

Problems and Perspectives of the Urban Sewage System: A Geographical Review

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ABSTRACT

The present study deals with the problems of urban sewage system and trying to find out the geographical perspectives behind the same. For this assessment, previous literature has studied and analysed. Basically, the urban sewage system deals with the collection, treatment and disposal of the generated wastewater. Now a day, the continuous growth of population and the process of urbanization crating overload on the available service of the sewage system. The blockage, clogging, backwater, overflow etc are the major concern of the same. Resulted, many health issues, environmental pollution and hazards within the urban places. Dynamic nature of the city, lack of public awareness, challenging physical set-up of the region and sewer construction, maintenance and cleaning issues, inappropriate collection and treatment, poor economy etc are the major geographical perspectives of the urban sewage system issues.

1. Introduction

The archaeological remains of urban civilization represent the sophisticated and systematic infrastructure of ancient life i.e., city planning (Robinson, 2003; Qiao, 2017), architecture of building (Sitte, 1979), road connectivity (Hitchner, 2012), water supply (Morgan, 1902; Tassios, 2007), wastewater and stormwater system (Koutsoyiannis et al., 2008; Angelakis and Spyridakis, 2010; Du and Zheng, 2010; Mithen, 2010)etc. Such structures reflect the application of scientific methods with available knowledge and resources (Delleur, 2003). Ultimately which built the technical base of todays modern development (Brown et al., 2009). At the same time, such progressions also create multidimensional challenges in it (Broere, 2016).The urban sewage system is one of them (Schütze et al., 2002).

The system of sewage designed to maintain the clean, pollution free and hygiene environment of the settlement and supports to the higher level of life. This is one of the basic amenities of the settlement or urban places which is must and expected uninterrupted services. While, the continuous growth of population and process of urbanization creates the enormous pressure on available service (Asoka et al., 2013). The unsustainable provision, issues of the personal cleanness, decline the level of household to community hygiene and sanitation, environmental degradation etc are the worst results of such overburden on the sewage system (Acharya, 2018).

the present study designed to find out such issues and crises of the sewage system and trying to evaluate the geographical base behind the same. For fulfilment of the study goal, the designed objectives as follows.

2. Objectives

1. To understand the geographical profile of the cities.
2. To analyse the urban sewage system.
3. To evaluate the issues of urban sewage system with geographical perspective.

3. Research Methodology

The present study based on the previous literature development regarding the research objectives. The articles and research papers, newspapers, books, repots of authorized institute, authentic websites analysed for to find out the problems and perspectives of the urban sewage system.

4. Result and Discussion

With respect to study objectives, the issues of urban sewage system have listed in table 1, while table 2 highlights the worldwide urban places with different problems and causes of the same.

Table 1. Issues of the Urban Sewage System

Type of Issue	Index	Type of Issue	Index
Blockage	1	Urban Flooding	6
Clogging	2	River/Ocean Pollution	7
Overflow	3	Groundwater Pollution	8
Backwater	4	Health	9
Seepage	5	Environmental	10

(Source: Proposed Ph.D. work by Vidhyatai Patil, SRTM University)

