

# **Chapter 3**

# **Data**

# **Analysis**

# Project components



Diagram 3-1: activity components

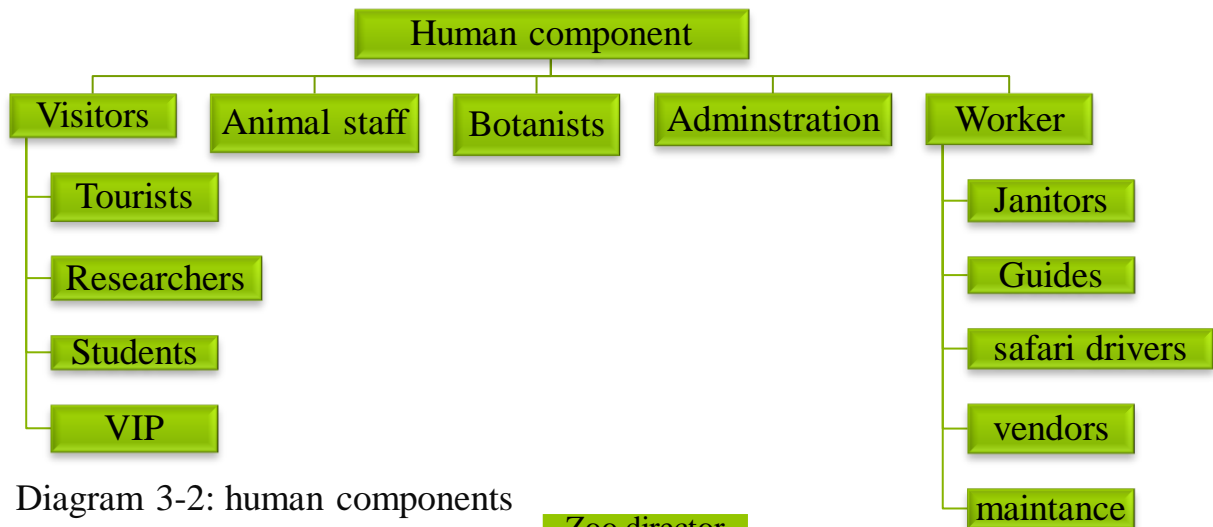


Diagram 3-2: human components

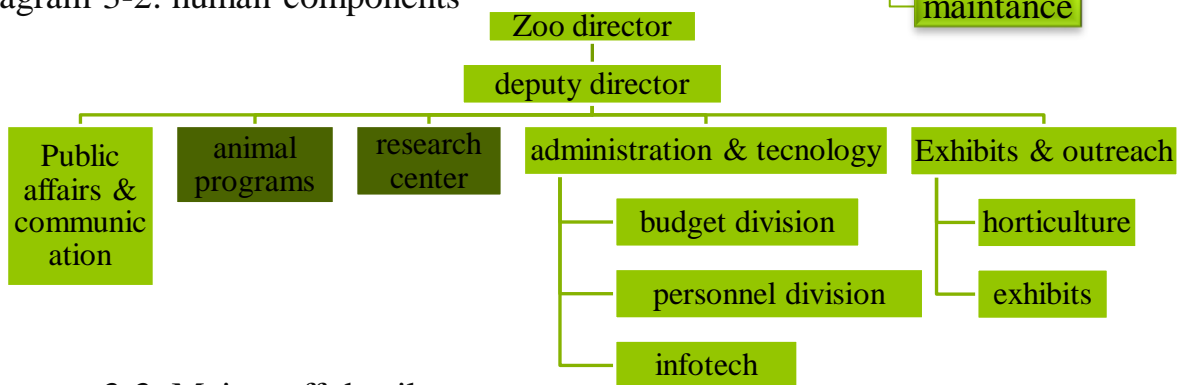


Diagram 3-3: Main staff details

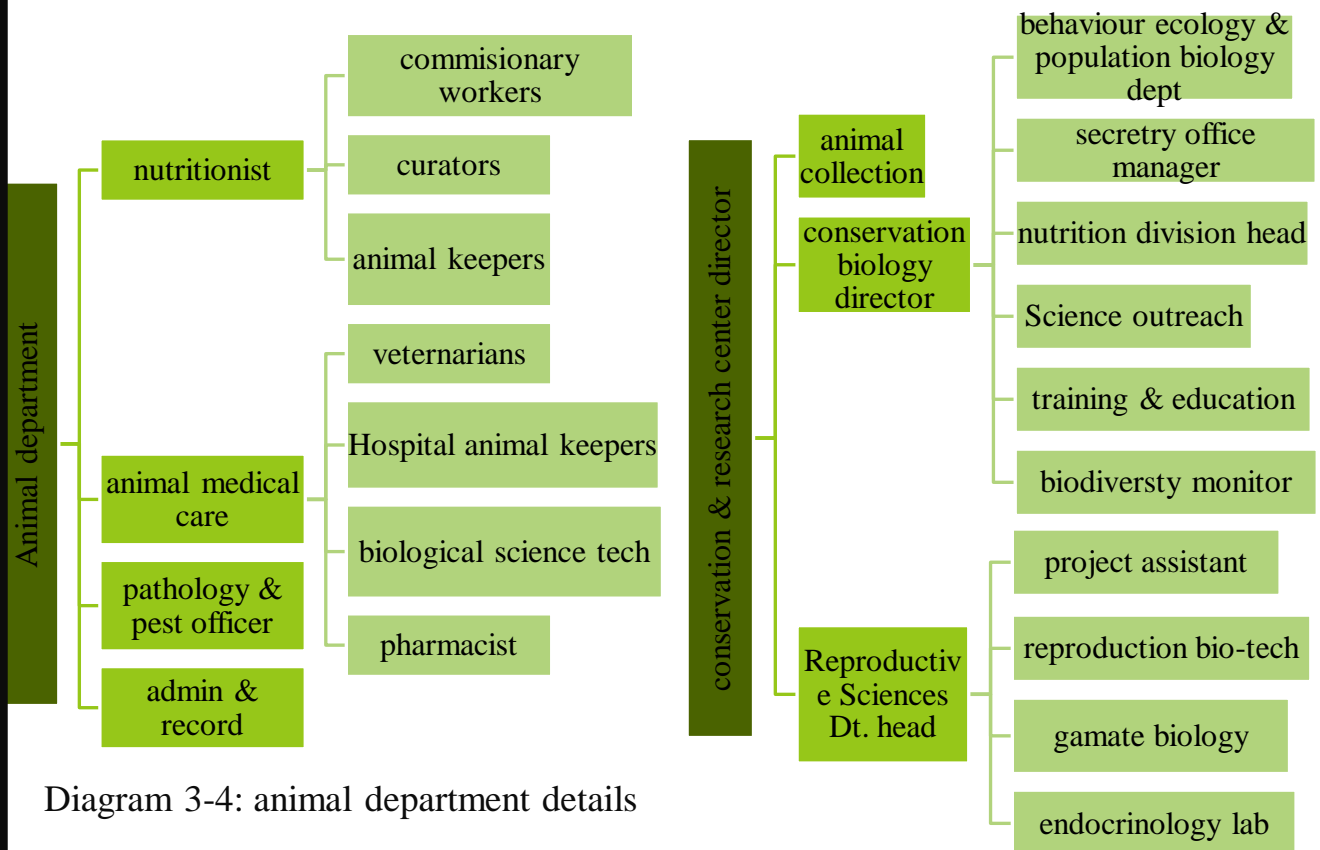


Diagram 3-4: animal department details

Diagram 3-5: Research center staff details



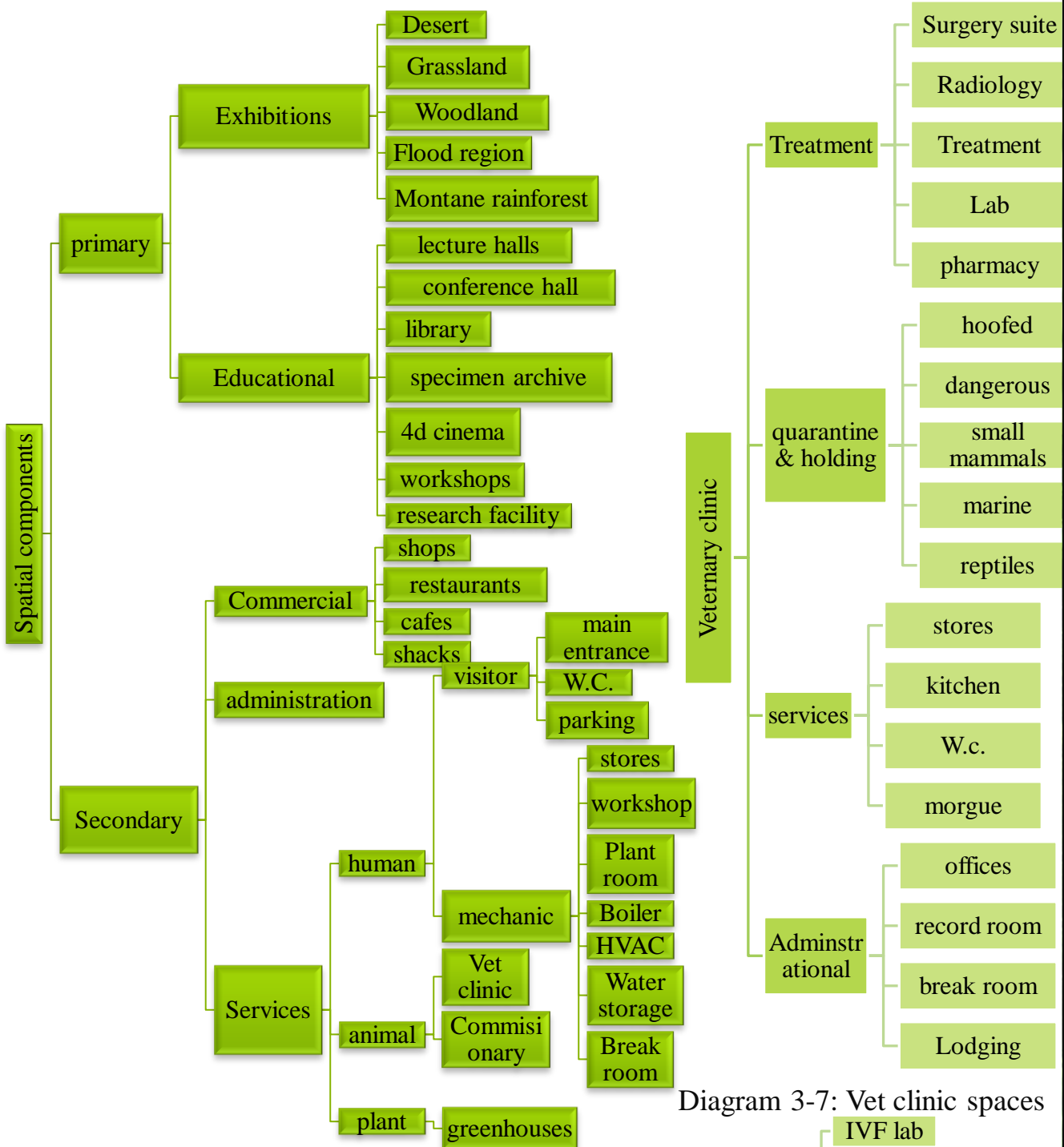


Diagram 3-7: Vet clinic spaces

Diagram 3-6: Spatial components

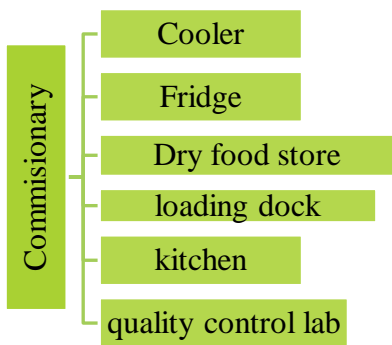


Diagram 3-8: commisionary spaces

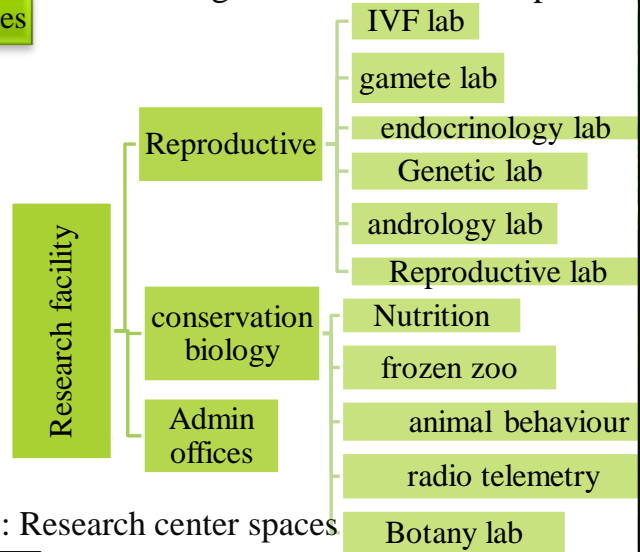


Diagram 3-9: Research center spaces

# Space study

## Biome exhibits:

Because the project focuses equally on plants as animals (while also explaining the effects of climate on them verbally during the tour), equal spaces should be allocated for them + space for circulation

## Total exhibit area =

Animal enclosure 40% + plant area 40% + circulation 20%

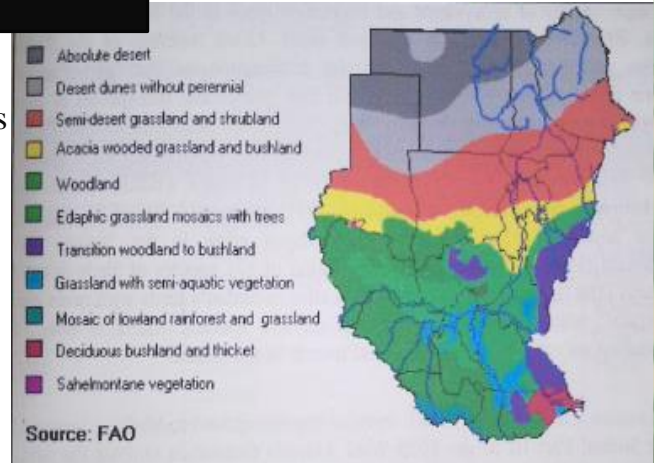


Figure 3-1: Vegetation zones in Sudan

((Detailed list of plant species per zone in appendix))

	Animal	Risk	No.	Outdoor area	Indoor area	Total area	Special requirements	Total
