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PUBLIC MANAGEMENT OF WATER IN IRRIGATED AERA: INFORMEL AGREEMENT, CORRUPTION AND RENT-SEEKING

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Abstract

The public water management in irrigated perimeter is marked by some failures. We can mention the theft of water, corruption and rent-seeking. These failures result in wastage of this scarce resource. We propose to study the public management of irrigated perimeter using the theory of transaction cost. To this end, we conduct an inquiry in the delegation of "Souk Essebt" in governorate of Jendouba (North West of Tunisia). The qualitative and quantitative information collected is used to describe the functioning of the perimeter. We conduct descriptive and econometric study to verify theoretical hypothesis.

Keywords: public management of irrigated perimeter, transaction cost, theft of water, corruption, rent seeking, transaction cost.

1. INTRODUCTION

Some economists (Montignoul 1997) consider that the nature of water and the incompleteness of contracts on the transaction defend its market management. The market provides an optimal allocation of this limited resource. Indeed, the market pricing allows the reallocation from less productive users to more productive. But a problem arises at this which is linked to the difficulty of quantifying external effects due to the use of water. The latter is also used for livestock, domestic use and cottage industries. Others argue for a public management of water in the irrigated perimeter. As part of this debate, we study the governance of water in the irrigated perimeter of "Souk Essebt" (governorate of Jendouba (north west of Tunisia)). This management is marked by some failures such as loss of water that reaches 50% of the amount pumped and not marked. In other words, the amount of water consumed is not billed. We assume that this wasted water is explained by acts of theft of water. The objective of this study is to explain this theft. For this, we adopt as the theoretical framework the theory of transaction cost [Williamson 1985, 1991, 1994 and 2002]. Williamson assumes that the choice of mode of governance depends on the attributes of the transaction. Transactions that relate to water are marked by the specificity, uncertainty and the average frequency. These attributes justify the use of public management of water in the irrigated perimeter. By cons, bounded rationality and opportunism of the actors of irrigated area (farmers, agents and officials of public administration) encourages market water management. At first, we try to see how the attributes of the transaction can explain its governance. This development will be the first part of this article. In a second step, we try to assess the public management of water in the irrigation perimeter. To this end, we present the theoretical model of Rinaudo and al (2000) which describes the relation between different actors in the irrigation perimeter. The relation is governed by informal agreements between some farmers (nominated by insiders), officials of public administration and politicians. Informal agreement deals with rent-seeking and corruption paid by "insiders" to officials of public administration. The results of this model are subject to empirical verification. To this end, we conducted a survey in the irrigated perimeter of "Souk essebt" which allowed us to understand the function (hydraulic, agronomic and socio-political) of the perimeter. In addition, this survey allowed us to check whether the assumptions leading or not to observed equilibrium in the perimeter. The data collected were the subject of primary and secondary statistical treatment. Finally, we test the predictive ability of the theoretical model trough an econometric study.

2. PUBLIC WATER MANAGEMENT: ATTRIBUTES OF THE TRANSACTION AND AGENT RATIONALITY

Williamson (1994) considers that the specificity of assets, the frequency and uncertainty are the three main attributes that determine the governance mode of the transaction. To what extent the attributes of the transaction justify its public mode of governance.

2.1 Attributes of the transaction

We present the attributes which are the frequency, the specificity of assets and the uncertainty

2.1.1 The frequency

The frequency of a transaction refers to the idea that certain transactions are repeated regularly. On the one hand, the higher the volume of trade, the greater the use of a structure created specifically for this transaction can be made profitable (Williamson 1994). On the other hand, the frequency is the source of reputation effects. These can give the advantage to carry out the transaction in a market. Thus, we can not base ourselves only on the frequency to determine the governance mode of the transaction. In the case of irrigated area of "Souk Essebt," we believe that demand for water is seasonal. Farmers have an important need water from the month of April until September.

2.1.2 Specificity of the assets

The specificity of an asset refers to the degree to which an asset can be redeployed to alternative uses without loss of productive value (Williamson 1994). The presence of specific assets in a transaction makes it impossible to break the contractual relationship without cost. Than bilateral dependence follows. This relationship causes the emergence of opportunism. One partner may have an incentive to expropriate the quasi-rent created in the transaction. In our case, asset specificity is physical and site. Assets and equipments are old and are subject to frequent breakage so maintenance costs have increased sharply. Thus, the private sector has no incentive to invest in the water sector particularly in agricultural. This is especially true as the duration of these investments is generally higher than the survival time farms.

2.1.3 Uncertainty

Uncertainty refers to "disturbances which are subject transactions" (Williamson 1994). It will impact mainly the ex post costs. Thus, increased uncertainty may cause additional costs which the State is able to confront. The uncertainty is related to demand and supply of water. This poses a problem of adaptation of contracts between irrigators and local government (supplier of water) due to the presence of a set of uncontrollable parameters (climate, choice of cropping farmers, etc.). Uncertainty can be external or internal. In the first case, it is linked to climatic and institutional measures. The scarcity during the dry season increases conflicts between users and highlights their opportunistic behavior. Moreover, institutional change (change the rules and laws) reinforces the sense of uncertainty and risk among farmers. In the second case, uncertainty may be due to the changed situation of the farmer (the change of his status), type of crop rotation and opportunistic behavior (diversion of water towers) of some actors in the perimeter. Williamson (1994) considers that the more uncertainty, the greater the incentive to internalize the transaction.

Thus, the attributes (asset specificity and uncertainty) of water justify its public governance.

2.2 Bounded rationality

Simon (1991) considers that agents behave rationally. However, they are limited by their cognitive abilities to acquire and process information. This limitation is due to the nature of "imperfect" of the individual and the environment in which they live. Bounded rationality is the source of the incompleteness of contracts and opportunism. These two phenomena are linked and cause free riding, corruption (Ostrom 1992) and rent seeking and are source of transaction costs.

2.2.1 Free-riding

Farmers are not habituated to pay for water. They do not accept the fact that water is an economic good. They still regard as a common property (Ostrom 1992). Its allocation is based on social, historical and even religious. Only the creation of infrastructure (pumping system, capture and transfer equipment) may give the water a certain right of ownership. The nature of water explains some opportunistic behaviour of farmers, especially free-riding. Free riding is that to take advantage of the collective system without contributing. In the case of irrigated area, it is to use water without paying. For this, the farmer can block the counter quantifying the amount of water. It can use the water from his neighbours illegally. Other methods may also be adopted. Free-riding is not without damage to the hydraulic system. Practices of theft of water cause the bursting of the pipe, water loss and interruption of supply to other customers.

2.2.2 Corruption

Informal agreements, also known as practical rules (Ostrom 1992), are distinguished from the formal rules that are imposed by the state and public administration. They are actually used and implemented through individual and collective actions of the participants. Practices of certain officials of local public Administration and farmers are marked by informal local arrangements that may be in total contradiction with the formal procedures. In irrigated systems, it is common to pay a "bribe" to aguadier to access illegally to water. This practice is so regular that community members know exactly what price to pay for various services rendered. These "bribes" will then form part of the "rules of thumb." The process of corruption is based on multiple negotiations between the farmer and the agents of administration to establish an informal contract. The terms refer to the amount of water illegally acquired and the amount of bribe to pay. In the field, free-riding is quickly spotted. Thus, such behavior does not persist over time. By cons, corruption and rent-seeking depends on the quality of governance across the whole economy.

