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Integration ofGreen Design Strategies in Urban Design:A Case of Arba Minch City, Ethiopia

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ABSTRACT

The importance of green infrastructure in urban area is to maintain climatic conditions,increase social and economic benefits of urban dwellers. Nevertheless, urbanization has destroyed urban green and open spaces and this create problem such as climate change, pollution, and alteration of natural systems on urban dwellers.

This study is going to investigates green infrastructure for Arab Minch city using mixed methodology and surveying methods. The research was conducted to the whole town by taking 68 sample blocks and plots based on systematic random sampling.

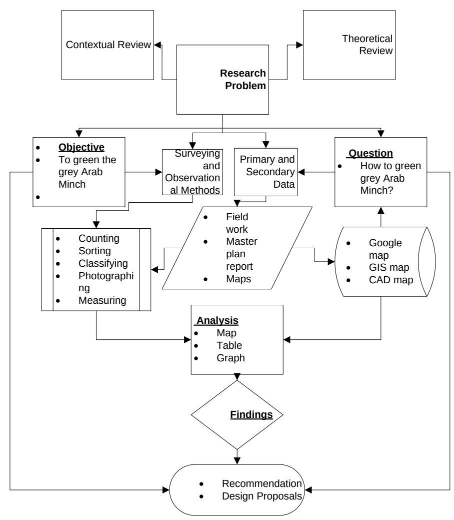
1. Introduction

Urbanization is a phenomenon that happens in cities due to rapid population growth. Therefore, infrastructures of urban areas are inadequate and the construction of new roads, streets, and sewage systems becomes inevitable to meet the needs of the population. Impervious surfaces that are associated with the construction of new grey infrastructures which alters the natural system of storm water in urban areas, this causes flooding and over flow of rainwater in city that hamper the activities of people during rainfalls. In addition, urbanization causes the replacement of green space and open spaces by built-up areas which leads to urban degradation and climate changes [5, 11, 15, 20,24, 32].

Arba Minch is one of the naturally gifted towns in Ethiopia. It is the largest town in Gamo Gofa Zone and the second town in SNNPR next to Hawassa. In the town, there are various natural resources like water bodies, vegetation, soil, and other land uses. Arba Minch is losing its natural resources due to high rate of urbanization and lack of proper attention, in planning, and management of urban landscape that has resulted in, climate change, and increase in average temperature. However still, there are no environmental interventions incorporated in the town, as a result different problems have occurred and become a set of environmental issue that need to be considered in order to reduce the problems. Therefore, the design of GI elements to the existing grey infrastructures and landscape based storm water management systems are carried to mitigate the problems and to make the town more Greener, livable and sustainable. [1, 5]

2. METHODOLOGY

This study is going to investigates green infrastructure for Arab Minch city using mixed methodology and surveying methods. The research was conducted to the whole town by taking 68 sample blocks and plots based on systematic random sampling,

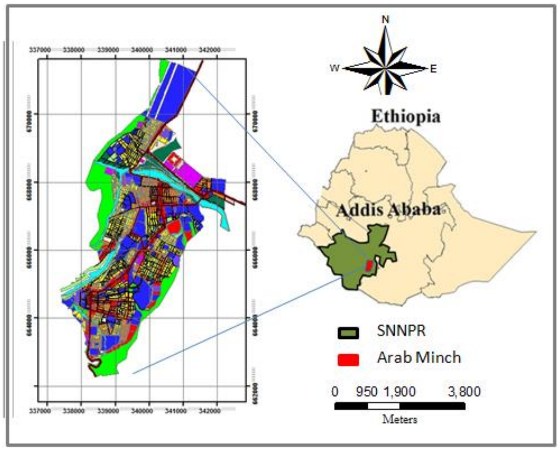


3. CONTEXTUAL REVIEW OF ARBA MINCH

Arba Minch has got its name after the local springs from where the city is supplied with naturally clean water. Astronomically it is located at the geographic co-ordinates of $6^{0}15`$ north latitudes and $37^{0}38`$ east longitudes. It is found in the Gamo Gofa Zone of the Southern Nations Nationalities and Peoples Region about 500 kilometers away to the south of Addis Ababa at an elevation of 1285 meters above sea level at the base of the western side of the great rift valley and has 55.57 km^2 area.[1, 49].