<b>Deser</b>	Addax	2	6	500	24	524	8) 27) 29) 30) 31)	40 animals
	Eastern addax	2	6	500	24	524	8) 27) 29) 30) 31)	
	Dorcas gazelle	2	5	250	20	270	6/8/1930	
<b>Semi desert</b>	Sommering's gazelle	2	5	250	20	270	6/8/1930	Closed exhibit :2568+60%= 4108.8 sqm
	Tora Hartebeest	2	3	500	24	524	8) 27) 29) 30) 31)	
	Darfur tiang	1	6	500	24	524	8) 27) 29) 30) 31)	
	Caracal	2	2	30	20	50	2) 4) 6) 11) 15) 21) 23)	
	Spotted Hyena	1	2	200		200	1) 11) 21)	
	Rock dassie	2	5	10	10	20	2)	Safari zone 870+60%= 1392 sqm 58 animals
<b>Grassland savannah</b>	Greater Kudu	1	5	500	40	540	8) 25) 26) 27) 31) 32)	
	Oryx beisa	2	5	500	40	540	8) 25) 26) 27) 31) 32)	
	Grants gazelle	2	5	250	20	270	6/8/1930	
	Waterbuck	1,2	5	250	20	270	6) 8) 27)	
	Bohor reed buck	2	5	250	20	270	6) 8) 27)	
	Roan antelope	1,2	5	250	20	270	6/8/1930	
	Tiang	1	3	250	12	262	8) 27) 29) 30) 31)	
	Lion	1	2	80	30	110	2) 4) 6) 11) 15) 21) 23)	
	Cheetah	1	2	200	20	220	2) 4) 6) 11) 15) 21)	
	Civet	2	2	16	16	32	2) 4) 6) 11) 15) 17) 21)	
	Ratel	1	2		8	8	2) 3)	
	Zebra	1	5	500	40	540	8) 25) 26) 27)	
	Giant pangolin	3	2		6	6		
	Patas monkey	1	5	25	25	50	2) 6) 11)	
	Vevet monkey	1	5	25	25	50	2) 6) 11)	



