TECHNISCHE UNIVERSITÄT DRESDEN

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Analysis of Stakeholder's Behaviours for an Improved Management of an Agricultural Coastal Region in Oman

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Motivation

Al Batinah coastal area is the main agricultural region in Oman. Agriculture is concentrated in Al Batinah, because of more fertile soils and easer access to water in form of groundwater compare to other administrative areas in the country.

The region now is facing a problem as a result of over abstraction of fresh groundwater for irrigation from the main aquifer along the coast. Well owners pump as much groundwater as they want without any restriction [1]. This enforces the inflow of sea water into the coastal aquifer and causes salinization of the groundwater. The groundwater becomes no longer suitable for irrigation which impacts the social and economical situation of farmers as well as the environment.

The aim now is to evaluate the implementation potential of several management interventions by analyzing opinions and responses of all relevant stakeholders in the region. This is done in order to identify potential conflicts among stakeholders and to foster a participatory process within the frame of an Integrated Resources Management for supporting decision makers to take more informed decisions.

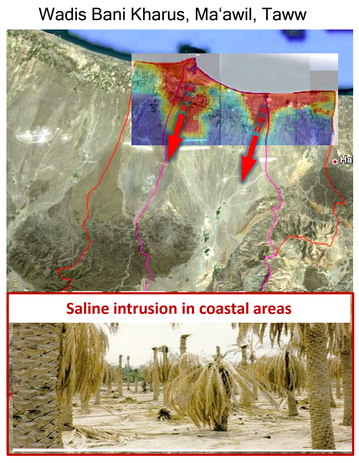

Fig. 1: Study area – South Batinah Region.

Methodology

- Stakeholders were identified e.g. water professionals, farmers from the study area and decision makers from different organizations .
- A list of interventions was prepared, after a pre-test survey, from stakeholder's ideas and from literatures.
- Questionnaires were designed according to the information and data to be collected from the different groups of stakeholders.
- A social survey has been performed – a combination of environmental, social and economical data were collected.
- The data were analyzed statistically for each group separately by using SPSS software package.
- Differences were examined between opinions of the farmers and decision makers regarding potential interventions (20 items).
- Differences were explored between the farmer's opinions and what decision makers believe about farmer's opinions.
- P-values were generated to accept or reject the hypothesis using Eq. (1.1):

$$p = 2\Phi(\bar{X} - \mu_0)/\frac{\sigma}{\sqrt{n}} \qquad 1.1$$

Where μ_0 is the hypothesized mean, σ is the population standard deviation, $\bar{X}$ is the sample mean and n is the sample size. The test was performed as a 2-tailed test

Data Collection

One of the most appropriate tools used to explore the opinion of different stakeholders in a domain is through distributing questionnaires and face to face interviews. Regarding environmental and management practices Delmas and Tofell [2] identified stakeholders to be including government, regulators, customers, competitors, community and environmental interest groups, and industry associations. For our study, Questionnaires were handled and sent by mails to 84 water professionals and decision makers, with 79 % response rate. The face to face interviews were mostly used with farmers. Fig. 2.

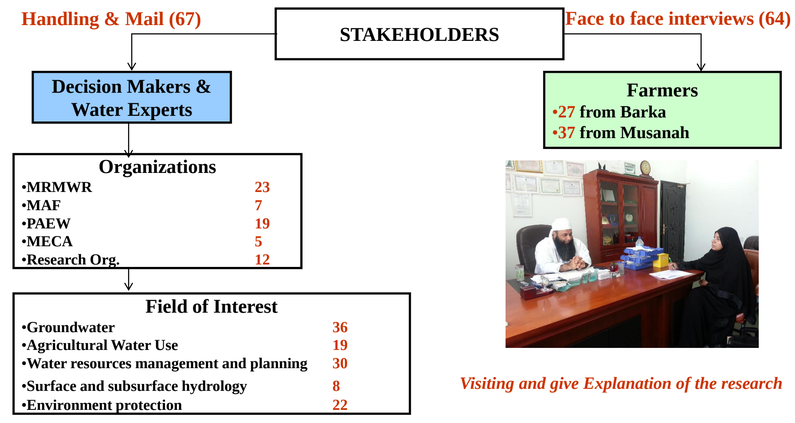

Fig. 2: Explanation of data collection and filed survey in South Batinah coastal region.

