REFERENCES

Adewumi, J. R., Ilemobade, A. A., & Van Zyl, J. E. (2008). Planning model for wastewater reuse system in South Africa. In *Water Distribution Systems Analysis 2008* (pp. 1-13).

Adewumi, J. R., & Oguntuase, A. M. (2016). Planning of wastewater reuse programme in Nigeria. *Consilience*, (15), 1-33.

Aggarwal, G., Jain, V., Ajmera, P., & Garza-Reyes, J. A. (2022). Modeling and analysing the barriers to the acceptance of energy-efficient appliances using an ISM-DEMATEL approach. *Journal of Modelling in Management*, (ahead-of-print).

Agra (2013). http://cgwb.gov.in/District_Profile/UP/Agra.pdf

Agra (2020). https://nmcg.nic.in/writereaddata/fileupload/3_Final%20Environmental%20and%20Social%20Due%20Diligence%20Report,Agra.pdf

Ahmed, Y. Z., El Gendy, A., & El Haggar, S. (2017). Sustainability assessment of municipal wastewater treatment. *World Academy of Science, Engineering and Technology, International Journal of Environmental, Chemical, Ecological, Geological and Geophysical Engineering*, *11*(2), 120-124.

Ajmi A.M.A.A., Satyanarayana. S.V, Kasa R. R. (2018). Performance Evaluation of MBR Technology Wastewater Treatment Plantat Sohar Port- A Case Study. International Journal of Advanced Research, 6(12), 1277-1281.

Akubue, A. (2000). Appropriate Technology for Socio-economic Development in Third World Countries. The Journal of Technology Studies. 26 (1): 33-43.

Alfonsín, C., Lebrero, R., Estrada, J. M., Muñoz, R., Kraakman, N. B., Feijoo, G., & Moreira, M. T. (2015). Selection of odour removal technologies in wastewater treatment plants: A guideline based on Life Cycle Assessment. *Journal of environmental management*, *149*, 77-84.

Ali, S. M., Hossen, M. A., Mahtab, Z., Kabir, G., & Paul, S. K. (2020). Barriers to Lean Six Sigma Implementation in the Supply Chain: An ISM Model. *Computers & Industrial Engineering*, 106843.

Allahabad (2014). https://www.nmcg.nic.in/writereaddata/fileupload/54_Final%20ESAMP%20Allahabad

Allahabad (2022). http://allahabadmc.gov.in/city_profile.html

Amoah, I. D., Kumari, S., & Bux, F. (2020). Coronaviruses in wastewater processes: Source, fate and potential risks. *Environment international*, 105962.

Angelakis, A. N., & Spyridakis, S. V. (1996). The status of water resources in Minoan times: A preliminary study. In *Diachronic Climatic Impacts on Water Resources: with Emphasis on the Mediterranean Region* (pp. 161-191). Springer Berlin Heidelberg.

Anzaldi, G. (2014). A holistic ICT solution to improve matching between supply and demand over the water supply distribution chain. *Journal of Sustainable Development of Energy, Water and Environment Systems*, *2*(4), 362-375.

Arlosoroff, S. (2007). Wastewater management, treatment, and reuse in Israel. In *Wastewater reuse–risk assessment, decision-making and environmental security* (pp. 55-64). Springer, Dordrecht.

Arroyo, P., & Molinos-Senante, M. (2018). Selecting appropriate wastewater treatment technologies using a choosing-by-advantages approach. *Science of the Total Environment*, *625*, 819-827.

Asano, T. (1998). *Wastewater reclamation and reuse: water quality management library* (Vol. 10). Crc Press.

Asano, T., & Levine, A. D. (1996). Wastewater reclamation, recycling and reuse: past, present, and future. *Water science and technology*, *33*(10-11), 1-14.

Asano, T., Maeda, M., and Takaki, M. (1996). Wastewater reclamation and reuse in Japan: overview and implementation examples. Water Science and Technology, 34(11), 219-226.

Attri, R., Dev, N., & Sharma, V. (2013). Interpretive structural modelling (ISM) approach: an overview. *Research Journal of Management Sciences*, *2319*, 1171.

Baawain, M. S., Al-Mamun, A., Omidvarborna, H., Al-Sabti, A., & Choudri, B. S. (2020). Public perceptions of reusing treated wastewater for urban and industrial applications: challenges and opportunities. *Environment, Development and Sustainability*, *22*(3), 1859-1871.

Babel, M. S., Gupta, A. D., & Nayak, D. K. (2005). A model for optimal allocation of water to competing demands. *Water resources management*, *19*, 693-712.

Banihabib, M. E., Mohammad Rezapour Tabari, M., & Mohammad Rezapour Tabari, M. (2019). Development of a fuzzy multi-objective heuristic model for optimum water allocation. *Water Resources Management*, *33*, 3673-3689.

Bassi, N., Babu, S. S., and Kumar, M. D. (2019). Water accounting for Kanpur metropolitan area in Ganges River basin. In Current Directions in Water Scarcity Research (Vol. 1, pp. 245-274). Elsevier.

BENK, N., Rev, E., & Fonyo, Z. (2000). The use of nonlinear programming to optimal water allocation. *Chemical Engineering Communications*, *178*(1), 67-101.

Berbel, J., Borrego-Marin, M. M., Exposito, A., Giannoccaro, G., Montilla-Lopez, N. M., & Roseta-Palma, C. (2019). Analysis of irrigation water tariffs and taxes in Europe. *Water Policy*, *21*(4), 806-825.

Bergel, A., & Bergel, A. (2022). Generating Visualizations from GitHub. *Agile Visualization with Pharo: Crafting Interactive Visual Support Using Roassal*, 233-261.

Bernat, R. F. (2021). *Managed Aquifer Recharge in Central Arizona: Long-Term Storage Credits, Central Arizona Groundwater Replenishment District and Effluent Reuse* (Doctoral dissertation, The University of Arizona).

Bielsa, J. and Duarte, R., 2001, 'An economic model for water allocation in northeastern Spain', Water Res. Dev. 17(3), 397–410.

BIS (1992). http://cwc.gov.in/sites/default/files/annexure-2.pdf

Biswas, S., Pamucar, D., Kar, S., & Sana, S. S. (2021). A new integrated FUCOM–CODAS framework with fermatean fuzzy information for multi-criteria group decision-making. *Symmetry*, *13*(12), 2430.

Bixio, D., Thoeye, C., De Koning, J., Joksimovic, D., Savic, D., Wintgens, T., & Melin, T. (2006). Wastewater reuse in Europe. *Desalination*, *187*(1-3), 89-101.

Blagojević, A., Kasalica, S., Stević, Ž., Tričković, G., & Pavelkić, V. (2021). Evaluation of safety degree at railway crossings in order to achieve sustainable traffic management: A novel integrated fuzzy MCDM model. *Sustainability*, *13*(2), 832.

Booty, W. G., Wong, I., Lam, D., & Resler, O. (2009). A decision support system for environmental effects monitoring. *Environmental Modelling & Software*, *24*(8), 889-900.

Bottero, M., Comino, E., & Riggio, V. (2011). Application of the analytic hierarchy process and the analytic network process for the assessment of different wastewater treatment systems. *Environmental modelling & software*, *26*(10), 1211-1224.

Bryman, A. (2016). *Social research methods*. Oxford university press.

Burney, S. A., & Ali, S. M. (2019). Fuzzy multi-criteria-based decision support system for supplier selection in textile industry. *IJCSNS*, *19*(1), 239.

Capodaglio, A. G. (2021). Fit-for-purpose urban wastewater reuse: Analysis of issues and available technologies for sustainable multiple barrier approaches. *Critical Reviews in Environmental Science and Technology*, *51*(15), 1619-1666.

Castillo, A., Vall, P., Garrido-Baserba, M., Comas, J., & Poch, M. (2017). Selection of industrial (food, drink and milk sector) wastewater treatment technologies: a multi-criteria assessment. Journal of Cleaner Production, 143, 180-190.

Chamberlain, B. C., Carenini, G., Öberg, G., Poole, D., & Taheri, H. (2013). A decision support system for the design and evaluation of sustainable wastewater solutions. *IEEE Transactions on Computers*, *63*(1), 129-141.

Chang, D., & Ma, Z. (2012). Wastewater reclamation and reuse in Beijing: Influence factors and policy implications. *Desalination*, *297*, 72-78.

Chen, C., Hayward, K., Khan, S. J., Örmeci, B., Pillay, S., Rose, J. B., ... & Zhang, T. (2021). Role of wastewater treatment in COVID-19 control. *Water Quality Research Journal*, *56*(2), 68-82.

Chen, Z., Wu, Q., Wu, G., and Hu, H. Y. (2017). Centralized water reuse system with multiple applications in urban areas: Lessons from China's experience. Resources, Conservation and Recycling, 117, 125-136.

Chu, J., Chen, J., Wang, C., & Fu, P. (2004). Wastewater reuse potential analysis: implications for China's water resources management. *Water Research*, *38*(11), 2746-2756.

Coe, J. J., & Laverty, F. B. (1972). Wastewater Reclamation in Southern California. *Journal of the Irrigation and Drainage Division*, *98*(3), 419-432.

CPCB (2007). http://cpcb.nic.in/GeneralStandards.pdf

CPCB (2011). Central Pollution Control Board. http://mahenvis.nic.in/Pdf/Report/report_nrm2.pdf

CPCB (2013). STP Evaluation Report. http://www.indiaenvironmentportal.org.in/content/381687/performance-evaluation-of-sewage-treatment-plants-in-india-funded-under-national-river-conservation-directorate-nrcd/

CPCB (2021). https://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvMTIyOF8xNjE1MTk2MzIyX21lZGlhcGhvdG85NTY0LnBkZg==

CPHEEO (2013). Manual on Sewerage and Sewage Treatment Systems. http://cpheeo.gov.in/cms/manual-on-sewerage-and-sewage-treatment.php

D'Odorico, P., Chiarelli, D. D., Rosa, L., Bini, A., Zilberman, D., & Rulli, M. C. (2020). The global value of water in agriculture. *Proceedings of the national academy of sciences*, *117*(36), 21985-21993.

Damania, R. (2020). The economics of water scarcity and variability. *Oxford Review of Economic Policy*, *36*(1), 24-44.

Das, S., & Radhakrishnan, K. (2019). Multicriteria decision making model of wastewater reuse: a stakeholders' perspective in the context of India. *Desalination and Water Treatment*, *163*, 17-25.

DeCook KJ (1977) Reuse of wastewater in desert regions.

