SENSITIVITY ANALYSIS OF THE BIOPHYSICAL SYSTEM



Study of the progression of salt water intrusion in the coastal aquifer within the study area through the development of various activities. \rightarrow Sensitivity level of biophysical system with respect to saline contamination factors



Activity 1: Changes over time of the piezometric level in the aquifer

The piezometric level of a coastal aquifer influences the depth of the salt and fresh water interface surface. Evaluation of the changes in the piezometric level within the study area was conducted through reconstruction of isophreatic contour variation over time, using interpolation of the available SWL values.



groundwater

The variation over time of the electric conductivity values for the groundwater represents an important parameter for evaluating variations in salinity levels in groundwater. The decrease in conductivity values from the ocean towards the coast may indicate the presence of marine contamination. Evaluation of the variation in electric conductivity values of the aroundwater within the study area was conducted through the reconstruction of isoconductivity contour variation over time, using interpolation of available EC values.



Activity 3: Analysis of the chemical characteristics of groundwater

In order to establish in which wells the salt water intrusion is of marine origin, the chemical characteristics of groundwater from wells in the study area were analyzed.

The analyses conducted were as follows: - Classification of water based on chloride (Cl-) content and Total Dissolved Solids (TDS) content; - Relationship between the concentration of CI- and TDS and distance from the coastline of various water points; - Analysis of the relationship between chloride content (CI-) and the concentrations of calcium (Ca2+), magnesium (Mg2+), sodium



Activity 4: Reconstruction and variation over time of the Activity 5: Correlation with characteristics of land use freshwater/saltwater interface

For each water point where chemical parameter analyses showed marine contamination, the depth of the interface was determined through analyses which considered various factors, including: - Electric conductivity;

- Well depth; Thermo-conductimetric log and VES, where available.

Through interpolation of the values obtained, hypothetical isobaths for the freshwater/saltwater interface were reconstructed relative to mean sea level.

SENSITIVITY ANALYSIS OF THE SOCIAL SYSTEM



(Na+) and potassium (K+).

Definition of the community's level of dependence on ground-water through the identification of prevalent typologies of water supply in different settlements present within the study area (use of 3 evaluation criteria). → Sensitivity level of the social system with respect to the possi-ble worsening of groundwater



Evaluation criterion 1: Socio-economic characteristics of the settled population \rightarrow Indicator: Presence in the houses of water storage tanks

Since the water resource cost is related to its quality and origin (groundwater, surface water, protected, unprotected, etc.), the choice about the supply methodology depends on people socioeconomic status.



Evaluation criterion 2: Morphological and infrastructural characteristics of the settlements \rightarrow Indicator: Settlement morphology

The typology and the quality of the urban fabric influence the presence or lack of the municipal water distribution system. Planned areas were found to be better connected to the water distribution system (at the structural level). As a result, the inhabitants in these areas have direct or indirect access to a protected water source.

On the other hand, in the informal areas the connection to the water distribution system is less widespread due to the structural deficiencies of the system







aroundwater

Activity 2: Changes over time to electric conductivity values for

Planned areas Unplanned areas Pubblic and Institutional services Industrial and Commercial areas Forests, Swamps and Uncoltivate

The results obtained from the preceding activities were correlated with characteristics of land use in the study area in order to determine which zones were most sensitive to saline contamination. The typology of land use (planned area, unplanned area, commer-cial and industrial area, green cultivated area, green uncultivated area) can be considered an indicator of possible sources of specific and general pollution (domestic wastewater, industrial waste, waste originating from agricultural activities).

Evaluation criterion 3: Functional characteristics of the settled activity \rightarrow Indicator: Typology of activities present

The type of prevalent economic activity (urban agriculture and grazing, industrial activity, formal or informal employment) influences water requirements, and as such impacts the level of exploitation of

In particular, the principle sources of water supply for urban agricultu-re and grazing are unprotected surface water or groundwater, and even the majority of industries (foodstuffs, chemical and mineral) use predominantly aroundwater for production.

Biophysical System Sensitivity Mapping

For the purpose of mapping biophysical system sensitivity, the zones within which water points demon-strated high values of electric conductivity were classified on the basis of a supposed predominance of one typology of contamination. An incrémental change in electric conductivity values in groundwater over time could be correlated to different factors, including:

- Augmentation of the ingression of salt water from ocean into the aquifer; - Natural salinization factors, such as rising saline "fossil" waters, and the chemical erosion of carbonate rocks (dissolution of calcite from limestone deposits)

- Presence of anthropogenic pollutants from household waste, agricultural or industrial activities (such as nitrates, phosphates, sulphates).

