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Striven Rajaratnam

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Classification and Guidelines for Biophilic design

by Striven Rajaratnam

Master thesis. Thesis seminar "Récits Digitaux"

Under the supervision of Dr. Laurent Lescop

Ecole Nationale Supérieure d'Architecture de Nantes.2021

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Being a work that required the utmost focus, discipline and organization, I was forced to go beyond the comfort of my everyday life to grow intellectually as an individual in order to deliver this quality work. This journey revealed to me the actual meaning of the saying “life begins where your comfort zone ends”

I also want to thank my parents and my relatives for the mental support that they gave me throughout this coursework without which I would not have been able to complete the latter. I also want to thank my friends who pushed me harder when I was in a bad spot, helping me to complete, step by step, the goals that I had.

Abstract

Biophilic architecture is a subject that is instinctively included in buildings' designs when architects think about the relationship of the construction with respect to its surrounding as well as ways of optimising the use of nature. However, I believe that it is not really as simple and mundane as the above explanation. This connection with nature that we lost in the industrial age is coming back and is being reinforced by the use of biophilic architecture. In a way, we are still evolving to produce a utopia where we will get a green city, mixing nature, technology and constructions in the right amounts giving birth to a new form of landscape.

Being a vast subject, patterns have been used to identify the characteristics of buildings which are closely related to biophilia. These patterns come in different forms namely, natural lighting, sunshades, ventilation, sound buffers, auto sufficient alimentation only to mention a few. This methodology is however only showing to us the end process which is the completed architecture and not the core concept behind which starts at the beginning of the reflexion phase.

The end result is more often a forest like image in appearance which I believe has the tendency to be purely greenwashing strategies. Is the architecture just a traditional one which was altered visually by adding plants in lost spaces? Is more data vital when considering how to produce a well organised space both for the inhabitants and the plants themselves?

An innovative and easily understandable way needs to be considered when identifying a biophilic building. It might be the use of patterns as mentioned above in addition to the factors it relates to as on its own, the patterns are not a proper way to gauge the amount of consideration given to any project's initial consideration for biophilic designs.

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Introduction



1.1 BIOPHILIA AND BIOPHILIC DESIGN

Biophilia as defined by Edward O. Wilson, an American biologist, is the “innate tendency to focus on life and lifelike processes”. Humans’ curious behaviour has been resounding throughout history when the latter wandered around trying to understand the unknown and explore life itself and its mysteries on the blue planet. This became the key factor for our evolution from nomads to farmers and settlers as it was no longer necessary to move where the food was but rather get the food to where we wanted to live. The ingrained need for nature to be near humans was lost when the era of new technological advancement came in the late 20th century. Down the road, this innovation led to the development of huge cities which are usually referred to as the concrete jungle due to the lack of greenery. This is a result of the architecture of buildings which changed drastically to be more functional, leaving no space for nature. Despite all this, we are now going back to our roots in search for a real connection with nature even in state of the art buildings for reasons that we cannot simply ignore: the wellbeing of people in their work environment, the benefits of biophilia in relaxation spaces and on a bigger scale, global warming.

Coming from the need to connect with nature, it is almost instinctive for architects to try to find the most efficient way of using natural lighting, natural ventilation or even to include a window that would capture a magnificent view of the landscape thus mimicking a live painting. However, biophilia’s definition is still blurred as it englobes so many elements into it. I, for once, thought that biophilic design was the incorporation of plants into a building either through renovation or from the conceptual stage until I actually researched the subject which led to the one conclusion; Right now, it is difficult to identify a biophilic building or whether the latter have biophilic characteristics. On the other hand, having plants on the façade makes it easier to know that the architect tried to provide a better exterior space as well as a better view not only for the residents but also for those who will be around it. The actual question is whether this is a

way to identify a biophilic design only from the exterior. What is the sensory journey once we are inside the building? Does it convey the same connection with nature as it does on the outside?

To understand how biophilic architecture works, case studies are necessary. Being in an age where most ideas have already been implemented, many attempts at defining biophilic design have been made from academic research to expert work. Going through these documents, I realised that it does not provide much specifications about the development process and that only the finished products have been categorised. Similarly, existing architecture does not provide enough insight on how they chose to draw the spaces.

Few architecture firms include plants from the conceptual design such as WOHA, a firm in Singapore. Other architectures are renovated to accommodate the plants, for example, Bosco Verticale in Milan which is in fact one of the first buildings you will see when searching for biophilic architecture on the internet. Lastly, the environment in which the building is found is decisive to how the implementation of biophilia is to be made. Frank Lloyd Wright made full use of the environment in his design, building in the middle of parks or untouched nature; even though his projects were not categorised as biophilic architectures.

To sum up, biophilic architecture is still confusing in a way that it is everywhere but not mentioned anywhere. As appealing as it can be when done right, it tends to be catastrophically expensive if ever any problem crops up. Furthermore, on the economic side of the affair, the clients do not know the implication of decorating a façade with flora, costing them a lot more than the precious budget. This is nevertheless avoidable if the architect explains to the client in the very first meeting itself about the idea of having plants in the overall design which are to be well maintained, resulting in earmarking a portion of the budget for that specific purpose.

1.2 CHOICE OF SUBJECT

It was always a dream of mine to be able to see what it would look like if we found the right balance between natural and man-made on an architectural level. Being someone who lived in a house surrounded by numerous gardens, I felt that, during these years in architecture school, it was my duty to introduce plants inside every project to share the experience that I had. I also feel that discussing these with the clients will provide them with a sense of satisfaction/appropriation as well as leaving them with a space they can use for relaxation.

On an urban level, I was positively surprised by what Singapore was doing in its cities. The decision to promote green buildings to create a new type of landscape that is between man-made and nature. I was further impressed by the designs of the buildings that came forward, some skyscrapers offering up to 40 percent of their volume to greenery like interior gardens or terraces.

Unfortunately, not all designs were good ones as some did not take much consideration of the environment in which they were placing the vegetation, leaving them with more problems than solutions. One example would be the Oasia hotel which uses a second metal skin to grow plants but significantly fails due to the hotness of the metal leaving them with the cooling of the skin which costs them higher energy that they would actually need.

1.3 OBJECTIVE OF THESIS

The goal of this thesis is to produce a new way of classifying biophilic architecture by using the characteristics of the buildings. This would help in the identification of biophilic building as well as the awareness of biophilia. It would also help the future architects or people with an interest in biophilic design to understand the impact and requirements of each type of building. This will result in a better understanding of biophilia in both the architectural community and also in society in general.

