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Impact Assessment of Urban Built-up Area on Groundwater Level of District Faisalabad, Pakistan

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Abstract: This paper attempts to explore the impact of built-up areas on groundwater levels in district Faisalabad. To understand the rate of built-up area expansion and changes in the level of groundwater in the study area, groundwater data has been acquired from the Land Reclamation Department for all tehsils in district Faisalabad. This study was conducted to assess spatial and temporal variation of groundwater level because of the built-up area change. Descriptive statistics (Scatter Plot correlation technique) have been applied to figure out changes in groundwater levels. Furthermore, some built-up area extraction methods have been incorporated that are always found to be effective tools for the assessment of built-up area change. The spatial analysis tool Spline has applied to 79 bore points in all tehsils of district Faisalabad. Results clearly show that a built-up increase of 41 km^2 in Faisalabad city is causing 1-foot depletion in groundwater as compared to other tehsils, where a built-up increase is negligible. Such research studies of groundwater changes would assist the planners to adopt effective sustainable measures.

Keywords: Assessment, built-up area, Faisalabad, groundwater level, spatial and temporal changes.

Introduction

Groundwater is the most important natural resource for drinking water provision worldwide. The contribution of groundwater is almost 34% of the total annual water supply that is consumed for commercial, domestic, or industrial purposes (Javaid et al., 2020). Every city needs to fulfill the water demands of its private, public, industrial and commercial users. With rapid population growth and the increasing trend of urbanization, there are two evident impacts on groundwater resources. Land use and land cover changes have great impacts on the groundwater system (Niemelä et al., 2011; Anwar et al., 2012). Impacts of this development on the urban environment are enormous i.e. intensifying floods, creation of urban heat islands, halting infiltration, and reducing natural recharge rate (Salvati et al., 2011; Bhalli et al., 2013; Myint et al., 2013; Parveen et al., 2019). Expansion of cities with more population inflow also creates the volume of wastewater (Wakida and Lerner, 2002). Water scarcity and increasing water demand can lead to drastic situations. Firstly, the transformation of pervious surfaces into concrete sealed surfaces such as the construction of buildings and highways (Rahman et al., 2019). These rapidly increasing impervious surfaces create disturbance in the natural recharge rate. Secondly, groundwater contamination is yet another concern due to industrial effluents, poor maintenance of sewage and drainage network (Baier et al., 2014; Zara et al., 2015).

It has been reported that Pakistan is facing the threats of increased demand for water utilization, deteriorating water quality, and depleting groundwater sources. Per capita, the water availability of Pakistan was about 5,000 cubic meters (m^3) in 1951 that has dropped to 1,100 m^3 in 2006 (Martin et al., 2006). Another study conducted by Margat (2008) reports that Pakistan ranks 4th in groundwater abstraction with total groundwater extraction of 64 km^3/year which is used for domestic, agricultural, and industrial purposes (Margat, 2008). The main objective of the study is to assess the impact of built-up area change on groundwater spatially temporally.

Materials and Methods

Study Area

The area of interest, district Faisalabad is located 850 kilometers northeast of Karachi. The Ravi River flows on the eastern and the Chenab river on the western boundaries of the district. The district lies from 30°-42' to 31°- 47' north latitudes and 72°- 40' to 73°- 40'east longitudes (GoP, 2000; Bhalli et al., 2012). District Faisalabad has an area of 5856 square kilometers (Bhalli et al., 2012a). It is surrounded on the north by Jhang, Hafiz Abad, and Sheikhupura districts on the east by Sheikhupura, Okara, and Sahiwal districts, on the south by Sahiwal and T.T. Singh districts, and on the west by T.T. Singh and Jhang districts (GoP, 2000; Bhalli et al., 2012b).

Data and its sources

For the study, the bore location of the study area has been shown in Fig. 1 is used to accomplish the situational analysis of groundwater in district Faisalabad. Selected bores are used for agricultural and domestic purposes particularly. The methodology used in the present study was also employed in several studies for groundwater assessment (Nistor et al., 2020; Pande & Moharir, 2018). Each year, some bore remains inactive and some remain operational. The number of bores in every tehsil is different in quantity. The tehsil, Tandlianwala has the least number of bores while the Samundri has a wide range of bores. The total number of boreholes is shown in Fig. 2 (a). In addition, an increase in the number of bores is clear from 2009–18 as shown in Fig. (2b). The Land Reclamation Department (LRD) has been targeted to collect the groundwater table depth data that was organized and tabulated according to the Faisalabad district and separated tehsil-wise. The data was given in unit feet. For this purpose, an instrument piezometer is used commonly.