It is the largest town in Gamo Gofa Zone and the second town in SNNPR next to Hawassa. It consists of the upper town Shecha, Lower town Sikela and

Limat. Since 1999E.C/2006 G.C the town becomes city administration with 4 sub town and 11 kebele these sub towns are Sikela, Shecha, Nechsar and Abaya. Arba Minch is known from its fruit, fish, and crocodile farms. Moreover it is surrounded by natural resources, which enhanced the attraction of the town such as Lake Abaya, Kulfo River that crosses the city, A.M natural forest, and Bridge of God in the east, and Lake Chemo. Forty spring from where the town is supplied withnaturally clean water in the west of the natural forest [1, 49].



(Source: Local Authority, Arba Minch)

Precipitations

The mean annual precipitation depth recorded at Arab Minch station in 13 years period from 2001 to 2013 is about 871.64 mm. There is a significant seasonal variation for rainfall. Almost 35 % of the mean annual rainfall occurs in the two rainy months of April and May with maximum mean values of more than 144.8 mm. November, December, January, and February on the other hand are the driest months, which account for 25 percent of the annual total[1, 49].

Temperature

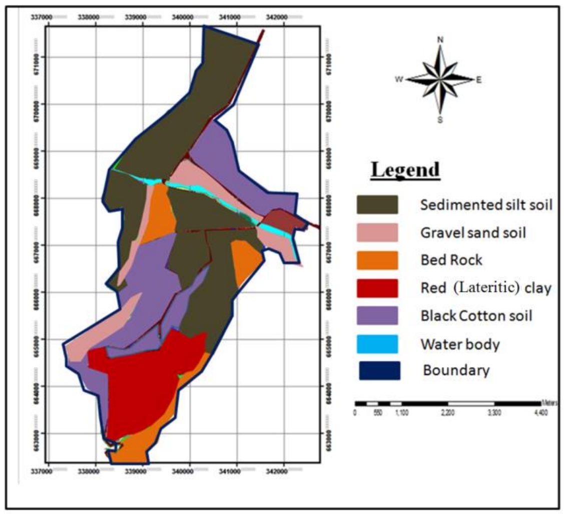
The monthly mean Maximum and minimum temperature records of Arab Minch In the year between 2001 to 2013 indicates that the highest mean monthly maximum temperature occurs in the months of February and March 33.5 ^{0}C July 27.8 ^{o}C. While the mean monthly minimum temperature range for the lowest 15.4 ^{0}C in December to the highest 18.4 ^{o}C in the month of March. In Arba Minch, the temperature often exceeds 15 ^{o}C. In general, the temperature is, considered as hot Humid for most days with some sort of uncomfortable climatic conditions [1, 49].

Humidity

The monthly mean Maximum and minimum humidity records of Arab Minch In the year between 2001 to 2013 indicates that the highest mean monthly maximum humidity occurs in the month May which is 64.7 %. While the mean monthly minimum humidity occurs in the month of February which is 42.01 % [1, 49].

Soil Type

In Arab Minch the type of soils are Red (lateritic) clay soil around Bekele Mola hotel, Chemo campus, and condominium building site areas in Secha. Gravel (sandy soil) found along the sides of Kulfo River. Sediment silt soil covers the whole Limat, flat area of Sikela and Konso sefer. Black cotton soil covers the whole Yetnebersh, Medhanialm church, Full Gosple church and around Mekaneyesus Technical college. Bed rock covers the areas around Kalehiwt church (Robot school), Arab Minch detention center andaround High land area [1].



