating potential of irrigation financing from water charges, as compared to cost recovery, remains untapped. Hence, the kind of cost recovery actually in use does not function as a governance mechanism that can help steer the delivery system towards an efficient O&M service provision.

6. Legal Insecurity

A factor with enormous consequences for the functioning of service relationships in the water delivery system of the Jordan Valley is the low level of legal security. Legal security and the availability of an impartial legal body are important "secondary" governance mechanisms that make service relationships function. In the Jordan Valley legal security for service providers (JVA staff) and clients (farmers) is low - unless one can appeal for help to high levels of political power.

If JVA staff tries to sanction unauthorized water withdrawal and shut off water delivery, they will not be able to do so if this withdrawal is done by or for an influential farmer. Applying a sanction or fine for illegal water extraction seems impossible under current circumstances. Hence, illegal offtakes abound in the Jordan Valley. On the other hand, if small farmers try to sue JVA staff for preferential allocation of water to large farmers, they run the risk of incurring service 'hold-up' activities in the future.

There is no strong and impartial legal body that can apply sanctions irrespective of the economic and political status of the offender. This places severe constraints on governance of the service delivery system for irrigation in the Jordan Valley.

7. Toward a solution of Principal-Agent problems in Jordan Valley Irrigation

It is not the intention of this article to describe the comprehensive change strategies under discussion at JVA at this moment. However, concentrating on principal-agent problems we discuss in the following some orientations for the solution of such problems taking the Jordan Valley irrigation as an example.

In general, it will be difficult for outsiders to propose the 'proper' ways in which solutions for problems of the kind described above are to be achieved. In a multi-actor service system where different interests need to be coordinated, improvements

can only be brought about through discussion and negotiation between different stakeholders. However, such negotiations and change processes can be supported by a methodology, which, if based on the approaches used in this paper, can help answer the question whether or not viable service relationships can be expected. Hence, whatever organizational setup is chosen for Jordan irrigation in the future, as long as service relationships are not well coordinated and governance mechanisms are not functional, effective and efficient O&M cannot be expected to emerge.

The main recommendation of this study is that the JVA should, whatever organisational model will be chosen in the future, enter into in-depth discussions with representatives of all key stakeholders about how to achieve effective service relationships. This should be based on an analysis of institutional problems similar to the one presented in this paper. Proposals for organizational changes should be based on assessment of who are the key actors involved, about the primary services, internal services and the returns to be provided and the service relationships and governance mechanisms needed to make the delivery system function as agreed in a consensus among stakeholders.

This process may involve the following steps:

1. Identification of services and supporting services to be provided.
2. Identification of critical services that are not supplied in a satisfactory manner.
3. Identification of the actors involved in the provision of each service in question.
4. Analysis of service relationships between actors

This analysis should answer in details the following questions:

- What makes up the exchange relationship? Or: What is the service provided and what is the return or compensation for this service, that makes the relationship function in the long run?
- There are three key questions from the perspective of the client: (1) In a worst case scenario, what may be the hidden self-interests of the service provider that might induce it to take actions that deviate from the official service provision? (2) What new incentives may minimize such deviant behavior by the provider? and (3) What new governance mechanisms could induce the provider to deliver the expected service?
- From the perspective of the provider, one may ask three other questions: (1) What may be the hidden self-interests of the client to exploit the service relationship to his/her advantage or to avoid paying the expected return? (2) What new incentives might minimize such opportunistic behavior? and (3) What new governance mechanisms could be introduced into the situation to induce the client to act in the way expected by the provider (and agreed by both parties)?

Working through all the bi-polar service relationships in the given multi-actor network will then reveal whether or not an effective service provision can be expected and if not, where the major constraints are located.

A process of systematic analysis and development of governance mechanisms has rarely been followed in the irrigation sector so far. Yet it has the advantage that it can be done in a participatory and transparent way through discussions and negotiation between all relevant stakeholders. The method for finding solutions to problems in service relationships will mainly be similar to such a negotiation process.

The following recommendations should only be taken as rough indications about the direction in which discussions and negotiations might evolve.