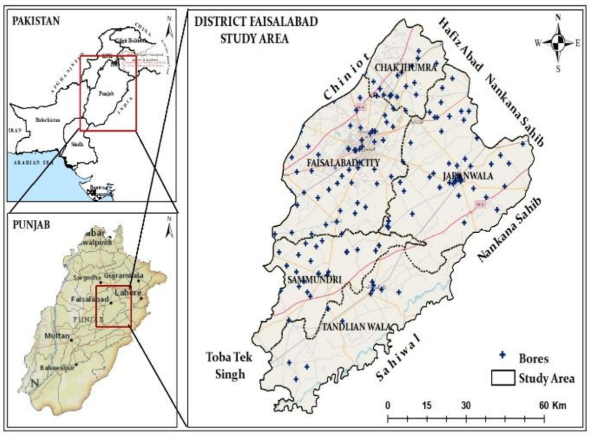

Fig. 1 Depicting study area and Location of Bores, Faisalabad District

Data and analysis

The location of bores has been marked on Google earth that was later converted from KML to layer for further process. The interpolation technique was opted by following previous studies (Gong et al., 2014; Nistor et al., 2020). All the data with tehsils interpolated separately. In the interpolation, the Inverse Distance Weighting (IDW) has been used to manipulate the data into map layout. A lighter to the darker tone of a shade has been used to visualize the depth of water level beneath the surface. The technique has been applied on the Faisalabad District on each tehsil separately. Later, to establish a relationship between built-up and groundwater, the degree of correlation has been calculated for each tehsil. The correlation scale from low to high have r value from 0.1 to 0.3 depicts the low range while 0.4 to 0.7 have medium and 0.8 to 1 shows high correlation.

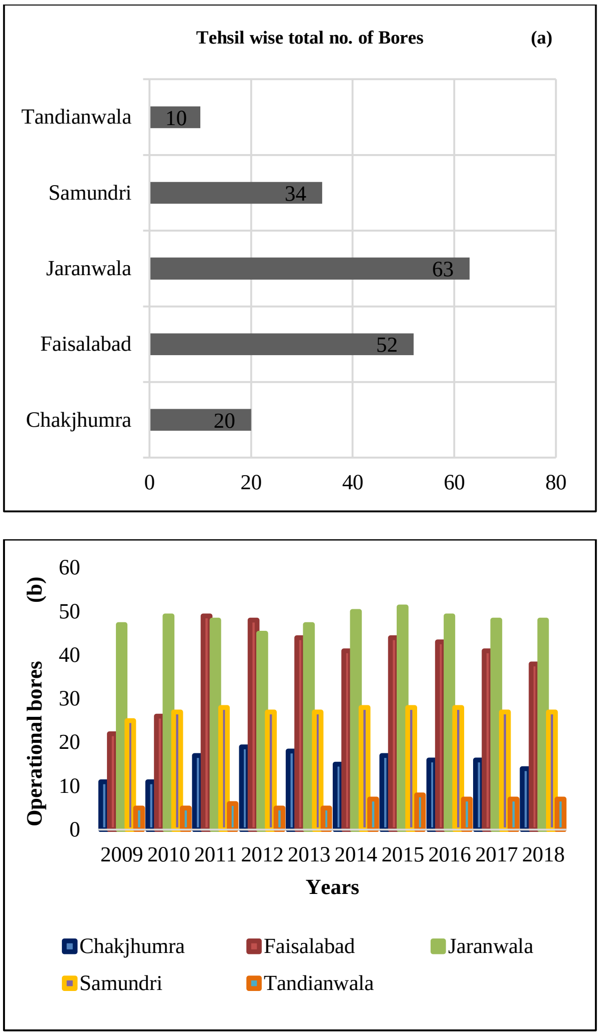

Fig. 2 a) Tehsil wise no. of bores, b): Tehsil wise no. of operational bores from 2009-18 in district Faisalabad.

Results and Discussion

Situational analysis of Groundwater Table

The groundwater level in every tehsil has varied (Fig. 3). The built-up area and water table have a strong relationship with each other. Urban sprawl has great effects on water table depth. Groundwater has become the most essential source and its usage has been increased over the few past decades for drinking, irrigation, industrial, etc. (Chidambaram, 2010). Urban areas require water for domestic, private as well as public, commercial or industrial uses, and urbanization has always drastically affected the local aquifer system in terms of quantity or quality. Colours chrome ranging from light blue to dark blue has been used with 5 classes. The recorded range of water level in each tehsil is different. Therefore, the highest and lowest values are considered to categorize water table levels with the same color chrome (Fig. 3).