2.2.3. Rent seeking

The theory of rent was gradually detached from its original classic design. It was extended to all production factors in situations of scarcity and rigidity of supply (as in water). In a contemporary version, it is called the theory of rent-seeking (Krueger 1974). Rent results from market imperfections. It is defined as the excess profits that come from the use of factors of production compared to what these factors could bring in its best alternative use of competitive markets. In irrigated perimeter, some farmers seek to influence (directly or indirectly) the officials of the Administration to obtain an additional quantity of water. These activities are illegal and part of the rent is redistributed to members of the Administration. This redistribution is done in different ways: direct financial transfers in the case of corrupt transactions and economic, social and political support.

Thus, bounded rationality is a source of incomplete contracts and opportunistic behaviour (free riding, corruption and rent seeking). These failures do not plead for a public management of water in the irrigated perimeter.

In all, the attributes of the transaction call for its public governance. Indeed, on one side assets in transaction have a high degree of specificity; the transaction is characterized by high uncertainty and an average frequency. On the other hand, transaction is linked to an institutional and political cadre marked by non respect of rules and laws (corruption and rent seeking). Moreover, water is considered a sovereign transaction (Williamson 1994). Thus, based on the predictions of the theory of transaction costs, a tendency to internalize water management in irrigated areas should be found (all things being equal).

However, the question that we address is: how the opportunistic behavior of the actors of irrigated perimeter may hinder the governance of public water? We try to provide some answers in what follows.

3. PUBLIC MANAGEMENT OF WATER IN THE IRRIGATED PERIMETER: A PROBLEM OF GOVERNANCE

The loss of water is explained by the theft. For example, it is the case when we acquire a quantity of water without paying in return for an amount of corruption. Corruption takes the form of an informal agreement made between the various players in the irrigated area. To represent the behavior of various actors in the perimeter; we adopt the theoretical model of Rinaudo et al (2000) which perfectly represents the observed behavior of the actors in irrigated perimeter. This development will be the first part of this work. In the second part, we try to verify empirically the lessons of the theoretical model.

3.1. Behavior of the perimeter players: informal contract

The players of irrigated perimeter are farmers, officials of public administration responsible directly or indirectly on water allocation and politicians. Farmers in the perimeter are of two types. Firstly farmers who have access to the informal contract, they are designated by "insiders" such as politician and / or administration officials. Every "insider" negotiates with officials (workers, aguadiers, technicians, cadres of the administration, etc.) terms (amount of water illegally acquired and the amount of corruption) of the informal contract. While there are farmers who can not access to this contract. They are designated by "outsiders". The latter can not maintain direct or indirect relationships (high corruption and rent-seeking) with agents of the Administration because of their economic and social situation.

3.1.1. Insider's behavior

Negotiation between an insider farmer and an official of the Administration gives rise to an informal contract. The terms refer to the additional water (acquired in an illegal manner) and the bribe paid to officials of the Administration. These elements vary from one farmer to another in terms of over-quota of water (α_i) and the bribe received by the agent of the Administration which is the amount of corruption (γ_i). We found on the ground that the measure of the amount of illegally water is difficult to measure. However, the act of corruption is detected by the finding of a manipulation of water infrastructure (terminal, vacuum, solid plate, etc.) which lasts over time. The official knows the demand function of the farmer because he knows its area and the type of crop grown. Informal contracts are temporary and must be renewed at the end of each season or at the end of each year. This renewal can also be explained by the instability of local officials in their positions (mutation at any time). Farmers take into account this variable when establishing their strategies to minimize their risks. Farmers have an important need of water from April to September. The official and the farmer "insider" agree on contract (α_i, γ_i) such as income from corruption: $\sum_{i=1}^{N} \gamma_i$ is maximum given the official constraint (we present it in what follows) of the public Administration. In addition, the official does not disclose information about insider farmers. This strategy minimizes the information on the intensity of corrupt transactions and reduce the possibility of dispute and coalitions between outsider farmers.

3.1.2. Behavior of water managers

Each delegation has a total amount of water (Q_p) (amount pumped by the hydraulic service area) that is shared among a group of farmers. Every act of corruption is an act of diversion of resources of amount of α_i for the benefit of users, in return for a sum γ_i. Officials chose a total level of resources acquired illegally as: $Q_d = \sum_{i=1}^{n} \alpha_i$

The choice is such that $Q_d + \varepsilon = Q_p - Q_f$ (Q_f is the amount of water billed, Q_p is the amount of water pumped by the Administration and ε is the loss of water due to its infiltration into the channels). Q_d allows employees to maximize their illegal income given the risk of sanctions when their activities were detected. Water loss due to its infiltration (ε) represents more than 15% of the amount pumped by the Administration. The amount of water pumped and unbilled is equal to 50%. This loss was the basis for the selection of an optimal corruption level. The later depends on the amount of water lost (Q_d). The penalty for the quantity (Q_d) is denoted $C_s(Q_d)$, the probability of detecting corruption is denoted $\lambda_d(Q_d)$ (the probability of detection depends on the amount Q_d, if Q_d increases so λ_d increases) and the income of corrupt officials of the Administration depends on Q_d. The maximization program of the administration official responsible for the management of water is: Max $\gamma_i(Q_d) - \lambda_d(Q_d)C_s(Q_d)$ under the constraint of Q_d.

We suppose that the informal agreement can not persist over time, if the superior is not involved in the conclusion of this agreement either directly or indirectly. The benefit that can have the official is $(1-\Phi)\gamma_i Q_d$. Φ depends on the willingness of the superior not to monopolize the maximum of corruption. This behavior helps to motivate officials (who are at the lower hierarchical level) to maximize the amount of corruption. However, the expropriation of water resources is not complete nor definitive. In fact, Q_d depends on the reaction of other farmers outsiders. They can protest and engage in acts of resistance against the corrupt and rent seeking. This behavior is very common during the period of water stress.

3.1.3. Behavior of outsiders and income of corrupt

Access to the informal agreement is not automatic because of the constraint (Q_d limited). Those who can not access (outsiders) may not always remain passive. Because of their large numbers, Rinaudo and al (2000) show that the outsiders may engage in compensatory action. For example they mobilize government officers and put pressure on local Administration. These actions can come from individual actions, group or state. The latter can be informed by different sources of corrupt officials.

The program of the official could be reformulated as follows:

$\text{Max}\,(1-\Phi)\gamma_i Q_d - \lambda(\text{Q}_\text{d})C_{ac}Q_d$ under the constraint of Q_d $\gamma_i(Q_d)$: the amount of corruption in a given volume of water Q_d .

Φ : the coefficient of redistribution of the amount of corruption to the immediate superior.

$C_{ac}\,Q_d$: costs due to compensatory actions carried out by "outsiders" against officials who have been affected by corruption. However, a third actor may occur on the perimeter who is the local politician (governor, deputy, etc.). He can defend outsiders or corrupt officials.

3.1.4. Behaviour of politicians and rent-seeking

Politicians in the perimeter can influence the decisions of water allocation and thus enter the market of rent by various means, including the threat of officials careers such promotion, threat of mutation, etc. Politicians can intervene with the officials for some influential farmers (faction leader, tribes, landowners, etc.). They can also intervene in favor of outsiders when they are organizing in collective action. The irrigated perimeter of "Souk Essebet" is characterized by crops that have a great need of water from the April and May until September. Small farmers say they can not support the costs of production including the cost of water. The intervention of politicians with these farmers will aim to "save" the corn crop. This is an important variable of the agricultural policy of the state. These interventions take forms of opening of certain irrigated taps sanctioned, debt rescheduling of some farmers, credit facilities, etc. This policy reflects the sovereignty of the transaction resulting from the sovereignty of the agricultural sector.

