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INTEGRATED ENVIRONMENTAL ASSESSMENT OF SOIL AS AN INDICATOR FOR ENVIRONMENTAL SUSTAINABILITY IN URBAN AREAS UNDER THE DPSIR FRAMEWORK

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ABSTRACT

Although the development of global society has brought about dramatic progresses, the world has paid its price by facing excessive environmental degradations and pollutions. In the city of Tehran, the capital of Iran, growth of construction and land use change from one hand and industrial activities on the other hand end in sinking of pollution in the air and water and finally soil resources which plus very high negative environmental consequences, will also gather in soil as a final receptor and entering the foot chain and can cause serious consequences on the civilians' health. Considering the complexity of soil pollution problem, an integrated and holistic approach is needed to address this issue and propose an environmental planning solution. This paper is a part of State of Environment Report (SoER) which was prepared for the period of 2008-2010 using the DPSIR framework for interpreting different environmental factors in the city of Tehran. In this research, the growth and concentration of activities and facilities, degradation, pollution and over consumption of resources were recognized as the main drivers. In the analysis of the pressures, constructions, industries and mines, air and water pollution and stresses were determined. In the state section, soil pollution and erosion and in the impacts reduction in sustainability and stability of ecosystems and soil fertility was distinguished. At the end, by means of the DPSIR conceptual framework, responses for each part of the causal chain were proposed.

Key words: Soil degradation, Driving force- Pressure-State-Impact-Response framework, Systemic approach in environmental planning.

INTRODUCTION

Soil is the life substrate and a prerequisite for human habitat settlement. Fertile soil plus enough water resources are considered as the most important factors shaping civilizations throughout history. Soils are also considered as the nature's purifier which act as the final receptor and sink for water and air pollutions. Comparing to other components of the environment, the as self-purification ability is less in soil, therefore, soil contaminations is an irreversible impact. The danger of soil pollution is no less than air pollution, but as far as this pollution is not visible, less attention is paid to it. Soil degradation and loss due to human and even natural disturbances are considered as threats soil faces.

Soil natural changes and dynamics are very slow; however anthropogenic factors can accelerate them, so as soil dynamics are highly considered in scientific researches (Porta & Poch, 2011).The most important phenomenon reflecting the anthropogenic forces on the soil is land use change, and urban areas and related features (roads, industries etc…) are among the most important land uses and degraded soil resources. Despite the fact that urban areas are less recognized as natural areas with dominance of manmade areas, the subsurface plays a significant role in urban development (Jago-on, et al., 2009) and thus protecting not built areas possessing soil can have an important role in ecosystem stability and extending green area and preventing run-off and thus further soil erosion.

The DPSIR model is a functional analysis framework to depict the cause-effect relationships in connection with environmental problems (Smeets & Weterings, 1999); (Ness et al., 2010). Jago-on, et al (2009) investigated subsurface environments to understand the major cause and effect relationships of subsurface environmental issues by using the DPSIR (Driving force–Pressure–Status–Impact–Response) approach as the framework of analysis. Omann, et al. (2009) Discussed some of the important socio-economic driving forces of climate change, Based on an analysis using the DPSIR framework with a focus on energy use and transportation. Hou et al. (2014) proposed a DPSIR framework for coupling ecological integrity, ecosystem services and human well-being and suggest DPSIR indicators for the case study area Jiangsu, China based on available statistical and surveying data.

In city of Tehran, expansion of built areas and reduction of natural and open areas, have cause soil degradation. Moreover, industrial activities that exist inside the city and sinking of the air and water pollution in the soil, cause concentration of dangerous substances in soil which not only brings about critical environmental impacts, but also entrance into food chain can cause health consequence for the dwellers.

This paper is a part of the second report on State of Environment of Tehran, which has used an integrated and holistic approach for understanding and covering the complicated environmental degradation in this city. The ecological systems area basically complicated compositions of biotic and abiotic factors(Reza & Abdullah, 2011). Predicting the behavior of such complicated systems is difficult. Thus for proposing managerial measures and decisions, information about the status, present conditions and ecosystem trends are necessary. This research is based on the systemic approach of Driving force- Pressure-State-Impact-Response (DPSIR) which takes into account proper criteria for each component of the framework in city of Tehran, and its systemic structure makes it possible to identify and better management of effective factors on soil degradation and finally proposing the proper responses and strategy separately for each part of the causal framework of the DPSIR.