(Source: Local Authority, Arba Minch)

Topography of the study area

The town has a sloped land topography situated on the north western of the natural forest and forty springs. The slope varies from apparently zero to slightly over 20 % in specific area. The general slope orientation of the town is slightly towards Lake Abaya and the natural forest, which are located to the east of the town. The drainage direction is most dominantly towards Kulfo River, which crosses the town except for some areas, which drain in Lake Abaya. According to the slope analysis, the most dominant slope cover of the study area is 2 – 5 %, which is 856.1 hectares (39.3 %), and the minimum slope category of 15 – 20 % covers 187.89 hectares (8.63 %) of the total study area [1].

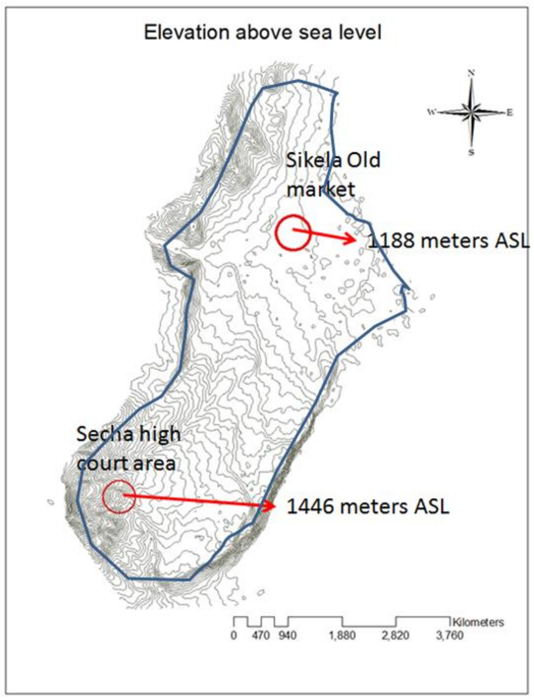
e

S/N	Slope	Area in	Percent

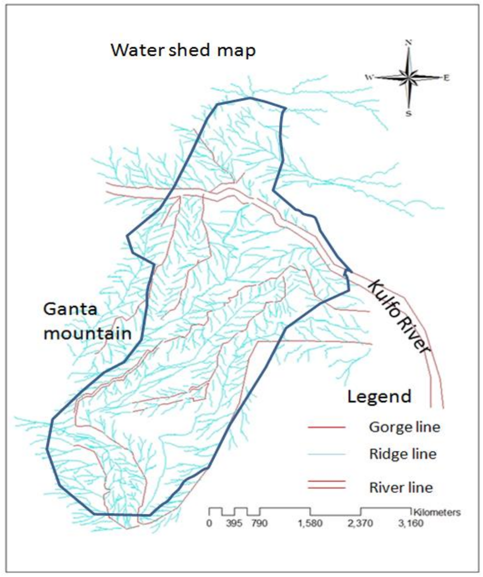
	category	hectares	
1	0-2	328.75	15.10 %
2	2-5	856.10	39.32 %
3	5- 10	309.37	14.21 %
4	10-15	226.42	10.40 %
5	15-20	187.89	8.63 %
6	>20	268.65	12.34 %
Total		2177.14	100 %

(Source: author)
(Slope classification and percentage share calculated from slope map)

Elevation variation in the area ranges, from 1188 m above sea level at the central part of the town Sikela and the higher is 1446 m above sea level at Secha area around the higher-level court [1].