Delhi (2020). Jain, H., & Dhupper, R. A study of effectiveness of treatment technology of wastewater treatment plants in Delhi and NCR regions.

Desingh, V. (2022). Internet of Things adoption barriers in the Indian healthcare supply chain: An ISM-fuzzy MICMAC approach. *The International journal of health planning and management*, *37*(1), 318-351.

Distefano, T., & Kelly, S. (2017). Are we in deep water? Water scarcity and its limits to economic growth. *Ecological Economics*, *142*, 130-147.

Divakar, L., Babel, M. S., Perret, S. R., & Gupta, A. D. (2013). Optimal water allocation model based on satisfaction and economic benefits. *International Journal of Water*, *7*(4), 363-381.

Dixit, A., Suvadarshini, P., & Pagare, D. V. (2022). Analysis of barriers to organic farming adoption in developing countries: a grey-DEMATEL and ISM approach. *Journal of Agribusiness in Developing and Emerging Economies*, (ahead-of-print).

Duperrin, J. C., & Godet, M. (1973). *Méthode de hiérarchisation des éléments d'un système: essai de prospective du système de l'énergie nucléaire dans son contexte sociétal* (Doctoral dissertation, Centre national de l'entrepreneuriat (CNE); CEA).

Dursun, M. (2016). Evaluation of wastewater treatment alternatives using fuzzy VIKOR method. *Journal of Advanced Management Science Vol*, *4*(4).

Engin, G. O., & Demir, I. (2006). Cost analysis of alternative methods for wastewater handling in small communities. *Journal of Environmental Management*, *79*(4), 357–363.

Erceg, Ž., Starčević, V., Pamučar, D., Mitrović, G., Stević, Ž., & Žikić, S. (2019). A new model for stock management in order to rationalize costs: ABC-FUCOM-interval rough CoCoSo model. *Symmetry, 11*(12), 1527.

Exposito, A., & Berbel, J. (2017). Why is water pricing ineffective for deficit irrigation schemes? A case study in southern Spain. *Water resources management*, *31*, 1047-1059.

Fadda, E., Perboli, G., Rosano, M., Mascolo, J. E., & Masera, D. (2022). A decision support system for supporting strategic production allocation in the automotive industry. *Sustainability*, *14*(4), 2408.

Fane, A. G., Tang, C., & Wang, R. (2011). Membrane technology for water: microfiltration, ultrafiltration, nanofiltration, and reverse osmosis. *Treatise on water science*.

Farris, D. R., & Sage, A. P. (1975). On the use of interpretive structural modeling for worth assessment. *Computers & Electrical Engineering*, *2*(2-3), 149-174.

Finkbeiner, M., Schau, E. M., Lehmann, A., & Traverso, M. (2010). Towards life cycle sustainability assessment. *Sustainability*, *2*(10), 3309-3322.

Fishburn, P. C. (1967). Additive utilities with incomplete product set: Applications to priorities and assignments. Journal of the Operations Research Society of America.

Fito, J., & Van Hulle, S. W. (2021). Wastewater reclamation and reuse potentials in agriculture: towards environmental sustainability. *Environment, Development and Sustainability*, *23*(3), 2949-2972.

Florida (1995). Proposed Revisions to Reuse of Reclaimed Water and Land Application. Florida Department of Environmental Protection, Tallahassee, Florida.

Fonou-Dombeu, J. V. (2019, June). A comparative application of multi-criteria decision making in ontology ranking. In *International Conference on Business Information Systems* (pp. 55-69). Springer, Cham.

Ganguly, K. K., & Das, D. (2020). Analysing the barriers in Indian stone crushing industries: an ISM and fuzzy AHP approach. *International Journal of Applied Management Science*, *12*(3), 242-264.

Garrido-Baserba, M., Reif, R., Hernández, F., & Poch, M. (2012). Implementation of a knowledge-based methodology in a decision support system for the design of suitable wastewater treatment process flow diagrams. *Journal of environmental management*, *112*, 384-391.

Garthe, E. C., & Gilbert, W. C. (1968). Wastewater reused at the Grand Canyon. *Journal (Water Pollution Control Federation)*, 1582-1585.

Ghazy, M. M. E. & El-Senousy, W. M. (2008). Performance evaluation of a waste stabilization pond in a rural area in Egypt. American Journal of Environmental Sciences 4 (4), 316–325.

Gherghel, A., Teodosiu, C., Notarnicola, M., & De Gisi, S. (2020). Sustainable design of large wastewater treatment plants considering multi-criteria decision analysis and stakeholders' involvement. *Journal of environmental management*, *261*, 110158.

Ghernaout, D. (2019). Direct Potable Reuse: The Singapore NEWater Project as a Role Model. *Open Access Library Journal*, *6*(12), 1.

Gikas, G. D., Akratos, C. S. & Tsihrintzis, V. A. (2007). Performance monitoring of a vertical flow constructed wetland treating municipal waste water. Global NEST Journal 9 (3), 277–285.

Giusti, E., & Marsili-Libelli, S. (2015). A fuzzy decision support system for irrigation and water conservation in agriculture. *Environmental Modelling & Software*, *63*, 73-86.

Global Risks report (2019). https://www3.weforum.org/docs/WEF_Global_Risks_Report_2019.pdf

Gomez-López, M. D., Bayo, J., García-Cascales, M. S., &Angosto, J. M. (2009). Decision support in disinfection technologies for treated wastewater reuse. Journal of Cleaner Production, 17(16), 1504-1511.

Goyal, K., & Kumar, A. (2020). A modelling approach to assess wastewater reuse potential for Delhi city. *Water Supply*, *20*(5), 1716-1725.

GRBMP Report (2010). "Sewage Treatment in Class I Towns". https://nmcg.nic.in/writereaddata/fileupload/16_31_003_EQP_SandR_02.pdf

Guttman, Y., Sellinger, A., & Bein, A. (2020). Simultaneous freshwater production and wastewater reclamation in a coastal aquifer at the Dan Plant, Israel. In *Management of aquifer recharge for sustainability* (pp. 321-326). CRC Press.

Haarhoff, J., & Van der Merwe, B. (1996). Twenty-five years of wastewater reclamation in Windhoek, Namibia. *Water Science and Technology*, *33*(10-11), 25-35.

Hamby, D. M. (1994). A review of techniques for parameter sensitivity analysis of environmental models. *Environmental monitoring and assessment*, *32*(2), 135-154.

Hamoda, M. F., Al-Ghusain, I., & Al-Mutairi, N. Z. (2004). Sand filtration of wastewater for tertiary treatment and water reuse. *Desalination*, *164*(3), 203-211.

Han, J., Zhang, X., He, S., & Jia, P. (2020). Can the coronavirus disease be transmitted from food? A review of evidence, risks, policies and knowledge gaps. *Environmental Chemistry Letters*, 1-12.

He, C., Liu, Z., Wu, J., Pan, X., Fang, Z., Li, J., & Bryan, B. A. (2021). Future global urban water scarcity and potential solutions. *Nature communications*, *12*(1), 1-11.

Herbig, F. J. (2019). Talking dirty-effluent and sewage irreverence in South Africa: A conservation crime perspective. *Cogent Social Sciences*, *5*(1), 1701359.

Hermann, B. G., Kroeze, C., & Jawjit, W. (2007). Assessing environmental performance by combining life cycle assessment, multi-criteria analysis and environmental performance indicators. *Journal of cleaner production*, *15*(18), 1787-1796.

Hertel, T., & Liu, J. (2019). Implications of water scarcity for economic growth. In *Economy-Wide Modeling of Water at Regional and Global Scales* (pp. 11-35). Springer, Singapore.

Hochstrat, R., Wintgens, T., Melin, T., & Jeffrey, P. (2006). Assessing the European wastewater reclamation and reuse potential—a scenario analysis. *Desalination*, *188*(1-3), 1-8.

Hou, C., Wen, Y., Liu, X., & Dong, M. (2021). Impacts of regional water shortage information disclosure on public acceptance of recycled water—evidence from China's urban residents. *Journal of Cleaner Production*, *278*, 123965.

Idelovitch, E., Terkeltoub, R., &Michail, M. (1980). The role of groundwater recharge in wastewater reuse: Israel's Dan Region Project. *Journal-American Water Works Association*, *72*(7), 391-400.

Ilangkumaran, M., Sasirekha, V., Anojkumar, L., Sakthivel, G., Raja, M. B., Raj, T. R. S., ... & Kumar, S. P. (2013). Optimization of wastewater treatment technology selection using hybrid MCDM. *Management of Environmental Quality: An International Journal*.

IMF (2021). World Economic Outlook Database April 2021. https://www.imf.org/en/Publications/WEO/weo-database/2021/April

IPCC Report (2014). ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-PartA_FINAL.pdf

IRWM (2005). http://www.iricen.gov.in/iricen/books_jquery/water_supply.pdf

IS Code 1172 (1993). https://civilplanets.com/wp-content/uploads/2020/04/1172.pdf

Izady, A., Khorshidi, M. S., Nikoo, M. R., Al-Maktoumi, A., Chen, M., Al-Mamari, H., & Gandomi, A. H. (2021). Optimal water allocation from subsurface dams: a risk-based optimization approach. *Water Resources Management*, *35*, 4275-4290.

Jaipur (2015). https://scbp.niua.org/sites/default/files/Jaipur_1_0.pdf

Japan Sewage Works Association (1993) Sewerage in Japan -Iu Status and Plans. Tokyo, Japan

Lucknow (2015). https://lmc.up.nic.in/pdf/Final%20CDP%20-%20Volume%20I.pdf

Jödicke, G., Fischer, U., & Hungerbühler, K. (2001). Wastewater reuse: a new approach to screen for designs with minimal total costs. *Computers & Chemical Engineering*, *25*(2-3), 203-215.

P., Karmakar, S., & Asolekar, S. R. (2012). Selection of an appropriate wastewater treatment technology: A scenario-based multiple-attribute decision-making approach. *Journal of environmental management*, *113*, 158-169.

Kalbar, P. P., Karmakar, S., & Asolekar, S. R. (2013). The influence of expert opinions on the selection of wastewater treatment alternatives: A group decision-making approach. *Journal of environmental management*, *128*, 844-851.

Kanpur (2013). https://kmc.up.nic.in/smartcity/Kanpur%20CSP_%20Final_Report_%202013_RS_ASCI.pdf

Kanpur (2006). http://www.indiaenvironmentportal.org.in/files/CDP_Kanpur.pdf

Khorasani, M., Abdou, M., & Hernández Fernández, J. (2022). Streamlit Basics. In *Web Application Development with Streamlit: Develop and Deploy Secure and Scalable Web Applications to the Cloud Using a Pure Python Framework* (pp. 31-62). Berkeley, CA: Apress.