In order to contribute to the conceptual process of buildings, I wanted to focus on what possibilities we could have when designing a biophilic living space in one of the categories. Strategies that can be implemented during the conception phase of the design have been proposed.

As it would be impossible to provide a guideline for all regions across the world, I focused on one particular climate which is tropical and my preferred choice of location is Mauritius, which is a small island known as the star and key of the Indian ocean. The temperature variation of the chosen place has a small variation between summer and winter which are the only two seasons yearly.

A simple and clear analysis will be that of a room where consideration will be given to the size of opening in the room and other biophilic elements to produce a zoning with the mention of different strategies to place the appropriate plant in the appropriate place.

1.4 CONTENT OF THESIS

This thesis consists of 3 main parts; An introduction to biophilia as explained by the first person to quote the definition of biophilic architecture. This will then lead to the reasons why biophilic architecture exists and why it is necessary in different domains of work throughout the world especially in developing countries. To further understand the characteristics of biophilic design, it is a must to study some of the buildings that made good use of nature as their base points. This will lead to the confirmation of many hypotheses on how biophilia has been implemented into buildings until now.

After understanding the basics of biophilia, we can find a new way to classify the buildings based on their characteristics and use of nature that each building made. To further promote biophilia, I will propose some guidelines on how to implement strategies into conceptual drawings to help in creating one type of biophilic architecture that would have already been explained. It will be even easier with the help of a library of plants which can be grown almost everywhere.

In the end, a critical analysis of the work done and whether it will be helpful in the future or is it just an attempt to promote something that is already being used. In conclusion, I will debate the factors that contribute to the wellbeing of biophilia in the architecture community.



Fig 1

What is Biophilic Architecture?

2.1 CLASSIFYING BIOPHILIC DESIGN

Briefly explained, it is a constant connection with nature through different characteristics of the building. There have been many different ways of describing and categorising it up till now. The '14 patterns of biophilic design' is a fine example of how buildings can be regrouped into categories with a similar approach to the atmosphere that they create and for some time now it has become the guideline to how biophilia exists in architecture. Similar other books are available like 'Nature By Design: The Practice Of Biophilic Design' by Stephen R. Kellert or simply academic research by students around the world.

To understand biophilic architecture both these books need to be read and compared to find similarities in what they are explaining. The first book focuses more on the ambiances that the biophilic design creates thus regrouping them into patterns that are recurring in some architecture or experiences that we have when entering some biophilic architecture. As a matter of fact, the last 4 patterns/experiences explained in the book are subjective feelings which might be present in some people and absent in others.

TABLE 1. BIOPHILIC DESIGN PATTERNS & BIOLOGICAL RESPONSES

Table 1 illustrates the functions of each of the 14 Patterns in supporting stress reduction, cognitive performance, emotion and mood enhancement and the human body. Patterns that are supported by more rigorous empirical data are marked with up to three asterisks (***) indicating that the quantity and quality of available peer-reviewed evidence is robust and the potential for impact is great, and no asterisk indicates that there is minimal research to support the biological relationship between health and design, but the anecdotal information is compelling and adequate for hypothesizing its potential impact and importance as a unique pattern.

14 PATTERNS	STRESS REDUCTION	COGNITIVE PERFORMANCE	EMOTION, MOOD & PREFERENCE
Visual Connection with Nature	<ul style="list-style-type: none"> Lowered blood pressure and heart rate (Brown, Barton & Gladwell, 2013; van den Berg, Hartig, & Staats, 2007; Tsunetsugu & Miyazaki, 2005) 	<ul style="list-style-type: none"> Improved mental engagement/ attentiveness (Biederman & Vessel, 2006) 	<ul style="list-style-type: none"> Positively impacted attitude and overall happiness (Barton & Pretty, 2010)
Non-Visual Connection with Nature	<ul style="list-style-type: none"> Reduced systolic blood pressure and stress hormones (Park, Tsunetsugu, Kasetsani et al., 2009; Hartig, Evans, Jamner et al., 2003; Orsega-Smith, Mowen, Payne et al., 2004; Ulrich, Simons, Losito et al., 1991) 	<ul style="list-style-type: none"> Positively impacted on cognitive performance (Mehta, Zhu & Chieema, 2012; Ljungberg, Neely, & Lundström, 2004) 	<ul style="list-style-type: none"> Perceived improvements in mental health and tranquility (Ii, Kobayashi, Inagaki et al., 2012; Jahncke, et al., 2011; Tsunetsugu, Park, & Miyazaki, 2010; Kim, Ren, & Fielding, 2007; Stigsdottir & Grahn, 2003)
Non-Rhythmic Sensory Stimuli	<ul style="list-style-type: none"> Positively impacted on heart rate, systolic blood pressure and sympathetic nervous system activity (Li, 2009; Park et al., 2008; Kahn et al., 2008; Beauchamp, et al., 2003; Ulrich et al., 1991) 	<ul style="list-style-type: none"> Observed and quantified behavioral measures of attention and exploration (Windhager et al., 2011) 	
Thermal & Airflow Variability	<ul style="list-style-type: none"> Positively impacted comfort, well-being and productivity (Heerwagen, 2006; Tham & Willem, 2005; Wigö, 2005) 	<ul style="list-style-type: none"> Positively impacted concentration (Hartig et al., 2003; Hartig et al., 1991; R. Kaplan & Kaplan, 1989) 	<ul style="list-style-type: none"> Improved perception of temporal and spatial pleasure (alliesthesia) (Parkinson, de Dear & Candido, 2012; Zhang, Arens, Huzenga & Han, 2010; Arens, Zhang & Huzenga, 2006; Zhang, 2003; de Dear & Brager, 2002; Hechong, 1979)
Presence of Water	<ul style="list-style-type: none"> Reduced stress, increased feelings of tranquility, lower heart rate and blood pressure (Avarsson, Wens, & Nilsson, 2010; Pheasant, Fisher, Watts et al., 2010; Biederman & Vessel, 2006) 	<ul style="list-style-type: none"> Improved concentration and memory restoration (Avarsson et al., 2010; Biederman & Vessel, 2006) Enhanced perception and psychological responsiveness (Avarsson et al., 2010; Hunter et al., 2010) 	<ul style="list-style-type: none"> Observed preferences and positive emotional responses (Windhager, 2011; Barton & Pretty, 2010; White, Smith, Humphreys et al., 2010; Karmansov & Karmel, 2008; Biederman & Vessel, 2006; Heerwagen & Orians, 1993; Russo & Atzwanger, 2003; Ulrich, 1983)
Dynamic & Diffuse Light	<ul style="list-style-type: none"> Positively impacted circadian system functioning (Figuero, Brons, Pittack et al., 2011; Beckwith & Roden, 2009) Increased visual comfort (Elyezadi, 2012; Kim & Kim, 2007) 		
Connection with Natural Systems			<ul style="list-style-type: none"> Enhanced positive health responses; Shifted perception of environment (Kellert et al., 2008)
Biomorphic Forms & Patterns			<ul style="list-style-type: none"> Observed view preference (Vessel, 2012; Joye, 2007)
Material Connection with Nature		<ul style="list-style-type: none"> Decreased diastolic blood pressure (Tsunetsugu, Miyazaki & Sato, 2007) Improved creative performance (Lichtenfeld et al., 2012) 	<ul style="list-style-type: none"> Improved comfort (Tsunetsugu, Miyazaki & Sato, 2007)
Complexity & Order	<ul style="list-style-type: none"> Positively impacted perceptual and physiological stress responses (Salinas, 2012; Joye, 2007; Taylor, 2006; S. Kaplan, 1988) 		<ul style="list-style-type: none"> Observed view preference (Salinas, 2012; Hagerhall, Lake, Taylor et al., 2008; Hagerhall, Purcella, & Taylor, 2004; Taylor, 2006)
Prospect	<ul style="list-style-type: none"> Reduced stress (Grahn & Stigsdottir, 2010) 	<ul style="list-style-type: none"> Reduced boredom, irritation, fatigue (Cleanwater & Coss, 1991) 	<ul style="list-style-type: none"> Improved comfort and perceived safety (Herzog & Bryce, 2007; Wang & Taylor, 2006; Pethrick, 2000)
Refuge		<ul style="list-style-type: none"> Improved concentration, attention and perception of safety (Grahn & Stigsdottir, 2010; Wang & Taylor, 2006; Wang & Taylor, 2006; Pethrick, 2000; Ulrich et al., 1993) 	
Mystery			<ul style="list-style-type: none"> Induced strong pleasure response (Biederman, 2011; Salimpoor, Benavoy, Larcher et al., 2011; Kemi, 2005; Blood & Zatorre, 2001)
Risk/Peril			<ul style="list-style-type: none"> Resulted in strong dopamine or pleasure responses (Kohno et al., 2013; Wang & Tsien, 2011; Zaid et al., 2008)