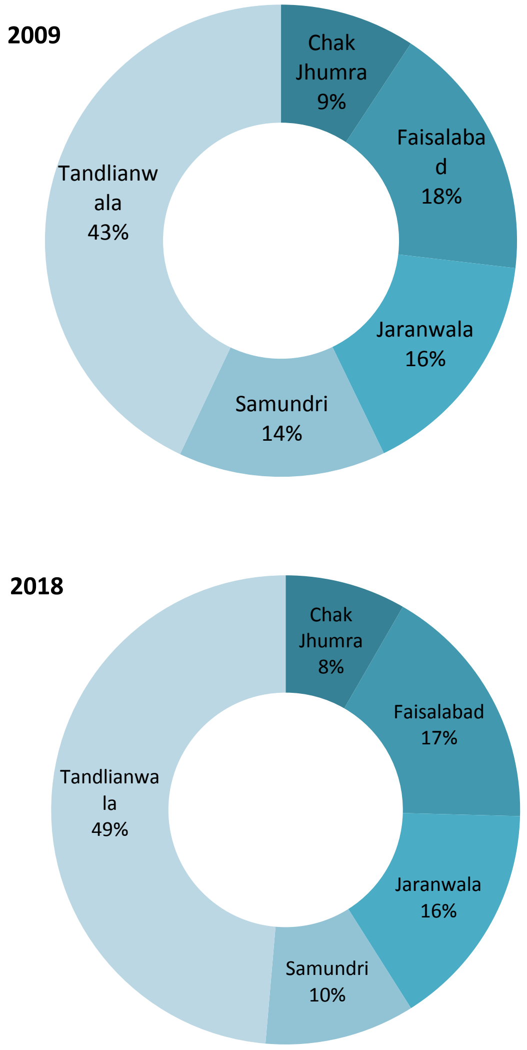

Fig. 3 The groundwater level in Faisalabad.

Low water table depth ⟶ High water table depth

City Faisalabad	>20	20-30	30-40	40-50	50<
Chak Jhumra	>3	3-6	6-9	9-12	15<
Jaranwala	>20	20-30	30-40	40-50	50<
Samundri	>6	6-12	12-18	18-24	25<

Fig. 4 Classification of the depth water table (feet).

Faisalabad city is the major tehsil of Faisalabad District. It is highly urbanized and comprised of 41% of the urban population as compared to other tehsils. Temporal analysis showed that there is a dramatic and unpredictable shifting of groundwater (Fig. 5 a, b). It is observed that groundwater can be accessed in less than 20 feet at the northwestern side of Faisalabad city that declined up to 50 feet in 2018. In addition, the groundwater level is accessible at 20 feet in 2018 but, that declined up to 20-50 feet on the southern side including Kohala and Gokhwal areas in 2009. The water table depth is accessible at less than 20 – 30 feet in the maximum area of Faisalabad.