<b>Woodland savannah</b>	Bushbuck	2	10	500	40	540	6) 8) 27)	Closed Exhibit: 3241 + 60% = 5185  Safari area: 2200+60%=3520  72 animals
	Sable antelope	1,2	5	500	40	540	8) 25) 26) 27) 31) 32)	
	Sudan reedbuck	2	10	500	40	540	6) 8) 27)	
	Oribi	2	4	100	12	112	6)	
	Red fronted gazelle	2	5	250	20	270	6) 8) 30)	
	Lelwell Hartebeest	2	5	500	40	540	8) 25) 26) 27) 31) 32)	
	Salt dik dik	3	2	50	6	56	4	
	Leopard	1	2	50	25	75	2) 4) 6) 11) 15) 21) 23)	
	Golden cat	2	2	10	10	20	2) 4) 6) 11) 15) 17) 21)	
	Wild cat	2	2	16	16	32	2) 4) 6) 11) 15) 17) 21)	
	Stripped Hyena	1	2	200		200	1) 11) 21)	
	African dog	1	4	200		200	1) 3) 6) 8) 11)	
	Bat eared fox	2	2	60		60	1) 3) 6)	
	Baboon	1	5	25	25	50	2) 6) 11)	
	Elephants	1	2	350	75	425	24) 25)	
	White rhino	1	2	500	50	550	11) 24) 25) 26)	
Black rhino	1	2	500	50	550	11) 24) 25) 26)		
Giraffe	1	4	500	100	600	33) bulls 26)		
Cape pangolin	3	2		6	6			
<b>Flood region</b>	Buffalo	1	5	500	40	540	8) 25) 26) 27) 31) 32)	2635+60%= 4216 sqm  52 animals
	Eland	1	5	500	40	540	8) 25) 26) 27) 31) 32)	
	Sitatunga	2	5	250	20	270	6/8/1930	
	White eared kob	1,2	5	250	20	270	6/8/1930	
	Nile lechwe	1,2	5	250	20	270	6/8/1930	
	Mongalla gazelle	2	5	250	20	270	6/8/1930	
	Long nosed dik dik	3	2	50	6	56	4	
	Lesser kudu	2	4	100	12	112	6)	
	Serval	2	2	30	20	50	2) 4) 6) 11) 15) 21) 23)	
	Red monkey	3	5	25	25	50	2) 6) 11)	
	Hippo	1	2	200	20	220	4) 24) 29)	
	Bush pig	1	2	10	8	18	8) 17) 25) 27) 29)	
	Tree dassie	2	5	10	10	20	2)	

<b>Red sea</b>	Barbary sheep	3	8	400		400	2)	6)	8)	27)		
	Jackal	2	4	100		100	3)	6)	34)			
	Red fox	2	2	60		60	1)	3)	6)			
	Wild rabbits	3	5	20		20	1)	6)				
<b>Montane Rainforest</b>	Nabian ibex	1,2	4	400	16	416	2)	6)	8)	28)		
	Mountain reedbuck	2	4	400	16	416	2)	6)	8)	28)		
	Klipspringer		2	50	6	56	2)	6)				
	Green monkey	3	5	10	10	20	2)	3)	6)	34)		
	Wart hog	1	2	10	8	18	8)	17)	25)	27)	29)	
	Wild ass		5	500	40	540	8)	25)	26)	27)		
	Bongo		5	500	40	540	8)	25)	26)	27)	31)	32)
	Black & white colobus	1	5	15	15	30	2)	6)	11)	12)		
	Red tail monkey	3	5	15	15	30	2)	6)	11)	12)		
	chimpanzee	1	3	35	35	70	2)	6)	11)	14)		
	Giant forest hog	1	2	20	16	36	8)	17)	25)	27)	29)	
Aardvark	2	2		40	40	1)	3)					

2272+60% = 3635 sqm 63 animals

Table 3-1: exhibits space study

**Total animals:** 285 animals

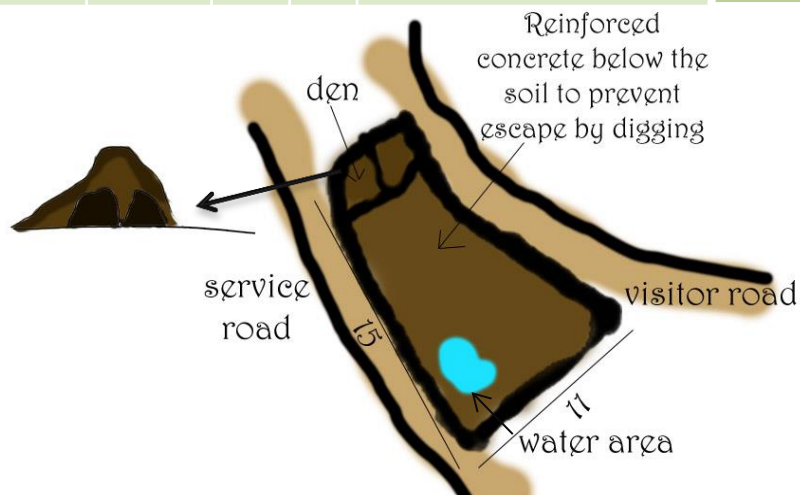
25 outdoors 260 indoors

**TOTAL:** 26820 Sqm

**Total Exhibit area:** 21908

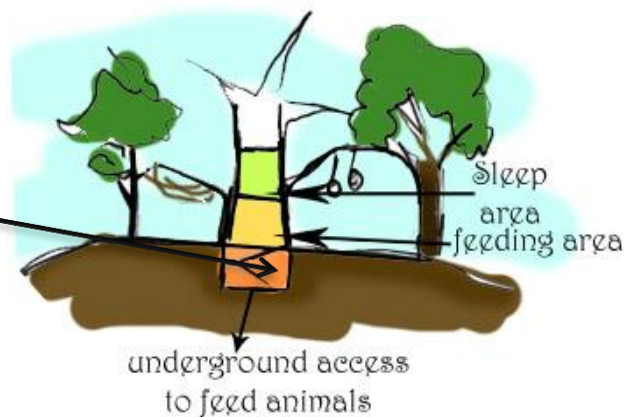
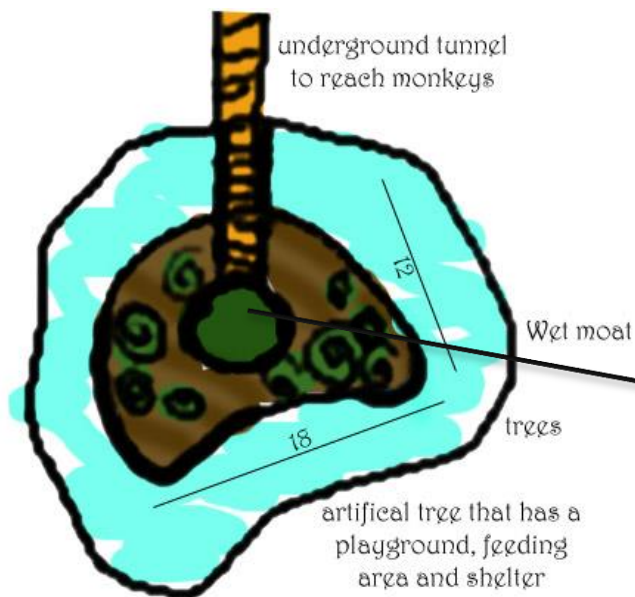
sqm Safari zone: 4912 sqm