© 2014 Terrapin Bright Green / 14 Patterns of Biophilic Design

Fig. 2



Fig. 3



Fig. 4



Fig. 5

2.2 14 PATTERNS OF BIOPHILIC DESIGN

The different patterns are quite appropriate in the way that they are explained to represent an experience in the architectural environment but do not usually refer to a specific characteristic or feature of the building. The first part, the first 7 patterns are physical patterns that can be experienced with our five senses using at least two of the senses in each case. A brief explanation on each of the pattern is as follows:

-Visual connection with nature

As its name implies it consists of a constant visual connection with nature which may lead to other sensory information like auditive information when there is a breeze or airflow going through plants. It does not consist only of a view on plants but can be on a landscape or even simply on natural elements like rocks or falling water on a wall. This gives us a world to escape to when we are tired of focusing on work, helping us reorganise our thoughts or simply find another approach.

-Non visual connection with nature

The use of other senses is also a way to make us feel in a biophilic environment. The use of materials that reminds us of nature might be one way to introduce biophilia into the building. The use of scents as well as sounds that come from nature into the rooms also gives a sense of transportation into another natural setting.

-non - rhythmic sensory stimuli

This one is a bit different as it involves an experience that is only momentary. It can come in different forms that affect different senses but it will disappear after some time. This type of experience might leave us with a wish for more which helps us regain focus on our work or even try to improve the ambiance to invite these instantaneous stimuli.

-Thermal and airflow variability

One good example of a building that makes use of these characteristics is the amphitheatre of moufia located at Sainte Clotilde, Réunion island which makes use of its structure to let the hot air rise in the middle and flow out of the space. It is simply the use of the difference of temperature causing an air pressure which leads to an airflow. Some buildings also make use of biomimicry to copy the characteristics of nature to let the air flow out of the building.

-Presence of water

The presence of water in a building existed even before the word biophilia was quoted by Edward. O. Wilson as it was one of the fundamentals that feng shui asked us to include in kitchens like small fountains or streams of water that would help in control of the humidity of the atmosphere. The use of flowing water at a slower rate than opening a tap also gives a different sound that is quite appealing for some.

-Dynamic and diffuse light

Using direct sunlight might be a problem for some regions as it is simply too strong and would raise the temperature of the space rapidly. It is much more useful to use a tree that would dim the light or even use the reflection of the light on a white wall instead of using it directly. It also makes for a dynamic light which evolves throughout the day as the direction changes and the weather is also unpredictable.