Table 1. Sewage System Issues and Causes of the Urban Places

Location		Type of Issue (as per the index of table 1.1)	Cause
Country	City		
India	Indore	1,3	Large size solids (Tahir and Visaria, 2017).
India	Delhi	1,2,3,4,5	Improper sewer gradient (MailOnline, 2017).
India	Mumbai	1, 2, 7	undeveloped a sound network of sewage system (Bhagat, et al., 2006;Yedla, 2006).
India	Bangalore	1,2,3	Failure of "Wet Well" due to the irregular supply of electricity and lack of maintenance (Bangalore Mirror, 2019).
India	Chennai	3	Open sewer (Sethuram, 2014).
India	Hyderabad	1,2,3,4	improper solid waste disposal, lack of awareness, coverage issue and miss connectivity (Devi and Samad, 2008).
India	Pune	1,2,3,4	Lack of cleaning and maintenance (Pune Mirror, 2019).
India (MH)	Kolhapur	1,2,3	45 per cent households have not connected with the sewer line, bathroom and kitchen wastewater discharge around the house. (The Environmental Status Report of Kolhapur Municipal Corporation, 2015-16).
India	Jammu (J&M)	9	Inadequate sewage collection and disposal (Malaviya and Bhagat, 2013).
India	Gandhinagar, Gujrat	1,2,3,4	Improper cleaning, population load, need to upgradation (Rajpurohit, et al., 2016).
India (UP)	Mirzapur,	1,2,3	dumping of waste in the drains, lack of lined drainage, Majority of houses not connected to existing sewage system (Tiwary, 2014).
India	Aligarh city	1,2,3,9	Most of sludge disposal in open cemented drains or dumped in the yard or dumped in the street rather than covered (Singh and Rahman, 2001).
India (Odisha)	Bhubaneswar,	1,2,3, 10	Several areas in the city are not covered by sewage system, sewage is discharged on open plot and road (Jena and Lohani, 2014)
India Nagaland	Mokokchung	1, 2, 3	Disposal and discharge of solid waste into the drain (Lyndem and Imtimakla, 2019)
,Iraq	Karbala	3	overburden (Obaid, et al, 2014).
Bangladesh	Dhaka	1, 2, 3, 6	Inappropriate sewer gradient, low capacity and gravity, lack of proper maintenance (Alom and Khan, 2014; Subrinaand Chowdhury, 2018).
Bangladesh	Mymensingh	1,2,	Solid waste collection issue (Uddin, et al., 2018).
France	Lyon and Mulhouse	1,2,3,4	hydraulic overloading and line break (Caradot, et al, 2011).
Australia	Australia	1	Tree root intrusion (Thomson, 2008; DeSilva, et al., 2011).
Australia	Sydney	1,2	tree root intrusion (Lim et al., 2010).
United State (US)	US	1,2,3	Fat, oil, and grease (FOG) (Keener, et al., 2008).
Florida, US	Southern Pinellas County	1, 2,3	Infiltration by damaged pipe (Akabogu, 2018).
US (Colombia)	Bogota,	1,2,3,	Again and structural deterioration (Rodríguez, et al., 2012).
Zimbabwe	Zimbabwe	1,2,3	Low sanitation coverage, Low efficiency of collection (Ngwenya, 2013).
Zimbabwe	Chinhoy,	1,2,3	Low self-cleansing capacity, Non-covered manholes, unwariness and dumping/flushing solids into the sewer (Chinyama and Toma, 2013).
Zimbabwe	Kadoma	1,2,3,4	increases in population, old age of sewer systems, disposal of solids into the system (Nigusssa, et al., 2009).
Germany	Berlin	1,2	Flushing of wet wipes (Mitchell, et al., 2017).
Germany	Rastatt	9	Old sewage system, again issue, damaged sewer (Eiswirth and Hötzl, 1997).
Pakistan	Ahmedpur East, Bahawalpur,	1,2,3	badly deteriorated Sewage network (Mohsin and Anwar, 2015).
China	China	1,2,3,4	poor construction quality, Grim situation of maintenance, (Huang et al., 2018).
China	Guangzhou	1,2,3,4	rapid urbanization, high density of buildings, low quality of the drainage pipe network (Wu, et al., 2016).
China	China	1,4,7	Network Connectivity issues between storm and sanitary sewer (Miao, et al., 2018).

Morocco	Morocco	1,2	Lack of sanitation collection and wastewater treatment (McDougall, 2011).
South Korea	Seoul	1,2,3,4	Infiltration and inflow, lack of sewer rehabilitation (Lee, et al., 2009).
Kenya	Nairobi	1,2,3,4	Rag and grit related chock-up (Ngaruiya and Ngigi, 2014).