**Sample plans:**



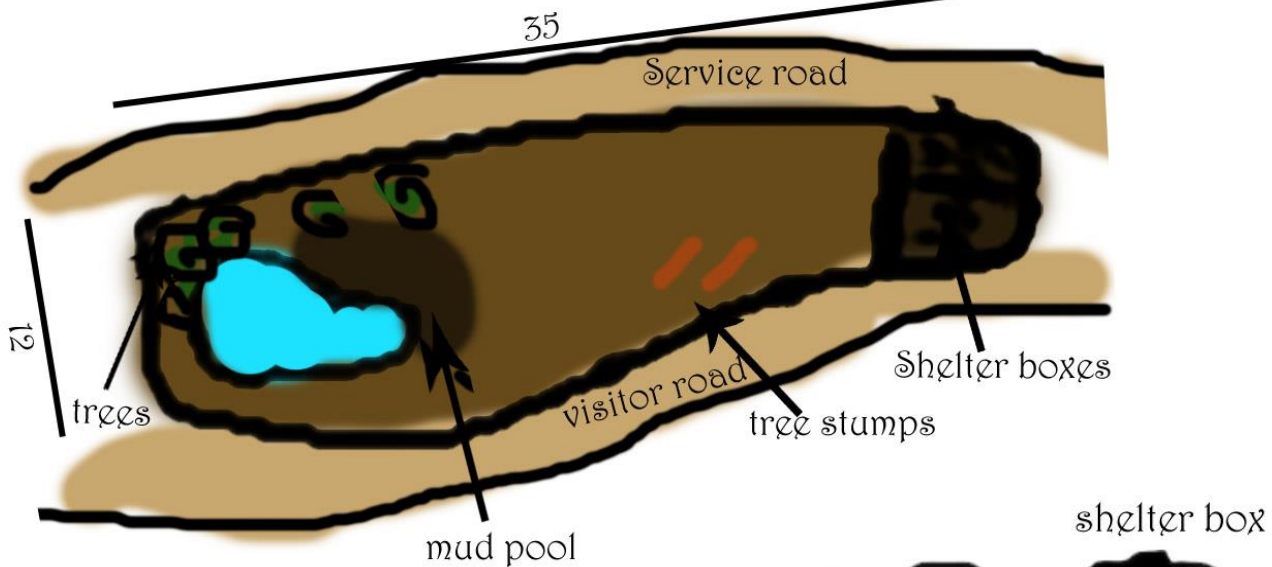
**Hyena exhibit**

artificial tree

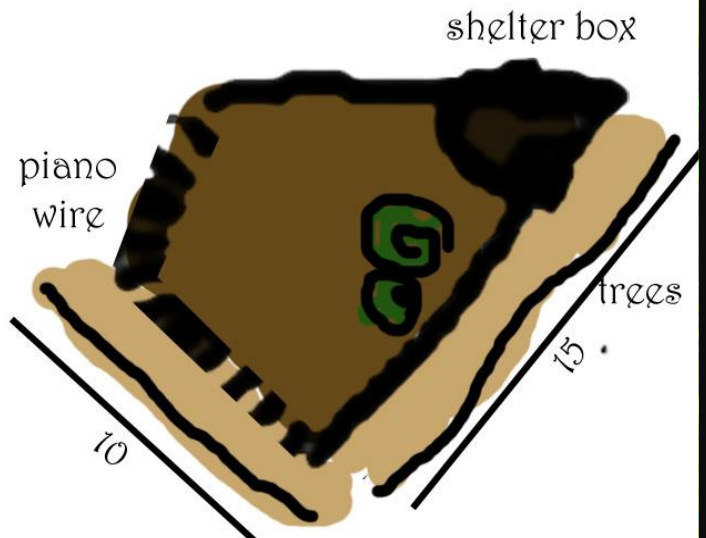


**Monkey island exhibit**





Gazelle exhibit



Piano wire exhibit

For small animals separated from the visitors by piano wires

### Conservational

Using the Ecorium as a reference: ecorium exhibit area was 9300, so my project is 300% bigger

**Lecture hall**

for 200 seats  $12.5 \times 12.8 = 160 \text{ sqm}$

**Workshops:**

(Gardening, water & electricity, Waste management, general) 2 of each = 8 (30 seat) workshops, each one 150 sqm

$8 \times 150 = 1200 \text{ sqm}$

**Shops:**  $9 \times 100 = 900 \text{ sqm}$

**Research facility:** 310

**Total area: 7950**

	Ecorium area	300% increase
<b>Exhibitions</b>	1350	4000
<b>Conference hall</b>	400	1200
<b>4d Cinema</b>	210	630
<b>Archive &amp; library</b>	150	450

Table 3-2: Conservational space study

embryo transfer	65	nutrition studies	25
in vitro fertilization	42	reproductive physiology	25
Animal behavior	25	endocrinology	25
radio telemetry	25	genetics	25
Andrology lab	11	frozen zoo	25
Ultra sound	16	Total	310

Table 3-3: Research center space study



## Services:

### 1. Animal services:

- ❖ Animal reserve area:

animals are kept here before being introduced to exhibit, 7000 sqm

- ❖ Commisionary

Oklahoma zoo was used as a reference, its **Size:** 376650 sqm, **no. of animals:** 18000

so my project has 5% of its animals

(staff 2 nutrition center keepers, zoological manager, 1 nutritionist)

•**Food prep:** St Louis 1400 sqm so 5% of it = **70 sqm** (which is the same as

Oklahoma zoo that serves 1000 animals)

- **Storages:**

**Hay dry store:**

	St louis	5%
<b>Hay</b>	17252 kg per month	862 kg per month

1 hay bale weighs 16 kg so 862 kg= 54 bales

Table 3-4: Hay consumption per month

each one is 35cmx45cmx110cm= 0.173 sqm

so the 54 bales need 9.342 sqm + 20% circulation= **11 sqm**

**Meat freezer:** (Source: Nutrition advisory group publications)

According to **The Ethiopia Sanitary & Phytosanitary Standards & Livestock**

**Meat Marketing** a single beef carcass yields 200 kg of meat with bone, so we need

6 bull carcasses per month.....2000 sqm fridge = 2400 carcasses so 6 carcasses need

**5sqm**

**Fruits & vegetables fridge:** 20sqm..

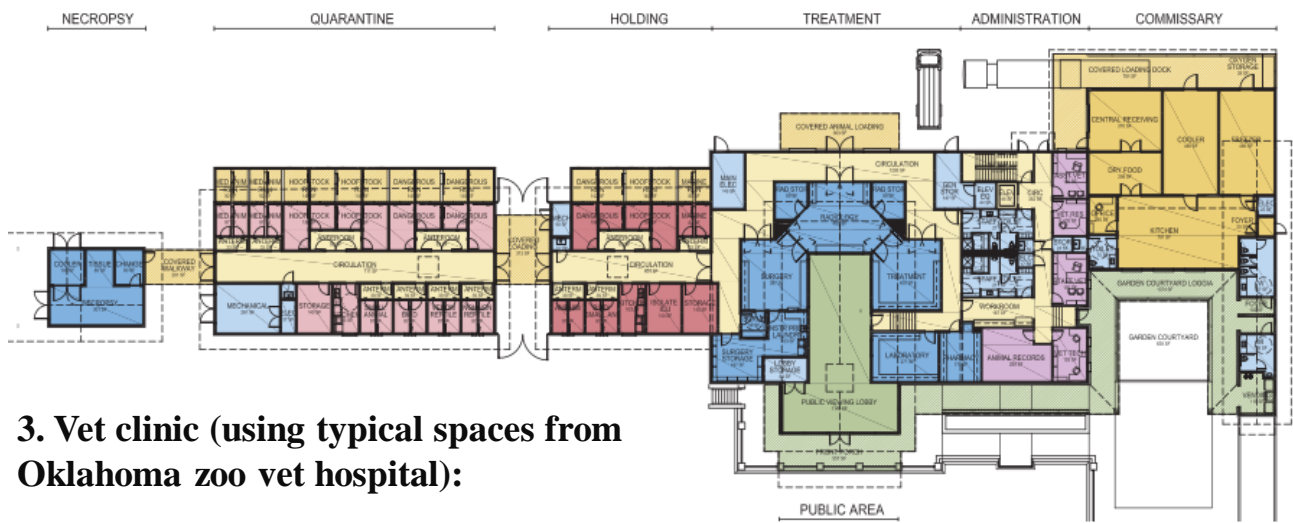
**Loading bay:** 50 sqm. **Oxygen store:** 3sqm

Animal	Kg per day	No. of animal	Total kg	Kg per month
monkeys	2	20	20	600
Chimps	5	3	15	450
Baboons	2	5	10	300
Hogs	2.5	6	15	450
			Total	1800

Animal	Kg per day	No of animal	Tota l kg	Kg per month
lion	5	2	10	300
leopard	3.5	2	7	210
Small cats	0.5	10	5	150
Hyena	2	4	8	240
Wild dogs	1.1	2	2.2	66
Foxes	1	6	6	180
				1146 kg

Table 3-5: Vegetable consumption per month

Table 3-6: meat consumption per month



**3. Vet clinic (using typical spaces from Oklahoma zoo vet hospital):**

	Space	Area per unit	No. of units	Total		Space	Area per unit	No. of units	Total
Treatment	Surgery suite	55	1	55	Morgue	cooler	9	1	9
	Radiology	40	1	40		change	8	1	8
	Treatment	30	1	30		tissue	7	1	7
	Lab	11	1	11		Dissection	25	1	25
	Pharmacy	16	1	16		Stores	10	4	40
	Animal loading	30	1	30	Services	Kitchen	10	1	10
Quarantine	Hoofed	15	2	30		w.c.	1.5	4	5
	Small mammals	8	1	8		Electric room	20	1	20
	Dangerous	15	1	15		Admin.	Offices	12	7
	Marine reptile	8	1	8	Record room		25	1	25
	anteroom	10	1	10	Break room		18	1	18
Isolate ICU	15	1	15	lodging	32		1	32	
					Total: 560 sqm				

Table 3-7: Vet clinic space study

**2. Building Services:**

	Area per unit	No. of units	Total area
workshop	25	2	100
storage	50	3	150
Plant rooms	30	4	120
Green houses	1000	5	5000
Water treatment	20	1	20
<b>Total</b>			<b>5390</b>

Table 3-8: Building service

Total area = 5390 + admin 365 = **5755 sqm**

	Area per unit	No. of units	Total area
Zoo director	30	1	30
Secretary	10	1	10
Director offices	25	5	125
General offices	20	7	140
Meeting room	25	1	25
Reception	30	1	30
w.c.	1.5	2	3
		Total	365

Table 3-9: Administration space study



Tourists in	2010	2011	2012	2013	2020	2025
Sudan	459161	536400	574645	612890	880605	1071830

Table 3-10: tourist statistics in Sudan (curtesy of ministry of tourism)