Kraujalienė, L. (2019). Comparative analysis of multicriteria decision-making methods evaluating the efficiency of technology transfer. *Business, Management and Education*, *17*(1), 72-93.

Kukar, M., Vračar, P., Košir, D., Pevec, D., & Bosnić, Z. (2019). AgroDSS: A decision support system for agriculture and farming. *Computers and Electronics in Agriculture*, *161*, 260-271.

Kumar, P., Ahmed, F., Singh, R. K., & Sinha, P. (2018). Determination of hierarchical relationships among sustainable development goals using interpretive structural modeling. *Environment, Development and Sustainability*, *20*(5), 2119-2137.

Lahlou, F. Z., Mackey, H. R., & Al-Ansari, T. (2021). Wastewater reuse for livestock feed irrigation as a sustainable practice: A socio-environmental-economic review. *Journal of Cleaner Production*, 126331.

Lahnsteiner, J., Van Rensburg, P., & Esterhuizen, J. (2018). Direct potable reuse–a feasible water management option. *Journal of Water Reuse and Desalination*, *8*(1), 14-28.

Lavrnić, S., Zapater-Pereyra, M., & Mancini, M. L. (2017). Water scarcity and wastewater reuse standards in Southern Europe: focus on agriculture. *Water, Air, & Soil Pollution*, *228*(7), 1-12.

Lazarova, V., Hills, S., & Birks, R. (2003). Using recycled water for non-potable, urban uses: a review with particular reference to toilet flushing. *Water Science and Technology: Water Supply*, *3*(4), 69-77.

Lee, H. C., & Chang, C. T. (2018). Comparative analysis of MCDM methods for ranking renewable energy sources in Taiwan. *Renewable and Sustainable Energy Reviews*, *92*, 883-896.

Liao, Z., Chen, Z., Xu, A., Gao, Q., Song, K., Liu, J., & Hu, H. Y. (2021). Wastewater treatment and reuse situations and influential factors in major Asian countries. *Journal of Environmental Management*, *282*, 111976.

Ling, J., Germain, E., Murphy, R., & Saroj, D. (2021). Designing a Sustainability Assessment Framework for Selecting Sustainable Wastewater Treatment Technologies in Corporate Asset Decisions. *Sustainability*, *13*(7), 3831.

Ling, Y., Xu, S. B., Lin, Y. X., Tian, D., Zhu, Z. Q., Dai, F. H., ... & Lu, H. Z. (2020). Persistence and clearance of viral RNA in 2019 novel coronavirus disease rehabilitation patients. *Chinese medical journal*.

Lizot, M., Goffi, A. S., Thesari, S. S., Trojan, F., Afonso, P. S., & Ferreira, P. F. (2021). Multi-criteria methodology for selection of wastewater treatment systems with economic, social, technical and environmental aspects. *Environment, Development and Sustainability, 23*(7), 9827-9851.

Lyu, S., Chen, W., Zhang, W., Fan, Y., & Jiao, W. (2016). Wastewater reclamation and reuse in China: opportunities and challenges. *Journal of Environmental Sciences*, *39*, 86-96.

Maldonado-Devis, M., & Almenar-Llongo, V. (2021). A Panel Data Estimation of Domestic Water Demand with IRT Tariff Structure: The Case of the City of Valencia (Spain). *Sustainability*, *13*(3), 1414.

Mandal, A., & Deshmukh, S. G. (1994). Vendor selection using interpretive structural modelling (ISM). *International journal of operations & production management*.

Mannina, G., Rebouças, T. F., Cosenza, A., Sànchez-Marrè, M., & Gibert, K. (2019). Decision support systems (DSS) for wastewater treatment plants–a review of the state of the art. *Bioresource Technology*, *290*, 121814.

Marcher, C., Giusti, A., Schimanski, C. P., & Matt, D. T. (2019). Application of decision support systems for advanced equipment selection in construction. In Cooperative Design, Visualization, and Engineering: 16th International Conference, CDVE 2019, Mallorca, Spain, October 6–9, 2019, Proceedings 16 (pp. 229-235). Springer International Publishing.

Marleni, N. N. N., & Raspati, G. S. (2020). A Critical Review of Wastewater Resource Recovery Implementation in Indonesia. In *Journal of the Civil Engineering Forum* (Vol. 6, No. 1, pp. 89-102).

Maryam, B., & Büyükgüngör, H. (2019). Wastewater reclamation and reuse trends in Turkey: Opportunities and challenges. *Journal of Water Process Engineering*, *30*, 100501.

MATHUR, O. P., & THAKUR, S. (2003). URBAN WATER PRICING.

Maurya, S. P., Ohri, A., Singh, P. K., & Debnath, A. (2018). Development of a decision making tool for selection of waste water treatment technology based on urban water reuse. *International Journal of Civil Engineering and Technology*, *9*(2), 497-506.

McCosh, A. M., & Morton, M. S. S. (1978). *Management decision support systems*. Springer.

Metcalf, L., Eddy, H. P., & Tchobanoglous, G. (1991). *Wastewater engineering: treatment, disposal, and reuse* (Vol. 4). New York: McGraw-Hill.

Mercado, J. M. R., Kawamura, A., & Amaguchi, H. (2020). Interrelationships of the barriers to integrated flood risk management adaptation in Metro Manila, Philippines. *International Journal of Disaster Risk Reduction*, *49*, 101683.

Mijajlović, M., Puška, A., Stević, Ž., Marinković, D., Doljanica, D., Jovanović, S. V., ... & Beširović, J. (2020). Determining the competitiveness of spa-centers in order to achieve sustainability using a fuzzy multi-criteria decision-making model. *Sustainability*, *12*(20), 8584.

MoEF, (2019). Ministry of Environment and Forests, &thDecember, 2019. http://www.cea.nic.in/reports/others/thermal/umpp/fgd_newnorms.pdf

Molinos-Senante, M., Gémar, G., Gómez, T., Caballero, R., & Sala-Garrido, R. (2016). Eco-efficiency assessment of wastewater treatment plants using a weighted Russell directional distance model. *Journal of Cleaner Production*, *137*, 1066-1075.

Monney, I., Donkor, E. A., & Buamah, R. (2020). Clean vehicles, polluted waters: empirical estimates of water consumption and pollution loads of the carwash industry. *Heliyon*, *6*(5), e03952.

MoUD (2010). https://mohua.gov.in/upload/uploadfiles/files/TERI_UC_Report26.pdf

MoWRRDGR (2020). https://pib.gov.in/PressReleasePage.aspx?PRID=1606099

Mu'azu, N. D., Abubakar, I. R., & Blaisi, N. I. (2020). Public acceptability of treated wastewater reuse in Saudi Arabia: implications for water management policy. *Science of the Total Environment*, *721*, 137659.

Muga, H. E., & Mihelcic, J. R. (2008). Sustainability of wastewater treatment technologies. *Journal of environmental management*, *88*(3), 437-447.

Munaiah, N., Kroh, S., Cabrey, C., & Nagappan, M. (2017). Curating github for engineered software projects. *Empirical Software Engineering*, *22*, 3219-3253.

Naik, M. G., Kishore, R., & Dehmourdi, S. A. M. (2021). Modeling a multi-criteria decision support system for prequalification assessment of construction contractors using CRITIC and EDAS models. *Operational Research in Engineering Sciences: Theory and Applications*, *4*(2), 79-101.

Nauges, C., & Whittington, D. (2010). Estimation of water demand in developing countries: An overview. *The World Bank Research Observer*, *25*(2), 263-294.

Navarro-Hellín, H., Martinez-del-Rincon, J., Domingo-Miguel, R., Soto-Valles, F., & Torres-Sánchez, R. (2016). A decision support system for managing irrigation in agriculture. *Computers and Electronics in Agriculture*, *124*, 121-131.

NBC (2016). https://cgwa-noc.gov.in/landingpage/Guidlines/NBC2016WatRequirement.pdf

Neczaj, E., & Grosser, A. (2018). Circular economy in wastewater treatment plant–challenges and barriers. In *Multidisciplinary Digital Publishing Institute Proceedings* (Vol. 2, No. 11, p. 614).

Nemerow, N. L., Agardy, F. J., Sullivan, P. J., & Salvato, J. A. (2009). *Environmental engineering: water, wastewater, soil and groundwater treatment and remediation*. John Wiley & Sons.

Nhapi, I., Dalu, J., Ndamba, J., Siebel, M. A. & Gijzen, H. J. (2003). An evaluation of duckweed-based pond systems as an alternative option for decentralized treatment and reuse of wastewater in Zimbabwe. Water Science & Technology. 48 (2), 323–330.

NIPFP (2003). https://www.nipfp.org.in/media/medialibrary/2013/08/urban_water_pricing.pdf

Okun, D. A. (2002). Water reuse introduces the need to integrate both water supply and wastewater management at local and regulatory levels. *Water Science and Technology*, *46*(6-7), 273-280.

Olivieri, A. W., Pecson, B., Crook, J., & Hultquist, R. (2020). California water reuse—Past, present and future perspectives. In *Advances in Chemical Pollution, Environmental Management and Protection* (Vol. 5, pp. 65-111). Elsevier.

Otterpohl, R., Abold, A. and Oldenburg, M. (1998). Differentiating Management of Water Resources and Waste in Urban Areas – Proceedings of the Internet Conference on Integrated Bio-Systems, Lübeck, Germany: Internet Site http://www.soc.titech.ac.jp/uem/waste/oldenburg.html

Pamučar, D., Stević, Ž., & Sremac, S. (2018). A new model for determining weight coefficients of criteria in mcdm models: Full consistency method (fucom). *Symmetry*, *10*(9), 393.

Paredes, J., Andreu, J., & Solera, A. (2010). A decision support system for water quality issues in the Manzanares River (Madrid, Spain). *Science of the Total Environment*, *408*(12), 2576-2589.

Parida, V. K., Sikarwar, D., Majumder, A., & Gupta, A. K. (2022). An assessment of hospital wastewater and biomedical waste generation, existing legislations, risk assessment, treatment processes, and scenario during COVID-19. *Journal of Environmental Management*, 114609.

Park, J. S. and Dho, H. (2018). Analysis Of A2O Process In Wastewater Using Statistical Techniques. International Journal of Civil Engineering and Technology (IJCIET), 9(8), 120–129.

Parween, M., Ramanathan, A. L., & Raju, N. J. (2017). Waste water management and water quality of river Yamuna in the megacity of Delhi. *International Journal of Environmental Science and Technology*, *14*, 2109-2124.