(Source: Proposed Ph.D. work by Vidhyatai Patil, SRTM University)

Based on the evaluation of table 1 and 2, the geographical perspectives regarding the crises of urban sewage system discussed with the help of following points.

1) Overload or Pressure on the System

According to the Global Health Observatory data (WHO), in 1950 about 30 percent of the total world population lived at urban places, which is increased up to 54 percent in 2015 and it will be 60 percent in 2030 with respect to global population. Due to such continuous rural to urban migration process creates overburden on the available city sewage system. The Industrialization, employment opportunity, facility of basic services and amenities, higher standard of the social well-being etc are the major causes of the rapid urbanization. Addition to this, the higher educational facility, central business district, centres of larger manufacture, health and transportation facilities etc are the pulling factors for the same.

Moreover, the detail map of the urban places showing that, somehow the major sites having higher distribution and density of the population i.e., old core zone of the city, location of the slum zone, major economic services etc. Such highly populated areas become the major vulnerable zones for the crises of urban sewage system.

2) The Dynamics of City and Sewage System

The smart city concept arisen from the multidimensional challenges of the urban unplanned growth (Pawe and Saikia, 2018). City settlement strategy should have to base on the natural and social factors (Kadioğlu, 2011). While, the modern city approach design as per the unplanned built-up area (Anwar, et al., 2017). Due to such kind of growth, the urban sewage system plan has challenges to maintain the balanced between the unrestricted expansion of urban sprawl and restricted boundaries of the municipal corporation (Pendall, 1999; Rico, 2010; Hortas- Rico, 2014). Additionally, the unique and heterogeneous geographical set-up of the region become confront of the same.

Basically, the city plan always more focused towards the water supply than that of sewage management. Such uneven view not only responsible for the crises with wastewater but also creates the water quality, availability and supply issues as well. Furthermore, vertical expansion and compact buildings, narrow road network, slum zone, multi-type wastewater discharge etc are the major city concerns regarding the construction and maintenance of the sewage system.

3) The Sewage System: User Perspective

According to the United Nations World Water Development Report (2017), the highly engineering based designed of the city sewage system can be failure without public awareness regarding the appropriate understanding of the importance and implementation of the service. The sewer blockages concerning to the non-degradable and floating unflushable solids i.e., sanitary napkin, diaper, different size polythene, cooking oil and food etc. mainly enter into the drain

due to the irresponsible personal to community attitude towards the city sewage system.

4) Maintenance, Cleaning and Age Deterioration

The proper, timely and regular maintenance and cleaning issues have another aspect of the sewage system crises. Basically, the maintenance and cleaning task mainly deal with to provide the continuous and without any interruption service to the end user. The technical and non-technical problems such as the economic base and application of the sewage system type and utilization of the material, the number of skilled and non-skilled workers, quantity and quality of the available cleaning equipment's, communication gap between the user and service etc are the major causes for the inappropriate chore of the maintenance and cleaning. Addition to this, with the progression of time the age deterioration crises have arisen within artificial constructed network of the sewer.

5) Collection and Treatment of the Sewage

Within the urban areas many sites found without access of the sewer network, especially such sites have found at rural-urban fringes or urban sprawl areas. On the other hand, many users not connect their personal wastewater drain to the available network of city sewer. In both cases, the generated wastewater discharge around the houses on the open or vacant space or plot. Air, soil and groundwater pollution have results of the same. Additionally, the discharge of raw, partially, untreated wastewater has the major concern of city sewage system.

The 2017 report of United Nations World Water Development (UNWWD), figure out the income-based country data regarding the discharge of untreated wastewater. According to the same, from low-income countries about 92 percent raw and untreated wastewater release into the environment. While, 72, 62 and 30 percent observed from lower-middle-income, middle income and high-income nations respectively. In case of India, about 51 percent sewage treatment capacity have in metropolitan, this number decreased about 32 and 8 percent with subject to class-I and class-II cities respectively [Central Pollution Control Board (CPCB), 2009].