Fig. 6

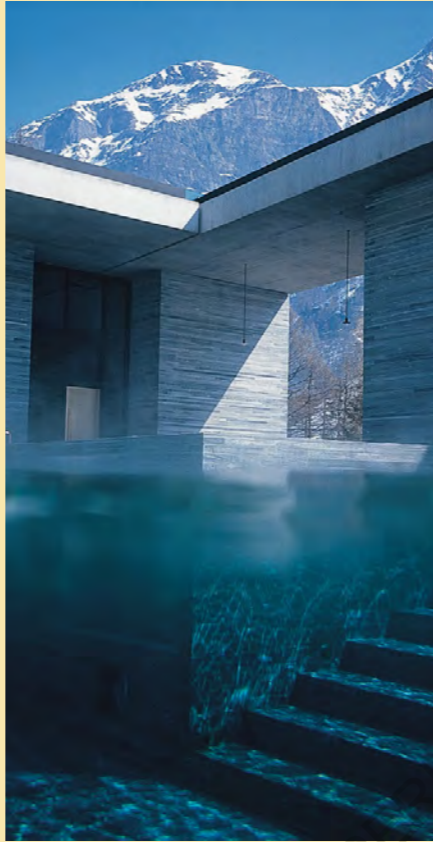


Fig. 8

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Fig. 9



Fig. 10

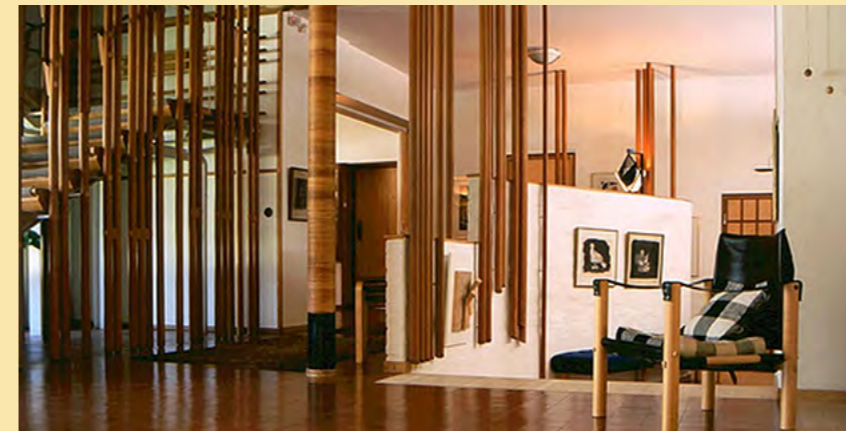


Fig. 11

-Connection with natural system

The inclusion of a natural system into an architecture might be hard as it would depend greatly on the controlled parameters inside. However, it is possible to include micro-ecosystem like aquariums which show the flow of life. It might simply be corals living in a tank or even an ant colony which changes the tunnels they use everyday. It might also be a good idea to try and explore the idea of including a natural system on a larger scale, like urban farming which will also show the growth of the plants throughout the year until they are collected.

-Biomorphic forms & patterns

Similar to how we can use characteristics of animals or plants to enhance our architecture, we can also take inspiration from the shapes found in nature. This also comes as a form of biomimicry that has been used all around the world by big architects like Renzo Piano or even by locals in their vernacular construction that take inspiration from their surroundings.

-Material connection with nature

Similar to how it can be used in the non-visual connection with nature category, it can also be a standalone characteristic that is exploited to its utmost. We can have an architecture that uses materials to transport us into a different world like for example the villa mairea by Alvar Aalto which makes full use of this possibility. The connection with nature through material is in fact one which has been used in various ways in many different types of architecture.

-Complexity and order

Bringing chaos into an architecture which seems to have order. It almost feels like letting a vine grow on a facade which seems unwanted but it is voluntary. It is simply not controlled leaving us with something complex but which was wanted in some way. It would also relate to the renaissance building in France which makes use of a lot of complex ornaments but which is all in order forming a symmetry or repetition in some sort.

-Prospect

A space that feels liberating, an open and wide plain that doesn't feel too vast that we would feel lost but big enough to let us feel free of any constrictions. It might be a meadow or even a plaza. The centre Pompidou in Paris makes good use of this concept as it uses only half of its land to build and the other half as a plaza which can be used for numerous activities. The use of this experience can also be seen in colonial houses in Mauritius where we have a large grassland surrounded by other vegetation in front of the house. It produces a different feeling just from entering the courtyard.

-Refuge

It is a feeling of safety that you get as you walk into a familiar setting. Creating your own world that would prevent you from going to the hard truth of reality whenever you feel overwhelmed. It is a break that is essential sometimes in our life to prevent breakdown or even sickness. It depends greatly from person to person which type of environment they feel safe in but a courtyard or a Japanese garden might be enough. One remarkable building which makes use of this concept is the Amazon Spheres found at the foot of the Amazon headquarters campus building in Seattle.



Fig. 12



Fig. 13



Fig. 14

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Fig. 15

-Mystery

An experience that always awakes your curiosity through different layering or different proportions. Simply putting a structure that would make someone think how is this possible is a win in this situation. For example we can have a double layered aquarium filled with water in between the layers and a mini zen garden behind it with another water feature which would peak our interest. An example would be the Kandalama Hotel by Geoffrey Bawa in Sri Lanka which uses flora as a shell to hide the hotel creating this sense of mystery.

-Risk/peril

A bit of mischief in a way that would make us feel threatened but also arise in us the will to find more. The concept and risk and peril exist in nature throughout the world, the risk of falling when crossing a river on a fallen tree's bark or simply the possibility of a nest falling from a tree. In architecture when taken to the extreme, the effect could be used as in the Tokyo Skytree where the floor of the top level is made of reinforced glass where we get the feeling of walking on air and risking a fall at any moment.

Conclusion on the use of the patterns to describe biophilic architecture

As far as characteristics are concerned, they are a good way of describing biophilic architecture but we don't really identify a type of biophilic architecture through these defined elements. If we were to walk across the street and see an architecture with these characteristics, would we identify it as biophilic or something else? We need to use these characteristics to find a simple way of identifying biophilic architecture both from an exterior experience as well as an interior one. This will not only provide the ones using the space with a relaxing environment but also those passing by it.

2.3 THE PRACTICE OF BIOPHILIC DESIGN

On the other hand, Stephen R. Kellert has a more direct approach to biophilic design categorising the elements that were used in the architecture to create the building. In his approach, he shows the elements that are to be taken into account when producing a biophilic environment or when renovating to a more appealing atmosphere. He classifies them into three great categories which consist of:

- Direct experience with nature
- Indirect experience with nature
- Experience of space and place

The description of each element is not necessary in this case as it is already to the point. The elements are detailed and through each element we have different experience and feeling which can also be related to the last 4 patterns seen above in the terrapin's take on biophilic architecture. As a standalone these elements would not be able to create the feeling that we want the user of the space to have. The organisation of the space taking into consideration different elements in relation with each other results in the atmosphere that we want to create, of prospect, refuge, mystery and risk/peril.

Experiences and Attributes of Biophilic Design



DIRECT EXPERIENCE OF NATURE

- Light
- Air
- Water
- Plants
- Animals
- Weather
- Natural landscapes and ecosystems
- Fire



INDIRECT EXPERIENCE OF NATURE

- Images of nature
- Natural materials
- Natural colors
- Simulating natural light and air
- Naturalistic shapes and forms
- Evoking nature
- Information richness
- Age, change, and the patina of time
- Natural geometries
- Biomimicry



EXPERIENCE OF SPACE AND PLACE

- Prospect and refuge
- Organized complexity
- Integration of parts to wholes
- Transitional spaces
- Mobility and wayfinding
- Cultural and ecological attachment to place

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Fig. 17

2.4 SUMMARY ON THE EXISTING PATTERNS

As said before, the characteristics are present but do not provide an image of what biophilic architecture could be. It is still too vast even if we understand each and every element that forms part of biophilia. Creating a collection of different buildings with the use of biophilic architecture might also not be enough to find similarities between the constructions. The image of biophilic architecture is becoming a bit more focused through these research works but still requires the study of more buildings to find out the level at which we can push the dream of biophilia. What would be the perfect image of a biophilic structure? A combination of technology and nature that leaves us with a taste of one of the experiences mentioned above.