Results (I)

1. Comparison of opinions between groups about agriculture development

The results in Fig. 3 showed that very small proportions of respondents from both groups rated 'Strongly agree' or 'Agree' as their choices for the issue of 'Stop all agricultural activities in the coastal zone of Al Batinah', 9-16% of the farmers and 3-6% of DM's. The majority choose 'Disagree or 'Strongly disagree', 48% of the farmers and 68.5% of the DM's. Similar for the issue of 'Leave the system as it is without any changes', 8% farmers and 4.5% DM's only choose 'Strongly agree' and 'Agree', while 83% farmers and 82% DM's choose 'Disagree' and 'Strongly disagree'.

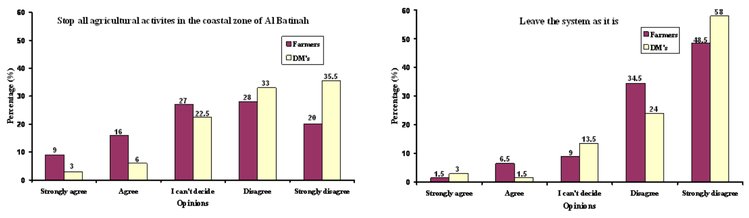

Fig. 3: Opinions of farmers and decision makers regarding agriculture development in the region.

2. Comparison of opinions between farmers and decision makers (DM's) regarding potential interventions

It is obvious that in many cases (12 of 18 items) the opinions of farmers were very different from the other group of stakeholders (Tab. 1). On the other hand, although the results in some options show differences in opinions between Farmers and DM's, it can noticed that the differences are not absolutely in an opposite direction.

Results (II)

Tab. 1: Comparison of opinions between farmers and decision makers results.

Intervention measures	Farmers (mean)	DM's (mean)	P value (farmers & DM's)	DM's believes about farmers (mean)	P value (farmers & DM's believes about farmers
Introducing water quotas.	3.47	1.88	.000	3.18	.243
Introducing water quotas with subsidies in form of equipments for modern irrigation systems.	2.75	1.70	.000	2.18	.005
Introducing water quotas with subsidies in form of guidance & training in agricultural management	2.94	1.58	.000	2.34	.005
Introducing using treated wastewater for agricultural use, if it is available and the quality is acceptable.	2.17	1.61	.001	2.30	.523
Encourage the farmer to reduce the withdrawal of groundwater pumped per day by guidance & training.	2.31	1.63	.000	2.45	.472
Implementation of centralized well field water distribution system for agriculture which provides water in a good quality to farmers.	2.42	2.27	.458	2.76	.114
Convince the farmer to change the type of crops to ones with lower crop water requirements.	2.48	2.03	.017	2.70	.270
Encourage farmers to improve their irrigation methods.	2.02	1.45	.000	1.87	.329
Encourage farmers to improve their irrigation methods with subsides in form of equipments for modern irrigation systems.	1.66	1.72	.636	1.58	.523
Encourage farmers to improve their irrigation methods with subsides in form of guidance and training in agricultural management.	1.86	1.66	.115	1.84	.874
Construction of injection wells near the coast line to form a barrier against the sea water intrusion, if water to be injected is available and the quality is acceptable.	2.19	2.13	.764	2.19	.969
Construction of more desalination plants for brackish and seawater, in order to use it for irrigation.	2.14	3.09	.000	2.54	.049
Increase the effectiveness of water use by public awareness.	1.55	1.46	.424	2.03	.000
Introduce water prices for pumped groundwater.	3.92	2.48	.000	3.51	.089
Introduce special energy tariffs for agricultural purposes.	1.86	2.49	.001	3.21	.000
Forming water managers groups.	1.88	1.91	.819	2.13	.134
Forming guidance & information water centre to support farmers in farm & water management.	2.11	1.63	.002	1.94	.278
Farms need to be evaluated and the government should take a decision to close some of them and change the land use.	1.97	2.52	.006	3.25	.000

