

DESALINATION PLANT SITE SUITABILITY ALONG KARACHI COAST AND PROTECTION OF MANGROVES BY SPATIAL DECISIONS SUPPORT SYSTEM (SDSS)

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ABSTRACT

The Population of Karachi metropolitan city is increasing at a rapid rate, therefore demand for drinking water day by day. This demand requires permanent fresh water supply for the residential areas. Consequently, desalination plants are needed on the coastal belt of the city on a priority basis. Desalination plants can potentially be harmful by their effects on adjacent ecology of the adjacent areas especially mangroves forests. The basic idea of this study is to select the appropriate site by using GIS-based Spatial Decisions Support System (SDSS) in which site locations will fulfill the given parameters to protect the mangroves. This system employs some pertinent variables for mangroves such as pollution, coastal suitable bathymetry, road networks, and residential area in close proximity to the desalination plant site along Karachi coast.

Key words: Mangroves forest, Desalination plant, GIS, Spatial Decisions support system (SDSS), Karachi water demand, bathymetry, pollution, Reclaim area, Coastline.

INTRODUCTION

The Karachi coast is an extremely active zone in some of the major factors; one factor is high rate of population increase. As a consequence of this fact fresh water demand is ever increasing (Chaudhury, 2013). This issue is always present on front line for local government of Karachi. In fact, shortage of drinking water is a global issue even in world's biggest metropolitan cities but this crisis in Pakistan especially in Karachi city seems to be more acute. One of the most important reservoirs of water is the rainfall that is stored in nearby Hub dam but due low and erratic rainfall and the consequent shortage of water in the dam ever increasing population, in various areas across Karachi the proper distribution is becoming a challenge to expand supply and manage (Jabeen *et al*, 2015). Although the underground water on the coastal area like DHA, Clifton and Gizri etc is available this ground water is extremely sour in taste and can't be used for daily usage therefore they either have a common area water tank or they switch toward getting water from commercial water tanker suppliers. Based on considering the various facts of water supply shortage a desalination plant at DHA Phase 8 near extension was inaugurated on February 2008 (see figure 1). The Large population and increase demand of this most essential utility of life appealing the greater development towards this alternative and successful way to overcome the requirement of fresh water.

Mangrove ecosystems

Mangrove biomes control the coastal wetlands of tropical and subtropical regions all over the world. Mangroves also play vital role in the shore protection from storm surges, tidal currents, and erosion. They also naturally filter the coastal water from acidification and pollution transport from wetlands toward coastal environment (Menendez and Priego, 1994; Suman, 1994). Mangrove forests along Indus deltaic region expedite fish and shrimp breeding by which hundreds of fishermen, local communities and sea food export industry levitate. The South Asian mangrove forests are highly bio-diverse and provide multiple ecosystem services upon which millions of people are reliant. In Pakistan these forests also have experienced same as global attitude of extensive deforestation owing to demand for commodities, and many studies have approved the development of aquaculture as mostly accountable. In the global forest cover by area only 3 % are mangroves but it has been estimated that at the existing rates of degradation, these forests can release up to 10% of the total carbon emissions from deforestation worldwide. Simultaneously, mangroves belong to the most threatened and vulnerable ecosystems worldwide and experienced a dramatic decline during the last half century. International programs, such as the Ramsar Convention on Wetlands or the Kyoto Protocol, underscore the importance of immediate protection measures and conservation activities to prevent the

further loss of mangroves forests (Davis, 1994; Totten *et al*, 2003; Seto and Fragkias, 2007; Gardner and Davidson, 2011).

