THE POTENTIAL OF GIS AS A MANAGEMENT TOOL FOR AVENUE TREES POPULATION IN SMALL COMMUNITIES; A CASE STUDY OF IDI-SHIN COMMUNITY, IBADAN, NIGERIA

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ABSTRACT:

This study demonstrates the potentials of Geographic Information System (GIS) as a management tool for avenue trees (Street trees) populations in small communities (using Idi-Ishin community, Ibadan, Nigeria as a case study). GIS is a decision support system which integrate data or set of data from different sources, bringing them under the same referencing system in a computer system. An Ikonos Imagery (1m Spatial Resolution) of the study area was digitized to produce a digital map using ArcGIS 10.1 version. The avenue trees species \geq 5cm diameter at breast height (DBH) was selected for enumeration. These trees were then measured and tagged. The Height, Girth and Geographic location (X &Y coordinate) of the trees were measured with Haga altimeter, Girthing tape and Hand held Global Positioning System (GPS) respectively. The species and families of the trees enumerated were also identified. Data were analysed for basal area (BA) and volume (V). A total number of 43 avenue trees were assessed in Idi-Ishin Community. *Roystonea regia* accounted for the majority of the avenue trees (25.58%), followed by *Polyanthia longiflora* (23.26%), *Gliricida seprium* (20.93%), *Eucalyptus toreliana* (13.95%), *Delunix regea* (6.98%). However *Terminalia catapa, Terminalia radii, Azadrachita indica* and *Newbodia levis* had the same abundance of 2.33%. It was also observed that the benefits derived from these avenue trees using ArcCatalog of ArcGIS 10.1 version. Based on the findings from the study (which serves as baseline information for the management of the avenue trees in the study area), it was therefore recommended that subsequent assessment should be carried out at 3-5 year interval in other to ensure proper and continuous monitoring and updating of the data.

1. INTRODUCTION

Avenue (Street) tree is an important component of the urban forest. They are trees located on land forming or adjacent to a street, which have both direct and indirect effect on those using that street (Heimlich et al, 2008). With their canopies overhanging the roadway, street trees help to protect asphalt from deterioration by sunlight (Mcpherson et al, 1993) and reduce storm-water runoff from impervious surfaces (Nowak and Crane, 2002). Their shade keeps pedestrians, parked cars, and nearby buildings cool in the summer (Scott et al, 1999; Akbari, 2002). Avenue trees can also help to buffer the sights and sounds of nearby roadways (Fang and Ling, 2003) and reduce driving stress (Wolf, 2003). The appearance of commercial areas is also improved by the presence of avenue tree (Anderson and Cordell, 1988). Fuwape (2001), stated that, the benefits of street trees include: amelioration of weather pattern, provision of clean air, protection of biological diversity, protection of watershed, soil and food crops and provision of recreational facilities. Street trees can contribute significantly to human health. For instance, study has shown that children living in areas with more street trees had lower prevalence of asthma compared to those living where there are few street trees (Lovasi et al., 2008). Because of their proximity to pedestrians, cars, sidewalks and other infrastructure, street trees can be both major assets and major liabilities.

Despite the various benefits offered by street trees, little or no effort has been made to take full advantage of them. Therefore a need to encourage such arose and GIS is presumed to be a better and long lasting management tool. GIS is a decision support system which integrate data or set of data from different sources, bringing them under the same referencing system in a computer system. The Spatial analytical functions of GIS prove to aid better understanding of the street trees. GIS can aid planners, local elected officials, landscape architects, urban foresters, and non profit groups in quantifying benefits and costs of municipal trees (McPherson et al., 2002). GIS tend to offer Long-term management, reduction of tree program costs, and increasing street trees' ability to maintain benefits. The results of the various spatial analyses of GIS can be presented graphically and can also be used for broad regional studies or to create detailed small site assessments. The GIS model also contains algorithms for tree growth to allow users to create maps of future tree cover and estimate the benefits provided by those larger trees. This paper therefore examined the potentials of Geographic Information System (GIS) as a management tool for street tree (Avenue trees) populations in small communities, using Idi-shin Community as a case study.

2. METHODOLOGY

2.1 THE STUDY AREA

Idi-Isin Community is situated in Jericho, Ibadan North West Local Government Area of Oyo State, Nigeria. The area lies between longitude 3° 51' 33.19" E to 3° 51' 3.56"E and latitude 7° 23' 56.04" N to 7° 24' 20.55" N. It has annual rainfall of about 1400mm-1500mm and average relative humidity of about 65%. The average temperature is 32° C with two distinct seasons, which are dry, usually commences from November to March and rainy season. It is bounded by Jericho and Ile-titun community.