Therefore, the informal agreement concerns three interacting agents and is responsible for three types of transaction. With regard to agents, there are farmers insiders, the corrupt officials of local government and politicians. With regard to transactions in the first category, insiders exchange with corrupts officials bribes against authorizations exceeded quota of water. In the second category, outsiders put pressure on politicians and employees of local government. This procedure reduces the illegal income of administration officials. In the third category, local politicians influence the decisions of officials by imposing the action to take.

3.2. Modelling the behaviour of actors in the irrigated perimeter

To simplify the model formulation presented above, Rinaudo and al (2000) focus on the case of a hydraulic system consisting of a secondary channel. This latest conducts water in two channels: one upstream and the other downstream. The function of the channel is assumed to be controlled by one officer of the local government (aguadier). The purpose of this hypothesis is to eliminate the idea of sharing corruption with the supervisors. Each channel delivers water to a group of farmers who must have an amount of water noted q. The amount of water received from the channel is equal to $2q-\varepsilon$. ε is a random variable (E $(\varepsilon) = 0$; et $\varepsilon < q$) which representing the loss of water due to the phenomenon of infiltration.

3.2.1. Formulation of the game

Rinaudo and al (2000) assume that the situation of two farmers is asymmetrical. The insider receives an amount of water which is equal to $(q+\alpha)$, α is the amount of additional water equal to the amount of corruption γ given to official monitoring the hydraulic system (often aguadier). The farmer outsider receives a quantity of water which is equal to $(q-\alpha)$. This amount is justified by the scarcity of water resources, especially during periods of water stress. This applies to the case of an inclined area where some farmers are upstream and other downstream. In such cases, if insider monopolizes illegally the amount α, the outsider deprives. The game will take place in two stages. In the first step, the two farmers ("insiders" and "outsiders") are competing to win the support of the politician. The latter is supposed to reduce or prevent the corrupt behaviors of Administration's officials. In the second stage, the farmer insider and the corrupt officials of local government negotiate a contract which dealing with corruption (α) and additional quantity of water (γ).

a) Farmers and politicians

The politician plays an important role in the allocation of the resource since he can put pressure on the official. The later is controlled by an inspector who belongs to the exploitation service. The control is on α. If $\alpha > 0$, the employee suffers a penalty $s(\alpha)$, $s'(\alpha) > 0$ and $s''(\alpha) < 0$. The local politician is solicited by the outsider. The latter provides an effort (X) in lobbying to get the agreement to send an inspector in the perimeter. The probability of sending an inspector is an increasing function of political lobbying effort made (X). The inspector can not be corrupted[2]. The farmer insider is investing in the training of political lobbying (Y). The objective is to reduce the chance of sending an inspection. Therefore, the probability of inspection $(p(X,Y))$ depends on the effort X and Y. We hypothesize that $p'(X) \prec 0$ and $p'(Y) \succ 0$. This assumption is justified by the quality of governance (Kaufman et al 2005) which is marked by a weakness in the accountability indicator (-0.99) and corruption control (-0.04)[3]. The collective action of outsiders is formed of small farmers who have low income and who could not get water in an illegal manner. The quality of governance is represented by two elements. The first relates to the function of punishment $(s(\alpha))$ that reflects the regulatory quality and respect of rules and laws. The second is related to the function $p(X,Y)q$ which reflects the collective action of insiders and outsiders and whose outcome depends on the characteristics of the political regime.

b) Insider and an official of the Administration

The definition of the contract (α, γ) is the result of bargaining between the farmer "insider" and the officials of local government. In this situation, both partners observe α. This negotiation is usually done during the season of water stress (April to September).

3.2.2. Game resolution

Rinaudo and al (2000) were based on the model of Rubinstein (1982) to solve this game. We begin by analyzing the agreement between the insider and the officials. We turn then to model the behavior of two types of farmer insiders and outsiders, with $p\ (X,Y)$ and α^* are given.

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[2] The purpose of this hypothesis is to eliminate the corrupt behavior modeling at different hierarchical levels.

[3] See Kaufmann et al 2005.

a) Farmer "insider" and official

The negotiation space is formed by (α, γ), $\alpha - \gamma \geq 0$ is a participation constraint of the farmer in the informal agreement and $\gamma - p\, s(\alpha) \geq 0$ is aparticipation constraint of the official (responsible for water allocation in the irrigated area) to the informal agreement. An agreement is possible if there is an interior solution is $s'(0) \prec 1$. The utility function of the official is represented by the equation: $\gamma\ p(X,Y)(s(\alpha))$. It reflects the value of the amount of corruption after deducting the value of the penalty multiplied by its probability. The utility of the insider is: $(\alpha - \gamma)$. If we denoted ρ as the power of insider negotiation with $0 \leq \rho \leq 1$, the solution must satisfy the program of maximizing of insider:

$$Max_{\alpha,\gamma}\ (\alpha-\gamma)^{\rho}[\gamma - p(X,Y)(s(\alpha))]^{1-\rho} \quad (1)$$

Differentiating (1) respectively over α et γ we get:

$$p(X,Y)s'(\alpha) = 1 \quad (2)$$

$$\alpha - \gamma = \frac{\rho}{1-\rho}[\gamma - p(X,Y)(s(\alpha))] \quad (3)$$

(2) represents the condition of maximization of corruption to share. It corresponds to the condition of efficient risk taking.

(3) represents the sharing rule of corruption.

(2) and (3) imply $\alpha > \gamma > p(X,Y)\,(s(\alpha))$ (4)

$s(\alpha)$ is strictly convex, we $\alpha s'(\alpha) \succ s(\alpha)$, using (2), we show that:

$$\alpha \succ \frac{s(\alpha)}{s'(\alpha)} = p(X,Y)(s(\alpha))$$

Using (3), we show that:

$$\gamma = \alpha - \rho(\alpha - p(X,Y))s(\alpha) \prec \alpha.$$

The sharing rule of corruption is then:

$$\gamma = (1-\rho)\alpha + \rho\ p(X,Y)s(\alpha) \quad (5)$$

γ can be analyzed as an incentive contract. The amount of corruption paid to the official depends on his effort in negotiating the amount of corruption $(1-\rho)$.

The program official is: Maximize $\gamma - [p(X,Y)(s(\alpha))]$ under constraint $\gamma = ((1-\rho)\alpha + \rho p(X,Y))(s(\alpha))$.

This program has the solution of equation (2): $p(X,Y)\ s'(\alpha) = 1$.

Equation (5) highlights the link between the bargaining power of outsiders and the intensity of the incentive for corruption. Plus this power is important, plus the incentive is low. When that power tends to 1, the amount of corruption received by the official exactly compensates the cost of the penalty that he may suffer and which is equal to P(χ , Y) (s(α)).When ρ tends to 0, the official takes up the entire corruption.

b) Farmer insider and farmers outsider

We characterize in this step the response of the official. In the second step, α^* is considered as exogenous and is a decreasing function of the probability of inspection:

$$\alpha = \alpha^* p(X,Y)\ ;\ \alpha' \prec 0 \qquad (6)$$

the differential of the equation (2) with respect to p gives:

$$s'(\alpha) + \left[p \frac{\partial \alpha}{\partial p} s''(\alpha) \right] = 0$$

$$\frac{\partial \alpha}{\partial p} = \left(\frac{-s'(\alpha)}{p(X,Y)}\right) s''(\alpha) \prec 0$$

We consider the function $\alpha^* p(X,Y)$ as a given and we analyze the behavior of insiders and outsiders. Farmers decide to commit resources (X and Y) in lobbying policy. Each farmer seeks to maximize its objective function. The program of the outsider is to maximize X : $q - [\alpha^* p(X,Y)] - X$ (evaluated in terms of monetary income).