The patterns and attributes can be used to simplify biophilic architecture in a simple way through the experience that we have from just looking at the building or from entering it. The biophilic experience would be better in buildings which makes the most efficient use of the attributes mentioned above as well as its surroundings. One building, however, which makes abstraction of its surroundings and still has what it takes to be one of the most innovative biophilic architecture, is the Amazon Spheres. Being in the center of town makes it difficult to find natural scenery around it so why not bring the scenery to the center of town. This might be the final image of the biophilic architecture that I searched for but not restricted to it.

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Why Use Biophilic Design?



3.1 PROSPECTS OF BIOPHILIC DESIGN

Many theories have been made claiming that biophilia can do good to the people. In some theses, we saw that biophilic design improves productivity in workspaces as it helps in changing the visual environment placing the employees in a more calming zone. It also produces other effects that help in creating a stress free workplace such as the humidity control as well as the increase in oxygen. Furthermore, if the persons are not allergic to pollen, they can decide to place floral plants, obtaining a more natural scent when the flowers are blooming. Another thesis focuses on the benefits provided by biophilic architecture in a hospital which is actually significant when compared to boring white rooms for patients in big hospitals. The fact is biophilia helps in many ways to boost the creativity, mental health and physical health of people and we need to introduce it into our architecture as we are growing rapidly on an urban level especially developing countries like Mauritius.



Fig. 18



Fig. 19



Fig. 20



Fig. 21

3.2 BIOPHILIC DESIGN IN HOSPITAL

According to a thesis by Seyed Sina Etezadifar, "The Role of Biophilia in Hospital Humanization", we can see through his analysis of the "San Luigi Gonzaga" that many prospect of biophilia have been used in the construction of the hospital. This shows that hospitals help people on a physical level which is not bad for small visits like when having an injection, but for long stays, it is better on a physiological and psychological level to have a space that you can connect to. A space that makes you feel at ease even though you don't know where you are. That feeling that the patients get should be dealt with on an architecture level to produce a more humanized volume where patients will be able to search inside of them the will to reconnect almost instinctively with nature.

Even though the design in Mauritius helps to accommodate big gardens and windows for every ward, it still feels very disconnected to nature. The reason being that the windows are simply too high and that the gardens are now being removed to make room for parkings. New buildings are being created but with the technology we have at hand, we create space that does not care for the need to be in connection with nature. In a way, the colonial architecture was better as it provided more space for patients to have a walk after staying in their room for very long hours but now they are constrained to their room with no possibility to even glimpse at a natural view. Biophilic design would have been a boon if it were implemented in the new hospitals that were just constructed several years ago. It would not only be a good mix between technology and nature but would have also given us Mauritians a sense of appropriation as most of us have gardens.

In islands that are still developing right now, the need to introduce biophilia is dire to create spaces that factors the humanization of space. Furthermore, it would not require much research as islanders are fond of plants and have a lot of knowledge on the local plants that can be used in those projects.

3.3 BIOPHILIC DESIGN IN WORKING SPACES

As for hospitals, workplaces also require the introduction of biophilia as it is a stress filled environment and it would be a plus to have an environment that promotes productivity and reduces the risk of burnout. Through biophilia we can also give back the space that we took from nature. As a matter of fact, we might even provide more plants than it would possibly be able to accommodate by using the verticality of the buildings. One way would be the use of green walls, walls specifically erected to allow the growth of creepers or other plants on it. It is actually becoming more popular and is being used mainly in the lobby of many skyscrapers. However, green walls may cost a lot as it requires a lot of attention depending on the plants that the landscaper or interior decorator chose. One great example is the amazon spheres which are part of the amazon headquarters campus found in seattle.

I can clearly state that it had an effect on a group of workers while I was working through my internships. The experience from my first internship where I sat near a window with a view on the neighbours garden actually helped me get through it better than the second one where I felt suffocated. In the second internship, the windows were always blocked by blinds which rendered the view to the green space inaccessible. We were in a controlled environment where we always had the lights on and used air conditioning. However, in November when it started to get hot, we opened up the windows to let the air flow and I realised that it was actually helping not just me but the others as well. We all finished our appointed task quicker leaving us with some freetime where we discussed or focused on other works. We may not have realised it but this small natural element affected us more than we thought it would.

A survey that would help to verify the reality of the theories on the effects of biophilia in office environments, would have been a proper way to demonstrate the effects of biophilia but it required

too much knowledge on the psychological level as well as a complete control of the environment. As an alternative, several web articles have been studied on the subject which gave insight on the purpose of biophilia in built spaces and offices. Human spaces, a blog which posts articles related to architecture and biophilia from the interface company, stated in a report that the use of biophilia would reduce the exhaustion of mental power as well as create a better sense of well being inside those spaces compared to other offices. These affirmations are reasons enough to prove that biophilia works in office layouts and that it should be promoted.

Workplaces being a very busy environment could use these small changes increasing the effectiveness of the office. When thinking about offices that are found in skyscrapers, the possibilities for introducing biophilia are limited as the view is blocked by the other buildings, even if it is an open floor layout the natural lighting won't be sufficient for some central zones as well as the inability to use natural ventilation. One of the possibilities for this type of situation, is the introduction of small gardens along the windows or even between desks to change the view and ambiance in the atmosphere. If the office is on several floors we can even introduce urban farming which has already been tested in many buildings in Japan such as the offices of pasona which dedicate 20% of its area to growing vegetables.

3.4 BIOPHILIC DESIGN IN HOUSES

Houses are meant to be relaxing zones that allow us to escape the reality of work where we spend most of our time. However, during these hard covid-19 quarantine times, we were obliged to work from home which brought the stress environment inside our shelter. People who did not have dedicated places for work at home have fallen in a vicious cycle where they were unable to distinguish the working space from the relaxing one. This led to a negative impact on many employees who either failed to meet their quota or who were just overworked, falling sick in the end. This situation also came as a possibility to introduce biophilia to help in the distinction of spaces as well as the use of it to reduce the impact of the quarantine on us in our house.

Introducing biophilia on a higher level is unlimited in houses as we can use gardens as well as courtyards to invite nature inside. We would automatically need to let natural lighting and ventilation inside to reduce the use of energy and to feel closer to nature as if living inside a hut in the middle of the jungle. In tropical regions, we see this connection to nature in individual houses but the fact that it disappears in towns is a real question to be asked. Some countries in the southern hemisphere have been hit hard by the growth of their population and to accommodate all these people they needed to build houses. Also, most of them being developing countries, they made the mistake of thinking of functionality over human spaces giving the families the bare minimum. It is also true for student residences that produce flats that look like rooms stacked on one another with no real openings in the rooms. One example would be the crous residence on the island of Nantes which provides in fact an adequate window but which does not always lighten the kitchen with natural light so most of the time the students need to use the lights to cook even during the day. Furthermore, all windows do not have a good view leading many of the students to buy their own plants to decorate it.