Pearce, F. (2018). *When the rivers run dry, fully revised and updated edition: water-the defining crisis of the twenty-first century*. Beacon Press.

Peavy, H. S., Rowe, D. R., & Tchobanoglous, G. (1985). *Environmental engineering* (Vol. 2985). New York: McGraw-Hill.

Pei, W. W., Xie, X., Ong, P., Trueman, B. F., McVicar, M. A., Walsh, M. E., & Gagnon, G. A. (2013). Water reclamation and reuse. *Water Environment Research*, *85*(10), 1308-1321.

Pianosi, F., Beven, K., Freer, J., Hall, J. W., Rougier, J., Stephenson, D. B., & Wagener, T. (2016). Sensitivity analysis of environmental models: A systematic review with practical workflow. *Environmental Modelling & Software*, *79*, 214-232.

Pizzichini and Russo, C. (2001). Water Purification-Desalination with Membrane Technology Supplied with Renewable Energy.

Plakas, K. V., Georgiadis, A. A., & Karabelas, A. J. (2016). Sustainability assessment of tertiary wastewater treatment technologies: a multi-criteria analysis. *Water Science and Technology*, *73*(7), 1532-1540.

Pujotomo, D., Sriyanto, & Widyawati, L. (2018, June). Analysis of the barriers of cleaner production implementation in Kampung Batik Semarang using interpretive structural modeling approach. In *AIP Conference Proceedings* (Vol. 1977, No. 1, p. 020025). AIP Publishing LLC.

Ramachandra, T. V., Bhat, S., and Shivamurthy, V. (2017). Constructed Wetlands for Tertiary treatment of Wastewater. ENVIS Technical Report 124, Energy and Wetlands Research Group, CES, Indian Institute of Science, Bangalore 560012.

Reca, J., Roldan, J., Alcaide, M., and Camacho, E., 2001, ‘Optimization model for water allocation in deficit irrigation system: I. Description of the model’, Agric. Water Manage. 48(2), 103– 116.

Renwick, M. E., & Archibald, S. O. (2018). Demand side management policies for residential water use: who bears the conservation burden?. In *Economics of Water Resources* (pp. 373-389). Routledge.

Reyes, M. F. (2022). Analysis of Water Supply and Demand Management Strategies in Overcoming Water Scarcity in Santa Cruz. *Water, Food and Human Health in the Galapagos, Ecuador:" A Little World Within Itself"*, 9.

Roccaro, P., & Verlicchi, P. (2018). Wastewater and reuse. *Current Opinion in Environmental Science & Health*, *2*.

Roozbahani, R., Schreider, S., & Abbasi, B. (2015). Optimal water allocation through a multi-objective compromise between environmental, social, and economic preferences. *Environmental Modelling & Software*, *64*, 18-30.
Sadr, S. M., Saroj, D. P., Mierzwa, J. C., McGrane, S. J., Skouteris, G., Farmani, R., ... & Ouki, S. K. (2018). A multi expert decision support tool for the evaluation of advanced wastewater treatment trains: A novel approach to improve urban sustainability. *Environmental science & policy*, *90*, 1-10.
Sah, R. D. (2004). Oxidation ditch management needs and lessons learned: A case study of Bagmati area sewerage construction project, Nepal. Proceedings of the 10th National Symposium on Individual and Small Community Sewage Systems – On-Site Wastewater Treatment, American Society of Agricultural and Biological Engineers, pp. 498–505.
Saisana, M., & Saltelli, A. (2008). Expert panel opinion and global sensitivity analysis for composite indicators. In *Computational methods in transport: Verification and validation* (pp. 251-275). Springer Berlin Heidelberg.
Salama, Y., Chennaoui, M., Sylla, A., Mountadar, M., Rihani, M., & Assobhei, O. (2014). Review of wastewater treatment and reuse in the Morocco: aspects and perspectives. *Europ Cent Res Train Develop UK*, *2*(1), 9-25.
Sandbhor, S., & Botre, R. (2014). Applying total interpretive structural modeling to study factors affecting construction labour productivity. *Australasian Journal of Construction Economics and Building, The*, *14*(1), 20.
Schmidt, C. J., Kugelman, I., & Clements III, E. V. (1975). Municipal wastewater reuse in the US. *Journal (Water Pollution Control Federation)*, 2229-2245.
Schumacher, E.F. (1973). Small Is Beautiful: Economics as if People Mattered. Harper and Row, New York.
Sgroi, M., Vagliasindi, F. G., & Roccaro, P. (2018). Feasibility, sustainability and circular economy concepts in water reuse. *Current Opinion in Environmental Science & Health*, *2*, 20-25.
Sharma C. and Singh S.K. (2013). Performance Evaluation Of Sewage Treatment Plant Based On Advanced Aerobic Biological Filtration And Oxygenated Reactor (BIOFOR) Technology- A Case Study Of Capital City -Delhi, India. International Journal of Engineering Science and Innovative Technology, 2(4), 435-442.
Sharma, A., & Rawal, N. (2021). The selection of wastewater treatment units based on analytical hierarchical process. In *Recent Trends in Civil Engineering* (pp. 1003-1019). Springer, Singapore.
Shen, L., Song, X., Wu, Y., Liao, S., Zhang, X., (2016). Interpretive Structural Modeling based factor analysis on the implementation of Emission Trading System in the Chinese building sector. Journal of Cleaner Production. 127, 214-227.

Shukla, S., Maheshwari, A., & Johri, P. (2021, December). Comparative analysis of ml algorithms & stream lit web application. In *2021 3rd International Conference on Advances in Computing, Communication Control and Networking (ICAC3N)* (pp. 175-180). IEEE.

Shuval, H. I. (1977). Direct and indirect wastewater reuse for municipal purposes. *Ambio*, 63-65.

Sikosana, M. L., Sikhwivhilu, K., Moutloali, R., & Madyira, D. M. (2019). Municipal wastewater treatment technologies: A review. *Procedia Manufacturing*, *35*, 1018-1024.

Singh, A., Sawant, M., Kamble, S. J., Herlekar, M., Starkl, M., Aymerich, E., & Kazmi, A. (2019). Performance evaluation of a decentralized wastewater treatment system in India. *Environmental Science and Pollution Research*, 1-17.

Singh, S., Samaddar, A. B., & Srivastava, R. K. (2010). Sustainable drinking water management strategy using GIS: case study of Allahabad City (India). Management of Environmental Quality: An International Journal.

Smol, M., & Koneczna, R. (2021). Economic indicators in water and wastewater sector contributing to a circular economy (CE). *Resources*, *10*(12), 129.

Smith, E. D., Sweazy, R. M., Whetstone, G. A., & Ramsey, R. H. (1979). A study of the reuse of reused water. *Groundwater*, *17*(4), 366-374.

Smith, K., Liu, S., Hu, H. Y., Dong, X., & Wen, X. (2018). Water and energy recovery: The future of wastewater in China. *Science of the Total Environment*, *637*, 14

Sobotka, A., & Sagan, J. (2021). Decision support system in management of concrete demolition waste. *Automation in Construction*, *128*, 103734.

Soto Rios, P. C., Deen, T. A., Nagabhatla, N., & Ayala, G. (2018). Explaining water pricing through a water security lens. *Water*, *10*(9), 1173.

Srivastava, R. R., & Singh, P. K. (2021). Reuse-focused selection of appropriate technologies for municipal wastewater treatment: a multi-criteria approach. *International Journal of Environmental Science and Technology*, 1-18.

Srivastava, R. R., & Singh, P. K. (2022). Selection of factors affecting integrated municipal wastewater treatment and reuse network: An interpretive structural modelling (ISM) approach. *Environment, Development and Sustainability*, 1-25.

State of California (1994). Notice of Availability of Changes to Proposed Regulations Regarding Wastewater Reclamation Criteria. California Department of Health Services, Sacramento, California.

Stefan, W., Dumencu, G., & Wang, Y. (2017). Decentralized Wastewater Treatment and Reuse System in Rural India Case Study. In *2017 ASABE Annual International Meeting* (p. 1). American Society of Agricultural and Biological Engineers.

STP
(2021) https://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvMTIyOF8xNjE1MTk2MzIyX21lZGlhcGhvdG85NTY0LnBkZg==
Stević, Ž., Tanackov, I., & Subotić, M. (2020). Evaluation of road sections in order assessment of traffic risk: Integrated FUCOM-MARCOS model. In *1st International Conference on Challenges and New Solutions in Industrial Engineering and Management and Accounting* (Vol. 1, p. 14).
Stevic, Ž., & Brković, N. (2020). A novel integrated FUCOM-MARCOS model for evaluation of human resources in a transport company. *Logistics*, *4*(1), 4.
Surampalli, R. Y., Tyagi, R. D. & Scheible, O. K. (2000). Sequencing batch reactors – technology and performance evaluation. Journal of Environmental Systems 28 (1), 25–43.
Syutsubo, K., Onodera, T., Choeisai, P., Khodphuvieng, J., Prammanee, P., Yoochatchaval, W., ... & Kubota, K. (2013). Development of appropriate technology for treatment of molasses-based wastewater. *Journal of Environmental Science and Health, Part A*, *48*(9), 1114-1121.
Takeuchi, H., & Tanaka, H. (2020). Water reuse and recycling in Japan—History, current situation, and future perspectives. *Water Cycle*, *1*, 1-12.
Tamanna, M., Jalil, M. A., Islam, S., & Anam, S. (2011). Greywater Generation and Quality Measurement at a Specific Site in Dhaka City. *Undergraduate thesis, Bangladesh University of Engineering and Technology*.
Tan, T. (2018). *Correlations between BIM implementation barriers in China's prefabricated buildings: an interpretive structural modeling approach* (Doctoral dissertation, University College London).
Tan, T., Chen, K., Xue, F., & Lu, W. (2019). Barriers to Building Information Modeling (BIM) implementation in China's prefabricated construction: An interpretive structural modeling (ISM) approach. *Journal of Cleaner Production*, *219*, 949-959.
Tang, V., Siu, P. K. Y., Choy, K. L., Lam, H. Y., Ho, G. T. S., Lee, C. K. M., & Tsang, Y. P. (2019). An adaptive clinical decision support system for serving the elderly with chronic diseases in healthcare industry. *Expert Systems*, *36*(2), e12369.
Tare and Bose (2009). Compendium of Sewage treatment Technologies; https://nmcg.nic.in/writereaddata/fileupload/15_Technologies%20Involved.pdf
Thakkar, J., Deshmukh, S. G., Gupta, A. D., & Shankar, R. (2005, January). Selection of third-party logistics (3PL): a hybrid approach using interpretive structural modeling (ISM) and analytic network process (ANP). In *Supply Chain Forum: An International Journal* (Vol. 6, No. 1, pp. 32-46). Taylor & Francis.

