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A Study on Interdependent and Asymmetrical Behaviours Associated with Land use and Land Cover at Ruhande, Huye, Rwanda

Ndayishimiye Jean Claude
M.Phil. Research Scholar, Victus Institute of Interior and Fashion Technology, Pondicherry, India
Nyirabuhoro Pascaline
Postgraduate Student in Geology, Department of Earth Science, Annamalai University, India

Abstract:
The race of the country in economic development involves an essential infrastructure and protected environment to ensure people and workplace healthy and safe respectively. The growth of this programme must go hand in hand with preliminary studies to harmonize these two elements, followed by executions and regular technical adjustments to prevent damages that may occur in future. From that reason, any attempt aiming to strengthen the quality and value of botanical garden devoted to trees at Ruhande over specific characteristics of some constructions it surrounds and vice versa may result in an asymmetrical and hazardous system rather than conservation and amenity desired at Ruhande. In this research work entitled "A study on Interdependent and Asymmetrical Behaviours Associated with Land use and Land cover at Ruhande, Huye, Rwanda," behaviours associated with functional relationship between Arboretum of Ruhande owned by Rwanda Agriculture Board and civil engineering laboratory owned by National University of Rwanda have been assessed to define interdependence and asymmetry and risks created by land use and land cover at Ruhande. To achieve this, both social and economic importance of the forest in the area has been assessed as opposed to the capacity of soil to support the loads applied to the ground, the needs for indoor air quality and visual comfort inside the laboratory during the daytime. The outcome revealed hazardous situation if and only if the state of balance between the systems is unmaintained over the period of time with appropriate measures.

Keywords: *Interdependence, asymmetry, risk, land use, land cover*

1. Introduction

The perfect harmonization of the stability, safety and comfort of the structures with natural environmental conditions is still doubtful. According to many researchers, geological situation of the ground, land use, vegetation cover and micro-climate of the building, openings and construction materials pose many problems for the reason that the true comfort and true well-being pass through there. The designers have assignment to design a structure responding simultaneously and efficiently to sustained natural environment and well-being of occupants. The major constraint in that creative and hard work to design a stable, safe and comfortable structure without damaging the natural environment is long-term planning and incorporating in construction the presence of variable settings usually caused by earthquake, irregular changes in weather patterns (precipitation, temperature, humidity, wind and daylight) and pollution, because uncontrolled interaction among those mentioned phenomena may grow slowly over period of time and suddenly burst into severe hazards. According to the Great Soviet Encyclopedia, 3rd Edition (1970-1979), the ability of a structure to resist to any force can be defined as "to withstand the action of forces attempting to drive it out of a state of equilibrium" while the comfort is related to the sense of well-being felt by the individual. Comfort could have various components depending on individual feels: (i) thermal comfort, (ii) visual comfort, (iii) odour comfort and (iv) noise comfort. Many scientists suggest the choice of location as the best option to prevent naturally occurring disasters and to maintain manmade activities less harmful synonymous with reduced energy consumption, pollution and vector borne-disease control.

2. Objective of the Study

The prime objective of this research work was to study the interdependent and asymmetrical behaviours associated with land use and land cover at Ruhande, to predict risks that may arise in the future.

3. Description of the Study Area

The selected study area in this research work is a civil engineering laboratory building located in the east end side of the block of Electronic and civil engineering laboratories at National University of Rwanda(NUR), Huye campus, and its surrounding botanical garden famous known as Arboretum of Ruhande (altitude: 1737m; latitude 2°36´S and longitude 29°44´E). The building was constructed in 1987 at 0.18 km from Mukoni gate and 0.23 km from the main building of the campus to serve as laboratory for engineering drawing and graphics, hydraulic construction and geotechnical engineering. The said botanical garden is a plantation forest of 200 hectares organized into 529 plots intercalated by alleys of about 6 m wide (Burren, 1995). This forest has been created in 1934 under the request of the former Resident of the colonial territory of Rwanda-Urundi (lldephonse Musafiri, 2014). According to Rwanda Agricultural Board (RAB), Arboretum of Ruhande is the largest arboretum in Africa and unique forestry resource internationally appreciated for its fine collection of Eucalypts (Burren, 1995). It is composed of over 207 native and exotic species, including 143 hardwoods with 69 Eucalyptus species, 57 softwood and 3 bamboo species (D. Nsabimana et al., 2008). The soil in arboretum is classified as a Ferralsols according to FAO (1998), formed from the parent material of schists and granites mixed with mica schist and quartzite (Steiner, 1998; Verdoodt and Van Ranst, 2003).