The program of the insider is to maximize $q + \alpha^* - \gamma^* - Y$ that is to maximize $q + \rho \alpha^* p(X,Y) - \rho\, p(X,Y) s \alpha^* p(X,Y) - Y$.

The equilibrium of this game is the pair of lobby effort (X^*, Y^*) which corresponds to (α^*, γ^*) which are the roots of the two equations above. By the derivative of the programs of the farmer outsider (p_{out}) and insider (p_{ins}) respectively over X and Y and we get:

$$\frac{\partial p_{out}}{\partial X} = \frac{-1}{\alpha^{*'} p(X,Y)} \qquad (7)$$

$$\frac{\partial p_{ins}}{\partial Y} = \frac{-1}{\rho s \alpha^* p(X,Y)} \qquad (8)$$

These two equations show that the solution depends on the quality of the institutional environment (formal and informal institutions). Indeed, the solutions depend on the effectiveness of collective action (lobby) $p(X,Y)$, laws and rules $s(\alpha)$. In other words, they depend on the quality of political governance of Tunisia. To simplify the calculation, Rinaudo and al (2000) were based on two assumptions. The first has no theoretical basis. It is used to simplify the calculation:

$$h_1 : s(\alpha) = \frac{e\alpha^2}{2}; \qquad (9)$$

e reflects the severity of the sanction.

the second is inspired by the theory of rent-seeking:

$$h_2 : p(X,Y) = p(k) \text{ avec } k = \frac{X}{Y}. \qquad (10)$$

$p(k) \succ 0$ pour $k > 0$ et $p'(k) > 0$

The hypothesis h_2 states that the amount of water illegally acquired depends on the ratio of the efforts made by both types of farmers and their power. From the hypothesis h_2 and equation (7), we obtain:

$$\frac{p'(k)}{Y} = \frac{1}{\alpha e^2} \qquad (11)$$

From (h_2) we have : $\frac{\partial p}{\partial X} = \frac{p'(k)}{Y}$

Combining with (7), we obtain: $\frac{p'(k)}{Y} = \frac{-1}{\alpha' p(X,Y)}$

Using (2) and the assumption h_1 with $\alpha\ e\ p\ =1$, we obtain equation (11).

From the hypothesis (h_1) and equation (8), we show that:

$$\frac{p'(k)X}{Y^2} = \frac{2}{\rho e\alpha} \qquad (12)$$

The assumption (h_2), we obtain $\frac{\partial p}{\partial Y} = -\frac{p'(k)}{\partial Y^2}$ by combining it with equation (7) we obtain:

$$\frac{X(-p'(k))}{Y^2} = \frac{-1}{\rho s\alpha(p(X,Y)}$$

Using the assumption (h_1), we obtain $\frac{p'(k)X}{Y^2} = \frac{2}{\rho e\alpha^2}$

Combining equations (11) and (12), we obtain:

$$\frac{X}{Y} = \frac{2}{\rho} \qquad (13)$$

This result shows that in equilibrium, the outsider at least twice invests more resources in lobbying policy that the insider (because $\rho < 1$). This can be explained by the power of outsiders compared to insiders. The activities of lobbying of "outsiders" depend on the political governance that characterizes Tunisia. Although this result depends on the formulation of hypotheses, and it shows the advantage enjoyed by the farmer insider in his bargaining power.

To determine the equilibrium $(X^*, Y^*, \alpha^*, \gamma^*)$ of this game, we set a number of assumptions:

I) $k^* = \frac{2}{\rho}$; this assumption reflects the ratio of the effects of lobbying of farmers;

II) $p^* = p(k^*)$; this assumption reflects the probability of inspection at the equilibrium;

III) $\psi = p'(k^*)$; this assumption reflects the sensitivity of inspection (ψ) to a change in the level of political interference (k^*).In other words, it reflects the risk that an inspector be manipulated by politicians. We assume that in equilibrium $\frac{\partial p^*}{\partial \psi} = 0$.

The solutions of the game are then as follows:

i) $\alpha^* = \frac{1}{ep^{*'}}$;

ii) $\gamma^* = \frac{(1-\frac{\rho}{2})}{ep^*}$;

iii) $X^* = \frac{2\psi}{\rho ep^{2*}}$;

iv) $Y^* = \frac{\psi}{ep^{2*}}$.

i) is obtained from (2);

ii) is obtained from (3) and i);

iii) is obtained from (11);

iv) is obtained from iii) and $\frac{X}{Y} = \frac{2}{\rho}$.

3.2.3. Discussion of the solution

The analytical solution allows us to understand the impact of important parameters on the equilibrium of the game. Other parameters can be introduced such that the parameter π (π such ($\frac{\partial p^*}{\partial \pi} = 1$)). The latter reflects the importance of human, technical (transport suitable for all types of terrain, availability of staff for control and monitoring, etc.) and financial resources which must have the local public Administration. In the perimeter of "Souk Essebt", these means are absents due to lack of funds. The parameters α^*, γ^*, X^*, Y^*

and p^* describe the behaviour of insiders and outsiders, the bargaining power of insiders (ρ), the capacity of regulatory and legislative power(e), the sensitivity of the inspection to the various pressures(ψ) and the availability of material and human resources available to the inspectors(π).These parameters reflect the characteristics of the institutional environment of the country and its financial capabilities. These two components affect the public management of water in the irrigation perimeter. The summary of results is presented in the following table:

Table 1: Summary of results

Solution equilibrium	The institutional environment: Parameters of the equilibrium			
	ρ	π	e	ψ
p^*	-	+	0	0
α^*	+	-	-	0
γ^*	+	-	-	0
X^*	+	-	-	+
Y^*	+	-	-	+

Source : Rinaudo and al (2000)

Note: (+): positive; (-): negative, (0): no effect

The results show that the amount of water illegally acquired (α) and the amount of corruption (γ) depends on the bargaining power of the insider farmer (ρ), the inspection (π) and the severity of punishment represented by (e). By cons, α and γ and do not depend on the parameter (ψ) which represents the sensitivity of the regulatory cadre to political pressure caused by outsiders. These results show that opportunistic behavior depend on the quality of political governance and the institutional environment in general. In particular, we can mention accountability, control of corruption, regulatory quality and enforcement of rules and laws. They also depend on the availability of resources (vehicles and personnel) for control and monitoring which are limited in the perimeter of “Souk Essebt”. Thus, opportunistic behavior (corruption and rent seeking) is explained mainly by the weakness in the indicators of the quality of governance and financial resources.

We seek, in what follows, to validate the results of the theoretical model presented above.

3.3. Model validation

We try to explain the loss of water (50% of the amount pumped and not billed) in the irrigated perimeter of "Souk Essebt." We try to see how this loss can be explained by the phenomena presented in the theoretical part. In other words, we try to check if it is acts of theft of water, or whether the loss of water depends on the quality of governance. The latter is marked by a lack of accountability, a non respect of laws and low control of corruption. This climate encourages corrupt behavior and rent-seeking. Prove and measure such phenomena is not an easy task. For this, we decide to take an interest in the act of manipulating irrigation tap which reflects an act of theft of water that is easy to detect and can interpret the phenomena of corruption and rent-seeking. Our study is based primarily on a survey conducted in the perimeter. We select variables that characterize the physical, social and economic environment of the farmer. We try to analyze the results of treatment of information collected during our investigation and at the same time to describe how the data were used. We first make univariate analysis of the key variables that gives the primary results that merely confirm or disprove the hypotheses. Then we pass to the bivariate analysis, which its result gives another dimension.