Impacts of desalination plant discharges

Desalination plant processing discharge into coastal water will increase the salinity levels, temperature, pH, dissolved inorganic carbon which also includes some chemicals which disturb the local marine ecosystem (Ariqat and Mohamed, 2005). To avoid the adverse effect of the desalination plant to the marine life and the ecology in the local plant vicinity we include deep water depth of nearly 3m which retaliates the effect to the local ecological environment especially of vulnerable areas such as mangrove forests, salt marshes and coral reefs. Desalination of seawater has been in practice for nearly 50 years and is considered to be as one of the main source of fresh water in many countries like Middle East and other regions of the world. Therefore, the planning for future desalination plants along Karachi coast requires the protection of ecology including Mangroves as well as the deleterious effect of desalination plants on the local to regional environment. We should be aware of the fact that the effluent discharges from the plant back to the sea may have a negative impact on marine environment and its ecosystem through its discharge (Hashim and Hajjaj, 2005; Miri and Chouikhi, 2005). As Arabian Sea play an important role in global physical and ecological environment (Khan *et al*, 2015).

The major objective of this paper is to highlight the application of SDSS for selecting a site for desalination plant in Karachi Pakistan in such a way that the mangrove forests are not affected. It discusses the need for desalination plant to address the existing water crisis in Karachi and at the same time we must be aware of the negative impacts of the use of desalination plant particularly in relation to mangroves. This raises the need for the use of SDSS to find a suitable site for the desalination plant.

Study Area

Study area for this model is Karachi city; it has grown to be the largest urban center of Pakistan. Its coast spreads from Cape Monze in the west to Korangi creek in the east. The Karachi coast is the border between the Indus delta and the northern most part of Arabian Sea (Fig.1). The coast of Karachi from Manora to Cape Monze is Rocky and sandy so the Bathymetry near this Part of Karachi coast varies from point to point in depth. Beaches of Karachi are famous, unceasingly and usually recreational points like Hawksbay, paradise Point and one of most popular one is Clifton (seaview) beach.

Methodology

Spatial Decision Support System

Spatial Decision Support System (SDSS) is an interactive, computer-based system designed to support a user or group of users to achieve more effective and accurate decision making while solving a semi-structured spatial decision problem (Crossland *et al*, 1995). SDSS are characterized by powerful graphical display capabilities and sophisticated handling of spatial data when compared to general purpose spatial SDSS (Beedasy *et al*, 1999). Additionally, SDSS provides specific analytical and modeling capabilities that have common lacking in a conventional GIS (Jelokhani-Niaraki and Malczewski, 2015). It is an integrated system approach which reflects the results in the spatial meanings; by using SDSS in the site selection of Desalination plant along the coast we have to analyze the effects of predefined parameters on the selection of site (Baayad *et al*, 2015; Tomaszewska *et al*, 2015; Shahabi *et al*, 2015). In this study model proceed in the following ways:

Model Parameters

In this study Spatial Decision Support System (SDSS) Model developed to estimate the position of desalination plant along the Karachi coast on the basis of some commonly define Parameters. Model parameters weightage are representing in the fig. 2 which shows the major parameters weightage using a weighting overlay technique. In this model the main Parameters used are:

i) Mangroves areas, ii) Pollutant water, iii) Road network, iv) Coastal depth, v) Coastline and v) Reclaims Area

Mangroves areas

Mangroves of Karachi coast spread over the Indus delta. Indus delta mangroves originally occupy an area of 600,000 hectares and consist of creeks, mudflats and forests between Karachi in the north and the Rann of Kutch in the south. It was once the 6th largest forest of its kind in the world. Now it provides fuel in the shape of wood to approximately 120,000 people, forage to 16,000 camels and other products to 28,570 households. The forest owes its sustenance to nutrient-loaded silt in the estuaries. Mangroves also act as shield against active tidal erosion in the area.