6) Construction Issues

Many geographical factors like flat or steep slope, undulating topography, tree root injection, higher level of bed rock and groundwater, soil type etc creating the many challenges for the planning, construction, implementation and maintains crises for the sewage system. Such critical geographical aspects inversely effects on the sewer gradient and total structural network of the sewer.

5. Conclusion

The blockage, backwater, overflow are the major crises of the urban sewage system. Resulted, the raw and untreated flow and discharge in to the environment. Which creates the

many sanitation, health and environmental hazards and issues i.e., flooding, flooding, water logging, air, water, groundwater, river, soil pollution etc. Additionally, it degraded the quality of social life. The poor economic status, lack of public awareness, planning and implementation issues, improper maintenance

and cleaning task, age deterioration, challenging physical set-up of the region, the dynamics of city etc are the major geographical factors concerns with the crises of urban sewage system.

References

- Anwar, B., Xiao, Z., Akter, S., and Rehman, R. U. (2017). Sustainable urbanization development goals strategy through public-private partnerships in a South-Asian metropolis. *Sustainability*, 9(11), 1–26. <https://doi.org/10.3390/su9111940>.
- WWAP (United Nations World Water Assessment Programme). 2017. The United Nations World Water Development Report 2017. Wastewater: The Untapped Resource. Paris, UNESCO.
- Tahir, A., and Visaria, A. (2017). Sewage Pollution in Water Supply in Indore. *Indian journal of occupational environmental medicine*, 21(3), 149.
- Lee, D.-J., Choi, J., Chung, J., Lee, Y., and Kim, Y. (2009). Effect of Infiltration Inflow in Dry Weather on Reducing the Pollution Loading of Combined Sewer Overflows. *Environmental Engineering Science*, 26(5), 897–906. <https://doi.org/10.1089/ees.2008.0>.
- Ngaruiya, J. K., and Ngigi, M. M. (2014). Analysis of Sewer Chokes Using GIS: A Case Study Nairobi City Western Region. *International Journal of Engineering Science Invention*, 3(7), 57–65. Retrieved from www.ijesi.org
- Miao, X., Lv, M., Liang, F., Jiao, C., and Wang, L. (2018). Diagnose Urban Drainage Network Problem Based on Internet of Things Big Data. In *MATEC Web of Conferences*, 246, 1–5.
- McDougall, E. D. (2011). Signature below of Paper Supervisor certifies successful completion of oral presentation completion of final written version. MPP Professional Paper, n Partial Fulfillment of the Master of Public Policy Degree Requirements The Hubert H. Humphrey School of Public Affairs The University of Minnesota.
- Wu, H., Huang, G., Meng, Q., Zhang, M., and Li, L. (2016). Deep tunnel for regulating combined sewer overflow pollution flood disaster: A case study in Guangzhou City, China. *Water*, 8(8), 1–14. <https://doi.org/10.3390/w8080329>.
- Eiswirth, M., and Hötzl, H. (1997). The impact of leaking sewers on urban groundwater. *Groundwater in the Urban Environment*, 1, 399–404.
- Mohsin, M., and Anwar, M. (2015). Analysis of Health Risks of Sewerage in Dense Parts of Ahmedpur East, Bahawalpur, Pakistan. *Sindh University Research Journal-SURJ (Science Series)*, 47(2), 209–214.
- Huang, D., Liu, X., Jiang, S., Wang, H., Wang, J., and Zhang, Y. (2018). Current state future perspectives of sewer networks in urban China. *Frontiers of Environmental Science Engineering*, 12(3), 1–16. <https://doi.org/10.1007/s11783-018-1023-1>.
- Mitchell, R. L., Thamsen, P. U., Gunkel, M., and Waschnewski, J. (2017). Investigations into wastewater composition focusing on nonwoven wet wipes. *Czasopismo Techniczne*, 1, 125–135. <https://doi.org/10.4467/2353737xct.17.010.610>