3.3.1 Empirical data

a) Dependent variable

We try to detect the theft of water. To this end, we think of acts of handling taps in the irrigated perimeter of "Souk Essebt." This act, if it lasts over time, it may reflect an informal agreement between the agents of the public Administration and the farmer[4]. We assume that this farmer belongs to the "insiders". He can be a great farmer, an official of the public Administration or someone else directly or indirectly involved in politics. He uses his power to illegally benefit from an additional quantity of water. For this, we took a sample of 200 closed tap (for more than six months) by the local Administration for reasons of non-payment of water bills from a set of 800 taps closed for the same reason. The perimeter contains 1000 taps which only 200 were operational during the period of our investigation. We try to see, among these taps closed, those that have been

[4] Information taken from officials of the public Administration in Jendouba.

manipulated to irrigate the land in question. First, we identify 200 taps on the map of distribution of the hydraulic system of the perimeter and second we collect all available information (irrigated area, wealth, economic and social situation of the farmer, etc.) on the owners of these taps. After, we conducted an unannounced visit to these taps during the "weekend". We found that, of the 200 taps closed by public Administration, 33 have been manipulated to irrigate land in question. However, the sample chosen and the duration of the visit (one "weekend") does not allow us to detect all cases of theft of water, thus underestimating their actual intensity. Here based on this observation, we created a binary variable that describes the state of the tap closed by assigning the value 1 if it has been manipulated (in other words, farmer use water for irrigation and other uses while his tap is normally closed for reasons of non-payment of water bills) and a 0 if not.

b) Explanatory Variables

The actual context in which we collected empirical data is more complicated than that presented in the theoretical model. On the perimeter, we found that there are several forms of manipulation of the irrigation system. We have identified a set of variables that can explain directly or indirectly theft of water. These were selected on the basis of theoretical studies [Ostrom (1992) and (Rinaudo and al 2000)], the field observations and interviews with engineers of public Administration. The main variables are related to the physical, economic, social and political context of the farmer.

Irrigated area (SUI)**:** we assume that the theft of water depends on the irrigated area. Some consider that the more irrigated area is increasing the need for water increases, the tendency of farmers to steal water increases. Others assume that more irrigated area increases, the farmer gives off an income that allows him to cover his spending, including those related to water. So hi doesn't need to steal water.

The presence of a well (PUI)**:** the incentives to steal the water are even lower than the farmer is able to have a well. The use of well water depends on its abundance, its quality and its cost of extraction. PUI is a binary variable, which takes the value 1 if there is a well on the parcel of land irrigated by the tap and a value of 0 if none.

The residence of the farmer (RES)**:** some consider the character of the resident farmer may discourage stealing water because he takes care of his reputation. By cons, others consider that to be a resident in the land let him developing relationships with agents of local Administration and he can acquire water in an illegal manner. RES is a binary variable that takes the value 1 if the farmer is resident and 0 otherwise.

Livestock (ELE)**:** Some assume that the diversification of activities as the practice of livestock, can weaken the incentive for the farmer to steal water. In this case, agriculture is not the only source of income for the farmer. ELE is a polytomous variable that takes the value 2 if the farmers practice livestock of cattle and sheep, 1 if he only practices one type of livestock (sheep or cattle) and 0 if he not practices any type of livestock.

Possession of machines or transports ($MAC1$)**:** some consider that this provides information on the type of farmer (poor or rich). If he is equipped with machinery and transportation he will be less incentive to steal water (all things being equal). $MAC1$ is a binary variable that takes the value 1 if the farmer has machines or transport and 0 otherwise.

Intensification of culture (INC)**:** some suppose that if farmer cultivates his land (more than once a year), he needs water so he is more prompted to steal. The intensification of culture is a polytomous variable that takes the value 1 if the farmer cultivates once a year, 2 if he cultivates twice a year and 3 if he cultivates his land three times a year. However, we note that the effect of this variable is ambiguous. For some, the cultivation of the land more than once during the same year shows that the farmer works and increases his income, therefore, he does not need to steal water. For others, the need for water, following the intensification of farming, let him to steal the water.

Farmer administrative and / or politician (CAP)**:** we have shown that in the theoretical model, the cost of obtaining water illegally depends on the bargaining power of insiders. We assume that they are generally administrative and / or politicians. We assume that a farmer "insider" (CAP) reflects the presence of corrupt behavior and rent-seeking. CAP is a binary variable that takes the value 1 if the manipulated tap belongs to politician farmer or to farmer who has a directly or indirectly relation with Administration and 0 otherwise.

3.3.2. Descriptive study for explanatory and predictive study

a) Univariate analysis of variables

Univariate analysis of variables shows that on average irrigated area is of 4[5] hectares. We find that 59%[6] of taps that make up our sample are accompanied by well. However, the high cost of drilling implies that the important source of water is the water of the North purchased by the administration. 85%[7] of taps are owned by resident farmers. 47%[8] of the

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[5] See table 1 of annex.
[6] See table 2 of annex.
[7] See table 3 of annex.

taps belonging to farmers who practice the cattle or sheep. 60%[9] of the taps belonging to farmers who have machines. 44.7%[10] of the taps belonging to farmers who cultivate their land twice a year. 61.5%[11] of taps are shared taps. 61.5%[12] of the taps belonging to farmer administrative and/or politician or en general who has a directly or indirectly relation with the two latter. Univariate study shows that farmers have an important need for water and the well water has a high degree of salinity. The majority of farmers are residents. The percentage of farmers who have the machines and who cultivate their land twice shows that these farmers aren't poor farmers. The majority of farmers are involved in politics and taps are mostly shared taps.

b) Bivariate analysis of variables

The bivariate analysis shows that 54.6%[13] of manipulated taps belong to outsiders, against 45.4% for insiders. In addition, there is a significant relationship (r = 4.29 and p = 0.03)[14] between the manipulated taps and political and social characteristic of farmer. 45.4%[15] of manipulated taps are shared taps. The analysis shows that there is a relationship (r= 4.29 and p = 0.03)[16] between manipulated taps and shared taps. 43%[17] of manipulated taps belongs to farmers who cultivate one a year their land, 50% of manipulated taps belongs to farmers who cultivate twice a year their land and 0,06% of manipulated taps belongs to farmers who cultivate three times a year their land. Furthermore, there is no a relation between manipulated taps and crop intensification (χ^2 = 0,72 et p = 0,69)[18]. We find that 46%[19] of manipulated taps belong to farmers who are owned machines. There is a relation (χ^2 = 3,23 et p=0,072)[20] between manipulated taps and possession of machines. 45%[21] of manipulated taps belongs to farmers who don't practice animal husbandry, 49 of manipulated taps belongs to farmers who practice one type of animal husbandry and 15% of manipulated taps belongs to farmers who

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[8] See table 4 of annex.
[9] See table 5 of annex.
[10] See table 6 of annex.
[11] See table 7 of annex.
[12] See table 8 of annex.
[13] See table 10 of annex.
[14] See table 10a of annex.
[15] See table 11 of annex.
[16] See table 11a of annex.
[17] See table 12 of annex.
[18] See table 12 a of annex.
[19] See table 13 of annex.
[20] See *table 13a of annex.*
[21] See table 14 of annex.

practice two types of animal husbandry (sheep and cattle). We notice that it doesn't exist a relationship between manipulated tap and animal husbandry (χ^2 = 2, 10 et p = 0, 35)[22]. 12%[23] of manipulated taps belong to non resident farmers against 87% for resident farmer. Furthermore, it doesn't exist any relationship between manipulated taps and the residence of farmers (χ^2 = 0, 25 et p = 0, 61)[24]. 46%[25] of manipulated taps belong to farmers who have machines. There is a relation (r= 3.23 and p = 0.072)[26] between manipulated taps and possession of machines. 43%[27] of manipulated taps owned by farmers who own wells and there is a relationship (r = 4.48 and p = 0.034)[28] between manipulated taps and possession of wells. Manipulated taps is independent of the irrigated area. Indeed, F is low (0.35)[29] and insignificant (0.55)[30], than the equality of means is confirmed.