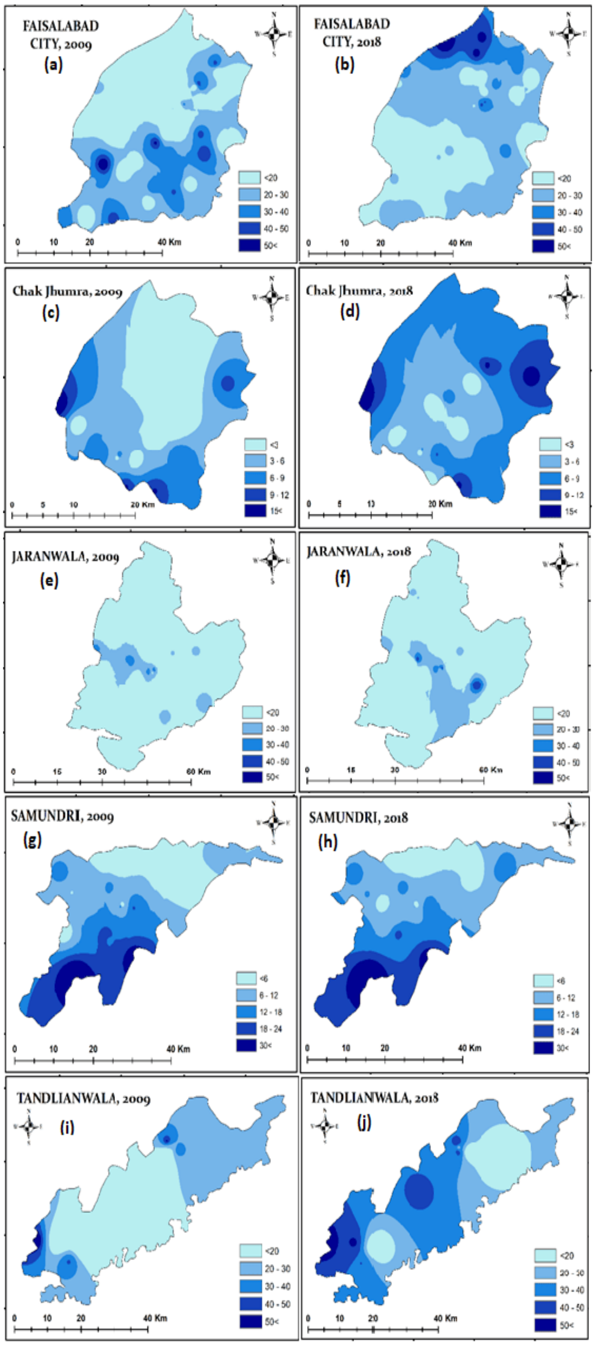

Fig. 5. Spatio-temporal analysis of groundwater Level

Chak Jhumra tehsil lies in the north of Faisalabad city. It comprised 85% of rural and 15% of the urban population according to census 2017. The depth of the water table ranges from less than 3 feet to more than 15 feet in Chak Jhumra in the study period (Fig. 5 c, d). The water table in Chak Jhumra is continuously declining from 2009-2018. In 2009, the northern side of tehsil including Mitranwali, Salarwala, and Pondorian 122, is found to have water table depth up to 3 feet only from the surface. However, water table depth declined up to 9-12 feet in 2018. Daska, Sahianwala, and Buriwala are the only areas where groundwater observes less than 3 feet depth.