In Mauritius, being influenced by colonial houses and having many laws preventing the construction on part of the land, we can see that most houses have a small garden at their entrance. It may be considered a problem by some but it provides a homogeneity that may turn into friendly competitions between neighbours. However, as mentioned before, in towns such as Port louis, the decrease in colonial houses led to the increase of modern buildings which bring with it the increase in temperature. We can still see lots of houses with gardens on the outskirts of the town however due to the situation downtown, they are also being affected by the rise in temperature. In this kind of situation biophilia could be reintroduced in a way to reduce the hard surfaces that emit or reflect heat rays by creating a soft sponge that would reduce the hard UV rays.

In conclusion, biophilic design is already present but not used to its utmost capabilities. In developing countries, it is almost everywhere but due to the increase in population as well as the lack of funding and awareness, we do not include it in our design process. Bringing a new way of conceptualising projects with a close relation to nature will be, not only for architects but also for people trying to build a new home, a real inspiration for those searching for a more relaxed environment.

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Case Study



4.1 CHOICE OF CASE STUDIES

Most buildings without a doubt have biophilic characteristics, and it would be difficult to go through each and everyone of them so to understand the design process a bit better, I chose 3 buildings that greatly exhibit biophilic characteristics but which had different approaches and thinking processes. The chosen architectures are in three different categories, biophilia by renovating, building around existing nature and finally introducing biophilia from the conceptual process.



Fig. 22



Fig. 23



Fig. 24



Fig. 25

4.2 CASE STUDY : BOSCO VERTICALE

First, we have the Bosco Verticale by Stefano Boeri, found in Milan which is one of the first buildings that comes up when you search for biophilic architecture online. I chose this building to study because it is a renovation and did not have the intention of adding the hundreds of plants that now form part of its facade. At the beginning, the building was simply one which was made to have big terraces but then with the renovation they decided to add the plants which came as a big surprise as it completely changed the view that people living either inside or near the building had. It provided a refuge to people inside the building and also embellished the view that others had on it.

From a more analytical point of view, the attribute that the final product uses are:

-Visual connection with nature

As it is a space filled with plants, we bring nature inside the building providing a small zone that is used as a way of replacing the landscape that is inaccessible to many. From the inside of the building, every opening leads to a view of different plants creating the connection.

-Non visual connection with nature

The trees and plants also give stimulation to the other senses leading to a constant connection. This reduces the anxiety and gives a calming feeling to the person living in the apartments.

-Use of dynamic and diffuse lighting

The use of these plants in front of every opening helps regulate the amount of sunshine that enters the building, especially the facade that faces the south and west side. It creates an atmosphere in the room that seems like you are underneath a tree's shadow. The fact that the branches keep moving also gives a dynamic shadow which keeps moving unlike the static shadows from curtains when the windows are closed.

-Connection with a natural ecosystem

As said, the skin created by the collection of plants acts as a new organism which forms its own new ecosystem which leaves us a giant tree in the middle of the city. It's adaptability also surprises us as the trees are still subject to the climate and not maintained in a specific time by technological means.

-Complexity and order

This characteristic is not necessarily seen from the interior but from the exterior of the building as a multitude of plants are placed on the different terraces. A repeating pattern is almost seen in this implementation as some similar plants are seen through the different levels of the building. From a passer-by point of view, we can simply not ignore the sight of this pattern in the green skin on this building.

-Refuge

From the exterior, we already see the building as a refuge from the heat as well as from the stress of life. From an interior point of view it also provides a new sight that mesmerises us from the first time keeping us away from the truth of reality.

-Mystery

As said above the green skin provides a sense of curiosity to the person asking the simple question of whether the rooms inside offer the same experience as we have from outside. What is beyond that green skin that holds our eyes glued to it?

The use of these different elements in combination with the organisation of the space leads to a beautiful mixture of architecture and nature. The surprising part in the building is the irrigation of the plants which is done manually without any specific system designed to distribute water which is a way to bring the person closer to the

nature present in their surroundings. Another characteristic of the building that is brought forward is the adaptability of the building to the ecosystem. It uses some seasonal trees which lose their leaves or even change colors, making the entire building alive and viewed as part of the ecosystem already present.

In terms of biophilia, it covers as mentioned some of the patterns from the terrapin bright booklet. The architecture may not be using biomimicry but creates an ecosystem through the numerous plants that provide shelter for insects as well as birds if allowed to. Some people will definitely be against it but others are for the idea of letting at least birds use some of the branches as shelter against the rain. In conclusion, the architecture was not initially one which used biophilic design in the conception process but after the renovation and the addition of the plants, it became one of the most prolific constructions in the biophilic milieu.



Fig. 26

4.3 CASE STUDY : FUJI KINDERGARTEN

The Fuji kindergarten by Tezuka Architects, one of the projects in Tokyo, Japan that chose to respect and build around the existing nature leading to a conceptual design a bit different from a normal workflow. The conceptual process was inspired by children on the site who were running around in circles. The simple design of a circular roof which lets the students run around in an infinite loop until they are tired is the biggest blessing they can have. Furthermore, they have different objects on the roof which lets the children explore and test without being in danger. Tezuka architects also unintentionally used the background noise to help the children with autism as the natural background noise occurring in the building at 20 kilohertz reduces the symptoms of the disease.

The patterns that are related to the architecture are as follows;

-Visual connection with nature

As it is built around existing trees and it is mostly open spaces, we get to have a constant view on the trees. Furthermore, we have the open space in the middle which was used once to grow a plain that was softer for the kid to play. On another level, several features have been added inside the rooms to help humanize the space.

-Non visual connection with nature

When we talk about other senses, the architecture privileges background noise which helps the children affected by autism. It also has other features as mentioned before that creates sounds found in nature like the water gargoyles or even the plants that bloom in the right season to provide a perfume.

-Connection with natural systems

With the pre-existing trees already having their own ecosystem around them, the architecture merges with it without destroying it. The trees are home to numerous organisms which will let the children have a real relation with nature as if camping out in the forest. To

further implement this idea of ecosystem, kindergarten usually have aquariums or pets that let them evolve in their own natural systems.

-Material connection with nature

The use of different materials is usual in Japan as they are a colonisation which have been experimenting to solve many problems. In the kindergarten, the use of wood in various forms can be seen everywhere, providing the children with a real attachment to nature as they will be seeing the evolution of wood from a raw material to a processed material.