- Ngwenya, S. T. (2013). Technical Constraints To Urban Wastewater Management in Zimbabwe. Master of Science Thesis in Water Resources Engineering Management, University of Zimbabwe, Department of Civil Engineering., 1–92.
- Chinyama, A., and Toma, T. (2013). Understanding the Poor Performance of Urban Sewerage Systems : Urban Planning Design Research (UPDR), 1(3), 43–49.
- Nigussa, F., Mberengwa, I., and Studies, L. D. (2009). Journal of Sustainable Development in Africa. *Journal of Sustainable Development in Africa*, 11(1), 248–267.
- Jena, S. K., and Lohani, T. K. (2014). Integrated study quality analysis of surface drainage sewer water for Bhubaneswar Municipal Corporation , India. *International Journal of Engineering Technical Research (IJETR)*, 2(10), 121–127.
- Rodríguez, J. P., McIntyre, N., Díaz-Granados, M., and Maksimović, Č. (2012). A database model to support proactive management of sediment-related sewer blockages. *Water Research*, 46(15), 4571–4586. <https://doi.org/10.1016/j.watres.2012.06.037>
- Akabogu, U. O. (2018). Hydraulic Performance Vulnerability on Sanitary Sewer Overflow in Southern Pinellas County, FL. A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering Department of Civil Environmental Engineering College of Engineering University of South Florida.
- Lim, S., Norzahari, F., and Lee, H. (2010). A GIS-based analysis of potential sewer choke in Western Sydney Region. *KSCE Journal of Civil Engineering*, 14(4), 601–612. <https://doi.org/10.1007/s12205-010-0601-y>.
- Keener, K. M., Ducoste, J. J., and Holt, L. M. (2008). Properties Influencing Fat, Oil, Grease Deposit Formation. *Water Environment Research*, 80(12), 2241–2246. <https://doi.org/10.2175/193864708x267441>.
- DeSilva, D., Marlow, D., Beale, D., and Marney, D. (2011). Sewer Blockage Management: Australian Perspective. *Journal of Pipeline Systems Engineering Practice*, 2(4), 139–145. [https://doi.org/10.1061/\(asce\)ps.1949-1204.0000084](https://doi.org/10.1061/(asce)ps.1949-1204.0000084).
- Obaid, H. A., Shamsuddin, S., Basim, K. N., and Shreeshivadasan, C. (2014). Modeling Sewer Overflow of a City with a Large Floating Population. *Journal of Waste Water Treatment and Analysis*, 5(2), 1–7. <https://doi.org/10.4172/2157-7587.1000171>.
- Alom, M., and Khan, Z. H. (2014). Environmental Social Impact Due to Urban Drainage Problems in Dhaka City , Bangladesh. *International Journal of Engineering Advanced Technology (IJEAT)*, 3(6), 128–132.
- Subrina, S., and Chowdhury, F. K. (2018). Urban Dynamics: An Undervalued Issue for Water Logging Disaster Risk Management in Case of Dhaka City , Bangladesh. *Procedia Engineering*, 212, 801–808. <https://doi.org/10.1016/j.proeng.2018.01.103>.
- Caradot, N., Granger, D., Chappier, J., Cherqui, F., and Chocat, B. (2011). Urban flood risk assessment using sewer flooding databases. *Water Science Technology*, 64(4), 832–840. <https://doi.org/10.2166/wst.2011.611>.
- Thomson, G. (2008). Investigation of Sewer Blockages Due To Tree Roots. In *71st Annual Water Industry Engineers Operators' Conference*, 71–78.
- Uddin, M., Hasan, K. M., Hossen, S., and Khan, B. (2018). People perceptions about using polythene bag its impact on environment at Mymensingh in Bangladesh. *International Journal of Natural Social Sciences*, 5(3), 37–43.
- Obaid, H. A., Shamsuddin, S., Basim, K. N., and Shreeshivadasan, C. (2014). Modeling Sewer Overflow of a City with a Large Floating Population. *Journal of Waste Water Treatment and Analysis*, 5(2), 1–7. <https://doi.org/10.4172/2157-7587.1000171>.