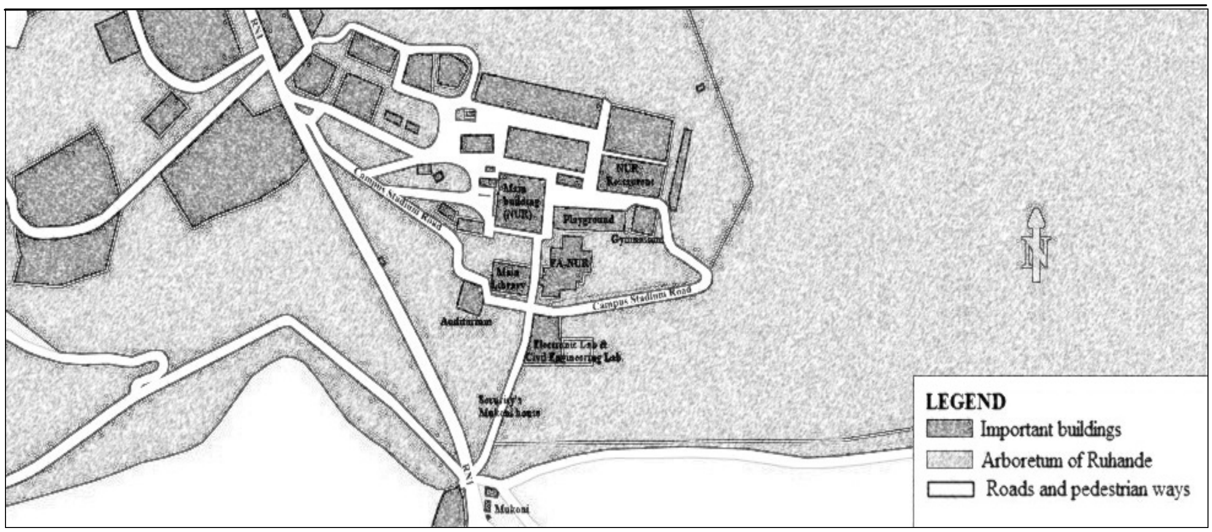

Figure 1: Sketch of the study area

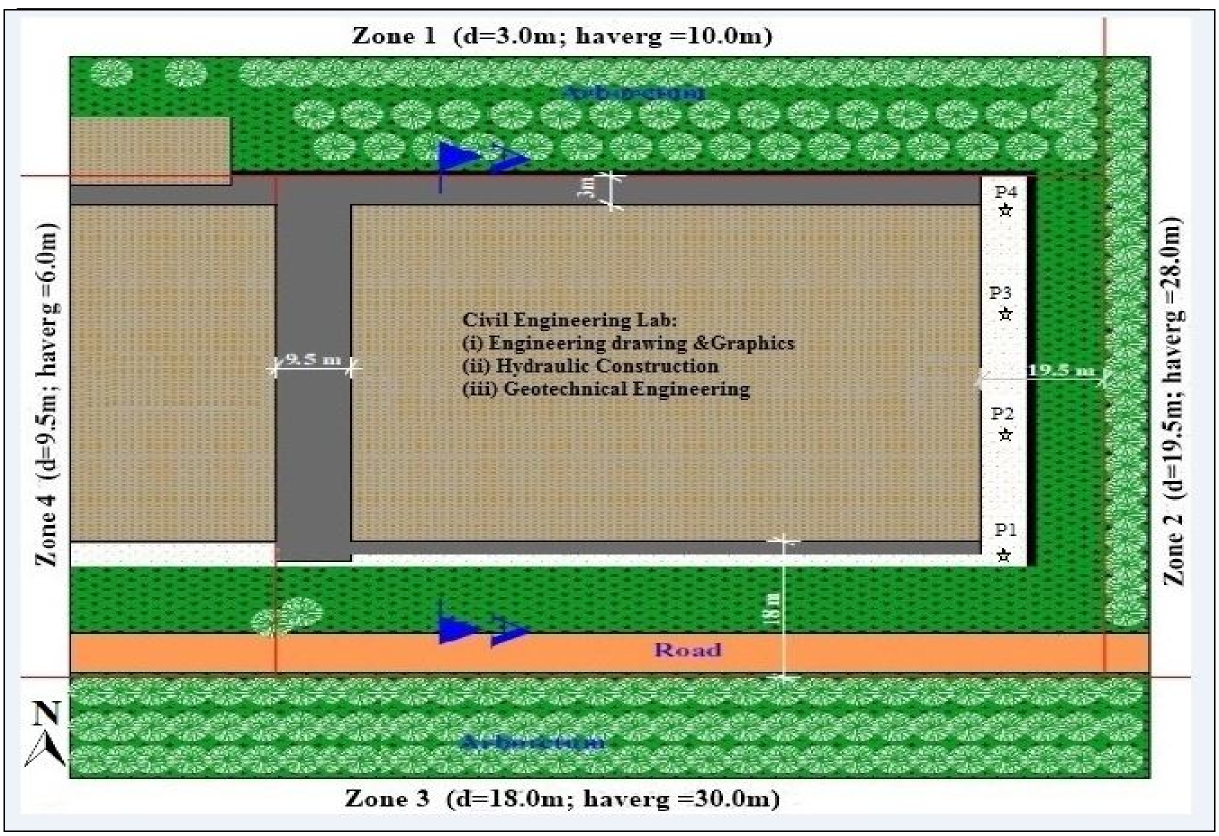

Figure 2: Study area zoomed out

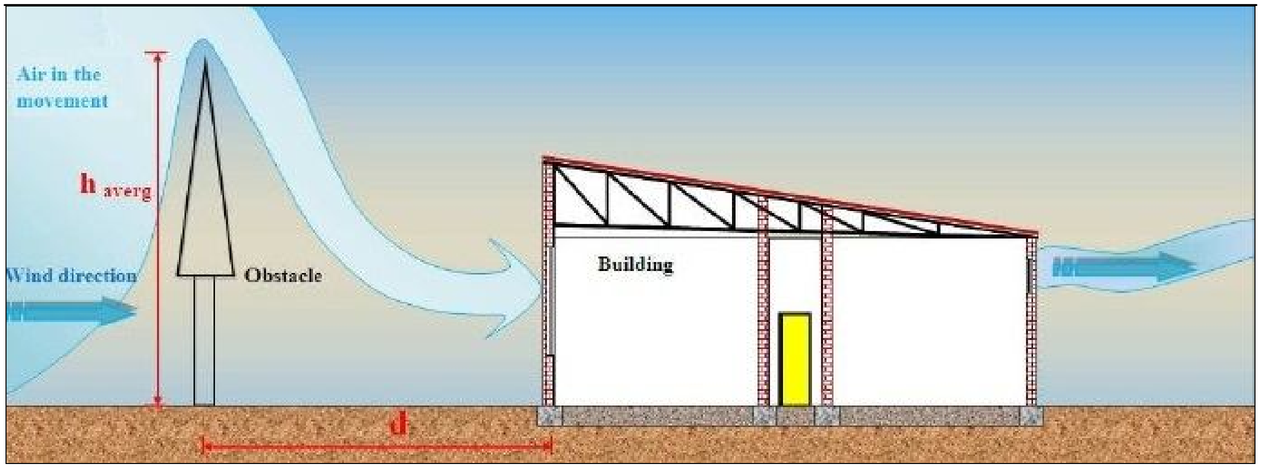

Figure 3: Cross-sectional A-A

4. Materials and Methods

In this study, the information about social and economic importance of Arboretum of Ruhande has been gathered by reviewing annually reports from the local government authority in Huye District, published journals, and available source of data from Rwanda Agriculture Board. Downwards to the core, a detailed list of particular effects that may affect the stability, safety and comfort of the building has been elaborated to check the accuracy in working drawings, general and specific prescriptions for materials and supplies and the assembling techniques. From this careful analysis, a noticeable change within the last 24 years was easily identified. The ambitious changes was traced and analysed using appropriate instruments and software as follows: (i) an ambitious change occurring in the ground was measured and treated using a static cone penetration test method and Microsoft Excel respectively, (ii) thermal exchange and indoor air quality maintenance at the daytime were measured and analysed using thermometers and Microsoft Excel respectively while (iii) visual comfort during the daytime was assessed using Relux Professional software.