### 3.Public services

Assuming 25% of tourists will visit the project

=  $1071830 \times 25\% = 267957$  per year = **730** visitors per day

Sudan's population will reach 41000000 by 2025\ if 5% of them visited the project

each year =  $2050000$  visitors per year =  $5300$  visitors per day

$5300 + 730 =$  **6030 visitors per day**

❖ **Parking:** 1 per 100 tourists per day = 603 cars

Area =  $19 \times 605 =$  **11,495 sqm**

❖ **Restrooms:** 3 per 100 people..  $6030 \div 100 \times 3 =$  180 people

Area =  $180 \times 1.8 =$  **325 sqm**

**Refreshment stands:** each stand 4 sqm,

each exhibit has 2 stands so  $2 \times 5 \times 4 =$  **40 sqm**

**Cafes & restaurants** 25% of visitors = 1507

1 m per visitor = **1507 sqm**

**Souvenir shops** 5 shops 40 sqm each = **200 sqm**

**Mosque:** for 15% of visitors = **904 x1 = 904 sqm**

**Total area = 2976 sqm**

#### Employee facilities:

In Oklahoma zoo, Current employees: 308 full time, 164 part time, 618 seasonal

So 5% = 15 full time 8 part time 30 seasonal

so at any one time there are 30 employees

	Number of units	Area per unit	Total area
w.c.	4	1.8	7.2
Lockers	15	0.5	7.5
Showers	3	1	3
Restroom	1	30	30
<b>Total area:</b>			<b>46.5</b>

Table 3-11: Employee facilities space s

# Space program

	Space	Area			Space	Area	
<b>Exhibits</b>	desert	4764	26821		administration	365	16360
	grassland savannah	4108			commisionary	160	
	woodland savannah	5185			Vet	560	
	safari	4912			Animal reserve area	100	
	flood region	4216			Maintenance	650	
	montane rainforest	3635			employee facilities	46.5	
<b>Conservation</b>	Eco gallery	4000	7950	<b>Services</b>	W.C.	325	
	4d Cinema	630			Restaurants & shacks	1550	
	Workshops	1200			souvenir shops	200	
	conference hall	1200			mosque	904	
	Lecture halls	160			parking	11500	
	Research facility	310					
	Archive & library	450					
<b>Total area</b>					57432.1		
<b>25% circulation &amp; lobbies</b>					71790		
<b>Built area</b>					47328		
<b>Total site area:</b>					177130		
<b>Percentage:</b>					25%		

Table 3-12: space program







# Relationship bubbles

Diagram 3-12: relationship bubbles

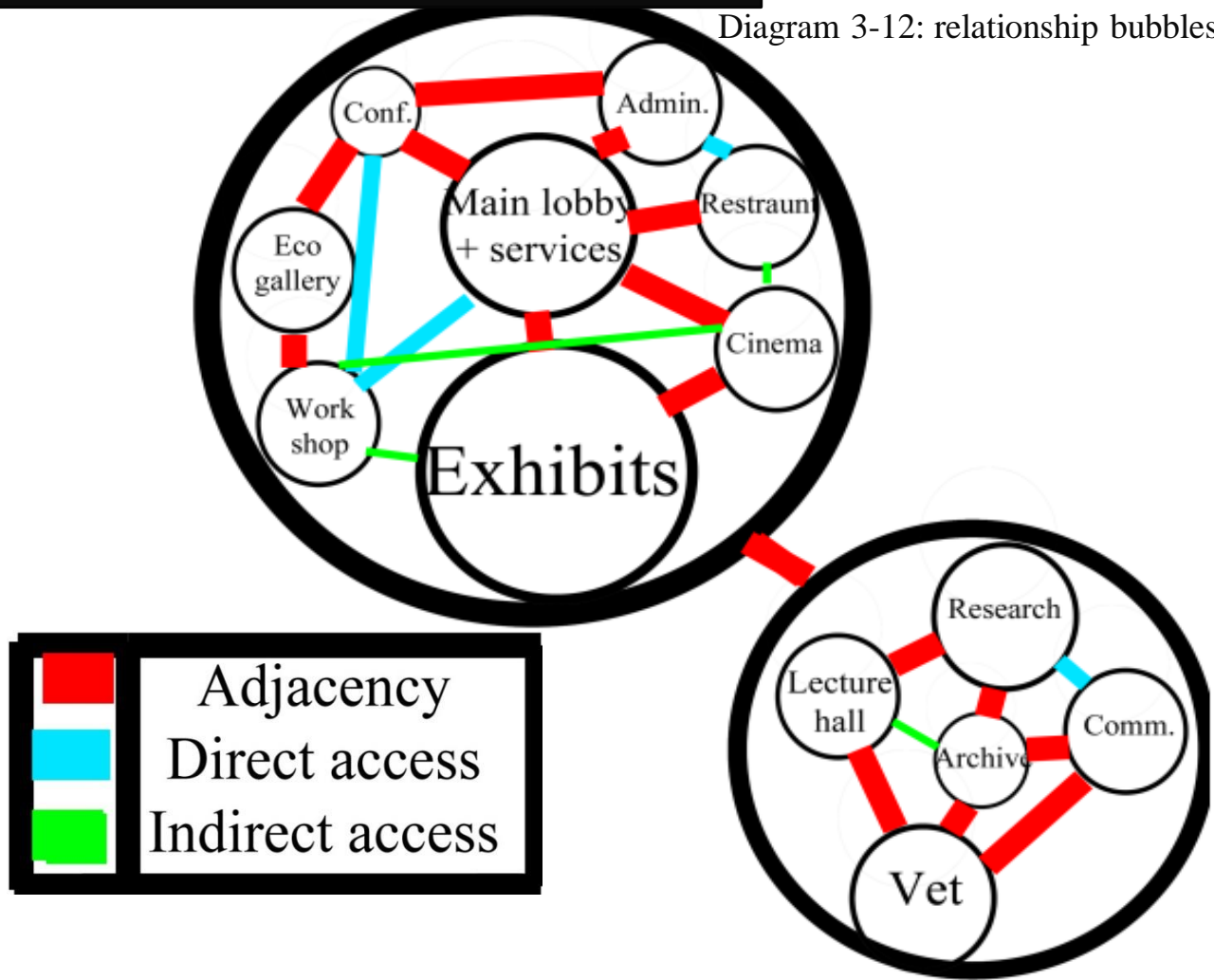
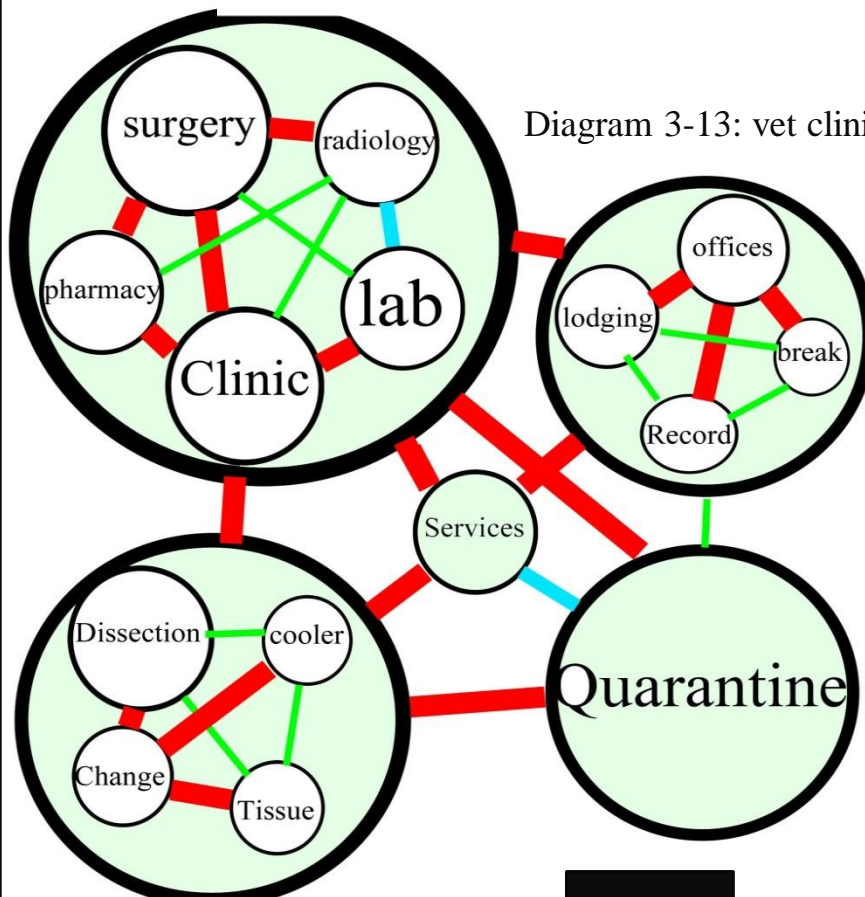