Thalla, A. K., Devatha, C. P., Anagh, K., and Sony, E. (2019). Performance evaluation of horizontal and vertical flow constructed wetlands as tertiary treatment option for secondary effluents. Applied Water Science, 9(6), 147.

Ullah, A., Hussain, S., Wasim, A., & Jahanzaib, M. (2020). Development of a decision support system for the selection of wastewater treatment technologies. *Science of The Total Environment*, *731*, 139158.

UNGWR (2017). https://unesdoc.unesco.org/ark:/48223/pf0000247153

USEPA (2012). https://www.epa.gov/sites/production/files/2019-08/documents/2012-guidelines-water-reuse.pdf

USEPA (2013). https://www.epa.gov/sites/production/files/2019-02/documents/emerging-tech-wastewater-treatment-management.pdf

Üstün, G. E., Solmaz, S. K. A., Çiner, F., & Başkaya, H. S. (2011). Tertiary treatment of a secondary effluent by the coupling of coagulation–flocculation–disinfection for irrigation reuse. *Desalination*, *277*(1-3), 207-212.

van Zyl, A., & Jooste, J. L. (2022). Retaining and recycling water to address water scarcity in the City of Cape Town. *Development Southern Africa*, *39*(2), 108-125.

Varanasi (2015). http://nnvns.org/data/Final%20CDP%20Varanasi.pdf

Varanasi (2006). file:///D:/Phd/New%20folder%20(3)/reuse/varanasi%20city%20development%20plan.pdf

Vashi, N. V., Shah, N. C., and Desai, K. R. (2019). Performance of UASB Post Treatment Technologies for Sewage Treatment in Surat City. Oriental Journal of Chemistry, 35(4), 1352-1359.

Vymazal, J. (2011). Long-term performance of constructed wetlands with horizontal sub-surface flow: Ten case studies from theCzech Republic. Ecological Engineering 37 (1), 54–63.

Wang, G., Wang, Y., & Zhao, T. (2008). Analysis of interactions among the barriers to energy saving in China. *Energy Policy*, *36*(6), 1879-1889.

Warfield, J.W. (1974). Developing interconnected matrices in structural modeling. IEEE Transactions on Systems, Man and Cybernetics; 4(1):51–81.

Wastiels, L., & Decuypere, R. (2019, August). Identification and comparison of LCA-BIM integration strategies. In *IOP Conference Series: Earth and Environmental Science* (Vol. 323, No. 1, p. 012101). IOP Publishing.

Wei L (2009) A Electronic Commerce risk evaluation method based on AHP and GRA. In: 2009 First International Conference on Information Science and Engineering. IEEE, pp 2791–2793

Wei, C., Wei, J., Kong, Q., Fan, D., Qiu, G., Feng, C., ... & Wei, C. (2020). Selection of optimum biological treatment for coking wastewater using analytic hierarchy process. *Science of The Total Environment*, *742*, 140400.

Whittington, D. (2002). Municipal water pricing: Getting started on tariff reforms and subsidies in South Asia. *National Institute of Public Finance and Policy, New Delhi. mimeo*.

WHO. (2017). Potable reuse: Guidance for producing safe drinking-water. http://apps.who.int/iris/bitstream/10665/258715/1/9789241512770-eng.pdf?ua=1

Winslow, C. E. A. (1923). *The evolution and significance of the modern public health campaign* (Vol. 6). Elliots Books.

World Bank Group (1998). https://documents1.worldbank.org/curated/en/758631468314701365/pdf/multi0page.pdf

Wu, W. W. (2008). Choosing knowledge management strategies by using a combined ANP and DEMATEL approach. *Expert Systems with Applications*, *35*(3), 828-835.

WWAP (United Nations World Water Assessment Programme) (2017). *The United Nations World Water Development Report 2017. Wastewater: The Untapped Resource*. Paris. ISBN 978-92-3-100201-4.

Xu, X., & Zou, P. X. (2020). Analysis of factors and their hierarchical relationships influencing building energy performance using interpretive structural modelling (ISM) approach. *Journal of Cleaner Production*, *272*, 122650.

Yang, H., & Abbaspour, K. C. (2007). Analysis of wastewater reuse potential in Beijing. *Desalination*, *212*(1-3), 238-250.

Yang, W. (2020). Ingenious Solution for the Rank Reversal Problem of TOPSIS Method. *Mathematical Problems in Engineering*, *2020*.

Yuan, M. H., Chiueh, P. T., & Lo, S. L. (2021). Measuring urban food-energy-water nexus sustainability: Finding solutions for cities. *Science of The Total Environment*, *752*, 141954.

Yuan, M., Chen, X., Liu, G., & Ren, H. (2022). Coordinated allocation of water resources and wastewater emission permits based on multi-objective optimization model: From the perspective of conflict between equity and economic benefits. *Journal of Cleaner Production*, *372*, 133733.

Zabala, J. A., Dolores de Miguel, M., Martínez-Paz, J. M., & Alcon, F. (2019). Perception welfare assessment of water reuse in competitive categories. *Water Supply*, *19*(5), 1525-1532.

Zaneti, R., Etchepare, R., & Rubio, J. (2012). More environmentally friendly vehicle washes: water reclamation. *Journal of Cleaner Production*, *37*, 115-124.

Zavadskas, E. K., Vainiūnas, P., Turskis, Z., & Tamošaitienė, J. (2012). Multiple criteria decision support system for assessment of projects managers in construction. *International journal of information technology & decision making*, *11*(02), 501-520.

Zeng, G., Jiang, R., Huang, G., Xu, M., & Li, J. (2007). Optimization of wastewater treatment alternative selection by hierarchy grey relational analysis. *Journal of environmental management*, *82*(2), 250-259.

Zhang, X., & Liu, Y. (2020). Reverse osmosis concentrate: an essential link for closing loop of municipal wastewater reclamation towards urban sustainability. *Chemical Engineering Journal*, 127773.

Zhang, Y., Lu, Y., Zhou, Q., & Wu, F. (2020). Optimal water allocation scheme based on trade-offs between economic and ecological water demands in the Heihe River Basin of Northwest China. *Science of The Total Environment*, *703*, 134958.

Zhang, Y., Zhang, C., Qiu, Y., Li, B., Pang, H., Xue, Y., ... & Huang, X. (2020). Wastewater treatment technology selection under various influent conditions and effluent standards based on life cycle assessment. *Resources, Conservation and Recycling*, *154*, 104562.

Zhao, S., Liu, W., Zhu, M., Ma, Y., & Li, Z. (2021). A priority-based multi-objective framework for water resources diversion and allocation in the middle route of the South-to-North Water Diversion Project. *Socio-Economic Planning Sciences*, *78*, 101085.

Zheng, C., Zhao, L., Zhou, X., Fu, Z., & Li, A. (2013). Treatment technologies for organic wastewater. *Water treatment*, *11*, 250-286.

Zhou, G., Gu, Y., Yuan, H., Gong, Y., & Wu, Y. (2020). Selecting sustainable technologies for disposal of municipal sewage sludge using a multi-criterion decision-making method: A case study from China. *Resources, Conservation and Recycling*, *161*, 104881.

LIST OF PUBLICATIONS BASED ON THE PRESENT STUDY

1. Srivastava, R. R., & Singh, P. K. (2022). Reuse-focused selection of appropriate technologies for municipal wastewater treatment: a multi-criteria approach. *International Journal of Environmental Science and Technology*, *19*(12), 12505-12522.

2. Srivastava, R. R., & Singh, P. K. (2022). Selection of factors affecting integrated municipal wastewater treatment and reuse network: An interpretive structural modelling (ISM) approach. *Environment, Development and Sustainability*, 1-25.

LIST OF BOOK CHAPTER

1. A book chapter on "A multi-criteria approach to appropriate treatment technology selection for water reclamation" accepted for publication in the Handbook of Environmental Engineering by Springer Nature.