29. Acharya, L. (2018). Addressing the Social, Cultural, Gender, and Equity Dimensions in WASH (Water, Sanitation, and Health), Orissa, Through Consumer Participation.
30. Punam Rajpurohit, J.D. Raol, Ajay Patel, I. P. (2016). Development of Sewerage system of developing city using Geo-Informatics Technology. *International Journal of Advance Research in Engineering, Science and Ternational Journal of Advance Research in Engineering, Science and Technology*, 4(4), 1–6.
31. Tiwary, A. N. (2014). Issues Challenges in Sustainable Urban Development: A Case Study of Issues Challenges In Sustainable Urban Development: A Case Study of Mirzapur City , U . P ., INDIA. *GE-International Journal of Management Research*, 2, 91–107.
32. Singh, A. L., and Rahman, A. (2001). Malaria related environmental issues in India: a case study of Aligarh city Abha. *GeoJournal*, 53(1), 89–99. <https://doi.org/10.1023/A>.
33. The Capital's sewers overflow with SEWAGE but Delhi's Jal Board says it can't fix it... things are now so bad even cups of TEA smell like POO. MailOnline India, 17 september 2017. https://www.dailymail.co.uk/indiahome/indianews/article-4922754/Delhi-s-sewers-overfflo_w_-_SEWAGE-cups-tea-smell-bad.html.
34. Bhagat, R. B., Guha, M., and Chattopadhyay, A. (2006). Mumbai after 26/7 deluge: Issues concerns in urban planning. *Population Environment*, 27(4), 337–349. <https://doi.org/10.1007/s11111-006-0028-z>.
35. Yedla, S. (2006). Dynamics of environmental problems in Mumbai. *Clean Technologies Environmental Policy*, 8(3), 182–187. <https://doi.org/10.1007/s10098-005-0030-7>.
36. Sewage overflow leaves residents in a cesspool. *Bangalore Mirror*, 29 January 2019. <https://bangaloremirror.indiatimes.com/bangalore/civic/sewage-overflow-leaves-residents-in-a-cesspool/articleshow/67731460.cms>.
37. Sethuram, S. (2014). Case Study: Water Management Issues in Chennai, India. *Universal Journal of Environmental Research and Technology*, 4(6), 299–306.
38. Devi, M. G., and Samad, M. (2008). Wastewater treatment reuse: an Institutional analysis for hyderabad , India. In *International Water Management Institute Conference Papers (No. H041888)*, 513–523.
39. Asoka, G. W., Thuo, A. D., & Bunyasi, M. M. (2013). Effects of population growth on urban infrastructure and services: A case of Eastleigh neighborhood Nairobi, Kenya. *Journal of Anthropology & Archaeology*, 1(1), 41-56.
40. Obaid, H. A., Shamsuddin, S., Basim, K. N., and Shreeshivadasan, C. (2014). Modeling Sewer Overflow of a City with a Large Floating Population. *Journal of Waste Water Treatment and Analysis*, 5(2), 1–7. <https://doi.org/10.4172/2157-7587.1000171>.
41. Overflowing sewage water raises a stink. *Pune Mirror*, 13 February 2019. <https://punemirror.indiatimes.com/pune/pune-speaks/overflowing-sewage-water-raises-a-stink/article show/ 67967015.cms>.
42. The Environmental Status Report, 2015-16. Kolhapur Municipal Corporation.
43. Malaviya, P., and Bhagat, N. (2013). Urban poverty health risk factors: A case study of slum dwellers of Jammu (JandK) India. *International Journal of Development Sustainability*, 2(3), 1645–1670.
44. Robinson, O. F. (2003). *Ancient Rome: city planning and administration*. Routledge.