- The zones with a prevalence of marine contamination factors are concentrated along the coastal strip, and they have increased notably over time. The zones where this tendency is most accentuated correspond to the urban areas of Kunduchi, Mbezi Beach, Kawe, Mikocheni, Msasani and Oysterbay.

- The zones with a prevalence of contamination factors deriving from domestic and agricultural activities (urban agriculture) have increased over time. They are concentrated predominantly in informal urban areas (and somewhat in planned areas), where there is no sewage system and the use of on-site sanitary facilities (pit latrines and septic tanks), whose effluents represent a potential source of pollution for the aquifer. The zones where this tendency is accentuated correspond to the urban areas of Manzese (outside the study area) and part of the Kunduchi, Kawe, Kijitonyama, Mwananyamala and Kinondoni areas.

- The zones with a prevalence of contamination factors deriving from industrial and commercial activi-ties correspond to part of the Mikocheni area, where foodstuff and manufacturing industries are loca-

- The zones with a prevalence of geological factors (natural salinization) correspond to part of the urban area of Kunduchi (Salasala), located in the margin between the Quaternary and Neogene deposits (possible rise of saline "fossil" water).







Social System Sensitivity Mapping

The qualitative analysis of the characteristics of the settlements under consideration, based on an evaluation of appropriate indicators corresponding to various evaluation criteria considered, identified the prevalent typology of water supply in different analyzed urban areas. This facilitated definition of the community's level of dependence on groundwater.

- The areas in which the community possesses a high level of dependence on groundwater are Kunduchi and Kawe. For these settlements, the limited access to the municipal water distribution system and the high presence of agricultural areas (and industrial ones in Kunduchi) seem to be the main sensitivity factors about the possible groundwater worsening.

- The areas in which the community possesses a medium level of dependence on groundwater are Mikocheni, Msasani and Kijitonyama/Mwananyamala/Kinondoni. The higher instance of industrial areas in the Mikocheni settlement seems to be the determinative factor in the community's medium level of sensitivity. For the Msasani and Kijitonyama/Mwananyamala/Kinondoni settlements, the presence of informal urban areas that are poorly serviced by the municipal water distribution system, and where alternative sources of water supply prevail (groundwater, surface water and buying and selling practices), together with the low economic power of the settled population, seem to be the decisive factors in the community's medium level of sensitivity to the possible groundwater worsening.

- The areas where the community has a low level of dependence on groundwater are Mbezi Beach and Oysterbay. The inhabitants of these settlements, who have the economic possibility of accessing different sources of water (for example, water tankers or travelling water vendors with pushcarts) are less sensitive to the possible groundwater worsening.

EVALUATION OF THE VULNERABILITY IN THE COMMUNITY WITH RESPECT TO SALT WATER IN-**TRUSION IN THE COASTAL AQUIFER**



Overlapping of areas where there is a predominance of marine contamination factors in the coastal aquifer with areas where inhabitants demonstrate a high dependence on groundwater. \rightarrow Community's level of vulnerability with respect to the salinization of the coastal aquifer (identification of critical areas)



Vulnerability Mapping

In order to define the community's vulnerability to salinization of the coastal aquifer, the interaction between social system sensitivity (level of dependence on groundwater) and level of exposure to disturbance (sensitivity of the biophysical system: progression of salinization of the coastal aquifer) was examined in various settlements within the study area. To that end, the results of the sensitivity analyses of the biophysical system were compared with the results of the analysis of social system sensitivity.

Through the overlapping of maps of biophysical system sensitivity and social system sensitivity, two critical zones were identified which present a high level of community vulnerability with respect to the salinization of the aquifer, and which represent high priority areas for the implementation of adaptation actions. The first zone coincides with the coastal area of Kunduchi, while the second corresponds to a section of the coastline within the Kawe area.

Sapienza - University of Rome MSc in Environmental Engineering

4 Kilometer

METHODOLOGY AND RESULTS

Evaluation of the vulnerability to climate change of the coastal communities in Dar es Salaam (Tanzania) as regards salt water intrusion in the aquifer

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