VOL. 04 NO. 4,
MAY, 2024
E-ISSN 3026-9210
P-ISSN 3026-815X



African Scholar Publications & Research International
www.africanscholarpub.com

Journal of Built Env. & Geological Research (JBEGR)

Assessment of Biodiversity Perceptions of Sustainable Urban Drainage Systems in Residential Plots in Satellite Town, Lagos, Nigeria

***Akagwu, M.; **Fadamiro, J.A. And ***Ayeni, Dorcas A.**
Department of Architecture, Federal University of Technology, Akure
**majaakagwu@gmail.com, **prof.fadamiro@gmail.com, ***dorcasayeni2@yahoo.com*

Abstract
Over the years, biodiversity decline have constantly being a major consequence of urban development due to the problems of design, enlightenment and planning. This study aims at evaluating the perceptions of residential plot users as regards plant biodiversity enhancement in open spaces within setbacks of their residential plots with a view of proposing a framework for enhancement and environmental sustenance within the urban development. The research focused on the plant biodiversity potentials of sustainable urban drainage system infiltration strategies, which is a water management strategy utilizing natural process, generally occurring as natural elements of unpaved areas within open spaces in setbacks of residential plots in Satellite town, Lagos, Nigeria. It utilized questionnaires distributed to elicit information on their socio-economic, residential site, sustainable urban drainage system statuses. Analysis, which involved descriptive statistics, spearman correlation analysis and regression analysis were carried out using Statistical Package for Social Science (SPSS) Version 21. The study revealed that the plant biodiversity perceptions of a residential site provided by the SUDS facilities, though varied with age, educational level and income status, is largely dependent on setback space, the level of unpaving and natural elements making up SUDS facility. The study concluded that through Government's implementation of the reduced level of paved area and adornment with natural elements of the percentage area set aside in the residential plot during approval and monitoring will improve plant biodiversity.

Keywords: Plant Biodiversity**,** Residential plot, Open space, Infitration, Sustainable urban drainage systems.

Introduction
It is unfortunate that the world's forests and biodiversity are generally decreasing rapidly and that calls for the need for immediate conservation and protection of nature (Coracero & Malabrigo, 2020). Nature responds quickly when land is managed in a way that is more favourable to biodiversity which is the variability among life forms on Earth (plants and animals) (Argarwal, 2015). According to Van Weelie and Boersma (2018), biodiversity is considered as a natural resource or environment and an index of measurement of variability in biological objects in space and time.

With urban areas predicted to triple in size by 2030 and natural habitats declining, it stands to reason that if urbanites don't want ecological robustness to decline as well, biodiversity must be designed into urban landscapes (Land8, 2015). According to Ian and Helen (2016), a growing population puts increasing pressure on biodiversity when residential areas encroach on natural systems. Finding ways to reduce the impact of climate change and urbanization on the environment, includes employing a systematic approach by reflecting the complexity of cities as socio-ecological systems (Artmann et al, 2017). Howe (2019) emphasized the importance of knowledge from education, information and awareness as important tools in achieving biodiversity conservation and management successes. Globally, the potential of education in addressing biodiversity related issues is highly appreciated (Ericson et al, 2019). Furthermore, Drainage systems

can contribute to sustainable development and improve the spaces where people live, work and play by balancing different opportunities and challenges that influence urban design and development of communities (Susdrain, 2024).

THE CONCEPT OF SUSTAINABLE URBAN DRAINAGE SYSTEMS

Among the set of practices utilizing nature and natural practices in urban planning, Sustainable Urban Drainage Systems (SUDS) represents promising solutions to reduce the negative effects of urban water run-offs and increase ecosystem services (Daniele & Viviana, 2020). SUDS is a water management system designed to handle natural water processes and efficiently manage drainage of surface water within the urban environment through natural principles (Build pass, 2021). Many countries, most notably the United Kingdom, United States and Australia have adopted the use of SUDS (Boluwatife, 2021). **Since the Brundtland Report, the Rio declaration and agenda 21, sustainable drainage systems have been highly promoted as an alternative and/ or complement to traditional approach to address long-term sustainability in the design of the system.** In contrast to traditional and highly centralized grey infrastructure, SUDS controls and manages runoff at its source through the process of evapotranspiration, infiltration and detention, synergizing with the hydrological circle in its natural conditions (Fletcher et al 2015; Sletts et al; 2019).