Figure 1. Location of the Study Area

2.2 Data Source

Both secondary and primary data source was used for this project. The secondary data collection includes;

i. An Ikonos Imagery (1m spatial resolution) of the study area, sourced from Google Earth

While the primary data include;

- i. The tree species assessment data
- ii. The coordinates of geographic features and location of the urban forest trees within the study area using Global Positioning System (GPS)

2.3 Data Conversion

The satellite image covering the study area was taken to the site for ground truthing. The imagery was then geo-referenced. Features (such as buildings and roads) were extracted (digitized) using ArcGIS 10.1 software. The roads were categorized into avenue, close, crescent, streets. The step by step approach (methodology) taken to achieve the stated objectives of this study are the following;



Figure 2. Flow Chart of the Research Methodology

2.4 Database Creation

A spatial database was created for the assessed avenue trees using ArcGIS 10.1 version. The attribute database was created by typing the attribute data into the themes attribute tables.

3. SPATIAL ANALYSIS AND INFORMATION PRESENTATION

3.1 Map Production



Figure 3. Produced Map of Idi-Ishin Community



Figure 4. Spatial Distribution of Avenue Trees

S/N	Name	X & Y	DBH	Height
5/11		Coordinate	(cm)	(m)
1	Roystonea	3 ⁰ 51' 34 27" E	85	13.8
1	regia	$7^{0} 23' 56.06'' N$, 05	15.0
2	Roystonea	3° 51' 34.20" E	76	8.2
-	regia	7 ⁰ 23' 55.69" N	, , , , ,	0.2
3	Roystonea	3 ⁰ 51' 34.19" E	81	11.5
5	regia	7 ⁰ 23' 55.30" N	, 01	1110
4	Rovstonea	3° 51′ 33.97″ E.	85	8.5
	regia	7 ⁰ 23' 54.95" N	,	
5	Rovstonea	3° 51′ 32.92″ E.	207	17.2
-	regia	7 ⁰ 23' 55.04" N	,	
6	Rovstonea	3 [°] 51′ 32.48″ E.	185	19.5
	regia	7 ⁰ 23' 55.08" N	,	
7	Roystonea	3° 51′ 31.95″ E,	188	16.2
	regia	7 ⁰ 23′ 55.20″ N		
8	Roystonea	3 [°] 51′ 31.37″ E,	184	17
	regia	7 ⁰ 23' 55.28" N		
9	Roystonea	3 [°] 51′ 32.77″ E,	, 170	16
	regia	7 ⁰ 23′ 54.64″ N		
10	Roystonea	3 [°] 51′ 32.07″ E,	, 171	20
	regia	7 ⁰ 23' 54.72" N		
11	Roystonea	3 [°] 51' 31.68" E,	, 71	19.3
	regia	7 [°] 23′ 54.81″ N		
12	Newbodia	3 ⁰ 51' 31.63" E,	, 37	5.4
	levis	7 [°] 23′ 59.88″ N		
13	Gliricida	3° 51′ 31.44″ E,	35	5.6
	seprium	7 [°] 23′ 59.92″ N		
14	Gliricida	3° 51' 29.25" E,	, 43	5.7
	seprium	7 [°] 24′ 1.45″ N		
15	Delunix regea	3° 51′ 29.19″ E,	, 45	5.3
		7º 24' 1.71" N		
16	Gliricida	3° 51′ 28.90″ E,	, 44	5.2
	seprium	7º 24' 1.97" N		
17	Gliricida	3° 51′ 28.64″ E,	, 49	5.6
	seprium	7° 24′ 2.17″ N		
18	Gliricida	3° 51′ 28.37″ E, 43 5.1		
	seprium	7° 24′ 2.27″ N		
19	Gliricida	3° 51′ 28.08″ E,	, 42	5.0