45. Schütze, M., Campisano, A., Colas, H., Schilling, W., & Vanrolleghem, P. A. (2002). Real-time control of urban wastewater systems-where do we stand today?. In *Global Solutions for Urban Drainage* (pp. 1-17).
46. Broere, W. (2016). Urban underground space: Solving the problems of today's cities. *Tunnelling and Underground Space Technology*, 55, 245-248.
47. Brown, R. R., Keath, N., & Wong, T. H. (2009). Urban water management in cities: historical, current and future regimes. *Water science and technology*, 59(5), 847-855.
48. Delleur, J. W. (2003). The evolution of urban hydrology: past, present, and future. *Journal of hydraulic engineering*, 129(8), 563-573.
49. Mithen, S. (2010). The domestication of water: water management in the ancient world and its prehistoric origins in the Jordan Valley. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 368(1931), 5249-5274.
50. Koutsyiannis, D., Zarkadoulas, N., Angelakis, A. N., & Tchobanoglous, G. (2008). Urban water management in Ancient Greece: Legacies and lessons. *Journal of water resources planning and management*, 134(1), 45-54.
51. Morgan, M. H. (1902). Remarks on the Water Supply of Ancient Rome. In *Transactions and Proceedings of the American Philological Association* (Vol. 33, pp. 30-37). Johns Hopkins University Press, American Philological Association.
52. Angelakis, A. N., & Spyridakis, D. S. (2010). A brief history of water supply and wastewater management in ancient Greece. *Water Science and Technology: Water Supply*, 10(4), 618-628.
53. Tassios, T. P. (2007). Water supply of ancient Greek cities. *Water Science and Technology: Water Supply*, 7(1), 165-172.
54. Hitchner, R. B. (2012). *Roads, integration, connectivity, and economic performance in the Roman Empire* (Vol. 5, p. 222). Chichester, West Sussex: John Wiley & Sons.
55. Du, P., & Zheng, X. (2010). City drainage in ancient China. *Water Science and Technology: Water Supply*, 10(5), 753-764.
56. Sitte, C. (1979). *The art of building cities: city building according to its artistic fundamentals*. Ravenio Books.
57. Qiao, Y. (2017). City, Urban Planning and the Creation of Urban Culture—Taking the Ancient City of Xi'an as an Example. In *MATEC Web of Conferences* (Vol. 100, p. 05072). EDP Sciences.
58. Rico, M. H. (2010). Urban sprawl and municipal budgets in Spain: a dynamic panel data analysis. *Documents de treball IEB*, (43), 1-35.
59. Pendall, R. (1999). Do land-use controls cause sprawl?. *Environment and Planning B: Planning and Design*, 26(4), 555-571.
60. Hortas-Rico, M. (2014). Urban sprawl and municipal budgets in S pain: A dynamic panel data analysis. *Papers in Regional Science*, 93(4), 843-864.
61. Kadioğlu, Y. (2011). Land use major issues of planning in city of Trabzon. *Procedia - Social Behavioral Sciences*, 19, 354–362. <https://doi.org/10.1016/j.sbspro.2011.05.142>.
62. Pawe, C. K., & Saikia, A. (2018). Unplanned urban growth: land use/land cover change in the Guwahati Metropolitan Area, India. *Geografisk Tidsskrift-Danish Journal of Geography*, 118(1), 88-100.
63. Lyndem, F. G., & Imtimakla, B. (2019). The Management of Drainage System in Mokokchung: A Case Study. *International Journal of Research in Engineering, Science and Management*, 2(6), pp 134-138.
64. https://www.who.int/gho/urban_health/situation_trends/urban_population_growth/en/
65. <https://www.cpcb.nic.in>