Note: 1) Mean score ranges between 1 for strongly agree and 5 for strongly disagree
2) The degree of significant differences is based on independent samples T-test
3) Items shaded in gray are significant
4) Items shaded in blue are highly rated by farmers, and those shaded in red are highly rated by DM's

Results (III)

3. Low rated intervention measures

Farmers were less likely to "Introduce water prices to the groundwater" as well as "Introducing water quotas" by the mean of 3.92 and 3.47 respectively. The decision makers were less likely to "construction of more desalination" plant as the mean was 3.09.

4. Drivers of farmer's opinions

Farmers 's frequency curves shows differences in opinions in some interventions, while differences in opinions were not so high within the group of DM's. From (fig. 3) it is shown that the percentage of farmers who agreed or reject the idea of water quota with subsidies is similar. Therefore, it is of interest to identify the drivers influencing farmer's opinions. Preliminary investigations by Discriminant Analysis, indicates that opinions influenced by "levels of groundwater salinity in the farm" and "levels of cooperation with Ministry of Agriculture".

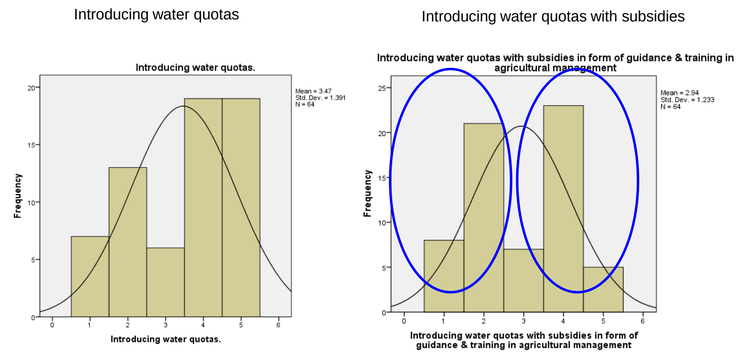

Fig. 4: Frequency curves of farmer's opinions regarding introducing water quotas.
Note: Mean score ranges between 1 for strongly agree and 5 for strongly disagree

General Results

- In most cases, farmers were more likely to the solutions of increasing water availability especially of good water quality, while DM's were more likely to the management issues especially demand management.
- Opinions of farmers were more diverse than DM's Opinions.
- Farmers are not fully aware about the limitation of the natural system, especially in form of quantity, as many of them (45%) reported; '*That the water is available, but salty*'

Conclusions

- The study underlines the importance of a participatory approach with contributions from all relevant stakeholders in order to achieve a real IWRM implementation process.
- Water management strategies should not only focus on the technical means, but should also be directed to improve management practices and social behavior changes
- Decision making should not be limited (only) to considering information collected from stakeholders, they should (instead) be treated as if they were DM's that must negotiate about the alternatives.

Discussion and Outlook

- The obtained data will be used for more advanced statistical analysis;
  - Methods to analyse the Heterogeneity in the group of farmers
  - identify parameters might be the reason behind
- Evaluating a Bayesian Network (BN) approach [3] will be used to combine environmental, social and economical data;
  - mapping the stakeholder's behaviours based on statistical analyses in order
  - to show the strength of relationship between dependant and predictor variables

References

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[3] Subagadis, Y., Grundmann, J., Schütze, N., & Schmitz, G.H., 2014: An integrated approach to conceptualise hydrological and socio-economic interaction for supporting management decisions of coupled groundwater–agricultural systems. Environmental Earth Sciences, DOI: 10.1007/s12665-014-3238-1.

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