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# Determinants of Farmers' acceptance of Treated wastewater in irrigated agriculture in the northern Gaza strip

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## Abstract
Growing water scarcity threatens economic development and sustainable livelihoods in the Gaza Strip. Using treated wastewater in agriculture is a potential alternative resource that may improve production conditions in farming systems and simultaneously save fresh water for domestic use. Knowledge about the determinants of farmers' acceptance of treated wastewater is a prerequisite for the formulation of programmes for the support of an unobstructed transition from the current situation to the expected management of water resources in the future. The presented analysis of determinants of farmers' acceptance was based on data from a random sample of 94 farmers in the Biet Hanoun Area in the northern part of the Gaza Strip. The study area will become a site with treated wastewater irrigation according to the plans of the Palestinian Water Authority. A classification of the existing farming systems according to their agricultural activities and family income revealed three relatively homogeneous classes: mixed cropping farmers (A), low-income perennial crop farmers (B) and high-income perennial crop farmers (C). Acceptance of treated wastewater was significantly lowest in class A, but showed no difference between farmers from the classes B and C, whereby the fear of diseases and pollution through treated wastewater use was the most frequently stated concern. Further analyses by a logistic regression model revealed that this concern was the major determinant of farmers' negative attitude towards the use of treated wastewater and has an even larger impact than the ownership of own wells, which ranged on the second place. Major determinants for a positive attitude were the area of non-irrigated land and the cropping pattern. Literacy of farmers and the share of irrigation costs in the farms' variable costs played an ambiguous role and may work in both directions. The overall highly significant results of the model support the hypothesis of a dominant impact of farmers' information on the acceptance of treated wastewater for irrigation purposes. The ambiguity arises from the finding that acceptance of treated wastewater may origin from better access to information as well as from the lack of awareness on potential side effects.

## 1. Background and objectives
The Gaza Strip, as all neighbouring regions, faces a serious freshwater deficit (PALESTINIAN WATER AUTHORITY, 2002). The core problem is the increasing fresh water consumption which can not be covered by the naturally and politically restricted water supply. This situation calls for the consideration of potential additional water resources. Agriculture, as the sector which consumes currently around two thirds of the fresh water(TUBAIL, K., *et al,* 2002), is the most promising sector for significant changes towards a sustainable water balance in the future. The replacement of freshwater in irrigation by treated wastewater is regarded as one of the major

potential alternatives towards the saving of freshwater for domestic use: It is, however, still questionable if the individual decision makers in the agricultural sector, i.e. the farmers, will react in a way that allows for the full exploitation of the potentials of the alternative water resource. The present study aimed to investigate the factors that affect farmers' decisions on using treated wastewater. It contributes thereby to the third area of a conclusive research approach that combines four areas of research on wastewater use: *(1)* the costs of different levels of treatment of wastewater, *(b)* the institutional frame of wastewater reuse, distribution and pricing policies, *(c)* farmers' perception on the use of treated wastewater and possible impacts on their living standard and *(d)* the importance of irrigation water quality in consumers' decision on agricultural products (*cf.* WOLFF *et al.*, 2005)

## 2. Methods

A survey in 94 representatively selected farms in Biet Hanoun provided the empirical data base for analyses and modelling. The farming population was classified into three types of farming systems which showed significant differences in cropping patterns and family income. Descriptive analyses illustrated the differences between the three farming systems. Based on the results of the descriptive analyses a set of variables were identified as hypothetical factors affecting farmers' decision on using treated wastewater for irrigation. A logistic regression model served for testing impacts of the selected factors on farmers' decision on using treated wastewater in irrigation.

### 2.1 Study area

The study area is situated in Biet Hanoun city and surrounding areas, which is located in the eastern part of the northern Gaza Strip and houses a population of 28,000 inhabitants. The economic environment of Biet Hanoun area relies strongly on agricultural production, especially citrus production, and was selected by the Palestinian Water Authority as one of the sites to use treated waste water for irrigation in the future. Irrigation with treated wastewater will be a novelty in the research area. Farmers are still suspicious of applying it to their crops even though most of them saw or practiced the use of treated wastewater in Israel.

### 2.2 Data collection

Different methods were employed to gather complementary types of data and information. Methods comprised family surveys using standardized questionnaire and informal interviews with key person. Supplementing secondary data came from governmental and non governmental statistics, studies and reports. The analysis of determinants of farmers' acceptance was based on data from a random sample of 94 farmers in the Biet Hanoun Area.