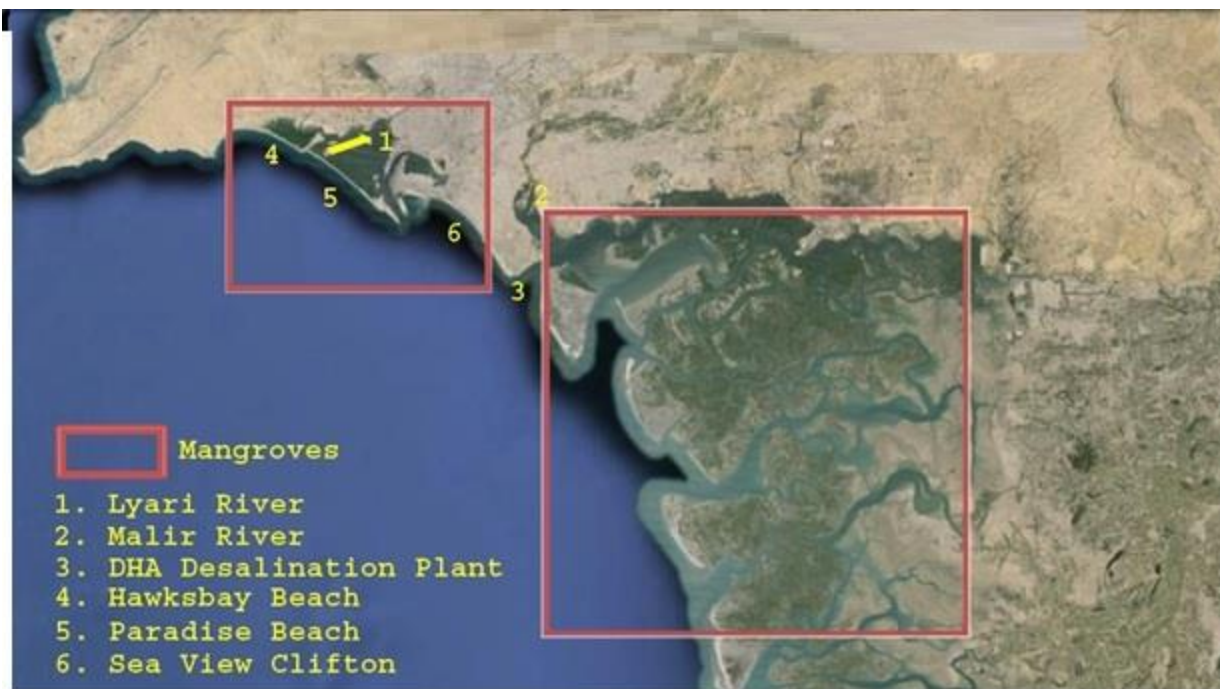


Fig. 1. Study Area (Two rivers Lyari and Malir, Existing desalination plant and famous Karachi beaches).