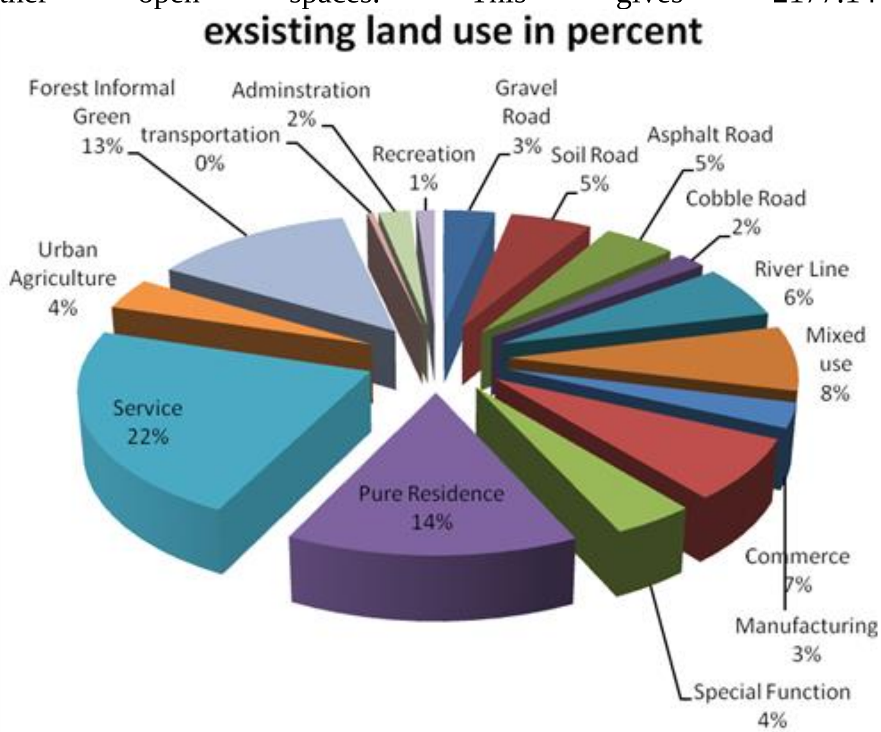


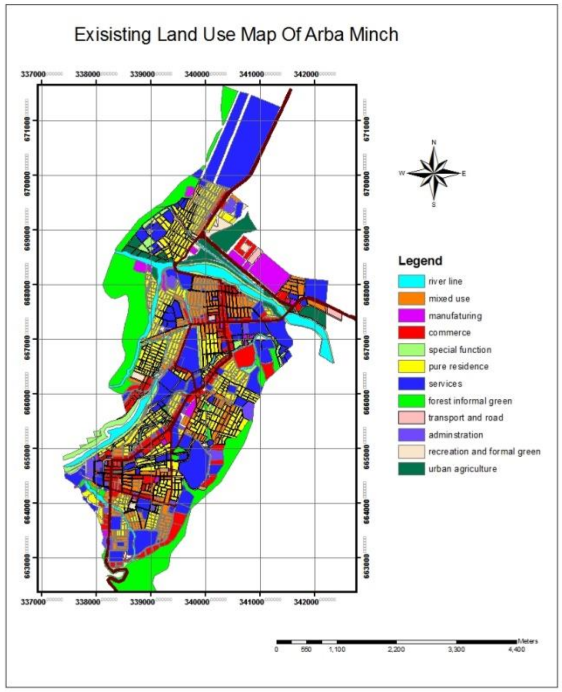
(Source: Local Authority, Arba Minch)



(Source: Local Authority, Arba Minch)
Water shed and drains direction

According to the existing situational analysis, there are thirteen land use types. Broadly categorized in to **build up and none built up** areas. Built up areas include residential, service, transport, administration, manufacturing and business areas. None built up areas include water bodies, green spaces and other open spaces. This gives 2177.14 ha.





(Source: Local Authority, Arba Minch)
existing land use of the study area

In the Figure above about 13-land use types are shown in different colors and the road, which is one of the land uses, is classified in to asphalt, cobble, and gravel and earth road according to their surfacing materials.