Materials and Methods

Study Area

Tehran is the capital of Iran and located between 35° 34′ – 35° 50′ N and 51° 02′ – 51° 36′ E. The area of the city of Tehran is about 570km2 (Ashrafi, 2012). Geographically, city of Tehran, is Located at the southern slopes of the Alborz Mountains, which gives it relatively rich resources of water and mild climate. A glance at the geography of Iran and the spatial distribution of population and settlement patterns, it clearly shows this excellent position (Atlas of Tehran metropolis, 2012). The local topography of Tehran with mountains surrounding the city forms frequent stagnant air masses, causing a natural reason for concentration of air pollutants in this mega city (Saadatabadi, et al., 2012). Excessive pressure on the resources of the city and whose environmental limitations are violated is another cause of Tehran's environmental poor condition.

Method

The Driving force- Pressure-State-Impact- Response (DPSIR) approaches is a valuable tool, able to evaluate economic, social and environmental parameters. DPSIR is an effective tool for describing the environmental issues and better understanding the relationship between a pollutant distribution and its consequence (Lundin & Morrison, 2002) This tool provides us with an organized structure for environmental problems analysis in different spatial scales from small watersheds to global systems (Carr, et al., 2007) This approach is based upon a cause-effect relationship which starts with human activities (driving forces) that pose pressure on the environmental resources quantity and quality, that cause societal responses in the final stage (Atkins, et al., 2011). This framework is an important starting point that leads us to a common understanding between scientists, natural resource managers and policy makers through deeper discussions over factors that threats the inherent functions of the natural systems.

Numerous studies have been conducted to inform managers and policy makers about DPSIR analysis results so as to facilitate systematic monitoring towards sustainable ecosystem management.

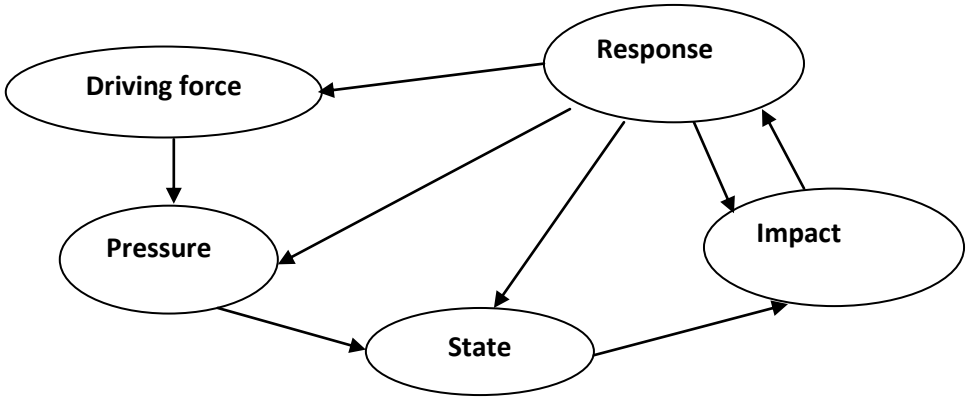

Figure 1- Driving force- Pressure- State- Impact- Response (DPSIR) frame work

(Smeets & Weterings, 1999)

Application of criteria in environmental planning is only useful when decision making is related to the important characteristics of the criteria such as being simple and precise, imagining the desired outcome and quantifying the required information (Gallopin, 1997). In order to apply the DPSIR model to analyze the soil degradation in the city of Tehran, quantified criteria for each of its components were derived from the related literature review and investigating all of the available indicators. Thus at first, the driving forces and pressures were recognized and the changes in status of the environmental systems which consisted of the physical, chemical and biological conditions were obtained. This would gradually cause impacts on natural and human systems which were traceable in decline in quality and quantity of the natural and soci- economic goods and services. After understanding the dynamics, in the final stage, required responses in the form of possible reactions needed by the society were presented.

Results

Driving forces analysis

The drivers that affect the soil parameter in the city of Tehran are key factors which form the origin of making changes and degradation of soil in this area. One of these major driving forces is building and infrastructure construction activities. During the period of 2008-2010 as the continuing trend from the previous decades, the metropolitan area of Tehran is a major place of concentration for all of the forms of economic activities in the country and undoubtedly is the focal economic center in the whole country of Iran.