Annexure 1

Program codes for DSS_IWWM

```
import
streamlit
as st
import pandas as pd
from PIL import Image
import numpy as np
st.set_page_config(layout="wide")
content = pd.read_csv("./dataframes/content_tech.csv")
st.subheader("Welcome to Decision Support System for Appropriate Wastewater Treatment Technology Selection")
img = Image.open("./images/home.png")
st.image(img)
st.write("Water scarcity has been regarded as a global risk with potentially devastating impacts. Climate change, exploding population, and industrialization are the main drivers behind such an imbalance in safe water availability. India is predicted to get most severely impacted by water scarcity owing to its high urban population. To tackle this imbalance between water demand and its safe availability, wastewater reclamation can be seen as a potential source of water, which if treated, can boost water availability as well as prevent environmental degradation. When treated wastewater is reutilized after treatment, it is referred to as wastewater reclamation. Municipal wastewater is considered a limitless source of water due to its high biodegradability and low toxicity profile. Globally, 80% of the wastewater generated is disposed of in the environment, causing hazardous impacts on the receiving water bodies. The burden of environmental degradation and water scarcity can be significantly reduced by utilizing treated wastewater as a water source. Several industrial and domestic activities do not require reliance on high-quality potable water but can utilize reclaimed water to obscure the issue of water scarcity. By observing the trend of water demand and the definition of relevant quality criteria, raw wastewater can be treated to produce a secondary water source.")
st.write("\n")
st.write("A technology that satisfies the demand of users with optimum resource utilization is appropriate. The concept of appropriate technology was given by economist Schumacher in his book “Small is Beautiful”. Appropriate technology has the potential to serve the desired purpose with no social, economic, or environmental ramifications. It is people-centric, local condition-specific, cost-efficient, and sustainable in nature.")
st.subheader("Secondary Treatment Technologies")
```

```
st.write("These sewage treatment technologies depend on biological processes for the decomposition of suspended and dissolved organic matter present in wastewater. They employ cultured micro-organisms to decompose organic matter and aid reproduction. Therefore, more populations of microbes become available for carrying out the biological decomposition of organic matter and obtaining treated wastewater. The oxygen required by microorganisms to carry out this process is referred to as Biochemical Oxygen Demand (BOD). These treatment processes can take place in the presence or absence of oxygen, known as, aerobic decomposition and anaerobic decomposition respectively. The associated microorganisms are also categorized as aerobic and anaerobic bacteria respectively. The aerobic process is suitable for the treatment of low strength wastewater (bCOD<1000mg/l) while the anaerobic process is considered suitable for high strength wastewater (bCOD>4000 mg/l). Various treatment technologies considered in this tool, are discussed in this section.")
data = content[content["Type"] == "Secondary Treatment Technologies"]
for i in data.index:
name = data.loc[i, "Name"]
desc = data.loc[i, "Content"]
with st.expander(name):
st.write(desc)
st.subheader("Emerging Technologies")
st.write("The main objective behind sewage treatment plants’ installation is to improve the effluent quality for safe disposal or reuse. Production of reclaimed water satisfying the desired quality criteria is the recent trend in the wastewater treatment industry and hence to deal with the problem of nutrient concentration in wastewater, several emerging treatment technologies are employed, which are discussed in the following paragraphs.")
data = content[content["Type"] == "Emerging Technologies"]
for i in data.index:
name = data.loc[i, "Name"]
desc = data.loc[i, "Content"]
with st.expander(name):
st.write(desc)
st.subheader("Tertiary Treatment Technologies")
st.write("Tertiary treatment technologies are utilised as polishing technologies, to further reduce the concentration of minute or very low concentration quality parameters.")
data = content[content["Type"] == "Tertiary Treatment Technologies"]
for i in data.index:
name = data.loc[i, "Name"]
desc = data.loc[i, "Content"]
```

```
with st.expander(name):
st.write(desc)

imp
ort
json
import streamlit as st
import pandas as pd
import numpy as np
import plotly.express as px
from plotly.subplots import make_subplots
try:
st.set_page_config(layout="wide")
except:
Pass
st.markdown("# Appropriate Treatment Technology Selection")
st.sidebar.markdown("# Appropriate Treatment Technology Selection")
# input for raw waste water
waste_labels = ["BOD(mg/l)", "COD(mg/l)", "TSS(mg/l)", "TN(mg/l)", "FC(MPN/l)"]
dev_labels = ['Land', 'Power', 'Capital Cost', 'O&M Cost']
# this function will load the all the csv files which are preprocessed
def load_tech():
return (
pd.read_csv("./dataframes/tech_coeff_pri.csv"),
pd.read_csv("./dataframes/tech_coeff_sec.csv"),
pd.read_csv("./dataframes/tech_coeff_ter.csv"),
pd.read_csv("./dataframes/reuse.csv"),
pd.read_csv("./dataframes/tech_stack_coeff.csv")
)
# this function will return a pandas.Series with boolean values where the dataframe matches the desired target along with max land and max power requirements
def match_for_config(df, targets, max_land, max_power, upgrade):
s = []
desired_reuse_array = np.array([[v for k, v in targets.items()] for _ in range(len(df))])
waste_values = df[waste_labels].to_numpy()
land_power = df[["Land", "Power"]].to_numpy()
land_power_max = np.array([max_land, max_power])
a = np.all(waste_values < desired_reuse_array, axis=-1)
b = np.all(land_power < land_power_max, axis=1)
if upgrade:
return a
```

```
else:
return np.all(np.array([a,b]).T, axis=-1)
def build_bar(df, land_cost, power_cost):
df["after treatment"] = df[waste_labels].apply(lambda x: ",\n".join([f"{label}:{round(x[label], 2)}" for label in x.index]), axis=1)
df["Land"] = df["Land"]*land_cost
df["Power"] = df["Power"]*power_cost
# df["Land (Ha)"] = df["Land"]
# df["Power (kWh)"] = df["Power"]
# df["Capital Cost"] = df["Capital Cost"] * 1000000
# df["O&M Cost"] = df["O&M Cost"] * 1000000
# st.write(land_cost)
st.write(df)
df.to_csv("test.csv", index=False)
fig1 = px.bar(
df,
x="Name",
y=["Capital Cost", "O&M Cost"],
barmode="stack",
color_discrete_sequence=px.colors.qualitative.Pastel,
# hover_data=["after treatment", "Land", "Power"],
)
fig1.update_xaxes(showgrid=False, title="Technology")
fig1.update_yaxes(showgrid=False)
fig2 = px.bar(
df,
x="Name",
y=["Power", "Land"],
barmode="stack",
color_discrete_sequence=px.colors.qualitative.Pastel2,
# hover_data=["after treatment", "Land", "Power"],
)
fig2.update_xaxes(showgrid=False, title="Technology")
fig2.update_yaxes(showgrid=False)
return fig1, fig2
def build_scatter(df):
st.write(df)
df["after treatment"] = df[waste_labels].apply(lambda x: ",\n".join([f"{label}:{round(x[label], 2)}" for label in x.index]), axis=1)
max_size = df["Land"].max()
df["size"] = df["Land"].apply(lambda x: round(x*50/max_size, 2))
df["Land"] = df["Land"].apply(lambda x: str(x) + " ha")
df["Power"] = df["Power"].apply(lambda x: str(x) + " kWh")
fig = px.scatter(
```

```
df,
x="Capital Cost weighted",
y="O&M Cost weighted",
size="size",
color="Power weighted",
hover_data=["after treatment", "Land", "Power"],
text="Name",
)
fig.update_traces(textposition='top center')
fig.update_xaxes(showgrid=False)
fig.update_yaxes(showgrid=False)
return fig
# load the dataframes
tech_primary, tech_secondary, tech_tertiary, reuse_df, tech_stack_df =
load_tech()
st.write("\n")
st.markdown("### Raw Wastewater Parameters")
raw_waste_inputs = dict.fromkeys(waste_labels)
for col, label in zip(st.columns(5), waste_labels):
with col:
raw_waste_inputs[label] = st.number_input(label, step=1., format="%2.f")
st.write("\n")
# STP parameters
# put a horizontal line here
st.sidebar.write("\n")
st.sidebar.markdown("### STP Parameters")
stp_capacity = st.sidebar.number_input("STP capacity(MLD)", 0)
raw_waste_inputs["cap_for_land"] = stp_capacity
raw_waste_inputs["cap_for_power"] = stp_capacity
raw_waste_inputs["cap_for_capital"] = stp_capacity
raw_waste_inputs["cap_for_om"] = stp_capacity
max_land = st.sidebar.number_input("Land upper limit(ha)", 0)
max_power = st.sidebar.number_input("Power upper limit(KWh)/day", 0)
# costs
st.sidebar.write("\n")
st.sidebar.markdown("### Costs")
land_cost = st.sidebar.number_input("Land Cost (Rupees per Ha)", 0)
eletricity_cost = st.sidebar.number_input("Eletricity cost (Rupees per kWh)",
0)
# weightage
cols = st.columns(4)
weights_coeff = {
1: 0.48,
2: 0.24,
```

```
3: 0.16,
4: 0.12
}
reference = ["None"] + list(weights_coeff.keys())
avaliable_weights = reference
weights = dict.fromkeys(dev_labels, "None")
# 'Land', 'Power', 'Capital Cost', 'O&M Cost'
with cols[0]:
weights["Land"] = st.selectbox("Land weightage", avaliable_weights)
with cols[1]:
weights["Power"] = st.selectbox("Power weightage", avaliable_weights)
with cols[2]:
weights["Capital Cost"] = st.selectbox("Capital cost weightage",
avaliable_weights)
with cols[3]:
weights['O&M Cost'] = st.selectbox("O&M cost weightage",
avaliable_weights)
if len(set(weights.values())) != 4:
_continue = False
st.error("Please select unique weight values for the parameters")
else:
_continue = True
st.write("\n")
st.markdown("### Required Reuse purposes")
desired_reuse_selection = st.multiselect("Select your reuse purpose",
reuse_df["Reuse"])
desired_reuse = dict.fromkeys(waste_labels)
required_demand =
reuse_df[reuse_df["Reuse"].isin(desired_reuse_selection)].reset_index().drop(
columns=["index"])
if len(required_demand) != 0 and _continue:
_text = []
for label in waste_labels:
_value = min(required_demand[label])
desired_reuse[label] = _value
_text += [f"Minimum {label}: {_value}"]
_ = [st.markdown(t) for t in _text]
st.write("\n")
upgrade = st.checkbox("Is there an already installed STP?")
if upgrade:
current_tech = st.selectbox("Select your technology", tech_primary["Tech"])
LPCO = tech_primary[tech_primary["Tech"] ==
current_tech][dev_labels].to_numpy()
# st.write(LPCO)
```

```
LPCO *= stp_capacity
# st.write(LPCO)
LPCO = list(LPCO)
raw_waste_array = np.array([[v for k, v in raw_waste_inputs.items()] for _ in range(len(tech_stack_df))])
after_treatment = tech_stack_df[waste_labels + dev_labels] * raw_waste_array
temp = after_treatment.copy()
temp["Tech Stack"] = tech_stack_df["Tech Stack"]
temp["Capital Cost"] = (temp["Capital Cost"]).map(lambda x: round(x, 2))
temp["O&M Cost"] = (temp["O&M Cost"]).map(lambda x: round(x, 2))
if upgrade:
temp_no_upgrade = temp.copy()
temp = temp[temp["Tech Stack"].map(lambda x: x.split("+")[0]==current_tech)].reset_index(drop=True)
# after_treatment = temp[waste_labels + dev_labels]
new_values = np.array([temp[waste_labels].iloc[0].to_numpy() for _ in range(len(tech_stack_df))])
# st.write(new_values)
after_treatment[waste_labels] = new_values * tech_stack_df[waste_labels]
# temp_no_upgrade.loc[waste_labels + dev_labels] = after_treatment
# st.write(after_treatment)
# st.write(temp_no_upgrade.columns)
temp_no_upgrade[waste_labels]=after_treatment[waste_labels]
# st.write(temp_no_upgrade)
# st.write(temp)
# st.write(desired_reuse)
temp = temp[match_for_config(temp, desired_reuse, max_land, max_power, upgrade)]
# st.write("non-supplementary")
# st.write(temp)
if upgrade:
temp_no_upgrade = temp_no_upgrade[match_for_config(after_treatment, desired_reuse, max_land, max_power, False)]
# st.write("supplementary")
# st.write(temp_no_upgrade)
try:
if len(temp) != 0 or len(temp_no_upgrade) != 0:
temp["Land weighted"] = (temp["Land"] * land_cost * weights["Land"]).map(int)
temp["Power weighted"] = (temp["Power"] * eletricity_cost * weights["Power"]).map(int)
temp["Capital Cost weighted"] = (temp["Capital Cost"] * 1000000 * weights["Capital Cost"]).map(int)
temp["O&M Cost weighted"] = (temp["O&M Cost"] * 1000000 *
```

```
weights["O&M Cost"]).map(int)
temp["Total Cost weighted"] = temp["Land weighted"] + temp["Power weighted"] + temp["Capital Cost weighted"] + temp["O&M Cost weighted"]