We summarize the results of the bivariate study in the following table:

Table 2: Summary of results of bivariate study

Characteristics of farmer and his the physical and socio-political environment	Manipulated taps
- Farmer "politicians";	+
- Shared taps;	+
- Farmers with machines ;	+
- Presence of wells;	+
- Crop Intensification ;	0
- Animal husbandry;	0
- Character resident of the farmer;	0
- Area irrigated.	0

Note: (0: no effect on the manipulated taps; +: positive effect on the manipulated taps).

Thus, manipulation of taps is not linked to material factors such the water requirement and the economic situation of farmers. Indeed, the intensification of crops, animal husbandry and irrigated area are not related to acts of manipulation of taps. For cons, the variables "have a well" and "possession of machines" are positively related to the manipulation of taps. Moreover, this descriptive study found that formal (political party, social or

[22] See table 14a of annex.
[23] See table 15 of annex.
[24] See table 15a of annex.
[25] See table 16 of annex.
[26] See table16a of annex.
[27]See table17 of annex.
[28] See table17a of annex.
[29] See table18 of annex.
[30] See table18a of annex.

economic) and informal (tribute, village or social class) membership to a group may be related to opportunistic behavior of some players of the perimeter.

After summarizing all the information from the survey, we try to verify and generalize the results.

c) A multivariate explanatory analysis

i) Presentation of the model

The dependent variable, denoted Y, is a qualitative binary. It takes the value 1 if the taps manipulated reveals the presence of a corrupt transaction, so an informal agreement and 0 otherwise. The value taken by Y depends on the value of net income that the farmer hopes to get and which is a result of the manipulation of the irrigation system. If this value is positive, Y equal to 1, if not $Y = 0$. This benefit corresponds to a latent variable denoted Y^*, whose values are not observable.

$$Y^* = \sum_i \alpha_i X_i + \sigma$$

Y^*: value of the latent variable;

$Y = 1$ if $Y^* > 0$;

X_i : explanatory variables;

α_i : coefficient of the explanatory variable;

σ : residue.

The estimation method used is the automated logistic regression ("stepwise").

ii) Discussion and Interpretation of results

Table 2: results of specification

Endogenous variables: Y

Variables	**Coefficient**	**Wald (t-stat)**	probability
*BOF*1	0,71	3,37	0,06
RES	-0,89	4,93	0,02
INC	-0,64	8,88	0,00
$\overline{R}^2$ ajusté	0,49	-	-
Overall Percentage	83,0	-	-

We estimated coefficients of the full model that is to say all the variables that may explain the manipulation of the taps. However, the coefficients were not significant. We have gradually simplified the model to retain only three variables which their coefficients are significant: the presence of shared taps $BOF1$, the residence of farmer RES and crop intensification INC.

The model explains 49%[31] of the variance of the dependent variable [R^2 = 49%] and the model is true in 83% of cases.

The presence of shared taps affects positively[32] its manipulation. This result confirms the bivariate analysis which shows that there is a relationship between the shared taps and its manipulation. Sharing the same taps encourages opportunistic behavior. No one can reveal the opportunistic behavior of the other is himself involved. The informal institution (the feeling of belonging to the group) is a revelation of an insurance against sanction of opportunistic behavior. Beside, the lack of control and monitoring encourages this opportunistic behavior.

The resident character of farmer explains negatively the manipulation of taps. The more the farmer is resident, the less he has incentive to manipulate taps. Ostrom (1992) shows that the residence of the farmer incentive him to have an appropriate behavior. This result highlights the role of informal institutions (reputation) in determining the behavior of agents that is based on honor, respect for laws, values and traditions.

Crop intensification explains negatively the manipulation of taps. More land is cultivated more than once a year, unless the taps are manipulated. In other words, the crop intensification reflects a high income of farmer which explains the reduction of opportunistic behaviour. This result is confirmed also by studies of Ostrom (1992) who shows that income or wealth explains positively coordination and cooperation between government and farmers.

Thus, the econometric study showed that theft of water (via the manipulation of taps) can be explained mainly by material and institutional factors. Indeed, the lack of equipment (vehicles) and agents (aguadiers) encouraged the theft of water. In addition, the sense of security due to belonging to group membership and financial position of farmers explain the theft of water.

3.3.3. Implications: large and / or small corruption

The empirical study presented in this work has validated the theoretical model in part (Rinaudo and al 2000). It showed that outsiders may put pressure on officials of public Administration. Indeed, the penalty (the closure of taps) also applies to insiders (45.4%) and outsiders (54.6%).

[31] See table 19 of annex.
[32] See table 19a of annex.

The lack of monitoring and control of the hydraulic system explain the theft of water that is practiced by insiders and outsiders. Thus, this study confirmed the presence of the phenomena of free riding and small corruption (54.6% of taps manipulated belong to outsiders against 45.4% for the insiders). However, the enormous loss of water that reaches 50% of the amount pumped and not billed can not be explained only by the free-riding (which is quickly spotted) and small corruption that is not stable over time (change of officials of local government and pressure of the collective action of "outsiders").

Thus, this study proves with certainty only the existence of the phenomenon of free riding and small corruption. The method we used could not reveal the grand corruption and rent seeking. This failure is explained by two phenomena. The first is theoretical and related to a lack of tools for analysis and quantification of transaction costs due to the behavior of corruption and rent-seeking. The second refers to a lack of data to measure these phenomenas.

4. Conclusion

Based on the finding of a great loss of water in the governorate of Jendouba (north west of Tunisia), this work aimed to see whether the public management of water in the irrigation perimeter is the appropriate mode of governance. Two parties compose this work. In the first, we presented the attributes of the transaction relating to the water. We have shown that the asset is highly specific and the life of the equipment is limited in time and requires continued investment. The transaction is uncertain and highly frequency in summer. Based on these attributes and under the teachings of the theory of transaction costs, public management seems to be the appropriate mode of governance. In the second part, we discussed the problem linked to public governance of water in the irrigated perimeter. The nature of water and bounded rationality of agents leads to the incompleteness of contracts which encourages opportunistic behavior of some players in the irrigated area. This opportunism results in acts of theft of water, which is scarce in Tunisia. This theft is explained by the activities of free rider, corruption and rent-seeking. To study these aspects, we adopted the theoretical model of Rinaudo and al (2000), which describes the behavior of actors in the irrigation perimeter. This model highlights some opportunistic behavior of the perimeter players, including free riding, corruption and rent seeking. These players are "insiders" who can access to informal agreements on corruption and rent seeking. As against the "outsiders" are those who are excluded from these agreements. We tried to verify this behavior in the perimeter to explain the significant loss of water. In addition to collecting data related to economic and social variables of the farmer, we conducted an informal survey to detect the theft of water. The treatment of the data showed that in addition to outsiders, there are two categories of insiders: big and small insiders. Small insiders use corruption to acquire an additional quantity of water in an illegal manner. The theft of outsiders is explained by the lack of control and monitoring of hydraulic equipment in perimeter. However, this study does not allow us to identify the great insiders who do not need to manipulate their taps to acquire illegally water they are involved directly in the decision of allocation of the resource.