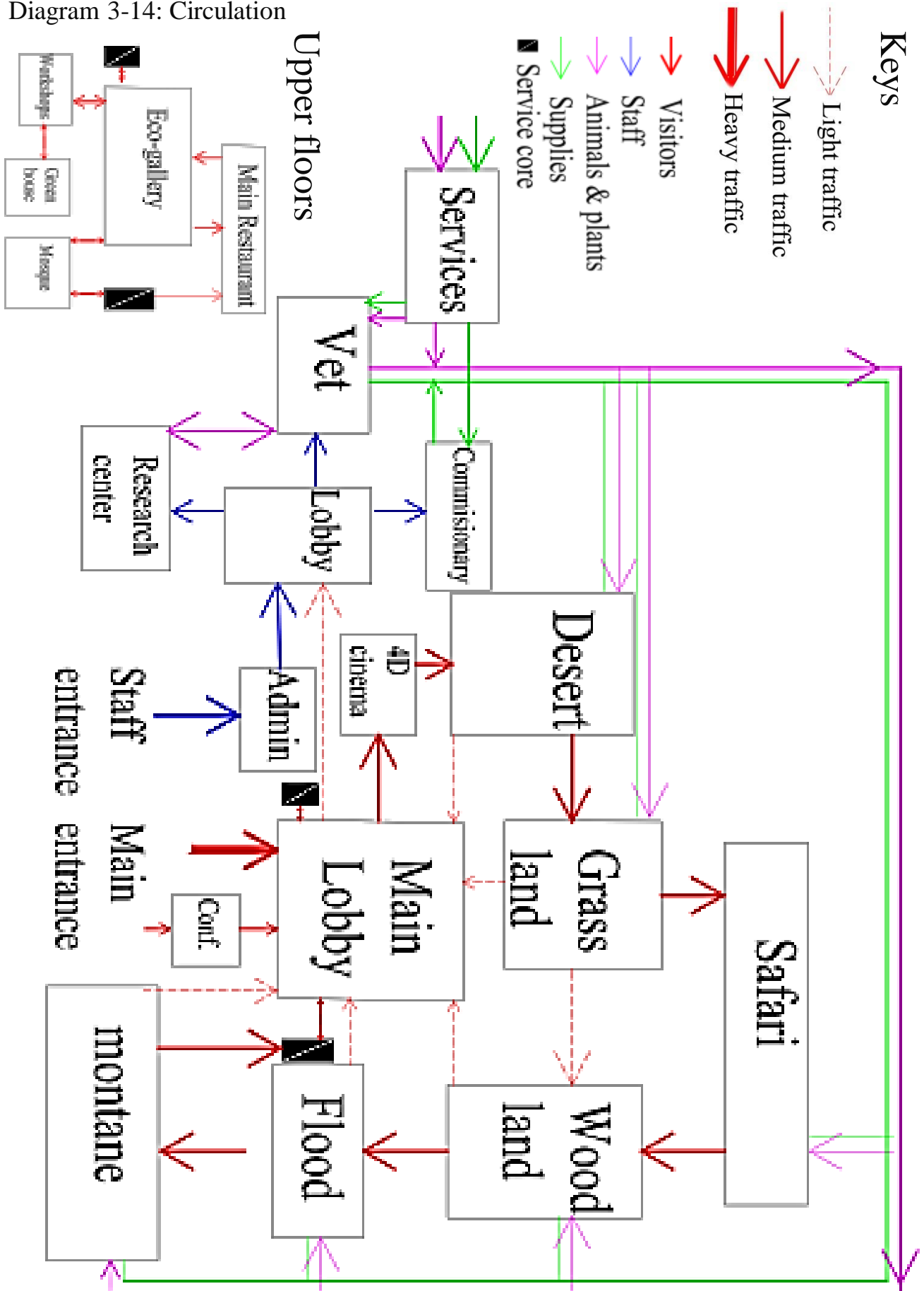
Diagram 3-13: vet clinic relationship bubbles





# Circulation

Diagram 3-14: Circulation



# Site study

## Site 1

Location: east soba

Public transport: Available

Services: available

## Site 2

Location: almogran

Public transport: available

Services: available

Note: in a tourist attraction area

## Site 3

Location: jabal awleeya

Public transport:

Services:

Note: in a tourist attraction area

## Site criteria: (from most important to least)

- ❖ Size must be at least 6 hectare
- ❖ Services; water & electricity are mandatory but sewage waste is treated on site to make fertilizers
- ❖ Location is must be in a designated tourist area or planned to be a park
- ❖ Must be easily accessed from the main road
- ❖ Must have public transportation nearby (preferably more than one)
- ❖ Must be on fertile soil to reduce soil replacing costs (not rocky)
- ❖ site proportions are best between 1:2 & 1:3
- ❖ Preferred to be surrounded by tourist attractions, farms or the Nile & not by a residential area
- ❖ Preferred away from air or sound pollution far from any airport, factory, hospital or military base
- ❖ Views needed for external activities like the safari, open galleries & café's.



Figure 3-2: soba site



Figure 3-3: Mogran site

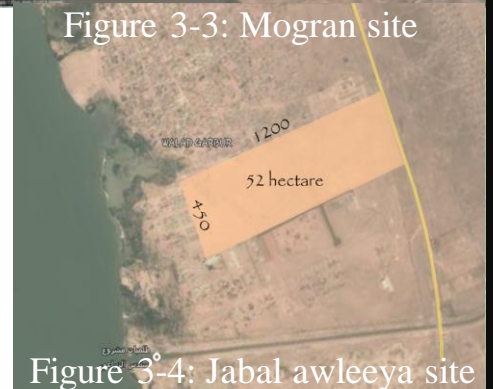


Figure 3-4: Jabal awleeya site



	Score	Soba	Almogran	Jabal awleeya			
<b>Size</b>	25	Suitable	24	A bit small	14	Too big	14
<b>Services</b>	15	All but sewage	12	All available	15	Water & electricity	12
<b>Location</b>	10	In the middle of farms	8	Tourist location	8	Tourist location	7
<b>Accessibility</b>	10	From small dirt side road	8	From a special service road	8	Direct from jabal awleeya road	7
<b>Transport</b>	10	Albageer or butri	9	All Omdurman buses pass here	10	Jabal awleeya	6
<b>Soil</b>	10	Very Fertile	8	Very Fertile	9	Very fertile	8
<b>Proportion</b>	5	Excellent	4	good	3	Too long	2
<b>Surrounding</b>	5	Near vet research institute	5	Near the Nile & almogran park	5	Near residential	3
<b>Pollution</b>	5	Quiet area away from the city center	5	In a busy area	2	Very quiet area	4
<b>View</b>	5	Farms	4	White Nile	4	No view	2
	100	87		78		65	

Table 3-13: site comparison



Figure 3-5: Sudan map

**Chosen site: site no.1 Soba**

### Site analysis

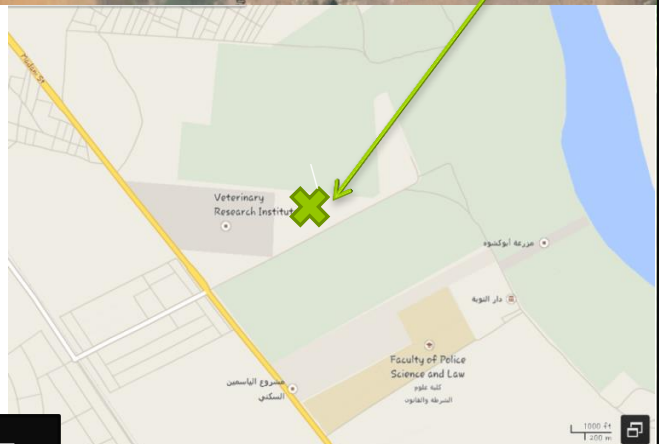
**Location:** Soba,

Behind the veterinary research center & (before al-yasmin project)

**Accessibility:** butri or albageer



Figure 3-6: Khartoum map



# Farms

**Noise:** no noise

**Views:** Farms in North, south

(natural background) and east

**Traffic:** madani road is busy during holidays but the side road leading from it to the site is quiet and empty

**Services:** Water & electricity from the south and west sides

**Streets:**

**South:** main road 10m per lane

**East & north:** 7.5m per lane road

**West:** 7.5 m per lane road



Figure 3-7: Site map

	Effect of site on neighbors	Effect of neighbors of site
<b>Farms</b>	<ul style="list-style-type: none"> <li>× increased traffic &amp; noise</li> <li>✓ animal manure acts as a fertilizer for farms</li> </ul>	<ul style="list-style-type: none"> <li>✓ provide a natural background</li> <li>✓ Very quiet and act as a buffer zone from city noise</li> </ul>
<b>Vet institute</b>	<ul style="list-style-type: none"> <li>✓ The project provides animals to study</li> </ul>	<ul style="list-style-type: none"> <li>✓ The institute serves the project animals</li> </ul>