-Prospect

The architecture being an open space, leaves the children with a feeling of disproportion. The center space also gives the children a feeling of liberty where they can run and play without having the constraint of walls or barriers as the doors of the rooms can be slid out of the way. This, as said by the architects, also reduces the risk of creating a hierarchy in the classrooms.

-Risk/peril

The creation of holes where we can have the effect of falling was an ingenious way to remind us of the power of gravity which lets us live our daily life. The nets placed around the trees let the children experience the risk of falling and conquer the fear of heights at a young age. The handrails around the roof are also a good feature as they are spaced to let only the feet of children through.

The use of biophilia was from the start a major part of the project as they wanted to preserve the trees that existed and provide a space that would let the kids play outside most of the time. The result is an open space separated only by boxes which reduce the hierarchy that is created by the children as explained by the architects. It also provides the opportunity to increase the size of the rooms if ever the need arises as they did with the big hall found at the west

side of the building.

In the design process, the site seemed like an excavation site instead of a construction one as the care given to the roots of the plants were on a very high level so as not to harm the trees. They inserted metal frames around the roots to prevent the construction of a base and then added above the roots more soil to give it enough space to grow. The conceptual process when including an existing tree changes considerably as it takes an enormous amount of thinking and precautions to build with it as they did in this project. The trees provide spaces just large enough to learn how to be more careful when they are walking around and with the features that were added it also provides even more exploration for the children.



4.4 CASE STUDY : PARK ROYAL

Under the new promotion of the government of Singapore, many buildings are including green spaces in order to receive an allocation. It gave birth to many new ideas on how to include flora into architecture and how to merge it with technology, especially in skyscrapers. WOHA, which has been one of the best architecture firms in Singapore, followed these guides to create buildings which definitely became a new style for them. One of their best projects, Park Royal, uses many attributes of biophilia to help both the environment and the person seeing or using the building. With a design inspired from the Hong Lim Park, the architect and landscaping team tried to incorporate the plants inside the building by forming the same space as the park by layering the building. This gave us a terracing design which provides about twice as much space as the surface area of the park.

The biophilic attributes that the building exhibits are:

-visual connection with nature

From the looks of the architecture, we can clearly understand that wherever you are in the hotel, you would have a visual connection with nature through either the window giving on the garden or on the park. This greenery is a reminder of the ecosystem that exists in the rainforest of Singapore. Simply said, the view on the flora produces a calming effect on the people around.

-Biomorphic forms and patterns

The inspiration for the form comes from rice paddies found on the slopes of mountains. It follows different curves and retracts a little bit with each floor as we go up. The use of biomorphic forms doesn't stop there as many furniture inside the building including desk and ceiling decoration use the principle of emergence: a part of the material that comes out to form the furniture.

-Complexity and order

The complexity of the building can be seen in the curves that are irregular. Within this irregularity, we can actually find an order as the plants create spaces, paths or even secret terraces on the floor that they are used. Orderly patterns mixed with complexity can also be seen in the decorations of the buildings which create a sense of closeness to nature but which do not form part of the architecture.

-Refuge

The garden found on the different floor can be used as barriers which prevent unwanted eyes from looking beyond the leaves. As a matter of fact, the flora creates a mental refuge for those that work in nearby buildings as they get to have a view on it. Eventually, the hotel has used its design to provide its client with a view that protects them from the city and offers them a comfortable zone.

-Risk/Peril

The bird cages are good features which make full use of the fear or consciousness of a person as the person venturing inside will be well aware of the distance between his feet and the ground. The fear of falling or that the metallic structure doesn't support them create this effect of risk which is also used on the bridge to cross to the bird cages or the elevators. The infinity pool also gives this effect of peril as it is on the edge of the building.

The simple fact that from the start they wanted to introduce a form of biophilia into the building, led to a different approach to the conceptual process, going as far as requiring the consultation of a landscaper to be sure that every plant is placed and maintained carefully. From the top view it would seem like different forests on different levels. The form given to each floor is inspired from

the asian rice paddies and goes even further inside the building as biomorphic forms are used on the furniture. This is a different type of process compared to the 2 other case studies as ParkRoyal is built for the introduction of new features which were not present on site but inspired from other rural places.

The end result which is now in use, is without a doubt a place that produces a calming effect on anyone visiting it. Not only offering top tier service and ambiance to its clients but also providing a refuge for the eye of every passerby who is surely tired of seeing the same type of towering buildings all around town. The different cuts being retracted a bit more on each level also invites you into the building like a natural landscape or a hill. The creation of a different type of ecosystem on each floor would have perhaps been a good idea to show the different ecosystems present in the country but it would require massive work from the landscaper. The building is a precious example of biophilic architecture done right as it has enabled the mixture of an architecture with an ecosystem that doesn't need a lot of provision.



Fig. 28

4.5 REVIEW ON CASE STUDIES

In summary, the case studies offered us a different perspective on how architects conceptualise projects with the notion of biophilia. These are not the only ways to introduce biophilia but they are the main categories when thinking about big architectures. The involvement of different knowledge and factors also become more and more important depending on the natural system existing and whether we want to build around or introduce new life. This will lead to the revision of the budget of a project which may have a big impact on the path to choose to erect a biophilic building. To conclude, all 3 ways lead to a beautiful biophilic design which helps in awakening the instincts that we have been suppressing; the wish to reconnect with nature.

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A New Way for Classifying Biophilic Architecture



5.1 ATTEMPTS AT CLASSIFYING BIOPHILIC DESIGN

For me it is without a doubt, impossible to really classify biophilic architecture. So why not simply create a new archetype that would take some of the chosen characteristics and regroup them into it. Biophilic architecture is still confusing, we don't have a definite image of what it could look like. What I'm proposing is a new way of classifying biophilic architecture both from the exterior and interior by either isolating the element forming the building or combining several characteristics to give one ambiance that is applicable to other existing buildings.

Throughout my research work, I didn't come across other theses that tried to define levels of biophilic design but I saw theses that provided strategies to implement biophilic design into already constructed spaces. It is also surprising that these theses were posted or worked on during the pandemic. As if it made all of us realise that we needed to rethink the way we were living. The theses are mentioned in the bibliography but unfortunately, I couldn't find one of the theses that I read and resembled the most to mine.

From the research, it would seem that biophilic architecture can be designed at different levels. So to continue in the same path, the proposal made for the classification of the different strata of biophilic architecture would be better if we go by designating them with degrees. As biophilic constructions are also widely spread it would be easier to indicate which ones are using nature in the most efficient way possible. It might be possible that a building has several characteristics of biophilia but doesn't lead to the final degree of the stratification.