Land use type	Area (ha)
Gravel Road	64.67
Cobble Road	36.67
Asphalt Road	92.02
Earth Road	103.56
Open space without vegetation	207.49
Mixed use	149.71
Pure Residence	281.02
Commerce	143.87
Administration	39.63
Service	440.82
transportation	8.68
Manufacturing	57.17
Urban Agriculture	73.23

River Line	121.16
Recreation	23.11
Forest Informal Green	254.82
Special Function	79.51
Total area	2177.14

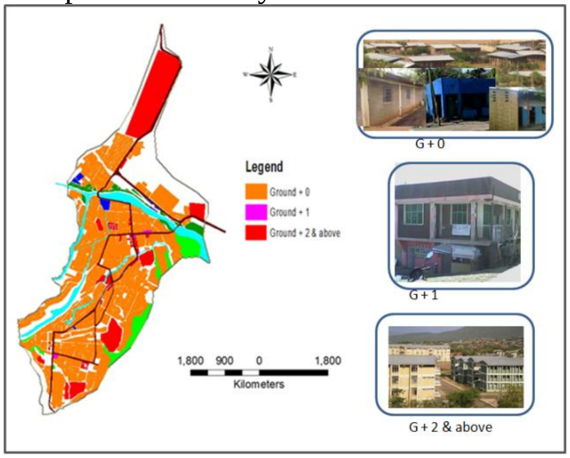
Existing Land Use Area in Hectares

Existing land use area in percent

The maximum and minimum land use covers in the study area are service and transportation that covers an area of 440.82 hectares and 8.68 hectares respectively which shows that service occupies 22 % of the total area where as transportation covers 0.1 %. Based on land use category in to Build up and Non-Built up the cover area are 1417.82 and 759.32 hectares, 65.12 %, and 34.88 % respectively. Therefore, according to the area and percentage cover it shows that built up land use is dominating.

Existing Building height

According to the survey made about building hight and construction materials of their wall and rooffrom 68 sample blocks 68 plots were selected as sample and buildings in those plots were analyzed.



(Source: Local Authority, Arba Minch)

Building height

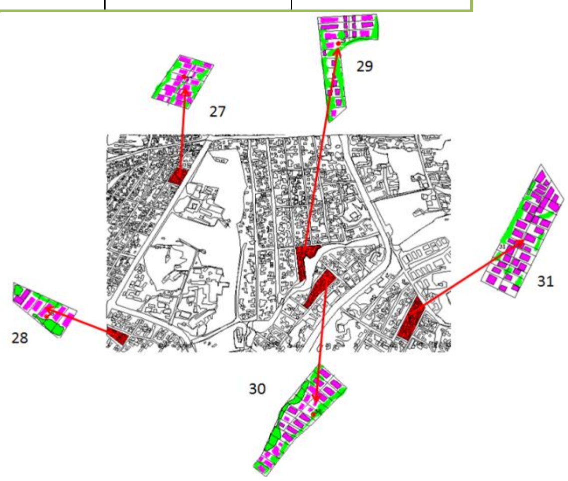
Hence most G + 0 buildings in Arab Minch are constructed from wooden wall of eucalyptous plasterd with soil mud (chika). The external wall is renderd with wier mesh reinforced cement mortar for prevention of wall damage from rain fall and some times coverd by bambu webing or left as it is. The use of hollow concrete block (HCB) as a wall construction material is not common specially in G + 0 residencial and institutional buildings. In the case of G + 1 and above are constructed from reinforced concret structure and HCB as external curtain wall and internal partition. Gable and shade roofs are used with slope of 15 – 25 % and coverd with corrugated Iron sheet (CIS) of different type and size.