Concentration of educational, administrative, services etc…in one hand and high expenses of living in Tehran on the other hand, have accelerated the growth of satellite habitats and therefore the daily presence of their dwellers in the Tehran metropolitan area is considerable. This amount of population brings the need for constructing more urban infrastructures such as new roads, tunnels, bridges etc… that definitely change and degrade the soil in different parts of Tehran. Natural resource degradation, pollution and over consumption are another mentionable driving force. Weak regulatory provisions could not control the

unleashed growth of the urban area in Tehran which besides changing the green and open spaces to built ones, cause over consumption of surface and ground water resources and thus bring severe degradations to soil of the area. Furthermore, due to the overall slope direction to the south, we can witness the reduction in the quality of the soil especially in the southern parts of Tehran that happens as a result of transferring of the pollutants by runoff.

Identification and Analysis of the Pressures

The bloom of the construction industry in the city of Tehran is one of the major factors that degrade surface soil and change it to the impervious surfaces. The number of issued construction permits is presented as a surrogate for urban construction in Tehran (chart 1). In the period of investigation, this figure has been 24150 cases in 2007 and 17017 cases in 2010. Although the overall trend is declining the number of permits has increased during the period of 2009 to 2010.

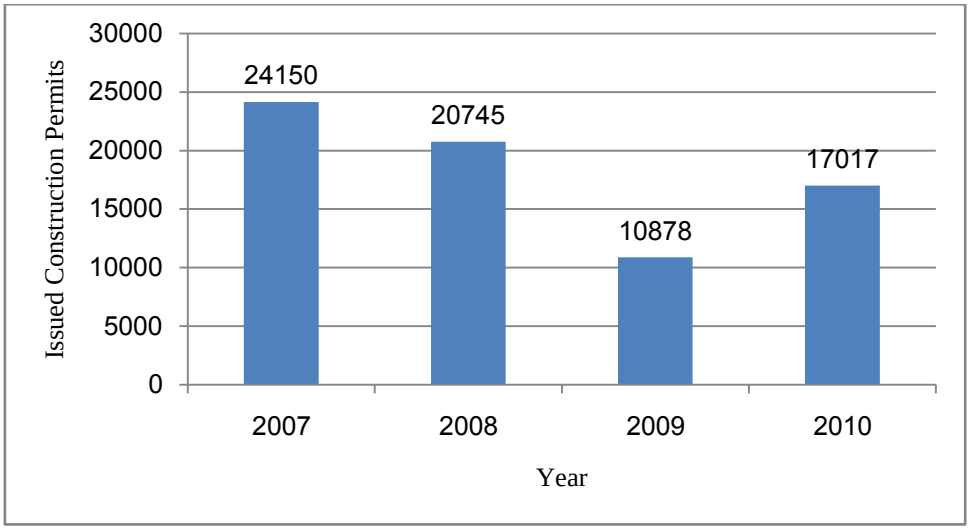

Chart1- The total number of issued construction permits during 2007-2010 (Office of Construction Permits of Tehran Municipality, 2001)

The interpretation of satellite images and derived land cover maps of the city of Tehran for 1988, 2002 and 2010 show that in the present boundary of Tehran, there has been only 37% built area in 1988 whereas this figure has increased approximately 20% in the following 22 years and reached 58% in 2010 (Fig 3).

Also considering the fact that the northern mountainous area of Tehran which has higher altitude is the origin for the rivers that run through the city, construction activities in these valuable riparian ecosystems cause degradation to the fertile soil that usually contains the native plants species. Constructing impervious surfaces in such areas dangerously increases the speed of runoff. Based on the "Riparian Limits Identification Guideline" (Guideline for identifying the riparian limits., 2010), the lawful limit of this area is up to 20 meters from the river bank. In Chart (2) the area of different land uses in 100m and 200m buffer from the river banks in the city of Tehran are illustrated as a quantified indicator for soil and ecosystems' instability. Based on this statistics, military, installations, storage areas and residential land uses have the highest proportions respectively.