SUDS are approaches utilized to manage surface water, taking into consideration, water quantity (flooding), water quality (pollution), biodiversity (wildlife and plants) and amenity (community liveability) (Susdrain, 2021). Furthermore, the system involves an integrated network of engineered vegetated areas and open spaces used to protect natural ecosystem principles and functions and to offer a wide variety of benefits to people and wildlife (Tang et al 2021). SUDS are known for providing multiple environmental benefits including climate change impacts reduction (Coutts and Haihn 2015, Ghods et al, 2020; Roseboro et al, 2021), along with ecological and social benefits and other potential monetary benefits in the long term (Hamann et al 2020).

BIODIVERSITY GOALS OF SUSTAINABLE URBAN DRAINAGE SYSTEMS

Implementation of sustainable urban drainage systems (SUDS) as part of cities transition towards climate resilience encompasses unique opportunities to enhance nature qualities (Rikke, Andy, Hans &Marina, 2018). The conservation or degradation of natural ecosystems in urban areas has the most obvious and immediate impacts on biodiversity. Ives et al (2016) stated that cities are often located in areas with high biodiversity and the process of urbanization itself is likely to have led to many species that formerly occurred in these places now being threatened. Creating opportunities in cities for everyday interactions with nature provides an unparalled opportunity to reconnect people with biodiversity and expose urban residents to the good health and wellbeing benefits provided by nature.

In an interdisciplinary workshop, landscape architects and urban ecologists designed individual SUDS elements with enhanced structural habitat heterogeneity, thereafter bio-SUDS were developed. Increased terrain difference, meandering edges, stones, gravel, boulders, dead wood and brown-roof-like vegetation were components most often employed in the bio-SUDS designs (Rikke, et al, 2018). Results from the study (Rikke, et al, 2018) showed that large bioSUDS elements returned higher index scores, concluding that implementation of bio-SUDS has potential to increase structural habitat heterogeneity, thereby providing habitat for biodiversity in green urban areas.

MATERIALS AND METHODS

In a study to explore the amenity perceptions of SUDS Suyeon et al (2017) selected three (3) case study sites to actualize the study. Furthermore in a similar study by Sanudo-Fontaneda et al (2019) to access community perceptions of SUDS, three (3) residential clusters were also assessed to achieve the desired aim of that study. Employing the approaches of these successful SUDS socio-ecological studies, the research population to gather quantitative data for this study is all the residential plots in the selected estate categories in satellite town. Satellite town has three (3) categories of estates.

Category one comprises of estates in which land areas (plots) were allocated by the Federal Ministry of Lands and Housing with buildings designed and developed by the owners. There are ten (10) estates in this type and site E comprising of 133 residential plots was selected as type one study population because it has the highest number of residential plots compared to the other sites (estates) in this type. Category two comprises of estates in which

buildings were designed and developed by the Federal Ministry of Lands and Housing before the plots allocation process. There are seventy seven (77) closes, grouped into 3 sectors. Sector 2 comprising of 496 residential plots was selected as type two study population because it has the highest number of residential plots compared to the other sectors. Category three comprises of land areas under the jurisdiction of the Federal Ministry Lands and Housing but in the custody of the traditional royal families (Agbojo-Alagbo Chieftancy Family), with the allocation of plots done the family representatives. New-site residential estate was randomly selected in this category and comprises of 714 residential plots. Hence, the research population to gather quantitative data is the combination of residential plots from the selected categories, which is a total of 1,343 residential plots as presented in table 1, whose house heads were respondents for the questionnaires. The research sample size was calculated using a sample size calculator according to Creative Research System (2012) at a confidence level of 95% and confidence interval of 5. The total sample size after adding the individual sample sizes generated by the sample size calculator for administered questionnaires is 567.

A set of questionnaire was designed to elicit quantitative data from respondents. The questionnaire is divided into Four (4) subsections. The first is designed to gather information on social status of respondents, while the second and third sections are to gather information on residential site plan and SUDS statuses respectively. The final section involves subjective information on effects and perceptions of SUDS on residential site plan users and environment.

Data collected from the field was sorted and then analyzed. Using the statistical package for social sciences (SPSS) version 21. The data analysis was done at three levels. The univariate analysis which described the population characteristics using frequency distribution tables, percentages and bar charts. The second level analysis was used to test the various hypotheses using the spearman correlation analysis and was being used for this study. Finally, the third level analysis was done using multiple regression analysis.