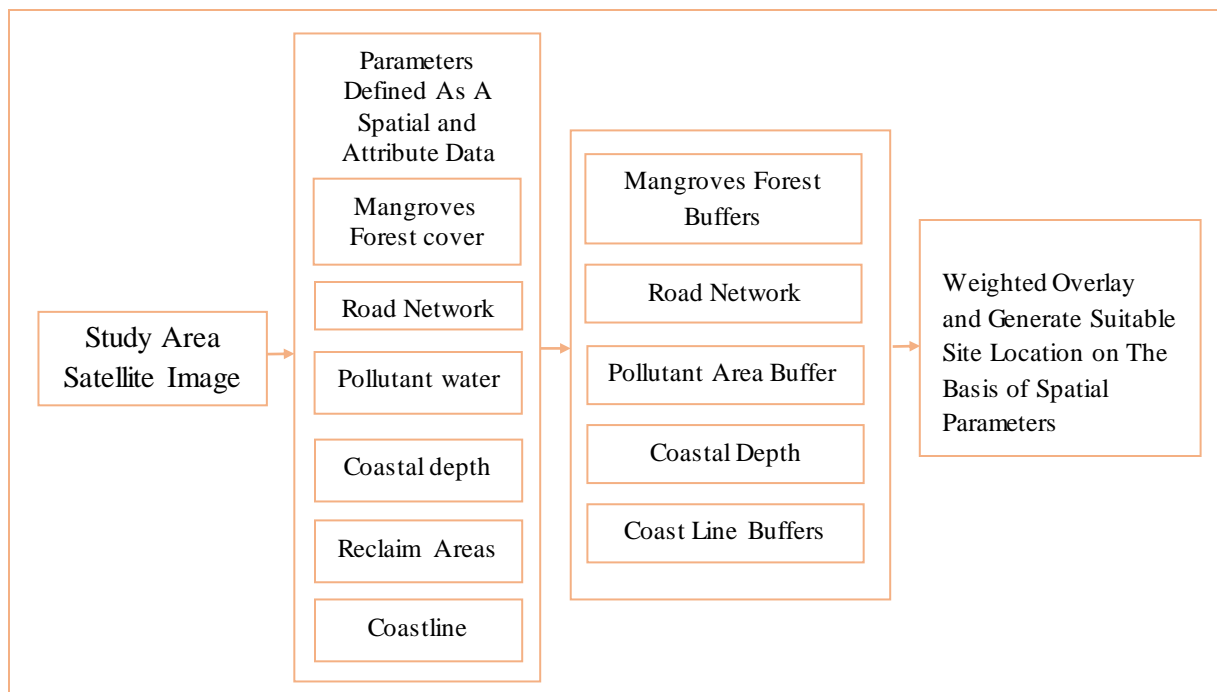


Fig. 2. Workflow model diagram.

Polluted water

Karachi has two rivers named Malir and Lyari Rivers which are sinking along the coast of the city. Malir River discharges lots of turbid and polluted water into the Arabian Sea along the SE coast of Karachi furthermore this water is not suitable to fulfill the requirements of healthy drinking water. Therefore the desalination plant at SE coast of Karachi. Fig. 4 shows the specific location of Malir and Lyari Rivers.

Road network:

Transportation linkage with the plant and the residential areas is very important in the site selection process because it's facilitating the users and workers of plant. Proper road network helps in the construction phase of Plant which provides ease of material shifting and other logistic requirements.

Coastal depth:

Water quality is another important factor in the site selection. Karachi waste water is usually discharged into sea through Malir and Lyari rivers so that the pollution level is on high side along the coastal waters of Karachi. The Coastal steep depth usually directed toward the rocky bottom has low pollution level as compared to the slope and sandy beaches. So the water quality is appropriate at that site.

Coastline:

Karachi coastline is approximately 62 km long which consist of Sandy, rocky and recreational beaches. Karachi coast has a gentle slope and on the other hand some parts of coast have sudden depths of 3 meters. So on consideration of depth and quality of water in this model has also been included as one of the parameter.

Reclaim Areas:

Karachi reclaim areas like DHA Phase 8 , EMMAR projects, crescent bay area's etc are mostly along Clifton beach so it can be predicted that Clifton beach area will be developed for residential purpose which will ultimately increases the demand of fresh water.

RESULTS

GIS-based map are used to present the model results which are highlighted with all variables in different colors and shapes scheme (Fig. 3 shows the final map of Model parameters and results). Result presented in the map form to easily highlight site location and indicates the buffer zones which are calculated by SDSS model (Fig. 4).

Karachi city has a valuable role in the economics of serving overall population of Pakistan. Recreational activities and public spot like deluxe and notable beaches for beach-goers who came from all over Pakistan. Real estate builders after having the desalination plant can plan and strategies the development of new housing schemes which will have direct and positive effect on the economic growth and as well as quality of life for a common citizen. Currently, the coastal housing schemes like DHA and Hawks bay housing schemes are facing problems in fresh water volume and several parts of Coastal communities along Karachi coast have fresh water supply once in a day from main supply line. Desalination plants along Karachi coast will supports to overcome the demand especially coastal communities of Karachi city. We divide the Karachi coast in two parts eastern and western part to explain results in more detail.