One of the important components of the pressure analysis of the DPSIR framework is industrial activities, in which 145 units reduction in the number of industrial workshops with more than 10 workers during 2008 to 2010 is reported in Tehran province. The reason for this drop can be either the policy of displacing the polluter industries from Tehran or the reduction in the number of active industries due to economic problems. Also from the aspect of types of activities, almost in all of the categories, a decline in number can be witnessed. Although the concentration of industrial activities in industrial estates and complexes has made them far from population centers plus optimum utilization of water, energy and other inputs, it can cause cumulative impacts and environmental consequences. But conditions like locating in the direction of prevailing wind and hydrological networks, high level of groundwater table can bring health and environmental impacts over the residential areas. Most of the industrial areas in Tehran province are located

in the southern parts which are susceptible to environmental problems due to high groundwater table. The adjacent agricultural activities can be exposed to transferring the pollution into the crops. Considering the environmental infrastructure, all of the industrial estates in Tehran province face the issue of disposing industrial waste that can result in serious soil pollution. Moreover, some of them lack refinery and waste water treatment facilities.

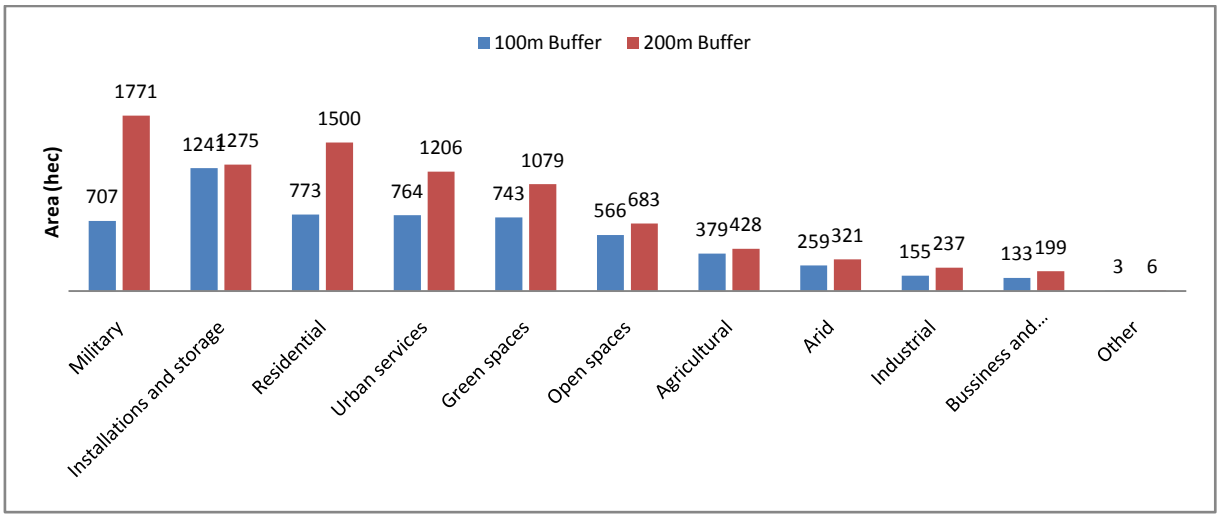

Chart (2): The areas occupied by different land uses in 100 m and 200 m limits of rivers in Tehran

Pressures

The other type of environmental pressure on soil is related to the mines. The number of operating mines in Tehran province has increased during the period of investigation. The highest increase has happen in the category of river sand extraction mines which cause serious impacts on the soil and riparian systems.

Agricultural activities are another factor affecting on the soil resources of the area. As illustrated in chart (3) the highest amount of agricultural land use can be found in district 18 and 22 with 800 and 289 hectares respectively. The highest number of agricultural land use patches is related to district 18 with 66 and district 5 with 62 patches (Baftshahr, 2010).