5. Results and Discussion

5.1. Social and Economic Importance of Arboretum of Ruhande

Arboretum of Ruhande plays a significant role at both local and national level with regards to education, research, conservation, hygiene, food, health, energy and tourism. According to the local government authority in Huye District and Rwanda Agricultural Board, Arboretum of Ruhande is an invaluable resource to the community. The well known importance of this forest includes:

1. Seed production at national level;
2. Genetic, biodiversity and ecosystem conservation especially conserved rare plant species;
3. Research on agro-forestry technologies and dissemination of best trees species;
4. Habitat to wild animals including monkeys, gazelles, birds, bats and a lot of insects;
5. Microclimate moderation and soil erosion prevention
6. Tourism at national level and recreational opportunities to students and local people;
7. Production of firewood, honey of high quality and traditional drugs to the communities in neighbourhood;
8. A memorial to colonial traces.

5.2. Origin of Longitudinal Hairline Cracks Appearing in the Foundation

In order to understand all phenomena currently occurring in the ground, in 2011, a cone on the end of a series of rods was pushed into the ground around the building at P1, P2, P3 and P4, and a record of continuous measurements of cone resistance (q_c) was compared with data collected in 1986. The results showed a continuous deviation of q_c values in the upper layers of the ground up to 4.5 meters deep. The major causes underlie beneath that deviation are ramified roots of giant eucalyptus trees growing onto the building foundation and high rate of evapo-transpiration in the post rainfall season (figure 4).

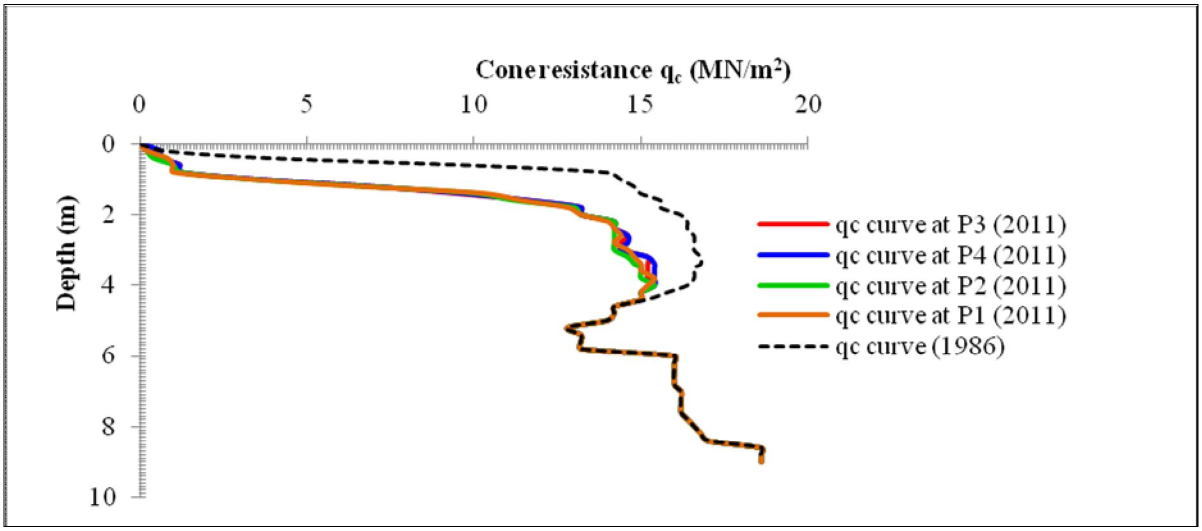

Figure 4: A comparative study of cone resistance curves (1986) and (2011)