Eastern Part of Karachi Coast

Eastern part from Karachi Port to EMMAR crescent bay or DHA desalination Plant site is composed of famous sandy beach named as Clifton sea view beach. From the past few years several housing schemes were planned and developed along the eastern part of Karachi coast with reclaiming developments. This part of Karachi coast has a large number of visitors on daily basis because of Sea view beach which is very popular across all over Pakistan. Malir River falls down near the DHA phase 8 but presently this river has pollution in the form of human and commercial waste furthermore coastal depth along the coast is shallow which composed of sandy beach and is therefore not feasible for desalination process. The end result is the water quality along the eastern part of Karachi coast is not feasible for setting up desalination plant.

Western Part of Karachi Coast

Spatial decision support analyses results in large numbers of Suitable site distribution for Desalination Plants along Karachi coast which are located on western parts of coast, because of a steep slope it is clear that the water quality is as per the standard requirements of desalination plant. Road network on the western part of coast is already available so the site construction and utilities availability at desalination plant are accessible. The eastern part of Karachi coast is comprehensively disturbing in the sense of reclaim activities on the other hand the western part of the Karachi coast have no reclaim portion.

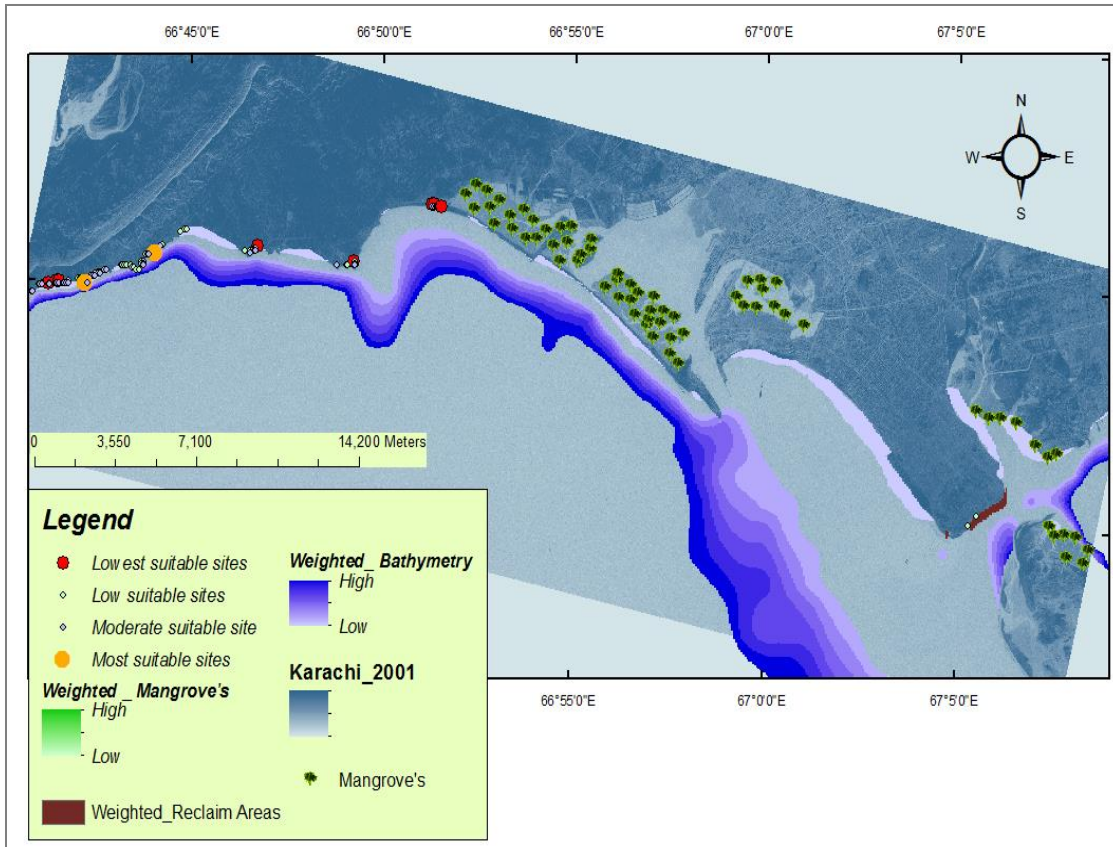


Fig. 3. Karachi coast map with weight of major parameters.