The previous article by HUPPERT and WOLFF has summarized in a table the different types of principle-agent problems, which may arise in service relationships and presented recommendations for their solution. The following are six guiding principles for applying principle-agent analysis in a participatory process to improve management of O&M of the JVA, or in another irrigation agency.

a) A first point of concern should be the technical system of water supply and distribution in the secondary system. As it is operated at the moment in the Jordan Valley, the system seems to be far too complicated and opens the door to information asymmetries at different levels. The attempt to estimate water demand of crops under conditions of widely varying cropping patterns and continuously changing crop water requirements throughout the season may be justified under a condition of ample water availability and of high data collection and processing capacities. With limited staff available at JVA and with increasing water shortages, ways have to be found to base water allocation on simpler, even if cruder, ways to determine water demand. Ongoing discussions in JVA to introduce simpler systems of "block demands" for particular user groups and using simplified demand calculations (such as not distinguishing between fruit trees and vegetables) should be further pursued. A major challenge for JVA is to make the basis for water demand more transparent for the major actors involved. Such a step is crucial in order to overcome information asymmetries and their effects.
b) A simplified system of demand projections aud supply determination may have potential to improve transparency and credibility between the O&M Directorates. It may help eliminate the problem of 'adverse selection' faced by the Central Directorate in its attempt to distribute scarce water resources in an equitable way.
c) A simplified system of demand projections and supply determination may solve the problem of inconsistent filing of orders by the farmers. Allocation may then be made on a simplified basis, such as on the basis of pre-established wholesale amounts for a particular group of farmers, such that individual filings may no longer be needed.

d) The risk faced by the O&M-Directorates to receive intentionally a suboptimal service provision when they are confronted with the allocation decisions by the Central Directorate ('Moral Hazard') may be overcome with a 'team-approach': If supply and demand information is not only available to the Central Directorate alone, but if it is shared between the Central Directorate and the O&M-Directorates, the 'Moral Hazard' dilemma may be overcome.

e) Farmers tend to perceive that they face a high risk of not receiving their fair share of water, while having incurred high costs for land preparation and purchase of agricultural inputs. This leads to repeated destruction of Farm Turnout Assemblies. A solution to this may be sought in two different ways.
   - One approach to a solution is 'vertical integration'. This is where the client and the service provider are brought together under one organizational 'roof' so that their interests coincide. In the case of water allocation at the FTAs, this may be achieved through 'wholesale' supply of water to groups of farmers. Farmer groups will receive water allocations. But they will have to distribute water amongst themselves and may thus be more inclined to want to have functional FTAs in order to ensure equitable distribution of water and water charges.
   - A second solution to hold-up problems as proposed by Principal-Agent theory, is the so-called 'taking of hostages'. The Agent hands over some kind of security to the Principal as a guarantee that he will provide the service as foreseen. Here again, possible options have to be adapted to local conditions. For example, a voucher system could be followed whereby farmers receive vouchers in advance for planned water delivery turns. They would hand over a voucher to the ditch-rider only when deliveries have been done in a correct way. The salary (or premium) of the ditch-riders will then be based on the number of vouchers they receive from the farmers as proof of effective implementation of water delivery.

f) The problem of disfunctional water meters depends primarily on the question of whether or not existing incentive systems can be altered in such a way that major actors have a genuine interest in having volumetric water measurement take place.
   - A 'whole sale approach' to supplying water to user groups may help solve this problem. There is only one water meter at the off-take for the group. This water meter may become the property of the group. A group with a non-functional meter may then not be supplied at all or be charged a higher price in case the withdrawal has to be estimated ex post (depending on the particular sanction adopted).
   - Such an approach may also be chosen in the case of individual FTAs if the JVA has sufficient authority to apply such sanctioning powers.

In general, however, financial autonomy for JVA with its resulting incentives to collect water fees, appears to be the best way toward incentive creation in this respect.

8. Conclusion

Looking at the complex service delivery system for water allocation and maintenance in the Jordan Valley irrigation system, one might ask: Should this service delivery system really be "improved"? Or: Should it be changed in a way that irrigation efficiencies increase? At first glance, this seems like a rhetorical question. The need for such improvements appears to be obvious, given increasing water scarcities and given low irrigation and distribution efficiencies that prevail throughout the system. However, irrigation systems cannot be regarded exclusively as technical systems but need to be seen as socio-technical systems. This is to say that people use such systems to achieve certain goals and pursue certain interests. The level of socio-economic efficiency achieved (as compared to a purely technical or economic efficiency) will thus depend on the extent to which major actors can achieve their individual goals and satisfy their personal incentives ("incentive compatibility").