Table 1: *Research Population for Residential Plots*

	ESTATE	**Research Population**	**Research Sample**
1	CATEGORY 1 **(Site E)**	133	99
2	CATEGORY 2 **(Close 17-Close 55)**	496	217
3	CATEGORY 3**(New site Estate)**	714	251
	Total	**1343**	**567**

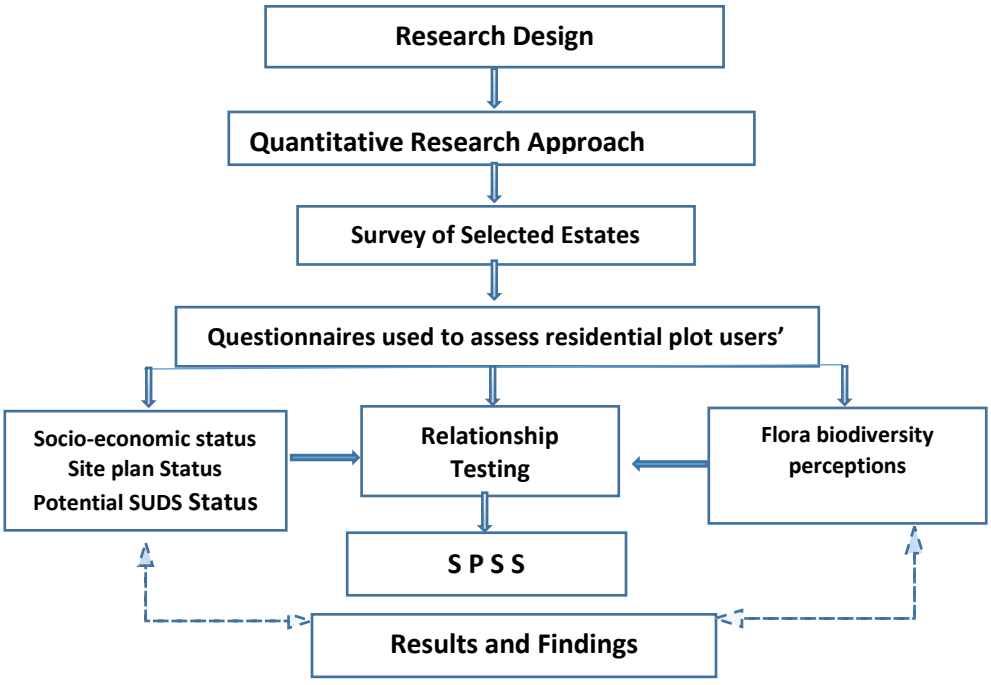


Fig 1.0: *Research Work flow*

RESULTS

From category 1 estate (Site E), all the 99 questionnaires administered were correctly filled, returned and analyzed. The analysis revealed that 83.9% were personally owned residential plots while 16.1% were rental ownership, which means that a larger percentage of the residential plots in the area were accommodated by their owners. The analysis further revealed that 16.1% of the respondents fall within the age interval of 25 – 34, 42.1% falls within the age of 35-44 and 32.2% within the age of 45-54 and 9.7% within the age of 55 and above. Also from the data, 75% of the respondents are tertiary institution graduates with different levels of degrees. This is an indication that most of the accommodated residential plots in the estate were occupied by young adult graduates and so are knowledgeable and can express themselves to a large extent. Also from the analysis, 19.4% of the respondents are professionals, 54.9% are business owners, 6.5% are civil servants, 12.9% are cooperate workers, 3.2% are retired and 3.1% are unemployed, which is an indication that virtually all the respondents are economically empowered.

From Category 2 estate (Closes 17-58), all the 217 questionnaires administered were correctly filled, returned and analyzed. The analysis revealed that 82.3% were personally owned residential plots while 17.7% were rental ownership, which means that a larger percentage of the residential plots in the area were accommodated by their owners. The analysis further revealed that 39.6% of the respondents fall within the age interval of 25 – 34, 50.5% falls within the age of 35-44 and 9.9 within the age of 55% and above. Also from the data, 90% of the respondents were graduates. This is an indication that most of the accommodated residential plots in the estate were occupied by young adult graduates with first degrees and so are knowledgeable and can express themselves to a large extent. Also from the analysis, 29.7% of the respondents are professionals, 50.4% are self-employed, 10.8% are civil servants and 9% are retired which is an indication that virtually all the respondents are economically empowered.