### 2.3 Classification and descriptive analysis

For analytical purpose the sample was clustered into three groups according to two criteria. The first criterion was cropping pattern which distinguishes between farmers who cultivate only perennial crops (mainly citrus) and farmers who cultivate annual crops. The choice of this criterion is related to the research questions since annual crops need water of higher quality compared to perennial crops. More than two third of the farm families have citrus farms, which is the main farm activity in Biet Hanoun area, which implied the need to subdivide the group of perennial crop farmers by another criterion. Family income was chosen due to the hypothesis that farm families with high income are more risk tolerant with regard to the application of treated wastewater than farmers with lower incomes. The classification thus lead to the three classes of relatively homogeneous farming systems: mixed cropping farmers, low-income perennial crop farmers and high-income perennial crop farmers.

The socio-economic comparisons between the three farming systems followed the rules of the Farming System Approach was applied. The analyses of farming systems according to this approach is based on the systems philosophy and is related to the development of farming activities as well as the well-being of the rural people (Doppler, 1999). The approach is also a behavioural approach due to its special emphasis on the cultural impacts of decision-making processes and the inclusion of participation of target groups and stakeholders (Doppler, 2000)., These analyses included analyses of resources availability and use efficiency as well as living standard analyses in addition to farmers' perception on using treated wastewater.

The results of the analyses enabled the identification of a set of factors that have the potential to affect farmers' decision on using treated wastewater in agriculture. Those factors were (a) fear of diseases and pollution, (b) possession of wells, (c) area of non-irrigated land, (d) cropping pattern, (e) share of irrigation cost in the variable cost and (f) literacy of household head.

**2.4 Logit model**

A logistic regression model was applied to test the impact of these factors on farmers' acceptance of treated wastewater in irrigation. Logistic regression is a statistical tool to determine the influence of independent on dependent variables when the dependent variable is binominal scaled (Katwijuke, 2004). The dependent variable in this case was a dummy variable that represented either acceptance (1) or rejection (0) of treated wastewater use. The analysis allows for the application of straightforward statistical tests and has a high capacity to incorporate non-linear effects and wide range of diagnostic power (Hair, et al., 1998). The model was used to test the influence of the above mentioned hypothetical explanatory factors on the dependent variable.

The model is expressed by the following formula:

$$L_i = \ln\left(\frac{P_i}{1-P_i}\right) = Z_i$$

Where Li = log of adds ratio

Pi = the probability of acceptance of treated wastewater use by the I $^{th}$ household.

1-Pi = the probability of rejection of treated wastewater use by the I $^{th}$ household

Whereby the value of $P_i = \frac{1}{1+e^{-z_i}}$ And the value of $Z_i$ is calculated by:

$$\mathbf{Z_i = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6}$$

With:

B0 = intercept

$B_1, B_2, B_3, B_4, B_5, B_6$ = The slope parameters of the model which measures the change in Li for a unit change in the explanatory variables Hence, it tells how the log-odds in favour being willing to pay as the value of the variable Xi changes by a unit.

$X_1$ = Fear of diseases and pollution (binominal dummy variable)

$X_2$ = Possession of well (binominal dummy variable)

$X_3$ = Cropping pattern (binominal dummy variable of mixed cropping)

$X_4$ = Share of water cost in farm variable cost (percentage)

$X_5$ = Literacy of household head (binominal dummy variable)

$X_6$ = Area of non irrigated land (Dunum = 0.1 Hectare)

The Zero-Hypothesis of the test was:

$H_0$ = There is no (linear) relationship between farmers' acceptance of treated wastewater in irrigation and any of the socio-economic factors listed above, i.e. farmers' decision on accepting the use of treated wastewater is not affected by any of the suggested socio-economic factors.

**3. Results and discussion**

The analysis of the farming systems showed that the costs of irrigation constitute a high share of farms' variable cost in agriculture for farmers who don't possess water resources and have fields with no attached water rights. This held in particular for perennial crop farms. Disapproval of the use of treated wastewater was – with about 63% - particularly high among mixed cropping farmers, while there was no significant difference in the rejection rate of about 50% by members of the both classes of perennial crop farmers., The most frequently mentioned reason for disapproval in all classes was the fear of diseases and pollution. Other reasons for disapproval, such as unsuitability of treated wastewater to irrigate annual crops and the risk of impacts on marketing, were also mentioned but less frequently. The reasons stated by the farmers were considered in the logit model as potential factors that may influence farmers' decision on using treated wastewater for irrigation.