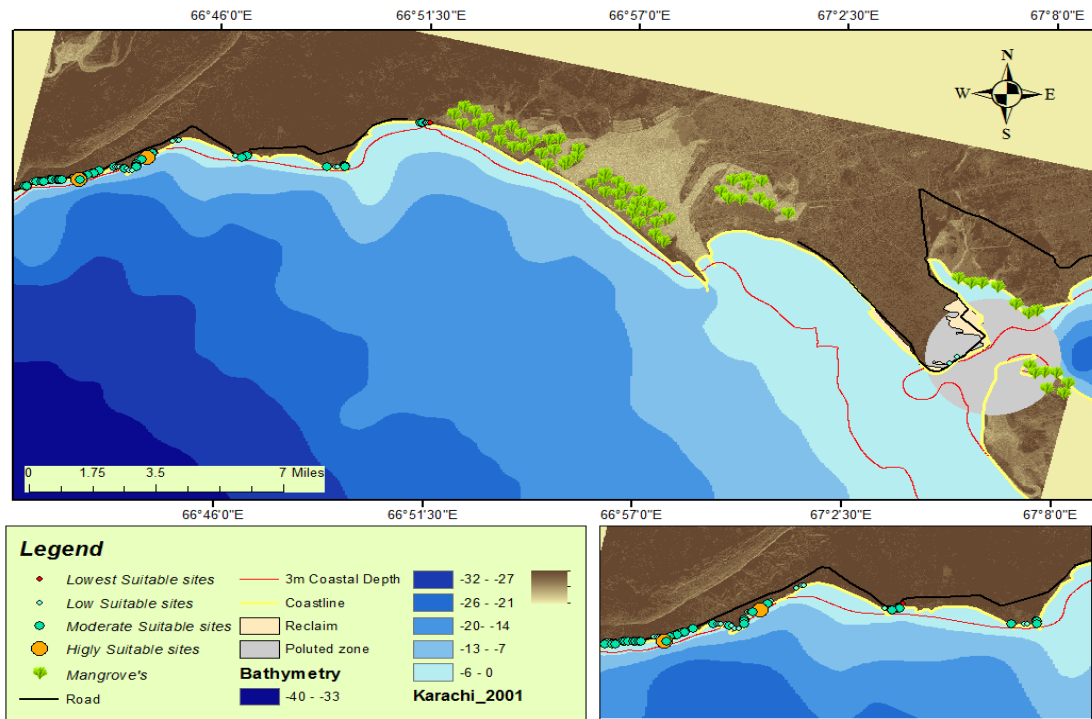


Fig. 4. Final map shows the suitable site location for desalination plants along Karachi coast.

DISCUSSION

GIS is one of the applied technologies in all the fields of basic sciences, which has long provided effective solutions to the integration, visualization, and analysis of information about land, is now being similarly applied to oceans (Hashim and Hajjaj, 2005). This paper is presenting the choice of desalination plant to overcome the negative impact of the desalination plants (Crossland *et al*, 1995). SDSS can play a vital role for planners in all fields of sciences. It can also use in future urbanization along Karachi coast. Fresh water deficiency will be overcome in coastal housing scheme with the improvements in quality life will along Karachi coastal communities. Karachi coastal tourism will be enhanced and socio-economic benefits will upswing.

Conclusions

Mangroves are vital for the maintenance of coastal environment. Communities are dependent upon resources produced and sustained by these dynamic ecosystems. The SDSS model is used to minimize the harmful consequences of desalination plant by deciding the ideal sites to keep the natural marine life. Mangroves of Karachi provide not only protection to the coast but also deliver necessities for the marine animal species therefore their growth in unpolluted clean environment is essential.

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