From Category 3 estate (Newsite estate), all the 251 questionnaires administered were correctly filled, returned and analyzed. The analysis revealed that 60.5% were personally owned residential plots while 38.5% were rental ownership and 1% were corporate ownership, which means that a larger percentage of the residential plots in the area were accommodated by their owners. The analysis further revealed that 6.5% of the respondents fall within the age interval of 25 – 34, 49.4% falls within the age of 35-44, 34.4% within the age of 45-54 and 9.7% within the age of 55 and above. Also from the data, 75.3% of the respondents are tertiary institution graduates with different levels of degrees. This is an indication that most of the accommodated residential plots in the estate were occupied by young adult graduates and so are knowledgeable and can express themselves to a large extent. Also from the analysis, 15.1% of the respondents are professionals, 49.5% are business owners, 13.3% are civil servants, 18.9% are cooperate workers and 3.2% are retired, which is an indication that virtually all the respondents are economically empowered.

Table 2: *Socio-economic Characteristics of Respondents*

	Variable	Frequency /Percentage		
		Category 1	**Category 2**	**Category 3**
i	**Ownership**			
	Personal	83 (83.9%)	178 (82%)	152 (60.5%)
	Rental	16 (16.1%)	31 (14.4%)	96 (38.2%)
	Coporate	-	8 (3.6%)	3 (1.3%)
ii	**Sex**			
	Male	89 (89.9%)	131 (60.4%)	226 (90.0%)
	Female	10 (10.1%)	86 (39.6%)	25 (10.0%)
iii	**Age**			
	25-34	16 (16.2%)	54 (24.9%)	16 (6.4%)
	35-44	42 (42.4%)	85 (39.2%)	124 (49.4%)
	45-54	32 (32.3%)	52 (24.0%)	87 (34.7%)
	55-Above	9 (9.1%)	26 (11.9%)	24 (9.5%)
iv	**Highest Level of Education completed**			
	Secondary	26 (26.3%)	13 (6.0%)	62 (24.7%)
	Tertiary	49 (49.5%)	172 (79.3%)	118 (47.0%)
	Masters	24 (24.2%)	32 (14.7%)	69 (27.5%)
	Doctorate	-	-	2 (0.8%)

v	**Profession**			
	Unemployed	3 (3.0%)	-	-
	Artisan	-	-	-
	Entrepreneur	55 (55.6%)	121 (55.8%)	124 (49.4%)
	Corperate	13 (13.1%)	18 (8.3%)	47 (18.7%)
	Civil Service	6 (6.1%)	23 (10.6%)	25 (10.0%)
	Professional	19 (19.1%)	32 (14.7%)	38 (15.1%)
	Retired	3 (3.1%)	23 (10.6%)	17 (6.8%)
vi	**Average Monthly Income**			
	20,000 – 99,000	-	-	-
	100,000 – 199,000	14 (14.1%)	83 (38.2%)	8 (3.2%)
	200,000 – 299,000	29 (29.3%)	52 (24.0%)	31 (12.4%)
	300,000 – 399,000	33 (33.3%)	39 (18%)	48 (19.1%)
	400,000 – 499,000	9 (9.1%)	30 (13.8%)	109 (43.4%)
	500,000 - Above	14 (14.1%)	13 (6.0%)	55 (21.9%)
	Total	**99**	**217**	**251**