Table 3-14: Site relationship to neighbors

Advantages	Disadvantages
Sufficient space	Not a significant area or tourist area
Very quiet area away from city congestion	The area is still under developed and the infrastructure is poor
Farm view	
Fertile	
services available	
Veterinary services nearby	
Good proportions	

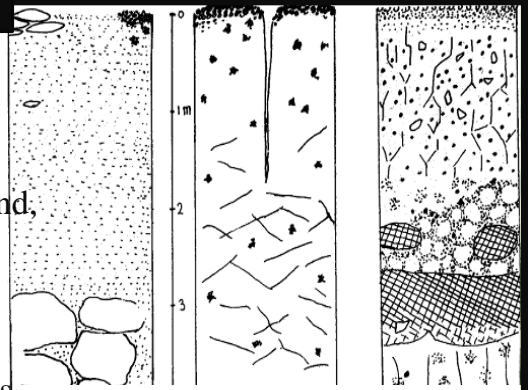
Table 3-15: Site advantages and disadvantages



# Sudan's biome

## Soil

- 1. Desert soil:** sand layers without much differentiation, overlying sandstone; on the surface salt crusts can be found, also stones rounded and smoothed by wind;
- 2. Dark cracking clay:** heavy clay deposits; during dry season wide & deep cracks develop; after start of the rains the soil swells and soil material fallen into the cracks is pushed out again; a relief of mounds and depressions on the surface is the result of these alternations; in the subsoil many smooth surfaces occur along which soil glides when swelling; the soil profile contains calcium concretions
- 3. Ironstone soil,** consisting of dark humus loam, crumbly and loose in upper 10cm, overlying less humus and less structured loam; a light clay follows with a weak block I structure, with frequent iron concretions and some stones; in the subsoil ironstone mottles become more continuous and an ironstone pan can be seen, overlying a heavy clay



Desert Dark clay Ironstone  
Figure 3-8: Sudan's soil types

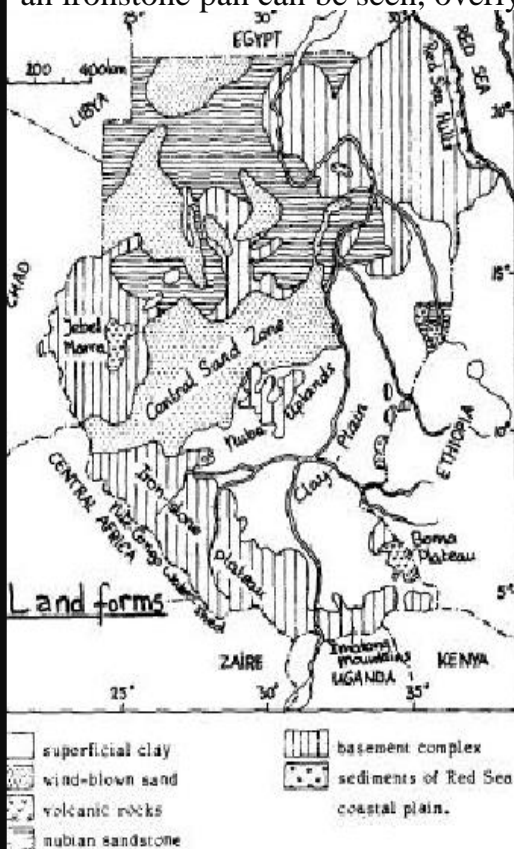


Figure 3-10: Sudan's soil Distribution

Sudan is divided into 6 major ecological zones

**Desert,**

**Semi desert,**

**Grassland savannah,**

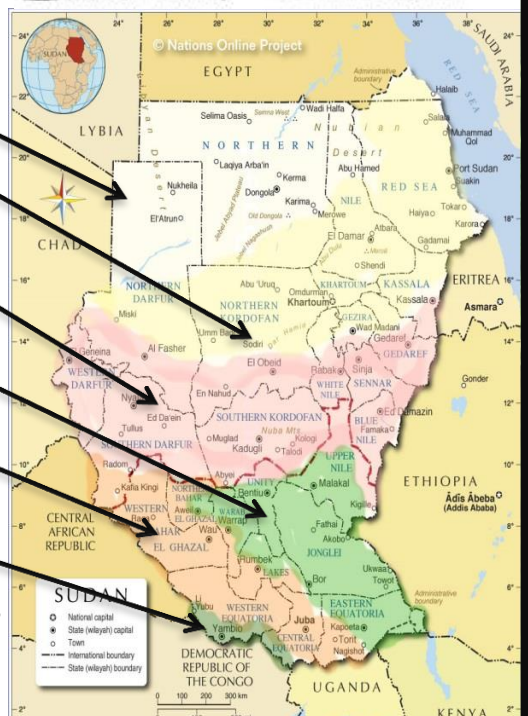
**Flood region,**

**Woodland savannah,**

**montane**

**rainforest**

Figure 3-11: Sudan's Ecological zones





## Ecological zones details

Major division	Sub division	Area
<b>Desert zone</b>		726000
<b>Semi desert</b>	Acacia totillis – maerua crassifala desert scrub	187000
	Semi desert grassland on clay	104000
	Semi desert grassland on sand	86000
<b>Rainfall 75-300</b>	Acacia meilifera- commiphora desert scrub	86000
	Acacia glaucophyila – acacia etbaica scrub	31000
	Total, semi-desert zone	494000
<b>Low rainfall woodland savannah</b>	Subzone 1. Low rainfall woodland savannah on clay	
	Acacia melifera thornland on dark crackling clays	96000
	Acacia melifera thornland on soils formed with commiphora bascia	119000
	Acacia seyal- balanities savannah woodland	
	Anogeissus – combretum savannah woodland	49000
	Total sub zone	264000
<b>Rainfall 400-800</b>	Sub zone 2 low rainfall woodland savannah on sand	
	Acacia sayel savannah woodland	65000
	Combretum kordofanum- albizzia	86000
	Terminalia-sclerocarya-angoeissus- prosopasis	65000
	Total sub zone 2	216000
<b>according to clay types- clay sand and special areas</b>	Subzone 3 special areas	
	Toposa area in East Equatoria	36000
	Hill catenas in ingessana area of blue Nile, nub ants and w. Darfur hills	70000
	Baggara catena in S.darfour & atmur areas	18000
	Ragaba catena	34000
	Total subzone 3	158000
	Total low rainfall woodland savannah	628000
<b>High rainfall woodland savannah</b>	Subzone 1 Savannah woodland	311000
	Sub zone 2 Woodland savannah recently derived from rainforest	36000
	Total high rainfall woodland savannah	347000
<b>Rainfall 900-1300 based on how the forest developed ecologically</b>		
<b>Flood region</b>	Sudd and toic areas in upper Nile	57000
<b>Montane zone</b>	Dongatona & didinga hills, imatong mts red sea hills & jebel mara	6500
<b>Total area</b>	2258500	

Table 3-16: Ecological zones details



# Climate Study:

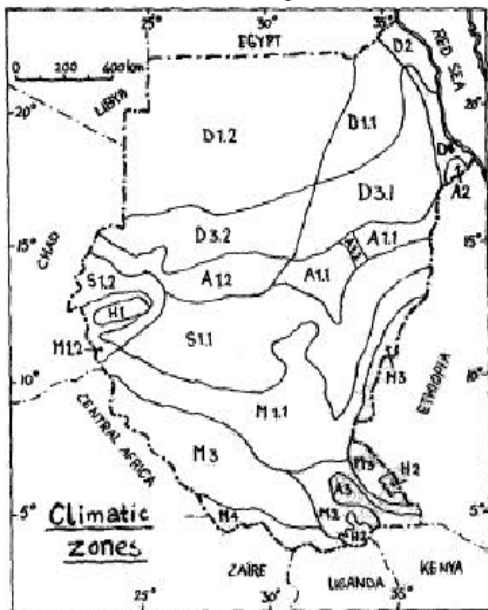


Figure 1.16 Climatic zones of the Sudan; D = desert, A = arid, S = semi arid, M = monsoon, H = highland; further details are given in table 1.1. (after FAO report).

Figure 1.18 Ecological zones of the Sudan. (Based on Jackson and Harrison, 1956).