In addition, our study was has led to four main contributions. First, we showed that informal agreements (corruption or rent-seeking) are explained by the quality of political governance, including lack of accountability. Second, the informal rules can explain and affect the behavior of individuals. Third, the choice of governance must be registered as part of the remediable inefficiencies, that is to say, it can be adopted only if it corresponds to a net gain. The latter is not only the result of applying the principle of alignment but also the nature of the environment (economic, political and social) of the transaction. Fourth, it has emerged from our study that while small corruption is explained by financial constraints (low-income of employees of the Administration), great corruption is informally institutionalized. Consequently, any form of governance depends on the nature of the transaction and the environment in which will not appear a feasible alternative solution at lower cost.

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***Annexe* i**

Localisation du périmètre de Souk Essebt

Le périmètre de Souk Essebt se situe à 15 kilomètres à l'Est de la ville de Jendouba et à 16 km de la ville de Bou Salem. Le périmètre appartient à la délégation de Jendouba Sud.

Ses limites physiques sont :

a) Au nord : Oued Medjerda ;
b) A l'Ouest : Oued Mellègue ;
c) A l'Est : Oued Tessa ;
d) Au Sud : des collines.

Le périmètre a une superficie de 5300 ha et il est irrigué à partir des eaux du barrage Bou Heurtma et du barrage Mellégue.

Annexe ii

Démonstration des résultats du modèle de Rinaudo (2000)

$\frac{\partial k^*}{\partial \rho} = \frac{-2}{\rho^2} \prec 0$; $\frac{\partial p^*}{\partial \rho} = \frac{\partial p^*}{\partial k}\frac{\partial k^*}{\partial \rho} = \frac{-2\psi}{\rho^2} \prec 0$;

$\frac{\partial \alpha^*}{\partial \rho} = \frac{2\psi}{\alpha p^{2^*}\rho^2} \succ 0$; $\frac{\partial \alpha^*}{\partial e} = \frac{-1}{\alpha^2 p^{2^*}} \prec 0$ $\frac{\partial \gamma^*}{\partial e} = \frac{-(1-\frac{\rho}{2})}{\alpha^2 p^*} \prec 0$; $\frac{\partial Y^*}{\partial \rho} = \frac{4\psi^2}{\alpha\rho^2 p^{3^*}} \succ 0$;

$\frac{\partial Y^*}{\partial \psi} = \frac{1}{\alpha p^{2^*}} \succ 0$

L'impact de ρ sur γ^* et χ^* est ambigu en effet :

$\frac{\partial \gamma^*}{\partial \rho} = \frac{(2-\rho)2\psi - p^* Y^2}{2\rho^2 e p^{2^*}}$; $\frac{\partial X^*}{\partial \rho} = \frac{2\psi}{e\rho^2 p^{3^*}}\left[\frac{4\psi}{\rho} - p^*\right]$;

L'impact de ρ sur γ^* et χ^* est positif

si $\psi > \frac{\rho^2 p^*}{2(2-\rho)}$ et $\psi > \frac{\rho p^*}{4}$.

Annexe iii

Ressource en eau du périmètre

Depuis sa mise en service en 1984, le périmètre est alimenté par les eaux du barrage Bou Heurtma jusqu'à la mise en service du périmètre Bou Heurtma III (superficie 3800 ha) en Mars 2002. Depuis cette date, les deux périmètres sont irrigués par l'eau mélangée dans le bassin de stockage B2 provenant de deux barrages Mellègue et Bou Heurtma. Les eaux de deux barrages sont refoulées via deux stations de pompage respectivement PAP2 (barrage Bou Heurtma) et BH3 (barrage Mellègue) dans le bassin de mélange et de mise en charge B2. Actuellement et dans le cadre de l'orientation générale d'économie d'énergie, les eaux du bassin B2 proviennent du barrage Bou Heurtma.

Table 1

Average irrigated area

Descriptive Statistics					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
irrigated area	200	,405	8,000	4,29051	1,429197
Valid N (listwise)	200				

(Source : our calculation on SPSS)

Table 2

Presence of wells

Presence of wells					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Absence of wells	82	21,8	41,0	41,0
	Presence of wells	118	31,3	59,0	100,0
	Total	200	53,1	100,0	
Missing	System	177	46,9		
Total		377	100,0		

(Source : our calculation on SPSS)

Table 3

Farmers residence

Farmers residence					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Non resident farmers	30	8,0	15,0	15,0
	Resident farmers	170	45,1	85,0	100,0
	Total	200	53,1	100,0	
Missing	System	177	46,9		
Total		377	100,0		

(Source :our calculation on SPSS)

Table 4

Practices of cattle and sheep

Practice of cattle and sheep					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Non practices	69	18,3	34,5	34,5
	Practices of cattle or sheep	94	24,9	47,0	81,5
	Practices of cattle and sheep	37	9,8	18,5	100,0
	Total	200	53,1	100,0	
Missing	System	177	46,9		
Total		377	100,0		

(Source : our calculation on SPSS)

Table 5

Possession of machines

Possession of machines					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	No machines	81	21,5	40,5	40,5
	Machines	119	31,6	59,5	100,0
	Total	200	53,1	100,0	
Missing	System	177	46,9		
Total		377	100,0		

(Source : our calculation on SPSS)

Table 6
Intensification of culture

Intensification of culture					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Culture once a year	86	22,8	45,7	45,7
	Culture twice a year	84	22,3	44,7	90,4
	Culture three times a year	18	4,8	9,6	100,0
	Total	188	49,9	100,0	
Missing	System	189	50,1		
Total		377	100,0		

(Source: our calculation on SPSS)

Table 7
Shared taps

Shared taps					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Absence of shared taps	77	20,4	38,5	38,5
	Presence de shared taps	123	32,6	61,5	100,0
	Total	200	53,1	100,0	
Missing	System	177	46,9		
Total		377	100,0		

(Source : our calculation on SPSS)

Table 8

Administrative and/ or politician farmer

Farmer administrative and/or politician					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Farmer who is neither administrative nor politician	77	20,4	38,5	38,5
	Farmer who is administrative and/or politician	123	32,6	61,5	100,0
	Total	200	53,1	100,0	
Missing	System	177	46,9		
Total		377	100,0		

(Source : our calculation on SPSS)

Table 9
Percentage of manipulated taps

Percentage of manipulated taps					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Intact taps	167	44,3	83,5	83,5
	Manipulated taps	33	8,8	16,5	100,0
	Total	200	53,1	100,0	
Missing	System	177	46,9		
Total		377	100,0		

(Source: our calculation on SPSS)

Table 10

Cross-table between manipulated taps and political and social characteristics of farmer

Manipulated taps * political and social characteristic of farmer				
Count				
		Political and social characteristic of farmer		**Total**
		Farmer who is neither administrative nor politician	Farmer who is administrative and/or politician	
Manipulated taps	Intact taps	59	108	167
	Manipulated taps	18	15	33
Total		77	123	200

Table 10a

Test de χ^2

Chi-Square Tests					
	Value	**df**	**Asymp. Sig. (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**
Pearson Chi-Square	4,297[a]	1	,038		
Continuity Correction[b]	3,524	1	,060		
Likelihood Ratio	4,189	1	,041		
Fisher's Exact Test				,050	,031
Linear-by-Linear Association	4,276	1	,039		
N of Valid Cases	200				
a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 12,71.					
b. Computed only for a 2x2 table					