show_in_graph = []
top_n = 5
names = []
if upgrade:
temp_no_upgrade["Land weighted"] = (temp_no_upgrade["Land"] * land_cost * weights["Land"]).map(int)
temp_no_upgrade["Power weighted"] = (temp_no_upgrade["Power"] * eletricity_cost * weights["Power"]).map(int)
temp_no_upgrade["Capital Cost weighted"] = (temp_no_upgrade["Capital Cost"] * 1000000 * weights["Capital Cost"]).map(int)
temp_no_upgrade["O&M Cost weighted"] = (temp_no_upgrade["O&M Cost"] * 1000000 * weights["O&M Cost"]).map(int)
temp_no_upgrade["Total Cost weighted"] = temp_no_upgrade["Land weighted"] + temp_no_upgrade["Power weighted"] + temp_no_upgrade["Capital Cost weighted"] + temp_no_upgrade["O&M Cost weighted"]
cols = temp_no_upgrade.columns.to_list()
cols = cols[-1:]+cols[:-1]
temp_no_upgrade = temp_no_upgrade[cols]
temp_no_upgrade.sort_values(by="Total Cost weighted", inplace=True)
temp_no_upgrade.reset_index(drop=True, inplace=True)
if len(temp) > 0:
LPCO = np.array(LPCO * len(temp))
# st.write(temp)
new_values = temp[dev_labels].to_numpy() – LPCO
temp[dev_labels] = new_values
# st.write(new_values)
cols = temp.columns.tolist()
cols = cols[-1:] + cols[:-1]
temp = temp[cols]
temp.sort_values("Total Cost weighted", inplace=True)
temp.reset_index(drop=True, inplace=True)
# try:
if upgrade:
st.warning('Since you have opted for an upgrade, the land and power upper limit with not be considered')
st.subheader("Upgrade options:")
else:
st.subheader("Available options:")
temp = temp[:10]
for i in temp.index:
```

```
with st.expander(f"{i+1} - {temp.loc[i, 'Tech Stack'].replace('+None', '').replace('+', ' + ')}"):
primary, secondary, tertiary = temp['Tech Stack'].to_list()[i].split("+")
show_in_graph.append(st.checkbox(f"show in plot and save for next step", value=True if i <= top_n-1 else False, key=i))
st.dataframe({
"Secondary Tech": [primary],
"Emerging Tech": [secondary],
"Tertiary Tech": [tertiary],
"Total Weighted Cost (cr Rs)": [temp.loc[i, "Total Cost weighted"]/10],
"Land (ha)": [temp.loc[i, "Land"]],
"Power (KWh)": [temp.loc[i, "Power"]],
"Capital Cost (cr Rs)": [temp.loc[i, "Capital Cost"]/10],
"O&M Cost/year (cr Rs)": [temp.loc[i, "O&M Cost"]/10],
})
names.append(f"{temp.loc[i, 'Tech Stack'].replace('+None', '').replace('+', ' + ')}")
if upgrade:
st.subheader("Supplementing with secondary technologies:")
temp_no_upgrade = temp_no_upgrade[:10]
for i in temp_no_upgrade.index:
with st.expander(f"{i+1} - {temp_no_upgrade.loc[i, 'Tech Stack'].replace('+None', '').replace('+', ' + ')}"):
primary, secondary, tertiary = temp_no_upgrade['Tech Stack'].to_list()[i].split("+")
show_in_graph.append(st.checkbox(f"show in plot and save for next step", value=True if i <= top_n-1 else False, key=i+50))
st.dataframe({
"Secondary Tech": [primary],
"Emerging Tech": [secondary],
"Tertiary Tech": [tertiary],
"Total Weighted Cost (cr Rs)": [temp_no_upgrade.loc[i, "Total Cost weighted"]/10],
"Land (ha)": [temp_no_upgrade.loc[i, "Land"]],
"Power (KWh)": [temp_no_upgrade.loc[i, "Power"]],
"Capital Cost (cr Rs)": [temp_no_upgrade.loc[i, "Capital Cost"]/10],
"O&M Cost/year (cr Rs)": [temp_no_upgrade.loc[i, "O&M Cost"]/10],
})
names.append(f"{temp_no_upgrade.loc[i, 'Tech Stack'].replace('+None', '').replace('+', ' + ')}")
temp = temp.append(temp_no_upgrade)
temp["Name"] = names
temp = temp[show_in_graph]
st.write("\n")
```

```
# st.plotly_chart(build_scatter(temp))
# f1, f2 = build_bar(temp.copy(), land_cost, eletricity_cost)
# fig = make_subplots(rows=1, cols=2)
# figure1_traces = []
# figure2_traces = []
# for trace in range(len(f1["data"])):
# figure1_traces.append(f1["data"][trace])
# for trace in range(len(f2["data"])):
# figure2_traces.append(f2["data"][trace])
# for traces in figure1_traces:
# fig.append_trace(traces, row=1, col=1)
# for traces in figure2_traces:
# fig.append_trace(traces, row=1, col=2)
# fig.update_layout(width=1024)
# st.plotly_chart(fig)
dump_data = [temp.iloc[i].to_dict() for i in range(len(temp))]
json.dump(dump_data, open("config.json", "w"))
# except:
# st.write("No matching technology found")
else:
st.error("Projected land/power requirements exceed defined upper limits. Increase upper limits for obtaining suggestions.")
except NameError as error:
Pass

import
streamli
t as st
import pandas as pd
import plotly.graph_objects as go
import json
# DODO: Mininmum requirement selection
# DODO: Change from category to reuse purpose
print("running")
try:
st.set_page_config(layout="wide")
except:
Pass
@st.cache
def load():
return json.load(open("config.json"))
@st.cache
def load_tech():
return (
```

```
pd.read_csv("./dataframes/tech_coeff_pri.csv"),
pd.read_csv("./dataframes/tech_coeff_sec.csv"),
pd.read_csv("./dataframes/tech_coeff_ter.csv"),
pd.read_csv("./dataframes/reuse.csv"),
pd.read_csv("./dataframes/tech_stack_coeff.csv")
)
@st.cache(allow_output_mutation=True)
def load_extras():
demand_formula = pd.read_csv("./dataframes/demand_formula.csv")
demand_formula["Formula"] =
demand_formula["Formula"].apply(lambda x: x.replace("*", " * "))
return (
demand_formula,
pd.read_csv("./dataframes/reuse_to_category.csv")
)
exports = load()
_, _, _, reuse_df, tech_stack_df = load_tech()
demand_formula, reuse_to_category = load_extras()
st.markdown("# Reclaimed Water Demand Allocation & Pricing")
st.sidebar.markdown("# Reclaimed Water Demand Allocation & Pricing")
name_technology = [tech["Name"] for tech in exports]
st.sidebar.subheader("Technology Selection")
technology = st.sidebar.selectbox("Select technology", name_technology)
# select the element in exports where the 'Name' is equal to the technology
selected
tech = [tech for tech in exports if tech["Name"] == technology][0]
st.sidebar.subheader("Price ratio for categories")
multiplier = {
"Public Utility": st.sidebar.number_input("Public Utility", min_value=1,
value=1),
"Agriculture": st.sidebar.number_input("Agriculture", min_value=1,
value=1),
"Domestic": st.sidebar.number_input("Domestic", min_value=1, value=3),
"Industrial": st.sidebar.number_input("Industrial", min_value=1, value=5),
"Commercial": st.sidebar.number_input("Commercial", min_value=1,
value=7),
}
st.sidebar.subheader("STP configuration and pricing:")
minimum_allocation = st.sidebar.number_input("Minimum allocation for
prioritized reuse(%)", value=50, min_value=0, max_value=100)/100
capacity = st.sidebar.number_input("STP capacity(MLD)", min_value=1,
value=120)
cost_per_kld = st.sidebar.number_input("Cost per KLD", min_value=1.,
value=8., step=0.1, format="%2.f")
```

```
inflation_rate = st.sidebar.number_input("Inflation Rate", value=5., step=0.1, format="%2.f")
reuse_dict = {
"Reuse": [],
"Category": [],
"Demand": [],
}
num_reuse = int(st.number_input("Number of Reuse", value=1, min_value=1))
# create a tabular form with the input fields where the user can enter the type of reuse purpose and the amount of that purpose
for i in range(num_reuse):
cols = st.columns(2)
with cols[0]:
selected = st.selectbox("Reuse Purpose", reuse_to_category["Reuse"], key=i+1000)
reuse_dict["Reuse"].append(selected)
reuse_dict["Category"].append(reuse_to_category[reuse_to_category["Reuse"] == selected]["Category"].to_list()[0])
with cols[1]:
demand_value = st.number_input("Demand (MLD)", value=0, min_value=0, key=i+20000)
reuse_dict["Demand"].append(demand_value)
df = pd.DataFrame(reuse_dict)
st.markdown(f"### Total demand: {df['Demand'].sum()} MLD")
if df['Demand'].sum() > 0:
if df["Demand"].sum() > capacity:
st.warning("The total demand is greater than the STP capacity")
elif df["Demand"].sum() < capacity:
st.warning("The total demand is less than capacity")
df["Final Allocation"] = df.apply(lambda x: 0 if x["Category"] == "Industrial" or x["Category"] == "Commercial" else x["Demand"]*minimum_allocation, axis=1)
remaining_capacity = capacity - df["Final Allocation"].sum()
# allocate the commercial and industrial categories to the remaining capacity
for i in range(len(df)):
# check if the category is industrial or commercial
if df["Category"].iloc[i] == "Industrial" or df["Category"].iloc[i] == "Commercial":
# check if the demand for the category can be met by the remaining capacity
if df["Demand"].iloc[i] > remaining_capacity:
df["Final Allocation"].iloc[i] = remaining_capacity
remaining_capacity = 0
```

```
else:
remaining_capacity -= df["Demand"].iloc[i]
df["Final Allocation"].iloc[i] = df["Demand"].iloc[i]
remaining_capacity = capacity - df["Final Allocation"].sum()
if remaining_capacity > 0:
# allocate the remaining capacity to non industrial and non commercial categories
for i in range(len(df)):
if df["Category"].iloc[i] != "Industrial" and df["Category"].iloc[i] != "Commercial":
remaining_demand = df["Demand"].iloc[i] - df["Final Allocation"].iloc[i]
if remaining_demand != 0:
if remaining_demand > remaining_capacity:
df["Final Allocation"].iloc[i] += remaining_capacity
remaining_capacity = 0
else:
remaining_capacity -= remaining_demand
df["Final Allocation"].iloc[i] += remaining_demand
remaining_capacity = capacity - df["Final Allocation"].sum()
df["Revenue Factor"] = df[["Final Allocation", "Category"]].apply(lambda x: x["Final Allocation"]*multiplier[x["Category"]], axis=1)
total_revenue = df["Revenue Factor"].sum()/capacity
x = cost_per_kld/(total_revenue)
# st.write(x)
price_for_reuse = {}
for key, value in multiplier.items():
price_for_reuse[key] = f"{round((value * x), 2)} per KLD"
revenue_each_day = df["Revenue Factor"].sum() * x * 365/10000
temp = tech_stack_df[tech_stack_df["Tech Stack"] == tech["Tech Stack"]][["Capital Cost", "O&M Cost"]] * capacity/10
# temp = tech_stack_df[tech_stack_df["Tech Stack"] == "BIOFOR+WUHERMAN+None"][["Capital Cost", "O&M Cost"]] * capacity/10\
st.write(temp.rename(columns={"Capital Cost": "Capital Cost", "O&M Cost": "O&M Cost/year"}))
costs = {
"Capital Cost": round(temp["Capital Cost"].to_list()[0], 2),
"O&M Cost": round(temp["O&M Cost"].to_list()[0], 2)
}
# capital_cost = tech["Capital Cost"]
# cost_list = [capital_cost] * 15
# om_cost = tech["O&M Cost"]
capital_cost = costs["Capital Cost"]
cost_list = [capital_cost] * 15
```

```
om_cost = costs["O&M Cost"]
om_list, revenue_list, recovery_list = [], [], []
recovery, break_even = 0, 0
for year in range(15):
om_cost *= (1+(inflation_rate)/100)
revenue_each_day *= (1+(inflation_rate)/100)
recovery += revenue_each_day - om_cost
om_list.append(round(om_cost, 2))
revenue_list.append(round(revenue_each_day, 2))
recovery_list.append(round(recovery, 2))
if recovery >= capital_cost and break_even == 0:
break_even = year
st.subheader("Allocation for the given reuse purposes:")
st.write(df)
st.subheader("Price for reuse:")
st.write(pd.DataFrame({
"Category": list(price_for_reuse.keys()),
"Price": list(price_for_reuse.values()),
}))
temp_df = pd.DataFrame({"O&M Cost": om_list, "Revenue Factor": revenue_list, "Recovery": recovery_list, "Year": range(15), "Capital Cost": cost_list})
# name the x and y axis
figure = go.Figure(
data=[
go.Scatter(
x=temp_df["Year"]+1,
y=temp_df["Recovery"],
name="Cumulative Recovery (cr)",
mode="lines+markers",
marker=dict(
color="green"
)
),
go.Scatter(
x=temp_df["Year"]+1,
y=temp_df["Capital Cost"],
name=f"Capital Cost = {capital_cost} (cr)",
mode="lines+markers",
marker=dict(
color="red"
)
),
]
```

```
)
st.subheader(f"Break even point analysis for technology combination: {tech['Tech Stack'].replace('+None', '')}")
figure.update_layout(
xaxis_title="Year",
yaxis_title="Cost (cr)",
font=dict(
size=18,
color="#7f7f7f"
)
)
# x axis: no grid, tick spacing of 1
figure.update_xaxes(
showgrid=False,
tickfont=dict(
size=18,
color="#7f7f7f"
),
ticks="outside",
tick0=0,
dtick=1
)
st.plotly_chart(figure)
if break_even > 0:
st.markdown(f"##### At average price of {round(cost_per_kld, 2)}, you can expect to achieve break even after {break_even+1} years and be profitable.")
else:
st.warning("Break even cannot be achieved in 15 years, try changing the technology or the cost per KLD")
with st.expander("How to calculate demand?", False):
# first reuse name, then the formula, then the legends, then a horizontal line
for i in demand_formula.index:
reuse = demand_formula.loc[i, "Reuse"]
formula = demand_formula.loc[i, "Formula"]
legend = demand_formula.loc[i, "Legends"]
st.subheader(f"{reuse}")
st.write(f"###### {formula}")
st.write(f"{legend}")
st.markdown("""---""")
```