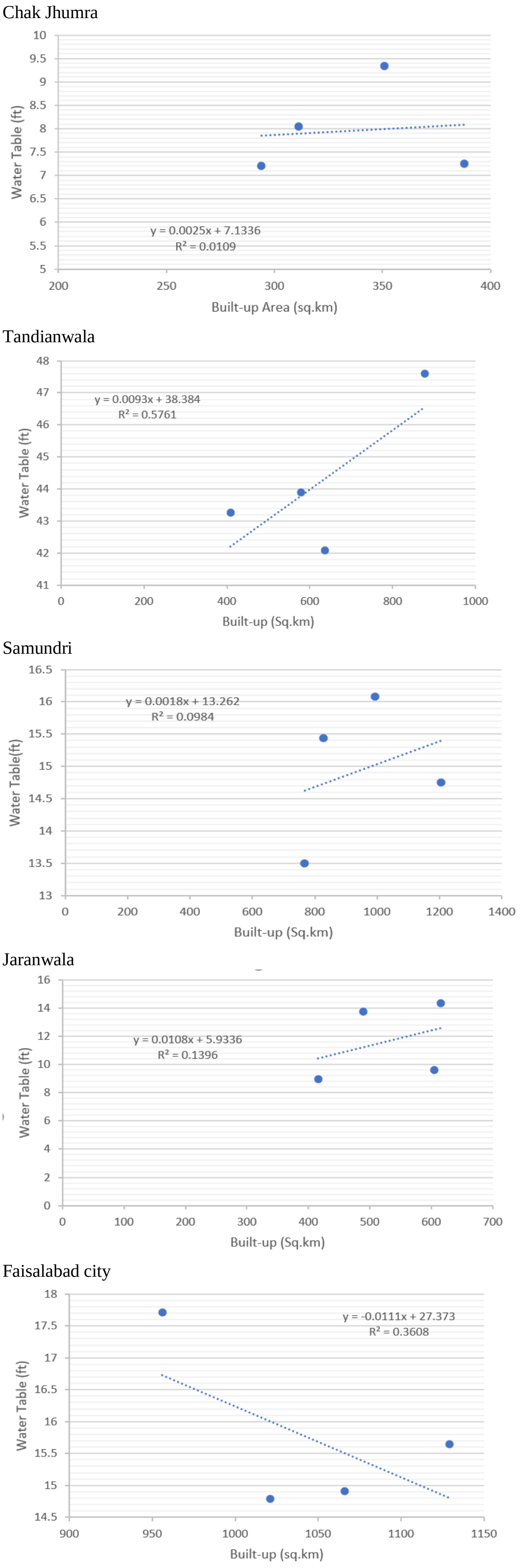

Fig. 6. Correlation between built-up area and groundwater table

Overall, situational analysis of groundwater situation is found better comparatively in Jaranawala Tehsil. Groundwater depth is found less than 20 feet from the surface in most parts of tehsil except Nanakpur, Chak 53 Manspur, and Chak Jassuana along Saholat Road. In these areas, groundwater can be accessed at the depth of 30-50 feet from the surface as shown in Fig. 5 (e) & (f). The decline of the water table is evident and expanding in the south-eastern side of Jaranwala in 2018. This south-eastern area is comprised of agricultural land across Jaranwala road. However, the Declining of the water table is subject to a maximum number of the operational bore in this tehsil.

Considerable variation in groundwater is identified alike in other districts except for Jaranwala. Groundwater is accessible at a depth ranging from 6 to more than 30 feet from the surface. Although, overall water depth remains the same groundwater accessibility at the depth of fewer than 6 feet shrinks particularly at the north side of the tehsil (Fig. 5 g, h). This northern side is comprised of the main Samundri where the major transformation of pervious to impervious surfaces, is witnessed in the last decade for development projects. Groundwater is found already deep up to 50 feet since 2009 in areas including Chak 213 GB Ladian and Khiderwala across Samundri Rajana road.

Alike other tehsils in District Faisalabad, the water table scenario is found the same. The decline in groundwater is identified while comparing the situation of groundwater in 2009 and 2018 (Fig. 5 i, j). However, the Central part of Tandianwala is experiencing a significant decline in groundwater. This central part includes Chak 398 GB keralianwala, Chak 615 GB Sarwar, Chak 615 GB Muhabbat, Chak 617 GB Kakkeke Wattu, and many other small communities that are developing at a rapid pace. This area is also famous for more than 10 large industries including an oil refinery, Food manufacturing, Agricultural machinery manufacture, and many others.

Degree of correlation between Built-up and Depth of Groundwater Table

Results reveal whether the groundwater table depth has any statistically significant relation with built-up change or not. All tehsils show no significant degree of correlation between built-up area and depth of growth water in Chak Jhumra, Jaranwala, Samundri, and Tandlianwala except Faisalabad city. The water table and built-up have shown significant results. Withholding all other factors constant, if the built-up in increasing 41 km^2 per year in Faisalabad city then the water table is declining at the rate of 1 foot per year. Unlike, Built-up has expeditious growth in Samundri by 58 km^2 from 2009 till 2018 and the groundwater table has reduced to 0.3 ft as year mentioned above. According to the results, the situation in tehsils as in Chak Jhumra, Tandlianwala, Samundri, Jaranwala, and Faisalabad city shows the low correlation among the water table level with built-up expansion according to the r values 0.019, 0.57, 0.09, 0.13, and 0.36. However, no significant relationship has been seen between groundwater change and built-up area expansion (Fig. 6).

Conclusion

Built-up area expansion is one of the most important aspects of urban development. The analysis reveals that a built-up area of 36 km^2 per year is increased and the water table has been sunk 0.14 feet per year in the past decade. A continuous decline in groundwater table depth is identified except in 2018. In addition, all five tehsils of District Faisalabad are identified with prominent variations except Jaranwala and observed with unpredictable changes in the groundwater table. It is also noteworthy that there is no significant relationship between built-up area expansion and groundwater level in all tehsils of Faisalabad district except Faisalabad city. Consequently, the built-up area correlates with groundwater table only where urban centers developing rapidly as in Faisalabad city tehsil only. Thus, the unplanned development of urban centers threatens the sustainability of an area by affecting groundwater levels and other environmental elements adversely. To conserve groundwater resources, there is a need for timely planning for the sustainable development of urban centers.

References

Anwar, M. M., Bhalli, M. N. (2012). Urban Population Growth Monitoring and Land use Classification by using GIS and Remote Sensing techniques: A Case Study of Faisalabad City, *Asian Journal of Social Science & Humanities*, **1**(1), 05-13.

Baier, K., Schmitz, K., Azzam, R., Strohschön, R. (2014). Management Tools for Sustainable Ground Water Protection in Mega Urban Areas–Small Scale Land use and Ground Water Vulnerability Analyses in Guangzhou, China. *Int. j. environ. Research*, **8** (2), 249-262.