- G + 0 occupies = 808.39 hectares
- G + 1 occupies = 2.86 hectares

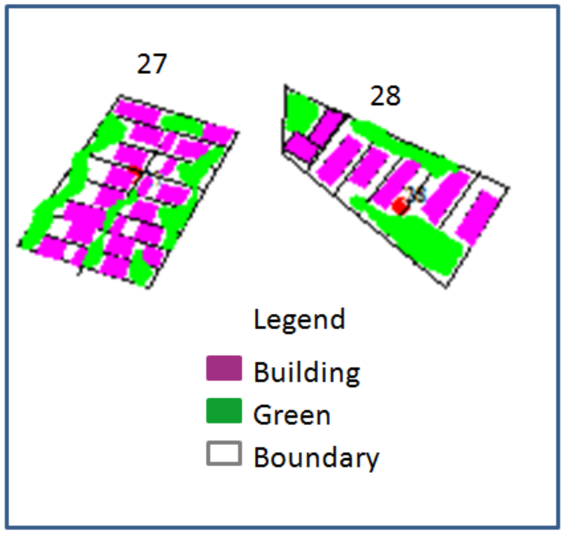
- G + 2 and above =245.1 hectares

Total plot area = 1056.35 hectares
Area occupied by building
G+0 = 192.02ha
G+1 & above =60.96ha
Total area occupied by building = 252.98 ha
Which is 75.9% G+0 and 24.1% G+1 & above.
G+0 building wall area to be greened is estimated two times the foof cover 192.02 x2 = 384.04 ha or 23.24% And G+1 & above building wall area is estimated three times the roof cover 60.96 x 3 = 182.88ha or 2.8%. Hence 26.04 % Green wall will be add to enhance green cover.
Total area left as green and open space without vegetation within the plots is = 803.37 hectares.
spaces with in Residential blocks and their Area

Urban structural typology	**Area**	**Percentage**
Building	1467.0 m^2	33.89 %
Green	479.59 m^2	11.08 %
Open space without vegetation	2381.73 m^2	55.02 %
Total	4327.91m^2	100%



Nechsar sub city AM hospital area sample blocks mapping

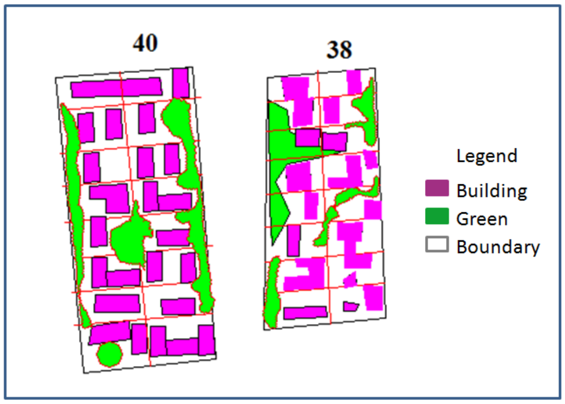


Private residence sample blocks (source own)

Urban structural typology	Area	Percentage
Building	3558.27 m^2	12.33 %
Green	1300.04 m^2	33.75 %
Open space without vegetation	5683.27 m^2	53.90 %
Total	10541.58 m^2	100%

(Source own)

Sikela sub city kebele 02 area sample blocks mapping



Sample Mixed use blocks (source own)

According to data collected from 68 sample blocks 15.76 % previous and 84.19 % impervious cover is available in the built up land use category. When the sample result is applied to the whole built up area of 1056.35hectares, the pervious and impervious surfaces occupies 166.48 hectares and 889.34 hectares respectively. Therefore adding the none built up land use of 759.32 hectares to the calculated pervious surface of built up land use category and the street cover area 305.03 hectares to the impervious surface the total pervious and impervious surface is, found to be 982.77 hectares and1194.37 hectares respectively. The total pervious and impervious surface cover in the study area is 45.14 % and 54.86 % respectively. Hence 54.86% impervious cover shows the river /stream quality is deteriorated as shown in the figure below of Kulfo River.