Annexure 2

Questionnaire Survey for Identification of Key Factors for Reuse Focused IWWM

The following questionnaire is prepared to understand the perceived importance of identified factors that will affect the implementation of IWWM. You are requested to rate the factors given in the table on the basis of their perceived importance on a scale of 1 to 5 and list the factors it can influence or get influenced by in the following columns.

No.	Factor	Importance Rating (1-5)	Factors it can influence	Factors it can get influenced by
1	Reuse Purpose			
2	Post-Treatment Distribution Network			
3	Demand for Treated Wastewater			
4	Power Requirement			
5	Material Requirement			
6	Nutrient Recovery			
7	Manpower Requirement			
8	Capital Cost			
9	Operation and Maintenance Cost			
10	Water Pricing			
11	Availability of Raw Wastewater			
12	Ease of Operation			
13	Social Acceptance			
14	Treatment Technology			
15	Technical Durability			
16	Centralized or De-centralized WWTPs			
17	Land Requirement			
18	Harmful By-Products and Greenhouse Gas Emissions			
19	Value of Saved Water			
20	Policy and Regulations			
21	Funding Availability			
22	Weather and Climatic Conditions			

- Please suggest any potential factor you would like to add to this list by inserting new rows at the bottom of the table, along with its importance rating and influencing characteristics.

Annexure 3

Table A3.1 California Board quality parameters for reuse purposes (State of California, 1994)

Type of Use	Total Coliform Limits	Treatment Required
Irrigation of Fodder, Fiber & Seed Crops, Orchards and Vineyards Processed Food Crops Flushing Sanitary Sewers	None Required	Secondary
Irrigation of Pasture Landscape Industrial cooling Soil Compaction Dust Control Road cleaning	23 MPN /100 ml	Secondary & Disinfection
Restricted Landscape-Impoundments	2.2 MPN /100 ml	Secondary & Disinfection
Non-restricted Landscape-Impoundments Non-restricted Recreational Impoundments Toilet Flushing Decorative Fountains Commercial Laundries Fire Fighting Snow-making	2.2 MPN /100 ml	Secondary, Coagulation, Clarification, Filtration & Disinfection

Table A3.2 Quality criteria for non-potable reuse (Florida, 1995).

Type of Use	Water Quality Limits	Treatment Required
Restricted Public Access Areas Industrial Uses	Faecal Coliform < 200 MPN/100ml TSS <= 20 mg/l BOD <= 20 mg/l	Secondary and Disinfection
Public Access Areas Food Crop Irrigation Toilet Flushing Re-creational Impoundments Fire Protection Aesthetic Purposes Dust Control	No detectable Faecal Coliform per 100 ml TSS <= 5 mg/l BOD <= 20 mg/l	Secondary, Filtration and Disinfection

Table A3.3 US EPA guidelines for reuse purpose quality criteria (USEPA, 2012)

Types of Reuses	Treatment	Reclaimed Water Quality	Reclaimed Water Monitoring	Setback Distance
Urban Reuse	Secondary Filtration Disinfection	pH = 6-9, BOD< 10mg/l, NTU < 2 No detectable faecal coli/100ml, Cl_2 residual >=1 mg/l	pH – weekly, BOD – weekly, Turbidity – Continuous, Coliform – daily, Chlorine residue - continuous	15 m to potable water supply wells
Restricted Irrigation	Secondary Disinfection	pH = 6-9, BOD< 30mg/l, TSS< 30mg/l, less than 200 faecal coli/100ml, Cl_2 residual>= 1 mg/l	pH – weekly, BOD - weekly, TSS – daily, Coliform – daily, Chlorine residue - continuous	90 m to potable water supply wells
Unrestricted Irrigation	Secondary Advance Disinfection	pH = 6-9, BOD< 10mg/l, NTU< 2, No detectable faecal coli/100ml, Cl_2 residual >= 1mg/l	pH – weekly, BOD – weekly, Turbidity – Continuous, Coliform – daily, Chlorine residue - continuous	15 m to potable water supply well
Industrial Application	Secondary Advance Disinfection	pH = 6-9, BOD < 30mg/l, TSS < 30mg/l, less than 200 faecal coli/100ml, Cl_2 residual = 1 mg/l	pH – weekly, BOD – weekly, TSS – daily, Coliform – daily, Chlorine residue - continuous	90 m to potable water supply wells
Groundwater Recharge	Site-specific and use-dependent	pH = 6.5-8.5, NTU<2, No detectable fecal coli/100 mL, Cl_2 residual >= 1mg/L	Depend on treatment and use	Site specific

Table A3.4 Quality criteria for non-potable reuse (Chen et al., 2017)

Parameter	Unit	Toilet Flushing	Road Cleaning	Industrial Cooling	Irrigation	Construction	Landscape	Vehicle Washing	Fire Protection
pH	--	6-9	6-9	6.5-8.5	5.5-8.5	6-9	6-9	5.5-9	6-9
Colour	TCU	<=30	<=30	<=30	--	<=30	<=30	--	<=30
Turbidity	NTU	<=5	<=10	<=5	--	<=20	<=10	--	<=10
SS	mg/l	--	--	<=30	<=60	--	--	100	--
TDS	mg/l	<=1500	<=1500	<=1000	<=1000	<=1500	<=1000	--	<=1500
BOD_5	mg/l	<=10	<=15	<=10	<=40	<=15	<=20	30	<=15
COD	mg/l	--	--	<=60	<=100	--	--	250	--
NH_3-N	mg/l	<=10	<=10	<=10	--	<=20	<=20	--	<=10
Fe	mg/l	<=0.3	--	<=0.3	<=1.5	--	<=1.5	50	--
SAR		--	--	26	26	--	26	5	--
Boron	mg/l	--	--	2	2	--	2	3	--
FC	MPN/l	<=200	<=200	<=2000	<=20000	<=200	<=200	--	<=200
DO	mg/l	>=1	>=1	--	>=0.5	<=1	>=1	--	>=1

Table A3.5 General standards for discharge of environmental pollutants to inland surface waters (CPHEEO, 2013)

S. No.	Quality Parameter	Standards
1	Suspended Solids (mg/l)	100
2	Ammoniacal Nitrogen (as N) (mg/l)	50
3	Total Kjeldahl Nitrogen (TKN (as N) (mg/l)	100
4	BOD (mg/l)	30
5	COD (mg/l)	250
6	Nitrate Nitrogen (as N) (mg/l)	10
7	Faecal Coliform (MPN/100 ml)	1000