The highly significant result of the $\chi 2$ statistics-based omnibus test, which reflects the models' overall goodness-of-fit, provided a strong statistical evidence for rejecting the null hypothesis, i.e. the independence of farmers' acceptance to use treated wastewater from the selected explanatory factors (Table1). The high percentage of correct predictions (89.5%) was an additional supportive indicator for this decision.

**Table 1 Logistic regression results of the farmers' decision on acceptance to use treated wastewater for agriculture, Biet Hanoun, 2004**

| Variables | Sign | Coefficient | Sig. |
|---|---|---|---|
| Intercept | - | 5.862 | 8.57 |
| Health Hazard | - | 4.824 | 0.000 |
| Ownership of water resource | - | 3.095 | 0.045 |
| Area of non irrigated land | + | 1.730 | 0.147 |
| Cropping pattern | + | 0.913 | 0.353 |
| Share of water cost in the farm expenses | + | 0.992 | 0.631 |
| Literacy of household head | + | 8.724 | 0.814 |

Sig. level ($\chi^2$ Omnibus test) sig. = 0.000 NagelkerkeR$^2$ = 0.666

Percentage of correct predictions = 86.5%

Results showed that all selected independent variables have the expected direction of relationship with the independent variable, i.e. the odds ratio of farmers' acceptance. Fear of diseases and pollution and possession of wells proved to have substantial effects as shown by the magnitude

and significance of their coefficients. This allows for the interpretation that farmers' knowledge about the potential side effects of using treated wastewater has an even more decisive impact on their decision to adopt this type of water than the – still highly influential -possession of own water resources. The cultivation of non-irrigated land was the major determinant for a positive attitude towards irrigation with treated wastewater. The low significance of the coefficients for farmers' literacy and water costs indicate the minor role of those two factors in farmers' decision on using treated wastewater.

## 4. Conclusion

The water deficit in the Gaza Strip demands for changes in the current distribution of scarce freshwater between the different sectors of water consumption. Agriculture as the main consumer of water will be on the downside of these changes, but may compensate at least parts of the reduction in freshwater supply by treated wastewater. Farmers' acceptance of using this alternative water resource in irrigation is a decisive factor in the frictionless implementation of the inescapable changes. Results from the presented study show that farmers' knowledge on potential impacts and side effects of using treated wastewater in agriculture is likely to be the major determinant for the success of the process of change. Improving farmers' knowledge may thus be a challenge of equal or even larger importance than finding solutions for compensating owners of private wells for the abandonment of freshwater withdrawal from the Gaza Strip's aquifers.

## 5. References


- DOPPLER, W. (1999) Setting the frame: Environmental Perspectives in Farming and Rural Systems Analyses. In: W. Doppler; A. Koustouris (eds.): Rural Farming Systems Analyses: Environmental Perspective. Proceedings of the 3rd European Symposium of the Association of Farming Systems Research and Extension in Hohenheim, Stuttgart, Germany, March 25-27 1998. Margraf Verlag, Weikersheim, pp. 1-10.
- DOPPLER, W. (2000) Farming and Rural Systems- State of the Art in Research and Development. In: W. Doppler, and J. Calatrava, (eds.): Technical and Social Systems Approaches for Sustainable rural Development. Proceeding of the 2nd European Symposium of the Association of Farming Systems Research and Extension in Granada, Spain, 1996.
- HAIR, J.F., R.E ANDERSON, R.L TATHMAN AND W.C. BLACK 1998. Multivariate data analysis. Prentice Hall inc., New Jersey, USA.
- KATWIJUKYE, A.K. (2005) Socio-Economic Analysis of Land Resource Use and Conservation in Uganda. W. Doppler, S. Bauer, (eds.) Farming and Rural Systems Economics. Vol. 71. Margraf Verlag, Weikersheim.
- PALESTINIAN WATER AUTHORITY, (2002) Water resources and management issues (Gaza strip, Palestine). July Report.
- TUBAIL, K., AL-DADAH, J. AND YASSIN, M. (2002): Present and prospect situation of wastewater and its possible reuse in the Gaza strip. Internet source: ( http:www.med-reunet.com/docs_upload/wastewater.pdf.).
- WOLFF, H.-P.., DOPPLER, W.; NABULSI, A (2005): Potential und Folgen der Verwendung von Abwasser in ruralen Räumen am Beispiel des Jordantals (*Potentials and consequences of wastewater use in rural areas. The example of the Jordan Valley*). In: *Neubert, S.; Scheumann, W.; van Edig, A.; Huppert, W.* (ed.) "Integriertes Wasserressourcen-Management (IWRM): Ein Konzept in die Praxis überführen". Nomos Verlagsgesellschaft, Baden-Baden (German), pp. 259-270