3.2	Abundance	and	Com	position
			~~~~	00010101

	senrium	7 ⁰ 24' 2 59'' N		
20	Polyanthia	3 ⁰ 51' 21 26" E	33	7.2
20	longiflora	7 ⁰ 23' 58 47'' N	55	1.2
21	Polyanthia	3 ⁰ 51' 21 19" F	46	6.8
21	longiflora	7 ⁰ 23' 58 57" N	10	0.0
22	Polyanthia	$3^{0}$ 51' 20 90" F	54	69
22	longiflora	$7^{0}$ 23' 58 96" N	54	0.7
23	Polyanthia	3 ⁰ 51' 10 94" F	55	8.5
25	longiflora	7 ⁰ 24' 11 45'' N	55	0.5
24	Polyanthia	$3^{0}$ 51' 10 94" F	22	57
27	longiflora	$7^{0} 24' 11 68'' N$	22	5.7
25	Polyanthia	3 ⁰ 51' 10 97" F	25	87
25	longiflora	7 ⁰ 24' 11 84'' N	25	0.7
26	Polyanthia	$3^{0}$ 51' 11.01" F	27	7.0
20	longiflora	7 ⁰ 24' 12 00'' N	21	7.0
27	Polyanthia	3 ⁰ 51' 11 11" E	24	67
21	longiflora	7 ⁰ 24' 12 17" N	21	0.7
28	Polvanthia	3 ⁰ 51' 11.27" E.	28	7.6
20	longiflora	7 ⁰ 24' 12.17" N	20	7.0
29	Polyanthia	3 ⁰ 51' 11 43" E	30	65
_,	longiflora	7 [°] 24' 12.36" N	20	0.0
30	Azadrachita	3 [°] 51' 11.56" E.	48	5.0
20	indica	7 ⁰ 24' 12.49'' N		0.0
31	Delunix regea	3 [°] 51′ 17.00″ E.	100	11.6
		7 ⁰ 24' 9.39'' N		
32	Eucalvptus	3 [°] 51′ 19.02″ E.	40	5.2
-	SDD	7 ⁰ 24' 7.89'' N	-	-
33	Eucalyptus	3 [°] 51′ 18.86″ E,	39	5.5
	spp	7 ⁰ 24′ 7.66″ N		
34	Eucalyptus	3 [°] 51′ 18.73″ E,	41	5.6
	spp	7 ⁰ 24' 7.43" N		
35	Gliricida	3° 51′ 20.10″ E,	50	5.0
	seprium	7 ⁰ 24′ 7.88″ N		
36	Gliricida	3 [°] 51′ 20.33″ E,	48	5.6
	seprium	7 ⁰ 24′ 7.82″ N		
37	Eucalyptus	3 [°] 51′ 23.36″ E,	41	6.2
	toreliana	7 ⁰ 24′ 6.09″ N		
38	Eucalyptus	3 [°] 51′ 23.81″ E,	43	6.0
	toreliana	7 ⁰ 24′ 5.66″ N		
39	Eucalyptus	3 [°] 51′ 24.34″ E,	40	5.9
	toreliana	7 ⁰ 24′ 5.47″ N		
40	Terminalia	3° 51′ 23.59″ E,	43	6.0
	catapa	7 [°] 24′ 5.83″ N		
41	Gliricida	3° 51′ 24.60″ E,	44	5.6
	seprium	7º 24' 5.17" N		
42	Delunix regea	3° 51′ 26.42″ E,	49	7.4
		7 [°] 24′ 5.95″ N		
43	Terminalia	3º 51' 7.72" E, 7º	36	4.5
	radii	24′ 14.91″ N		
Mear	1		66.21	8.53

Table 1. Trees Species Abundance with their Geo-Spatial Location

Table 1 presents the abundance and geo-spatial location of the tree species encountered. A total number of 43 avenue trees were assessed in Idi-Ishin Community. In terms of the species abundance, *Roystonea regia* accounted for the majority of the avenue trees (25.58%), followed by *Polyanthia longiflora* (23.26%), *Gliricida seprium* (20.93%), *Eucalyptus toreliana* (13.95%), *Delunix regea* (6.98%). However *Terminalia catapa*, *Terminalia radii*, *Azadrachita indica* and *Newbodia levis* had the same abundance of 2.33%.

22

23

Polyanthia

longiflora

Polyanthia

longiflora

No physical defect

No physical defect

Carbon

Carbon sequestration,

Carbon sequestration, Beautification, Wind break

Carbon sequestration, Shade

Carbon sequestration

Carbon sequestration

Carbon sequestration

Carbon

Carbon

Carbon sequestration, Shade

Carbon sequestration, Shade

Carbon sequestration, Shade

Carbon sequestration, Shade

Carbon sequestration,

sequestration

sequestration

sequestration,

Beautification,

Beautification, Wind break

Wind break

It was also observed from the study that the avenue trees are not well spatially distributed. The total Diameter at Breast Height (DBH) and Height of the assessed avenue trees species are 2847 cm and 366.8m respectively.

S/N	NAME	PHYSICAL CONDITION	BENEFITS	24	Polyanthia longiflora	No physical defect
1	Roystonea regia	No physical defect	Beautification, Shade		longijiora	
2	Roystonea regia	No physical defect	Beautification, Shade	25	Polyanthia longiflora	No physical defect
3	Roystonea regia	No physical defect	Beautification, Shade			
4	Roystonea regia	No physical defect	Beautification, Shade	26	Polyanthia longiflora	No physical defect
5	Roystonea regia	No physical defect	Beautification, Shade			
6	Roystonea regia	No physical defect	Beautification, Shade	27	Polyanthia longiflora	No physical defect
7	Roystonea regia	No physical defect	Beautification, Shade			
8	Roystonea regia	No physical defect	Beautification, Shade	28	Polyanthia longiflora	No physical defect
9	Roystonea regia	No physical defect	Beautification, Shade			
10	Roystonea regia	No physical defect	Beautification, Shade	29	Polyanthia longiflora	No physical defect
11	Roystonea regia	No physical defect	Beautification, Shade			
12	Newbodia levis	No physical defect	Carbon sequestration, Shade	30	Azadrachita indica	No physical defect