Table 3: *Assessment of Sustainable Urban Drainage Status*

	Variable	**Frequency**		
		Category 1	**Category 2**	**Category 3**
i	**Nature Consideration**			
	Half	67 (67.7%)	167 (76.9%)	138 (54.9%)
	One	32 (32.3%)	50 (23.0%)	113 (45.1%)
ii	**Nature Preservation**			
	Yes	35 (35.4%)	176 (81.1%)	87 (34.7%)
	No	64 (64.7%)	41 (18.9%)	164 (65.3%)
iii	**Nature Introduction**			
	Yes	74 (74.7%)	193 (88.9%)	201 (80.1%)
	No	25 (25.3%)	24 (11.1%)	50 (19.9%)
	Uncertain			
iv	**Type of paving used**			
	Concrete	87 (87.9 %)	202 (93.1%)	133 (52.9%)
	Interlocking stones with nylon	12 (12.1%)	15 (6.9%)	118 (47.1%)
	Interlocking stones without nylon	-	-	-
v	**Nature of unpaved area**			
	Sand	29 (29.3%)	23 (10.6%)	71 (28.3%)
	Gravel	10 (10.1%)	4 (1.8%)	-
	Grass Cover	-	18 (8.3%)	-
	Shrubs	-	-	39 (15.5%)
	Trees	-	-	-
	Sand & Gravel	-	-	-
	Sand & Shrubs	47 (47.5%)	158 (72.8%)	73 (29.1%)
	Sand & Trees	7 (7.1%)	14	-
	Grass Cover & Shrubs	3 (3.0%)	-	40 (15.9%)
	Grass Cover & Trees	-	-	-
	All of the Above	3 (3.0%)	-	28 (11.2%)
	Total	**99**	**217**	**251**

The relationship between income status and plant biodiversity perceptions of SUDS was assessed, employing Spearman correlation analysis to test the significance between income status and plant biodiversity perceptions of SUDS for the three (3) different estate categories as presented in table 4, table 5 and table 6 respectively. Spearman rho correlation analysis was used to test the significance of categorical variables.

Table 4: *SITE E – Hypotheses (H3 – Correlation Matrix – Spearman rho)*

Correlations

			Average Monthly Income Level	Improved - Biodiversity
Spearman's rho	Average Monthly Income Level	Correlation Coefficient	1.000	.599**
		Sig. (2-tailed)		.000
		N	99	99
	Improved site beauty - Biodiversity	Correlation Coefficient	.599**	1.000
		Sig. (2-tailed)	.000	
		N	99	99

****. Correlation is significant at the 0.01 level (2-tailed).**

Table 5: *CLOSES 17-58 – Hypotheses (H3 – Correlation Matrix – Spearman rho)*

Correlations

			Average Monthly Income Level	Improved site Biodiversity
Spearman's rho	Average Monthly Income Level	Correlation Coefficient	1.000	.808**
		Sig. (2-tailed)		.000
		N	217	217
	Improved site beauty- Biodiversity	Correlation Coefficient	.808**	1.000
		Sig. (2-tailed)	.000	
		N	217	217

****. Correlation is significant at the 0.01 level (2-tailed).**

Table 6: *NEWSITE ESTATE – Hypotheses (H3 – Correlation Matrix – Spearman rho)*

Correlations

			Average Monthly Income Level	**Improved site Biodiversity**
Spearman's rho	Average Monthly Income Level	Correlation Coefficient	1.000	.753**
		Sig. (2-tailed)		.000
		N	251	251
	Improved sIte beauty- Biodiversity	Correlation Coefficient	.753**	1.000
		Sig. (2-tailed)	.000	
		N	251	251

****. Correlation is significant at the 0.01 level (2-tailed).**

As shown in table 7, with an estimated F value (76.662 @ P<.001) accounting for 29.0% variance in Acceptance level on Biodiversity, the socioeconomic indicators of the respondents are statistical predictors of Acceptance level on Biodiversity in study area.

Table 7: *Multiple regression analysis to check relationship between socioeconomic characteristics of respondents and perceptions of plant biodiversity*

Collinearity Diagnosis						
		Age	**Education**	**Average Monthly Income**	**Site Beauty**	**Biodiversity**
Age	Correlation Coefficient	1.000	.771**	.712**	.141**	.261**
	Sig. (2-tailed)	.	.000	.000	.001	.000
	N	567	567	567	567	567
ɛation	Correlation Coefficient	.771**	1.000	.730**	.056	.166**
	Sig. (2-tailed)	.000	.	.000	.180	.000
	N	567	567	567	567	567
ıverage Monthly Income	Correlation Coefficient	.712**	.730**	1.000	-.168**	-.061
	Sig. (2-tailed)	.000	.000	.	.000	.145
	N	567	567	567	567	567
Site Beauty	Correlation Coefficient	.141**	.056	-.168**	1.000	.723**
	Sig. (2-tailed)	.001	.180	.000	.	.000
	N	567	567	567	567	567
Biodiversity	Correlation Coefficient	.261**	.166**	-.061	.723**	1.000
	Sig. (2-tailed)	.000	.000	.145	.000	.
	N	567	567	567	567	567