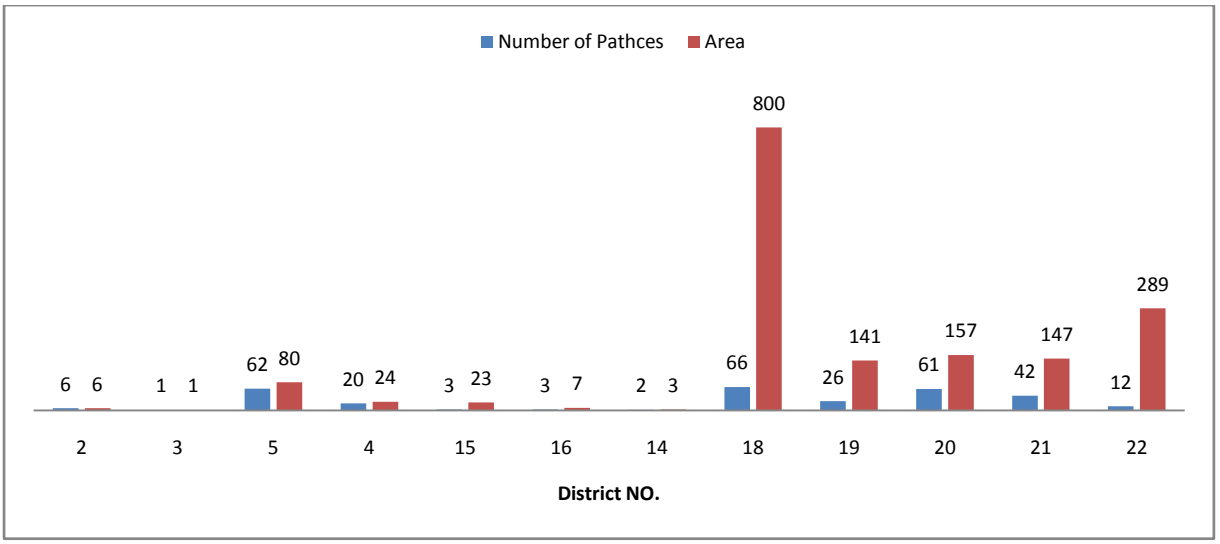

Chart (3): The number of patches and area of agricultural land use in Tehran municipal districts in 2009

The production and disposal of an enormous amount of municipal solid waste is another pressure on soil in Tehran. The total amount of garbage received in Araadkouh landfill has increased in 2008-2010 from 2788911 to 2973188 tons which means more pollution of soil and the need for more land for the disposal. Also the production of hospital wastes, which is classified as extremely dangerous, has increased in the period of investigation from 30343 tons in 2008 to 32767 tons in 2010 (Tehran Waste Management Organization, 2011). There is also a considerable amount of degraded and polluted land buried under the municipal and

construction wastes in landfill sites of Tehran, which has reached to 2000 hectares with 100 m width, and the leachate generated from waste has formed a pond near to this area.

The other considerable pressure on soil resources in Tehran is waste water production and its possible utilization in irrigation. In Tehran, wastewater disposal had been in form of absorption wells. Further development of the city and production of vast amount of wastewaters had increased the ground water level which caused worries about the groundwater and soil contamination in the south of Tehran. Therefore a gradual change in wastewater disposal system from absorption wells to wastewater collection network is being executed. The results of investigations on the soil in the southern part of Tehran showed the use of untreated water for irrigation purposes has resulted the rise in pH, EC, CaCO3, and heavy metals such as Fe, Mn, Cr, Pb in the soil (Barati, 2009). Although there is no statistics of using raw wastewater for irrigation, the water resources used for this purpose (Ministry of Energy of Iran, 2012) in the province of Tehran during the period of investigation, 47 MCUM of wastewater has been used for irrigation (Tehran Agriculutral Jihad Organization, 2012).

Another factor polluting the soil is the use of chemical fertilizers and pesticides which some of them have high durability in the nature which has change the pH rise the salinity and destroyed the living organisms in the soil of Tehran (Barati, 2009). The total amount of fertilizers used in the county of Tehran has a rise of 1084 tons with the highest rise for Urea. Also the amount of pesticides and herbicides distributed in the county of Tehran was 1.24 tons in the year 2010 (Tehran Statistical year Book, 2010)

The next mentionable factor causing pressure on soil in Tehran is acid rain incidents. Although there are no recorded statistics to prove this phenomenon, the air pollutants that can produce acid when combined with rain water can cause acid rain and dry acid sedimentation in Tehran.

Water stress is also considered an important pressure over soil resources. The extraction of ground water resources in Tehran-Karaj aquifer has made a serious drop in the groundwater table which is a 5.65 cm in the water year of 2008-2009 and 18.7 cm in 2010-2011. Also the highest amount of reduction in the volume of the reservoir in 2007-2008 and 2008-2009 periods has happened in Tehran and Karaj aquifer. The average reduction in the water table has been 36.17cm and 65.34 cm for water years of 2008-2009 and 2010-2011 respectively.

Gas and petroleum stations can also be mentioned as a source of pressure on soil because the transition and storage of fuels in those stations normally cause spill. The highest number of gas stations in 1000 hectares goes to district 12 with more than 8 stations and after than is district 11 with 6 stations. In the whole area of the city of Tehran, this criterion is 2 stations in every 1000 hectares.