4. THE GREEN DESIGN STRATEGIES

Proposed extensive green roof plants

Combinations of evergreens and flowering plants with a long blooming season provide a visual impact when grown together. However, summer droughts can turn flowering perennial plants into a mass of brownedout, dead-looking plants that could be a fire hazard. Similarly, grasses are difficult to keep green throughout the summer. To grow most annuals, perennial flowering herbaceous plants, and grasses, either irrigation must be present or substrate depths must be deeper than normally found on extensive roofs which the curent circumstances on existing buildings do not allow to do so. Therfore succulent species such as Sedum, Sempervivum, Costal Strawbery and Delosperma are considered good choices because of their ability to withstand extended drought conditions and other adverse environmental conditions often present on a rooftop.
Extensive green roof planting container can be made of plastic material, with perforated bottom to drain water. Which is portable and easy, to transport to the rooftops and maintenance [21, 26, 27].

Proposed Green Walls

Green screens walls of freestanding structures, such as fences or columns are proposed because of their screening, ventilation and cooling capacity that best fits to give solution and stabilize the weather condition of the study area. It can be applied to residential, commercial, and institutional building terrace, windows and any type of openings of a building.

Proposed green living walls

Living wall systems are composed of pre-vegetated panels, vertical modules that are, fixed vertically to a structural wall or frame. These panels can be made of plastic, expanded polystyrene, synthetic fabric, clay, metal, and concrete, and support a great diversity and density of plant species e.g. a lush mixture of groundcovers, ferns, low shrubs, perennial flowers, and edible plants. Due to the diversity and density of plant life, living walls typically require maintenance that is more intensive. Therefore, panels of plastic, expanded polystyrene, clay, and concrete are, proposed due to their availability and easy construction[21, 26, 27, 45, 46].

Green fence

According to the observation made to different sample plots it is found that there are three types of fences based on the type of material such as CIS, HCB, and masonry wall.

Proposed green street design

Most streets in the study area have no separet pedestrian walkway, vegitation and drainage ditch. Hence below are the proposed street designs along with appropriate street tree selection proposal. Termonilla spp and Gravilia Roubusta are, proposed as green street trees due to their evergreen and drought resistance character.

5. CONCLUSION

Green Infrastructure of a city is vested on Green Street, green space, impervious area, green roofs, green walls, green fences, and WSUD. The study area land use is categorized broadly in to built up and none built up. Accordingly, the surface covers of the built up and none built up was analyzed and found to be 1417.82 ha (65.12 %), and 759.32 ha (34.78 %) respectively. Showing that built up land use is dominating. Further categorizing built up spaces in to grey infrastructure and green infrastructure it is summarized as follows. Green infrastructures such as vegetation within plots (11.26 %), and non-built up space of 34.88% makes a total of 45.14% of the total study area. Grey infrastructures are all built impervious surfaces that include CIS roof (10.53%), Cobble stone road (2%), Asphalt road (5%), Gravel road (3%) Earth road (5%) and degraded bear land (29.33) gives a total of 54.86 %.According to American Planning Association standard of 1996, the study area impervious exceeds 25 %, considered as degraded, and needs intervention. Inclined CIS roof is the only impervious roof cover used in the area, which is 252.98 ha

(11.62%). The annual amount of storm water to be harvested from the entire roof of 252.98 ha of the study area is calculated and found to be 1,977,696 m3. The amount of green added from green roof and Green Street covers 558.01ha or 25.63% hence enhances the pervious cover from 45.14 % to 70.77 %. Application of green wall and green fence of 26.04% and 4% respectively will further increase the green cover of the area up to 100%. WSUD such as Drainage includes storm water flow velocity control, erosion mitigation, enhancing infiltration and pollution protection by GI techniques of check dam, level spreader, terrace of gabion, infiltration trench, bio-swale, bio-retention and other mechanisms are proposed to protect the environment and to green the grey spaces of the study area.

Generally, the research has proved that streets, walls, roofs, impervious areas, and WSUD of the city are the potential to green grey spaces of the town and it can be easily transformed into green spaces by integrating the green design strategies in urban design context.

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