**. Correlation is significant at the 0.01 level (2-tailed).
The table shows that none of the indicators have a multicollinearity in excess of .80

Table 8: ***Acceptance Level – Biodiversity***
Multivariate Analysis

Variable	*Coefficients*	*Standard Error*	*t*	*Sig*
(Constant)	2.793	.156	17.852	.000*
Age	1.273	.102	12.424	.000*
Education	.232	.103	2.260	.024*
Income	-.806	.061	-13.141	.000*

Dependent Variable: Respondents' Acceptance level on biodiversity, *Significant at 0.05 level

R^2 = 0.290 , F (3) = 76.662 , *P <0.001 , N = 567

FINDINGS AND DISCUSSION

For category one (Site E estate), test result on the relationship between income status and plant biodiversity perceptions of SUDS shows a positive correlation coefficient r_s of 0.599. This implies a 59.9% variation, indicating that income status influence respondents' plant biodiversity perceptions of SUDS. For category two (Closes 17-58 estate), test result on the relationship between income status and plant biodiversity perceptions of SUDS shows a positive correlation coefficient r_s of 0.808. This implies an 80.8% variation, indicating that educational status influence respondents' plant biodiversity perceptions of SUDS. For category three (Newsite estate),test result on the relationship between income status and plant biodiversity perceptions of SUDS shows a strong positive correlation coefficient r_s of 0.753. This implies a 75.3% variation, indicating that income status influence respondents' plant biodiversity perceptions of SUDS.

The relationship between the predictors (Age, income and education) and the dependent variable is positively fair. With a coefficient of -0.806 on respondents' monthly income, there is 80.6% decrease in respondents' acceptance towards biodiversity on a 100% increase in their monthly income (from #20,000 - #99,000 to above #500,000), t(567) = -13.141, P<.001. However, 1.273 and 0.232 coefficients on Age and Education indicate a 127.3% and 23.20% increase in respondents' acceptance level on a 100% increase in their Age distribution (from Adulthood to

Aged) t(567) = 12.424, P<0.001 and Education (from Secondary to Postgraduate) t(567) = 2.260, P = 0.024 respectively.

RECOMMENDATIONS AND CONCLUSION

Recommendations

The following are the recommendations evolving from results of the study

1. A certain percentage of the residential plot area be set aside as unpaved to serve as environmental sustaining area of residential plots during plot development, which must be shown and presented as part of the details of the site analysis on the site plan drawing for approval process.
2. The area designated for unpaving should specifically be at a level lower than the paved area with natural plant materials introduced, so as to improve landscape variety and generally enhance environmental aesthetics of residential sites.
3. Furthermore for nature to be appreciated more its importance should be incorporated into the educational system of children and youths as nature appreciation subjects and projects in their curriculum.
4. The government through its various physical planning authorities should periodically organise nature appreciation and sustainable development programmes to enlighten stakeholders in building development on the strategies and essence of developing ecologically and aesthetically.
5. Finally, find below is the proposed sustainable urban development framework for achievement of plant biodiversity enhancement within residential plots. The framework presents the residential environment as an ecosystem in the urban development, employing SUDS as its open space site design concept, incorporating different SUDS facilities existing as natural site potentials. According to the framework these facilities are incorporated in line with the site planning policies in line regional and local sustainable goals, all involving stakeholder (resident) enlightenment, education, preference and inputs, consequently resulting to a plant biodiversity sustainable environment.