Salinizing the roads by using a mixture of sand and salt for ice melting is another pressure on the soil. This salts finally get into surface waters and enters the soil especially in agricultural lands in south of Tehran.

Analysis of the State

Although soil survey maps are needed to guide efficient land management practices, about 75% of Iran lacks soil survey information (Pahlavan Rad, et al., 2016). Tehran is not an exception and due to the lack of information about the status of soil in the city of Tehran, in this research the unbuilt surface area is used as a surrogate for presence of soil. In 1988, in the present boundary of Tehran, there had been 63% of unbuilt spaces but in the year 2010 this criteria faced a reduction of 21% and became approximately 41%. Apart from few exceptions, there has been a decline in the area of unbuilt environment in all of the 22 municipal districts. Based on the interpretation of land sat satellite images of Tehran, in 1988, 2022 and 2010 the most of this decline is related to district 1 with more than 33.8% and after that stands district 5 with 32%. In the year 2010, district 22 has the highest portion of unbuilt spaces which is 73% and therefore had had a higher ecological stability from the aspect of presence of soil.

In chart (8) the area of land cover types of green, built and open spaces for 1988, 2002 and 2010 are compared in the city of Tehran, based on the land sat satellite images interpretation. Accordingly, the area of green and open spaces gradually declined and he built area has increased.

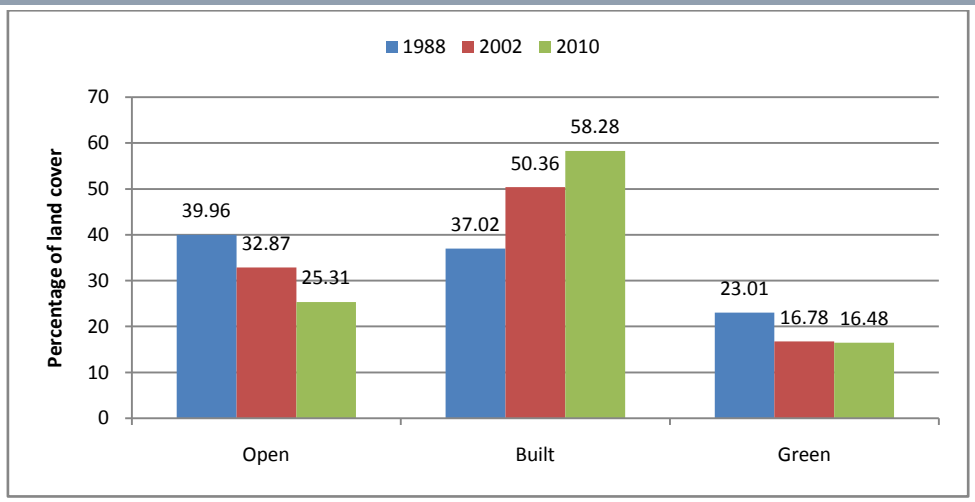

Chart (4): the percentage of green, open and built land cover types in 1988T 2002 and 2010 in the present boundary of Tehran

The southern part of Tehran is in the direction of huge amount of runoff from uplands. Thus the soil is affected by the polluting runoff passing the city, mines and industrial areas. In table (1) the concentration of heavy metals in 8 regions in southern part of Tehran is illustrated.

Table (1): Average concentration of heavy metals in the soil of southern part of Tehran (mg/kg) (Mardani, et al., 2010)

	Poin1	Poin2	Poin3	Poin4	Poin5	Poin6	Poin7	Poin8
Pb	58.7	62.8	110.2	74	58.5	74	57	55
Zn	113.4	120.8	155	299	51	70.2	61.2	64.4
Cd	1.7	1.8	3	6	2.5	1.3	1.2	0.7
Ni	3.8	3.8	41	96	86	18	8.5	4.4
Cu	34	68	83	94	87	8.8	4.6	3

Impacts Analysis

Soil is a vital component of natural environment and degradation of soil will end in reduction of the stability of the ecosystem. A natural hydrological system is maintained by the simultaneous combination of erosion and sedimentation. But in urban systems, this process is changed by placing stilling basins in the entrance point of watercourses to the city; the runoff would be without any sediment load, which causes more erosion to the river banks. For instance the stilling basins of the Farahzad and Darakeh rivers and changing the river valleys inside the city to the impervious channels will only pour water without nutrients to Kan River which not only causes severe erosion to its bank, but also doesn't leave any alluvium on the agricultural lands.