5.3. Indoor Air Quality

According to Directorate of Estate at National University of Rwanda, its civil engineering laboratory building had been designed so that the natural outside air movement will successfully cool and ventilate the laboratory whereas the sunshine will serve as the source of energy during the daytime. With respect to free flow of air mass onto the openings, a distance between the building and obstacle (d), geometry of the building and the average height of obstacles surrounding the construction (h_{averg}); the study area have been divided into four zones renamed zone 1, 2, 3 and 4, to compute the place at which the recovery of wind will be done (table 1). The results showed two risks: (i) inefficient use of natural wind to cool and ventilate all laboratories, and (ii) weak and old trees may fall over the building and building's users in the case of strong winds and heavy rain.

Zone Nº	d (m)	h_{averg} (m)	d =3h_{averg} (m)	Whether d is greater or less than h_{averg}	Recovery of the wind compared to the openings' position	Risks
1.	3.0	10.0	30.0	d < h_{averg}	27.0 metres backside	▪ Inefficient use of free flow of air mass; ▪ Free fall of old and weak trees over the building and building's users.
2.	19.5	28.0	84.0	d < h_{averg}	64.5 metres backside	
3.	18.0	30.0	90.0	d < h_{averg}	72.0 metres backside	
4.	9.5	6.0	18.0	d > h_{averg}	8.5 metres backside	

Table 1: Recovery of the wind compared to openings' position

According to American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), 7.5 l/s per person and 0.90 l/s/m^2 are currently required for odour control and outdoor air as a fraction of total air in each laboratory (table 2).

Parameters	Phenomenon	Engineering drawing room	Hydraulic constructio n lab	Geotechnical engineering lab
Area (m^2)	If recovery of the wind happens in the backside of the openings	117.30	96.46	48.64
Number of users (2011)		99.00		
Occupants/m^2		0.84	0.97	0.49
Wind speed (m/s)		12.50		
$\lvert\Delta T_{indoor} - \Delta T_{ambiant}\rvert$ (^{o}c)		0.17	0.19	0.28
Minimum ventilation rate (l/s)		600.57	581.81	538.71
	Required for odour control and outdoor air as a fraction of total air	848.07	829.32	786.27

Table 2: Negative effect from inefficient recorvery of the wind in the backside of the building's openings

From the above discussion, the building environs does not ensure the free flow of outdoor air synonymous to (i) elevated levels of carbon dioxide and low levels of oxygen, (ii) accumulation of dust, chemicals and biological contaminants, (iii) discomfort, and (iv)low productivity.

5.4. Visual Comfort

Visual comfort is essentially required to ensure accuracy in industrial design and laboratory experments. According to European Standards NF EN 12464-1-2011 et ISO 8995/CIE 8008A, an average illuminance of 750 lx and 500 lx is recommended for industrial design and experments respectively to maintain uniformity of light and refrectance.