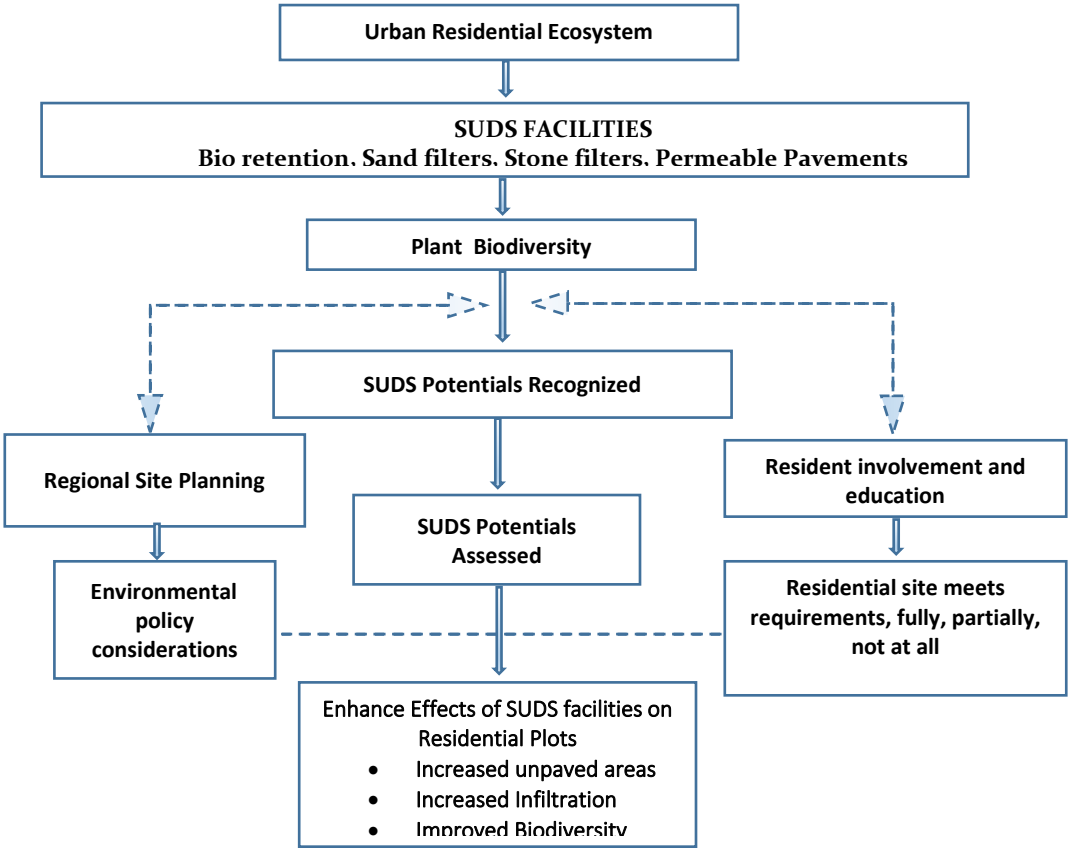


Fig 2.0: *Proposed Sustainable urban drainage (SUDS) Residential Site Planning Framework*

Conclusion

The study through its research methodology and analysis has presented results to show that socio-economic factors of residents can affect perceptions of SUDS qualities within residential plots. Also residential plots though have site designs but most do not follow approved design setbacks during plot development, hence having limited open spaces after plot development usually covered impervious floor materials. The study showed that an increase in the

setback distance within residential plots will increase the area of unpaved open spaces, hence creating more opportunities for SUDS implementation. Therefore the need for intensified enforcement from building control agencies to ensure setback compliance during plot development. Invariably, results from the experimental assessments confirms that some SUDS facilities can be incorporated within limited space. Furthermore with natural amenity and plant biodiversity being likely to increase with income and educational status, it implies that enlightenment through different means of the essential benefits of SUDS is important for adoption and implementation.

References

Artmann, M., Kohler, M.,Meinel, G.,Gan, J.,Loja, I.C (2017). *How smart growth and green infrastructure can mutually support each other: A conceptual framework for compact and green cities*. Ecological Indicators, (96), 10-22 , https//hal.science/hal-0327118

Boluwatife, I., (2022). *Sustainable drainage systems (SUDS): A different approach to managing urban flooding*. Retrieved from https://www.linkedin.com., 18th February 2024.

Buildpass (2021*). Sustainable urban drainage systems*. Retrieved from https://www.buildpass .com.au , 18th February, 2024

Coffman, L.S. (2002). *Low Impact Development: An Alternative Storm Water Technology, In handbook of water sensitive planning and design, France, R.L (ed*). Boca Raton .Lewis Publishers.

Coutts C. & Hahn, (2015). *Green infrastructure, ecosystem sewers and human health*. Int. Journal Environmental Resources, Public Health, 12 pp. 9768 – 9798.

Coracero, E. & Malabrigo jr, P. (2020). *Carbon storage potential of the tree species along the Ultramafic forest in Sitio Dicasalarin, Barangay Zabali, Baler, Aurora, Philippines.* AIMS Environmental Science, 7(6), 589-601. http://doi.org/10.3934/environsci.2020037.