The area of the arable and under cultivation lands in Tehran province in the period of investigation shows a reduction of more than 22% that can be due to land use change or reduced soil fertility or less economic benefits from agricultural activities. Also the consumption of chemical fertilizers in the county of Tehran shows more than 300% rise than can be a sign of soil infertility.

Polluted soils can transfer diseases to humans. This issue is mainly critical in residential areas near landfills, because solid wastes can transfer 18 types of known diseases to humans.

Proposing the Responses

Considering the fact that the main purpose of the DPSIR framework is proposing responses in order to compensate the shortcomings in a fundamental manner and to attain proper and effective measures, responses are proposed for each part of the causal framework separately (table 2).

Table (2): Proposing responses for soil factors using the DPSIR framework

DPSIR Components	Responses
Driving forces	• Reducing the population and decentralization • Moving the polluting industries from Tehran and its vicinity • Providing environmental measures in gas stations specially drainage systems and purification of the runoffs • Integrated Pest Management (IMP) and reducing the consumption of chemical pesticides and fertilizers
Pressures	• Completion of sewerage network • Proper municipal solid waste management • Reduction of municipal solid waste production • Managing the landfills and protecting the adjacent areas from leakage and reclamation of lands of old landfills • Compilation of a national standard for soil pollution and making it obligatory for industrial, agricultural and other soil polluting activities. • Obliging the industrial units and complexes to prepare their own solid and liquid waste management program. • Lowering the use of chemicals for melting snow and ice from the streets • Controlling the construction activities
States	• Reclamation of the polluted soil specially in the southern parts of Tehran • Watershed management in the province and reviving the natural plant covers using native plants special on the steep slopes to prevent soil erosion • Preventing construction on steep slopes and altitudes higher than 1800 m and reclamation of river valleys. • Completion of the comprehensive plan of Tehran.
Impacts	• Prevention of building houses near landfills. • Protecting the adjacent areas of the landfills from leakage • Monitoring Soil-borne diseases

Conclusion

For a better understanding of complexity of components and relationships between natural and human systems, many measures have been applied for illustrating the inherent order of complicated environmental systems. One of the integrated and holistic approaches to show this interconnectedness is the DPSIR framework, which is used in this research to analyze soil conditions in the city of Tehran.

The city of Tehran is the capital of Iran and with a population of more than 8 million faces the over concentration of population and activities and therefore needs more constructional activities. Increase in construction permits, high number of gas stations, increase in production of municipal solid wastes and its unhealthy disposal system, extending the impervious surface areas, construction activities on steep slopes and high altitudes and soil pollution with heavy metals are among factors that not only degrade the soil condition in the city of Tehran, but also cause pollution entrance into the ecosystem and jeopardize humans' health. Among the most important consequences of soil degradation in Tehran are reduction in ecosystem stability, soil fertility and health issues due to chemical and microbial pollution.

Among the required responses or the necessary societal reactions, we can mention the need to establish a national standard for soil pollution, and the completion of the sewerage network. As far as determining soil types and erosion sensitivity are to important baseline information for environmental studies, it is proposed that for getting to an understanding for ecosystem conditions in Tehran, preparation of these information should be given a priority. Also considering the fact that the mountainous uplands of Tehran are important sources of environmental services for the city, maintaining and preserving these areas should be considered in Tehran's comprehensive plans. It is proposed that a database bank on the status of land cover and land use change should be prepared for a more informed conservation plans.

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References

[1]. *Guideline for identifying the riparian limits.* (2010).Iran water resources management company, Bureau of Rivers & Coastal Engineering.

[2]. Ashrafi, K. (2012). Determining of spatial distribution patterns and temporal trends of an air pollutant using proper orthogonal decomposition basis functions. *Atmospheric Environment, 47*, 468-476.

[3]. Atkins, J. P., Burdon, D., Eliott, M., & Gregory, A. J. (2011). Management of the marine environment: Integrating ecosystem services and societal benefits with the DPSIR framework in a systems approach. *Marine pollution bulletin* , 215- 226.

[4]. (2012). *Atlas of Tehran metropolis.* TEHRAN : TEHRAN MUNICIPALITY ICT ORGANIZATION.

[5]. Bakkes, J. A., van der Bom, G. J., Helder, J. C., Swart, R. J., Hope, C. W., & Parker, J. D. (1994). *An Overviwe of Environmental Indicators: State of the Art and Perspectives, Environmental Assessment Technical Reports.* New York: United Nations Environment Programe.