(Source : nos calcul sur SPSS)

Table11

Cross-table between manipulated and shared taps

Manipulated taps* shared tap Crosstabulation				
Count				
		Shared tap		**Total**
		Absence of shared taps	**Presence of shared taps**	
Manipulated taps	Iintact taps	59	108	167
	Manipulated taps	18	15	33
Total		77	123	200

(Source : our calculation on SPSS)

Table 11a

χ^2 Test

Chi-Square Tests					
	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4,297[a]	1	,038		
Continuity Correction[b]	3,524	1	,060		
Likelihood Ratio	4,189	1	,041		
Fisher's Exact Test				,050	,031
Linear-by-Linear Association	4,276	1	,039		
N of Valid Cases	200				
a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 12,71.					
b. Computed only for a 2x2 table					

(Source :our calculation on SPSS)

Table 12

Cross table between manipulated taps and crop intensification

Manipulated taps* crop intensification Crosstabulation					
Count					
		Crop intensification			Total
		Culture once a year	Culture twice a year	Culture three times a year	
Manipulated taps	Intact taps	72	68	16	156
	Manipulated taps	14	16	2	32
Total		86	84	18	188

(Source: our calculation on SPSS)

Table **12a**

χ^2 Test

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,723[a]	2	,697
Likelihood Ratio	,767	2	,682
Linear-by-Linear Association	,016	1	,899
N of Valid Cases	188		
a. 1 cells (16,7%) have expected count less than 5. The minimum expected count is 3,06.			

(Source: our calculation on SPSS)

Table 13

Cross table between manipulated taps and possession of machines

Manipulated taps * possession of machines Crosstabulation				
Count				
		Machines		Total
		Absence of amachines	Possession of machines	
Tap manipulated	Intact taps	63	104	167
	Manipulated taps	18	15	33
Total		81	119	200

Table 13a

χ^2 Test

Chi-Square Tests					
	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	3,235[a]	1	,072		
Continuity Correction[b]	2,575	1	,109		
Likelihood Ratio	3,179	1	,075		
Fisher's Exact Test				,083	,055
Linear-by-Linear Association	3,219	1	,073		
N of Valid Cases	200				
a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 13,37.					
b. Computed only for a 2x2 table					

(Source: our calculation on SPSS)

Table 14

Cross table between manipulated taps and type of animal husbandry

Manipulatad taps *Animal husbandry Crosstabulation					
Count					
		Animal husbandry			Total
		Absence of animal husbandry	One type of animal husbandry	Two type of animals husbandry	
Manipulated taps	Intact taps	54	81	32	167
	Manipulated taps	15	13	5	33
Total		69	94	37	200

Table 14a
Test de χ^2

Chi-Square Tests			
	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	2,101[a]	2	,350
Likelihood Ratio	2,036	2	,361
Linear-by-Linear Association	1,595	1	,207
N of Valid Cases	200		
a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 6,11.			

(Source: our calculation on SPSS)

Table 15
Cross table between taps manipulation and residence of farmes

Manipulated taps * Residence of farmes Crosstabulation				
Count				
		Farmer		**Total**
		non -resident	**resident**	
Manipulated taps	Intact taps	26	141	167
	Manipulated taps	4	29	33
Total		30	170	200

Table 15 a
χ^2 Test

Chi-Square Tests					
	Value	**df**	**Asymp. Sig. (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**
Pearson Chi-Square	,257[a]	1	,612		
Continuity Correction[b]	,058	1	,810		
Likelihood Ratio	,269	1	,604		
Fisher's Exact Test				,792	,421
Linear-by-Linear Association	,256	1	,613		
N of Valid Cases	200				
a. 1 cells (25,0%) have expected count less than 5. The minimum expected count is 4,95.					
b. Computed only for a 2x2 table					

(Source :our calculation on SPSS)

Table 16
Cross table between manipulated taps and possession of the machines

Manipulated taps * possession of machines Crosstabulation				
Count				
		machines		**Total**
		no possession of machines	**Possession of machines**	
Taps manipulation	Intact taps	63	104	167
	Manipulated taps	18	15	33
Total		81	119	200

Table 16 a
χ^2 Test

Chi-Square Tests					
	Value	**Df**	**Asymp. Sig. (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**
Pearson Chi-Square	3,235[a]	1	,072		
Continuity Correction[b]	2,575	1	,109		
Likelihood Ratio	3,179	1	,075		
Fisher's Exact Test				,083	,055
Linear-by-Linear Association	3,219	1	,073		
N of Valid Cases	200				
a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 13,37.					
b. Computed only for a 2x2 table					

(Source: our calculation on SPSS)

Table 17
Cross table between manipulated taps and possession of wells

Manipulated taps * Possession of wells Crosstabulation				
Count				
		Wells		**Total**
		No wells	**Possession of wells**	
Taps	Iintacts taps	63	104	167
	Manipulated taps	19	14	33
Total		82	118	200

Table 17a
χ^2 Test

Chi-Square Tests					
	Value	**df**	**Asymp. Sig. (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**
Pearson Chi-Square	4,489[a]	1	,034		
Continuity Correction[b]	3,706	1	,054		
Likelihood Ratio	4,415	1	,036		
Fisher's Exact Test				,052	,028
Linear-by-Linear Association	4,466	1	,035		
N of Valid Cases	200				
a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 13,53.					
b. Computed only for a 2x2 table					

(Source: our calculation on SPSS)

Table 18
Test of equality groups

Group Statistics					
Manipulation of taps		**Mean**	**Std. Deviation**	**Valid N (listwise)**	
				Unweighted	**Weighted**
Intact taps	Irrigated area	4,31744	1,458342	167	167,000
Manipulatad taps	Irrigated area	4,15421	1,283326	33	33,000
Total	Irrigated area	4,29051	1,429197	200	200,000

(Source: our calculation on SPSS)

Table 18a
Test of equality of means

Tests of Equality of Group Means					
	Wilks' Lambda	F	df1	df2	Sig.
Irrigated area	,998	,358	1	198	,550

(Source: our calculation on SPSS)

Table 19
Estimation results

Model Summary			
Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	173,824[a]	,370	,493
a. Estimation terminated at iteration number 5 because parameter estimates changed by less than ,001.			

Table 19a
Cassification table

Classification Table[a]					
	Observed		Predicted		
			Taps		Percentage Correct
			Intact taps	Manipulated taps	
Step 1	Taps	Intact taps	154	2	98,7
		Manipulated taps	30	2	6,3
	Overall Percentage				83,0
a. The cut value is ,500					

Variables in the Equation							
		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1[a]	BOF(1)	,710	,387	3,370	1	,066	2,034
	RES	-,890	,401	4,934	1	,026	,411
	INC	-,645	,216	8,886	1	,003	,524
a. Variable(s) entered on step 1: BOF, RES, INC.							

Table 20
Volume pomped and billed (1999- 2004)

Years	**1999-00**	**2000-01**	**2001-02**	**2002-03**	**2003-04**
Volume pomped $10^3 m^3$	19681	14334	21743	12970	11614
Volume billed $10^3 m^3$	10407	6386	12907	7760	5811
Efficience %	53	54	59	60	50

(Source : CRDA Jendouba)

Table 21
Fluctuation of rate of unpaid bills in Souk Essebt

Years	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Rate of unpaid bills (%)	90	85	83	87	84	94

(Source : CRDA Jendouba)

Table 22
Number of farmers sharing taps

Number of farmers	**Number of sharing taps**
2	199
3	162
4	31
5	7
6	4
7	2
Total	405

(Source : CRDA Jendouba)