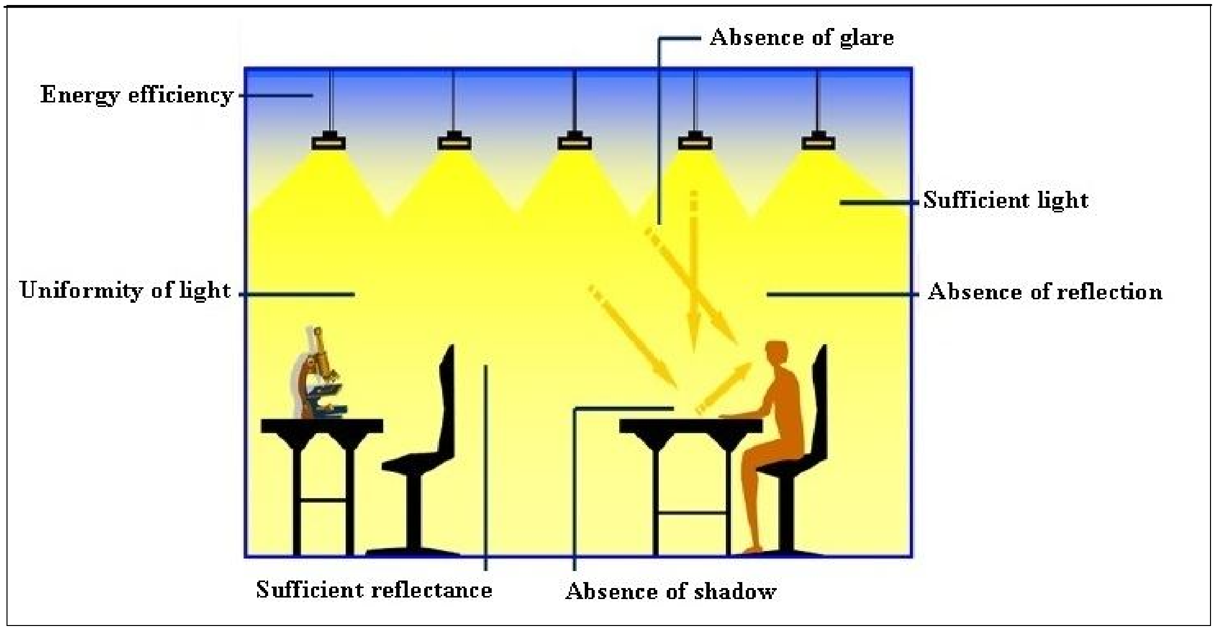

Figure 5: An overview for the visual comfort desired

A noticeable point from daylight assessment inside the building is that areas close to the openings are receing greater amount of the sunlight energy. This energy gradually decreases and the darkness formation starts at 1.5 to 3 meters away from the openings. This situation disrupts the vision by developing (ii) inability to match or select correct colours, and (ii) high human error rates and eyestrain and (iii) low productivity