13	Gliricida seprium	No physical defect	Carbon sequestration, Shade	31	Delunix regea	No physical defect
14	Gliricida seprium	No physical defect, requires	Carbon sequestration, Shade	32	Eucalyptus	No physical defect
15	Delunix regea	No physical defect. requires	Carbon sequestration.	33	Eucalyptus spp	No physical defect
16	Gliricida	pruning No physical	Shade Carbon	34	Eucalyptus spp	No physical defect
	seprium	defect, requires pruning	sequestration, Shade	35	Gliricida seprium	No physical defect, requires
17	Gliricida seprium	No physical defect, requires pruning	Carbon sequestration, Shade	36	Gliricida seprium	No physical defect, requires
18	Gliricida seprium	No physical defect, requires pruning	Carbon sequestration, Shade	37	Eucalyptus toreliana	No physical defect
19	Gliricida seprium	No physical defect, requires pruning	Carbon sequestration, Shade	38	Eucalyptus toreliana	No physical defect
20	Polyanthia longiflora	No physical defect	Carbon sequestration, Beautification, Wind break	39	Eucalyptus toreliana	No physical defect
21	Polyanthia longiflora	No physical defect	Carbon sequestration, Beautification.	40	Terminalia catapa	No physical defect
			Wind break	41	Gliricida seprium	No physical defect

#### 3.3 Physical Conditions and Benefits of the Avenue Trees

			Shade
42	Delunix regea	No physical defect	Carbon
			sequestration
43	Terminalia	No physical defect	Carbon
	radii		sequestration,
			Beautification

Table 2. Idi-Ishin Avenue Trees Physical Conditions and Benefits

Table 2 presents the physical conditions of individual trees species and benefits from them. Physical observations from the avenue trees revealed that majority of trees had no physical defect, while some of the trees needed to be pruned. According to Britt (2008), poor pruning causes decay that may lead to severe damages to healthy trees.

It was also observed that the benefits derived from these avenue trees includes; Carbon sequestration, Beautification, Wind break and shade, which is in accordance with Fuwape (2001), who stated that, the benefits of street trees include: amelioration of weather pattern, provision of clean air, protection of biological diversity, protection of watershed, soil and food crops and provision of recreational facilities

## 3.4 Database Query

Decision making requires information generated from spatial search and necessary operations performed. The database and graphics were manipulated and processed to generate information about the entities (spatial features) for GIS analysis. Data were retrieved from the database i.e. graphics and tabular data using ArcGIS 10.1. GIS analysis helps to ascertain the fitness of the database.



Figure 4. Query for Avenue trees (*Polyanthia longiflora*) available in the study area



Figure 5. Query for Individual Avenue Tree

### 4. CONCLUSION AND RECOMMENDATION

#### 4.1 Conclusion

Sustainable management of avenue trees is highly essential because of their environmental benefits such as energy conservation, carbon storage, air pollution abatement, storm water runoff reduction, etc. They are also known to enhance real estate value, tourism and commerce and citizen quality of life. With all these benefits that avenue trees offers; its calls for proper management. GIS as a decision support system has proven to be an effective and efficient tool for the management of these avenue trees populations in small communities.

#### 4.2 Recommendation

The findings from this study serve as baseline information for the management of the avenue trees population in the study area. Subsequent assessment of the avenue trees at 3-5 year interval is recommended in other to ensure proper and continuous monitoring and updating of the data. The use of GIS as a tool to manage avenue trees is also recommended to Local Government Authorities, State Government, Forestry Research Institute of Nigeria (FRIN), Forest Managers, etc, as GIS spatial analysis ensures efficient and economical ways for handling spatial problems. GIS will also ensure proper and continuous monitoring and updating of information about urban forest.

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