[6]. Barati, E. (2009). Soil pollution and environmental crisic. *Growth, Education and Geography, 88*, 14-21.

[7]. Blum, W. (2004). SOIL INDICATORS FOR DECISION MAKING – SHARING KNOWLEDGE BETWEEN SCIENCE, STAKE HOLDERS AND POLITICS. *International Soil Conservation Organisation Conference.* Brisbane: Conserving Soil and Water for Society: Sharing Solutions.

[8]. Carr, E. R., Wingard, P. M., Yorty, S. C., Thompson, M. C., Jensen, N. K., & Robertson, J. (2007). Applying DPSIR to sustainable Development . *International Journal of sustainable Development and Word Ecology, 14*, 543-555.

[9]. engineers, B. c. (2010). *Plan of conservation and Organazing Tehran's Gardens and Agriculutral Lands.* Tehran: Tehran urban planning and development authority.

[10]. Gallopin, G. C. (1997). Indicators and their Use: Information for Decision- Making. Sustainability indicstors: A Report on the Project on Indicators of Sustainable Development. In B. Moldan, A. S. Billharz, & R. Matravers, *A Report on the Project Indicators of Sustainable Development.* UK: John Wiley and Sons.

[11]. Hou, Y., Zhou, S., Burkhard, B., & Muller, F. (2014). Socioeconomic influences on biodiversity, ecosystem services and human well-being: A quantitative application of the DPSIR model in Jiangsu, China. *490*, 1012–1028.

[12]. Jago-on, A. B., Kaneko, S., Fujikura, R., Fujiwara , A., Imai , T., Matsumoto , T., et al. (2009). Urbanization and subsurface environmental issues: An attempt at DPSIR model application in Asian cities. *Science of The Total Environment, 407*(9), 3089–3104.

[13]. Lundin, M., & Morrison, G. M. (2002). A life cycle assessment based procedure for development of environmental sustainability indicators for urban water systems. *Urban water*, 145-152.

[14]. Mardani, G., Sadeghi, M., & Ahankoob, M. (2010). Investigating soil pollution in south of Tehran in the direction of runoff contaminated with heavy metals. *Water and Waste Water, 21*(3), 108-113.

[15]. *Ministry of Energy of Iran*. (2012). Retrieved from news.moe.gor.ir

[16]. Ness, B., Anderberg, S., & Olsson, L. (2010). Structuring problems in sustainability science: The multi-level DPSIR framework. *Geoforum, 41*, 479–488.

[17]. (2001). *Office of Construction Permits of Tehran Municipality.*

[18]. Omann, I., Stocker, A., & Jager, J. (2009). Climate change as a threat to biodiversity: An application of the DPSIR approach. *Ecological Economics, 69*(1), 24–31.

[19]. Pahlavan Rad, M. R., Khormali, F., Toomanian, N., Brungard, C. W., Kiani, F., Komaki, C. B., et al. (2016). Legacy soil maps as a covariate in digital soil mapping: A case study from Northern Iran. *Geoderma, 279*, 141–148.

[20]. Porta, J., & Poch, R. M. (2011). DPSIR Analysis of Land and Soil Degradation in Response to Changes in Land Use. *Spanish Journal of Soil Science*, 100-115.

[21]. Reza, M. I., & Abdullah, S. A. (2011). Regional Index of Ecological Integrity: A need for sustainable management of natural resources. *Ecological indicators, 11*(2), 220-229.

[22]. Saadatabadi , A. R., Mohammadian, L., & Vazifeh, Y. (2012). Controls on air pollution over a semi-enclosed

basin, Tehran: A synoptic climatological approach. *IJST*, 501-510.

[23]. Smeets, E., & Weterings, R. (1999). *Environmental Indicators: Typology and Overview.* Copenhagen: EEA.

[24]. Sodoudi, S., Shahmohammadi, P., Vollack, K., Cubasch, U., & Che-Ani, A. I. (2014). Mitigating the Urban Heat Island Effect in Megacity Tehran. *Advances in Meteorology, 2014*, 19.

[25]. *Tehran Agriculutral Jihad Organization.*(2012). Inquiry.

[26]. *Tehran Statistical year Book.* (2010). Tehran Governorship.

[27]. *Tehran Waste Management Organization.* (2011). Tehran Municipality.