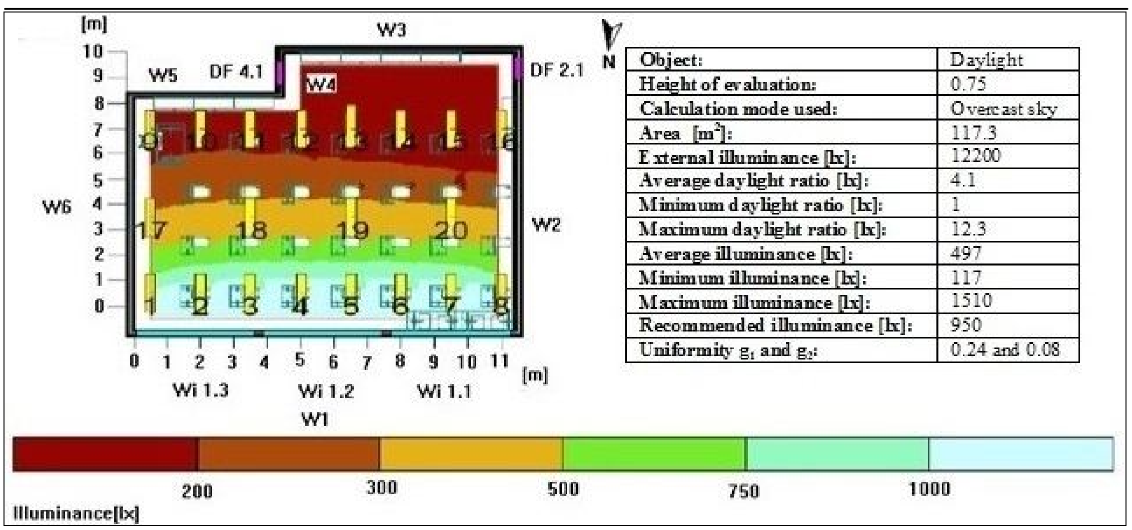

Figure 6: A daylight assessment in engineering drawing room

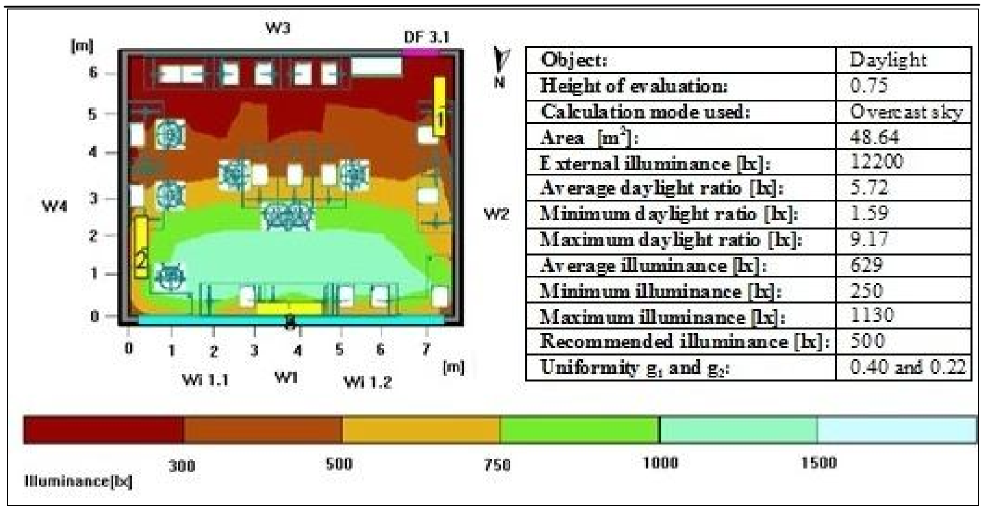

Figure 7: A daylight assessment in geotechnical engineering lab

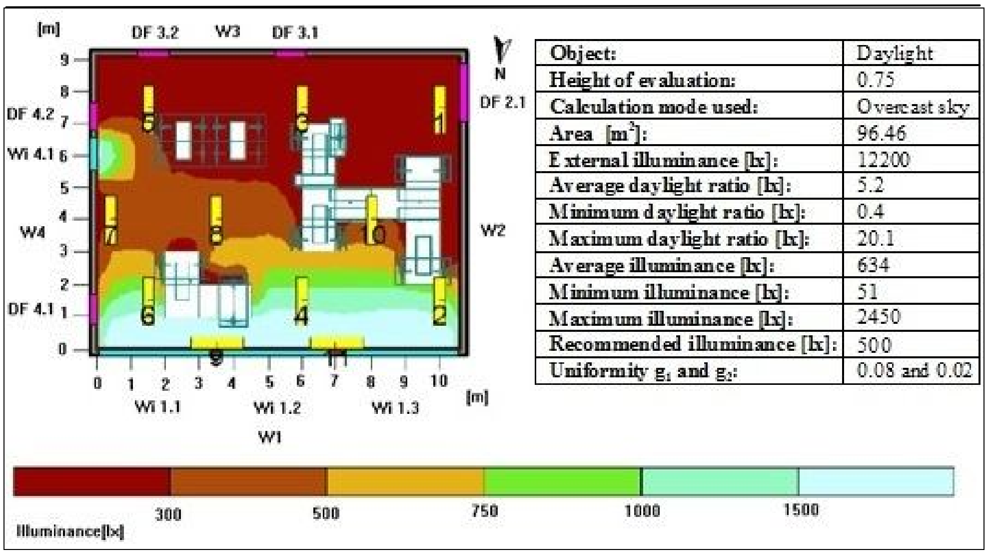

Figure 8: A daylight assessment in hydraulic construction lab

6. Conclusion

After work, the following are the body of the conclusion: (i) Arboretum of Ruhande is the engine of sustainable development not only in Huye City but also at national level as the main reservoir for the seed production and a laboratory for agro-forestry based research technologies in Rwanda, (ii) Instead of creating amenity, Arboretum of Ruhande reduces the wind speed and deviates out its direction, making difficult the free flow of air mass and thermal exchanges between the inside and the outside the building; (ii) Arboretum of Ruhande does not favour solar radiation to spread in the all corners of the rooms to maintain the minimum required luminance during the daytime synonymous to wastage of electricity and resource and complained visual discomfort by users of the building; (iii) in case of heavy rainfall and strong winds as well as unmonitored weak and old trees adjacent to the building, there is a high risk of sudden free fall of the trees over the building and this might endanger the life and the loss of the property, (iv) Ramified roots of giant eucalyptus trees around the building gradually disturb the construction due to the roots growing up onto the foundation of the building.

7. References

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