Bhalli, M. N., Ghaffar, A., Shirazi, S. A., Parveen, N. (2013). Use of Multi-temporal Digital Data to Monitor LULC Changes in Faisalabad-Pakistan. *Pakistan Journal of Science*, **65**(1), 58-62.

Bhalli, M. N., Ghaffar, A., Shirazi, S. A. (2012). Spatiotemporal Patterns of Urban Growth in Faisalabad-Pakistan: A GIS Perspective. *Journal of Research Society of Pakistan*, **49**(1), 115-134.

Bhalli, M. N., Ghaffar, A., Shirazi, S. A. (2012a). Remote Sensing and GIS Applications for Monitoring and Assessment of the Urban Sprawl in Faisalabad-Pakistan, *Pakistan Journal of Science*, **64**(3), 203-208.

Bhalli, M. N., Ghaffar, A., Shirazi, S. A., Parveen, N., Anwar, M. M. (2012b). Change Detection Analysis of Land use by using Geospatial Techniques: A Case Study of Faisalabad-Pakistan, *Science International*, **24**(4), 539-546.

Chidambaram, S. (2010). Recent Trends in Water Research: Hydrogeochemical and Hydrological Perspectives: IK International Pvt Ltd.

Gong, G., Mattevada, S., O'Bryant, S. E. (2014). Comparison of the accuracy of kriging and IDW interpolations in estimating groundwater arsenic concentrations in Texas. *Environmental Research*, **130,** 59-69.

GoP. (2000). District Census Report of Faisalabad 1998. Population Census Organization, Statistics Division Islamabad: Govt. of Pakistan. Retrieved from http://www.pbscensus.gov.pk

Javaid, M. S., Khalid, L., Khalid, M. Z. (2020). Analytical study of environmental impacts and their effects on groundwater hydrology. In *Ground water Hydrology*. IntechOpen.

Margat, J. (2008). Exploitations et utilisations des eaux souterraines dans le monde. *Coédition: UNESCO et BRGM,* ***52,*** 01-10.

Martin, P., Nishida, J., Afzal, J., Akbar, S., Damania, R., Hanrahan, D. (2006). Pakistan strategic country environmental assessment. *South Asia Region, World Bank,* **1**, 1-80.

Myint, S. W., Wentz, E. A., Brazel, A. J., Quattrochi, D. A. (2013). The impact of distinct anthropogenic and vegetation features on urban warming. *Landscape Ecology,* **28**(5), 959-978.

Niemelä, J., Breuste, J. H., Guntenspergen, G., McIntyre, N. E., Elmqvist, T., James, P. (2011).

Urban ecology: patterns, processes, and applications: OUP Oxford.

Nistor, M. M., Rahardjo, H., Satyanaga, A., Hao, K. Z., Xiaosheng, Q., Sham, A. W. L. (2020). Investigation of groundwater table distribution using borehole piezometer data interpolation: Case study of Singapore. *Engineering Geology*, **271**, 105590.

Pande, C. B., Moharir, K. (2018). Spatial analysis of groundwater quality mapping in hard rock area in the Akola and Buldhana districts of Maharashtra, India. *Applied Water Science*, **8**(4), 1-17.

Parveen, N., Ghaffar, A., Nasar-u-Minallah, M., Ali, M. (2019) Analytical Study on Urban Expansion using the Spatial and Temporal Dynamics of Land-use Change in Faisalabad City, Pakistan. *Int. j. econ. environ. geol.*, **10**(3), 102-108.

Rahman, A.-u., Khan, A., Haq, N., Shaw, R. (2019). Soil sealing and depletion of groundwater in rapidly growing Peshawar City District, Pakistan. *Urban Drought*, **2019**, 289-309.

Salvati, L., Bajocco, S., Ceccarelli, T., Zitti, M., Perini, L. (2011). Towards a process-based evaluation of land vulnerability to soil degradation in Italy. *Ecological Indicators*, 11(5), 1216-1227.

Wakida, F. T., Lerner, D. N. (2002). Nitrate leaching from construction sites to groundwater in the Nottingham, UK, urban area. *Water science and technology*, **45**(9), 243-248.

Zara, N., Bhalli, M. N., Parveen, N. (2015). Impact assessment of sewerage drains on groundwater quality of Faisalabad, Pakistan. A Physio-chemical Analysis. *Pakistan Journal of Science*, **67**(1), 52-58.