The spectrum of goals and interests that has to be somehow satisfied by JVA is wide, even if one restricts the focus to the 'services' of water allocation, water delivery and maintenance. Among these various purposes the following will be predominant:
- Allocating and delivering water to irrigation farmers in the Jordan Valley in the most efficient way possible, thereby satisfying crop related water demands of different farms.
- Distributing water scarcity, meaning confining demand-based water allocations to different farms in a way that takes into account increasingly restricted water availabilities and growing needs for domestic water use in Amman ('balancing out' supplies and demand).
- Serving the group of politically influential farmers in the Jordan Valley, so that this constituency does not feel negatively effected or disadvantaged in any way.

The achievement of these objectives is supposed to be reached:
- with a large body of grossly underpaid – and hence poorly motivated – staff
- with a multi-layered hierarchical structure with restricted responsibility and accountability at different management levels
- without an autonomous system of service-related financing
- in an environment of high legal insecurity.

It is obvious that such a set of goals will be difficult to achieve under the given circumstances while at the same time maximizing technical and/or economic

efficiencies of water allocation. In contrast, it may well be, that, given the conflicting goal orientations and the mentioned constraints, the existing system operates on a level of optimal socio-economic efficiency and incentive compatibility. In other words, the above discussed principal-agent problems may help to provide rent-seeking possibilities to poorly paid JVA staff, may help to give preferential treatment to influential landowners, and be the basis for achieving all of this with a minimum risk for the responsible professionals to be held accountable. At the same time, the system maintains a level of irrigation efficiency that is just high enough to avoid substantial farmer discontent.

However, the dynamics of increasing water scarcity and the professional insight of progressive JVA decision makers is about to upset this balance. An improved understanding of the intricacies of principal-agent situations can be of enormous help in this direction.

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Zeitschrift für Bewässerungswirtschaft, 37. Jahrg., Heft 2 /2002, ISSN 0049-8602 **Seiten 219 - 235**

Property rights and maintenance of irrigation systems

Verfügungsrechte und Instandhaltung in der Bewässerung

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Stichworte
Verfügungsrechte, Bewässerung, Instandhaltung, Wasserrecht
Keywords
Property rights, irrigation, maintenance, water right

Zusammenfassung
Der Artikel untersucht die Verbindungen zwischen Verfügungsrechten und Instandhaltungsbelangen in der Bewässerung. Er beginnt mit einer allgemeinen Definition von Verfügungsrechten und ihrer Bedeutung für die Bewässerung. Rechte in Bezug auf Bewässerungssysteme sind vielfältig und komplex und Konzepte einfacher „Eigentumsrechte" sind häufig wenig hilfreich. Der Artikel beleuchtet deshalb jene Bündel von Rechten, die in der Bewässerung eine Rolle spielen und untersucht, in welcher Weise sie für die hydraulische Infrastruktur, für das Wasser selbst und für Boden und andere Ressourcen zu betrachten sind. Das Papier geht aber insbesondere der Frage nach, warum Verfügungsrechte für die Instandhaltung wichtig sind, und betrachtet dabei ihre Rolle bei der Gestaltung von Anreizen. Besondere Aufmerksamkeit kommt dabei den Rechten und Ansprüchen zu, die sich aus deren unterschiedlicher Herkunft ableiten, nicht nur aus der staatlichen Gesetzgebung. Danach wird der Frage nachgegangen, wie Verfügungsrechte erworben werden und was dies für die Entscheidungsfindung in Betrieb und Instandhaltung der Bewässerung bedeutet. Auch die prakischen und auf der politischen Ebene liegenden Schwierigkeiten bei der Etablierung von Verfügungsrechten kommen zur Sprache. Schließlich wird diskutiert, wie die Anerkennung vorhandener Verfügungsrechte ausgeweitet werden kann und welche Fragen einer weiteren Untersuchung bedürfen.

Abstract
This paper examines the linkages between property rights and maintenance of irrigation systems. It begins with a general definition of property rights and their application to the case of irrigation. Rights in irrigation systems are complex, and concepts of simple "ownership" often do not apply. This paper therefore explores the different bundles of rights that should be examined in irrigation systems, and how they apply to rights to land, system infrastructure, the water itself, and other resources associated with irrigation systems. The paper examines why property rights are important for maintenance, with particular attention to their role in shaping incentives for management. Explicit attention is given to how rights and claims on resources can derive from many different sources, not just state law. We then turn to an examination of how people acquire rights, and the implications for who will be involved in irrigation decision-making and maintenance. Practical and political constraints to establishing property rights are then explored. The concluding section looks at how recognition of property rights can be expanded, and what issues need to be further addressed.