Khartoum state climate data: (note highlighted figures because they will be used for later comparison)

	Avg. Min Temp	Avg. Max Temp	Avg. Rain (mm)	Relative Humidity (%)
January	16	32	0	21
February	17	34	0	16
March	19	37	0	13.0
April	23	40	1	13
May	26	42	5	14
June	27	42	7	18
July	26	38	48	31
August	25	36	72	42
September	25	38	27	30
October	25	40	4	20
November	21	36	0	21
December	17	33	0	23

Figure 3-12: Sudan's climate zones

Table 3-17: Khartoum climate data

Biome	Code	Description	Rainfall	Mean min temp	Mean max temp
Desert	D 1.2	Desert, summer rain cool winter	100	8-13	42-44
Semi Desert	D 1.1	Desert, summer rain warm winter	100	13-15	42-44
	D 2	Desert, winter rain	75	13-18	42-44
	D 3.1	Semi desert, summer rain, warm winter	100-225	13-16	40-42
	D 3.2	Semi desert, summer rain, cool winter	100-225	8-13	40-42
	D 4	Semi desert, winter rain	75-225	18-20	40-42
	A 1.1	Arid, summer rain, warm winter	225-400	13-17	40-42
	A 1.2	Arid, summer rain, cool winter	225-400	8-13	40-42
	A 2	Arid, winter rain	225-600	13-20	40-42
Grassland savannah	A 2.1	Arid, no marked season	550-750	18-20	37-38
	S 1.1	Semi-arid, summer rain, warm winter	400-750	13-17	39-40
	S 1.2	Semi-arid, summer rain, cool winter	300-600	8-13	35-39
Flood region	M 1.2	Dry monsoon, long dry season, cool winter	600-850	5-13	38-39
	M 1.1	Dry monsoon, long dry season, warm winter	750-1000	17-20	36-41
Woodland	M2	Dry monsoon, medium dry season	850-1000	18-21	36-68
	M3	Wet monsoon, medium wet season	950-1400	10-12	34-39
Montane rainforest	M4	Wet monsoon, long wet season	1200-1600	14-19	34-35
	H1	Highland, short wet season, warm summer	600-1000	6-8	36-39
Table 3-18: Sudan climate zones			1000-1600	10-17	23-33



## Comparative weather analysis

To control the indoor environment we must know the worst possible outside environment

then design a system able to achieve stability even in that condition: **Solar radiation chart:**

max solar irradiance 2500 kwh/m<sup>2</sup> min solar irradiance 600 kwh/m<sup>2</sup>

Biome	Averages in each biome					Khartoum Comparison						
	Temperature		Avg. Rad.	Day light	Rain fall	Temperature		Radiation		Day light	Rain	
	max	min		hour		Max	Min	Max	Min	Avg	Max	Min
						42	16	2500	600	3664	72	0
<b>Desert</b>	43	8	2343	3800	100	1	-8	-156	1743	136	28	100
<b>Semi desert</b>	40	14	2282	3500	100	-2	-2	-217	1682	-164	28	100
<b>Grassland</b>	37.5	12.5	2170	3250	300-850	-4.5	-3.5	-329	1570	-414	778	300
<b>Woodland</b>	36.5	16.5	1957	2800	950-1400	-5.5	0.5	-542	1357	-864	1328	950
<b>Flood region</b>	38.5	19	1957	2800	750-1000	-3.5	3	-542	1357	-864	928	750
<b>Montane forest</b>	31	12.5	1917	2700	600-1600	-11	-3.5	-582	1317	-964	1528	600

Table 3-19: Climate comparison

**Optimum orientation:** depending on the amount of irradiance required each biome will be orientated towards the red side if more irradiance is needed and to the yellow if less is desired.

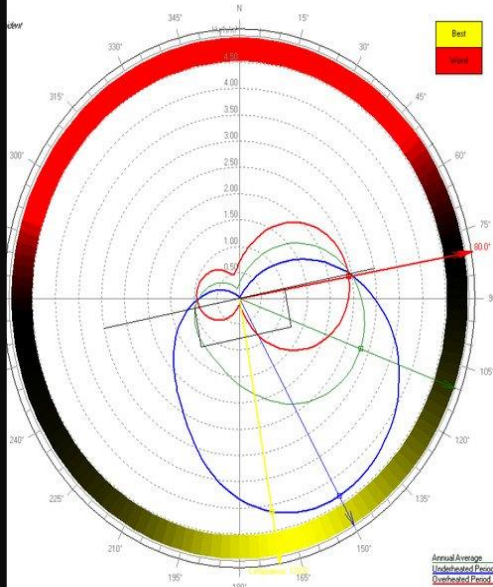


Figure 3-14: Optimum orientation

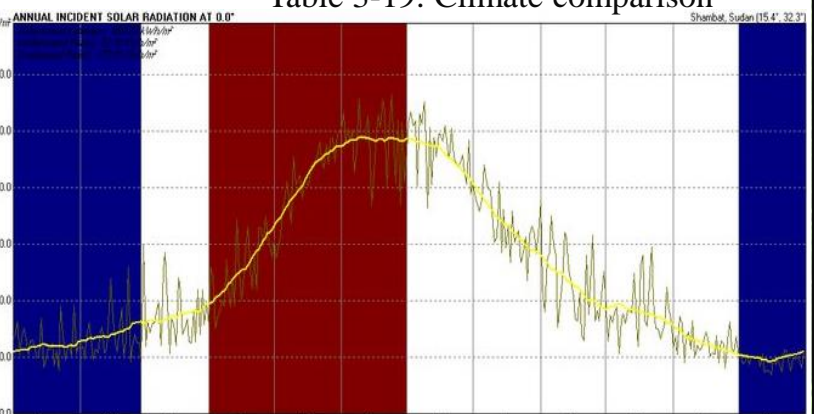


Figure 3-13: Khartoum radiation levels

**Prevailing winds:** wind is need to remove hot air from the greenhouses, the most frequent winds blow at 45° NE with speeds from 10-20 km/h

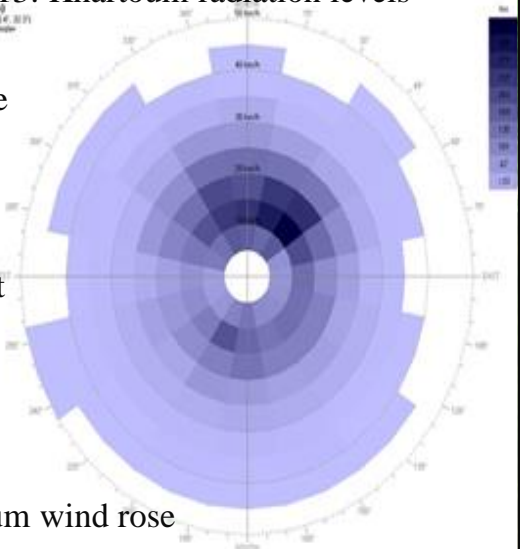


Figure 3-15: Khartoum wind rose



# Zoning

## Farms

Vet  
research  
institute



## Farms

Service entrance

first floor

second floor



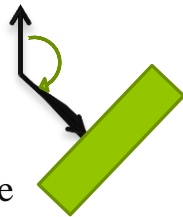
## Farms

Figure 3-16: Zoning

### Optimum orientation:

From the climate analysis to reduce the need for mechanic cooling and heating during the summer and the winter, the optimum orientations for each exhibit is as shown in the table

**Note:** the angles shown are from the north clockwise and perpendicular to the longest side



Biome	Angle	Summer radiation	Winter radiation
Desert	150°	0.75	4.5
Semi desert	165°	0.25	4.17
Grassland	180°	0.1	3.9
Woodland	195°	0.25	3.25
Flood region	210°	0.3	2.50
Montane rainforest	225°	0.5	2

Table 3-20: Optimum orientation

# Design indicators

- ❖ The main entrance should be from the south and the service entrance from the east.
- ❖ Walking distance through the exhibits shouldn't exceed 200 m without a break such as a safari car or chair lift or a café.
- ❖ The exhibits should be oriented to reduce the difference between the indoor and outdoor environment during the coldest and hottest months sustainably.
- ❖ The circulation must follow the storyline while still being flexible and allowing the visitors access to the main lobby if they want to leave in the middle of the tour & services such as washrooms at all times.
- ❖ Must use greenbelts around the site to give a natural background to conceal fences, near the parking to reduce the heat from the asphalt and especially in the south west to filter the sandy summer air.
- ❖ The commisionary, vet & research center should have direct access to the archive & exhibits while also having an internal link to the main building. & also to the service roads leading to each animal exhibit directly.
- ❖ The eco gallery should be open & flexible to allow changing exhibits
- ❖ The workshops should have access to stores and close to the shops. And should have 2 sections, one open for quick demonstrations for the general public and another closed one for organized classes and practical lessons.
- ❖ The shops must be layout in a way that forces the visitor to pass by them before leaving, to increase the number of buyers
- ❖ The botanic garden must be near the parking so visitors can buy heavy plants and load them directly to the car.
- ❖ The conference hall should have a separate entrance and access to the open exhibit and a separate elevator leading to the workshops and Eco gallery.
- ❖ The safari should be surrounded by water and double gate fences for safety issues and trees for a background and have a direct link to the savannah exhibits
- ❖ Delicate seedlings and young or new animals need to be kept in special greenhouses and animal reserves near the research center and vet clinic before being sent to the exhibits or al dindir park