Daniele, L., Viviana, P. (2020) Planning for Spatial Equity: *A Performance Based Approach for Sustainable Urban Drainage Systems*. Sustainable cities and society 53, 101885.

Ericson, E.C., Mark Christian, T.F., RB, J.G., Marlon, G.L., Kristina, M.A.L., Michelle, M.L., Karl Benz, G.M., Lesel, R.S., Mark John, A.S. (2021) *Knowledge and perspective of students towards biodiversity and its conservation and protection*. https://doi.org/10.24191/ajue.v18i1.17178

Fletcher, T.D., Shuster, W., Hunt, W.F., Ashley, R., Butler, D., Arthur, S., Mikklesen, P.S. (2015) *The evolution and application of terminology surrounding urban drainage*. Urban Water Journal, 12[7], 525-538.

Ghods, S.H, Zahmatkesh Z., Goharian E., Kerachian R., Znu Z. (2020). *Optional design of 100 impact development practices in response to climate change*. J. Hydrology. 580 p. 124266

Hamann F., Blecken G.T., Ashley R.M, Viklander M. (2020). *Valuing the multiple benefits of blue-green infrastructure for Swedish case study; contrasting the economic assessment tools BEST and TEEB*. Journal. Sustainable water built Environment, 6 (2020) Article 05020003.

Howe, C. (2019). *The role of education as a tool for environmental conservation and sustainable development*. Dissertation, Imperial College, London. https://www.iccs.org.uk/wp-content/thesis/phd-howe,caroline09.pdf.

Kim, S, An, K. (2017) Exploring Psychological and Aesthetic Approaches of Bio-Retention Facilities in the Urban Open Space. Sustainability, 9(11):2067. https//doi.org/10.3390/su9112067

Kumar, P. & Mina, U. (2018). *Biodiversity. Ecology and Environment*. A Short Course. 2nd Edition, Chapter 2. Pathfinder Publication, India.

Land8 (2015) *Biodiversity*. Retrieved from https://www.land8.com, 18th February, 2024

Morar, F. & Peterlicean, A. (2012). *The role and importance of educating youths on biodiversity conservation in protected natural areas*. Procedia Economics and Finance, 3, 1117-1121. https://doi.org/10.1016/s2212-5671(12)00283-3.

Rawat, U.S & Agerwal, N. (2015). *Biodiversity: Concept, Threats and Conservation.* Environment Conservation Journal, 16, 19-28. DOI: http://doi.org/10.36953/ECJ.2015.16303.

Rikke, J.M., Andy, G.H., Hans, P.R, Marina B.J. (2018) *Exploring Structural Habitat Heterogeneity in Sustainable Urban Drainage Systems (SUDS) for Urban Biodiversity Support*. Urban Ecosystems 21(6), 1159-1170.

Roseboro A., Torres M.N, Zhu Z., Rabideau A. J (2021). *Impacts of climate change and porous pavements on combined sewer over flows: a case study of the city of Buffalo, Newyork, USA*. Frontiers in water, 3(2021) pp. 1-10

Sanudo-Fontaneda, L.A, Robina-Ramirez, R . (2019). Bringing community perceptions into sustainable urban drainage systems: The experience of Extremadura, Spain. Landuse policy, Elsevier, vol. 89(C) https://doi:10.1016/j.landusepol.2019.104251

Susdrain (2021) *Sustainable Urban Drainage System*. Retrieved from http://www.susdrain.org/delivering.suds/using-suds/background/sustainable-drainage.

Suyeon, K., Kyungjin, A., (2017) *Exploring the Psychological and Aesthetic Approaches of Bio-retention Facilities in the Urban Open Space*. Sustainability 9(11), 2067

Tang S., J. Jiang, Zheng Y., Hong Y, Chung E., Shameldin A.Y, Weiy Y., Wag. X. (2021). *Robustness analysis of storm water quality modelling win LID infrastructures from natural event-based field monitoring*. Sci Total Environ, 753 Article 142007

Van Weelie, D. & Boersma, K (2018). *Recontextualizing biodiversity in school practice*. Journal of Biological Education, 52(3), 262-270. https://doi.org/10.1080/00219266.2017.1338596.