5.2 FIRST DEGREE OF BIOPHILIA

The first degree, as you would have guessed, is the use of simple biophilic attributes namely the natural lighting, the use of natural materials or the use of other elements. It is the use of these elements but isolated from others and therefore not providing any effect or feeling on the person inside. From an exterior point of view, it would simply be the use of windows to capture an awesome view or to let the light from the sky enter. The first degree of biophilic design can be seen in almost all buildings excluding bunkers which would prevent any kind of natural lighting or airflow. This type of biophilic architecture is just to let everyone know that nature is present all around us and that it is our duty to use it and protect it. Examples of this type of architecture can be seen all around the world where we promote functionality over the benefits that a better connection with nature would have offered. The rise of productivity as well as the well-being of a person only to mention a few are benefits that could come from elevating the connection with nature just a little more in this degree.

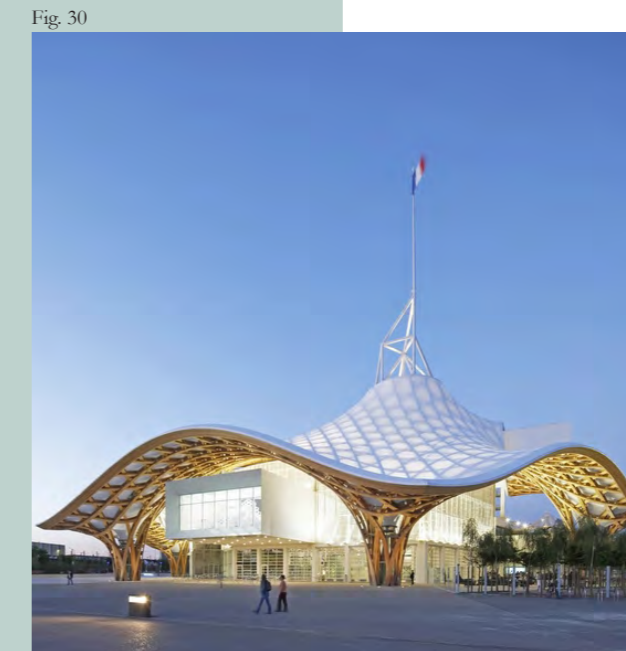
The first degree is in summary, the use of the attributes individually. Take for example one of the buildings of Zaha Hadid, the Galaxy SOHO; it is one which uses biomorphic forms and the use of a visual connection with nature as well as dynamic lighting but it stops there. It doesn't introduce nature into the building or even provide any sense of closeness to it. The natural form is used only as a decoration and from a workers point of view, it is just another office.



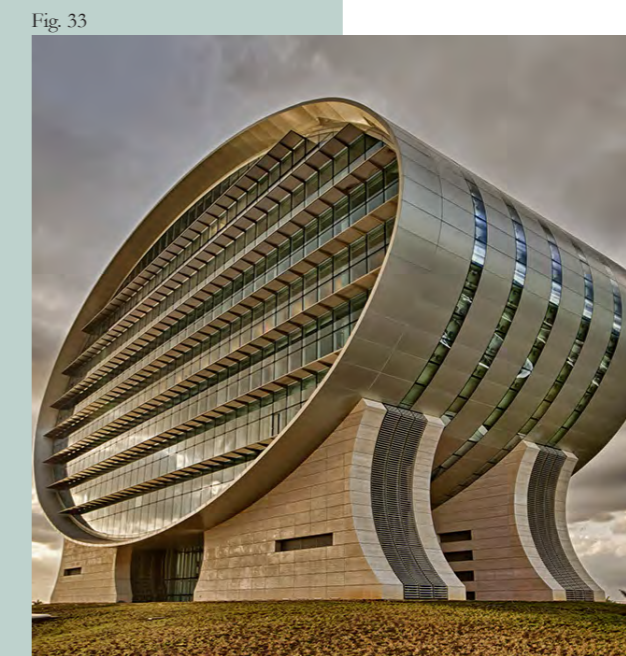
EPFL Rolex learning center - Lausanne, 2010



The Galaxy SOHO - Beijing, China, 2012



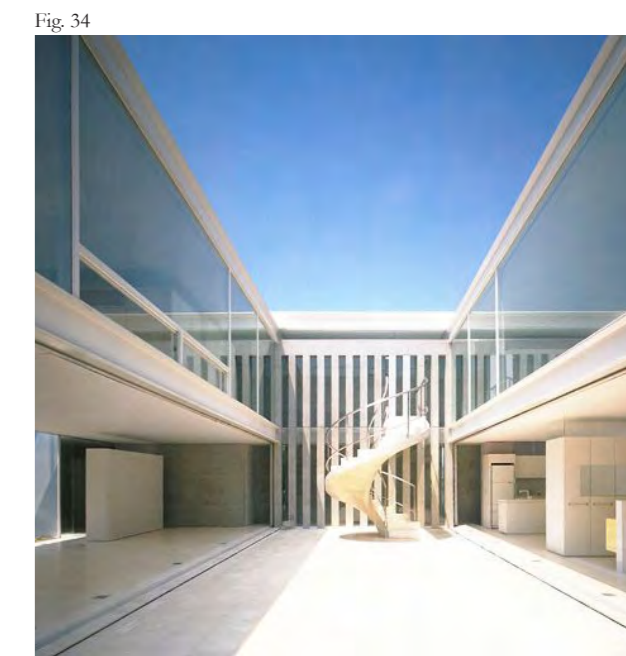
Centre Pompidou Metz - Metz, France, 2010



Mauritius Commercial Bank - Quatre-Bornes, Mauritius, 2012



National museum of Qatar - Doha, Qatar, 2019



2/5 HOUSE - Hyogo, Japan, 1995

5.3 SECOND DEGREE OF BIOPHILIA

The second degree, a bit more complicated, would involve a combination of several attributes but still not enough to produce an immediate effect or experience on the person. This category will be different from the first one in the way that it uses biomimicry in one of its forms: bio-form, bio-characteristics, or bio-ecosystem. It is better as it tries to reproduce and bring back the nature that it replaces on the ground that it is built on. It might also be inspired from the surroundings making it even more local to the land and gives a feeling of appropriation to the people seeing it.

From an exterior point of view, the building will blend with its surroundings. This leaves us with the interior either being the same as the exterior or simply another functional setup, in both cases, the architecture still is a second degree biophilic architecture. This also englobes architecture that tried to do good but failed in the application of the characteristics that they wanted. The most relevant example would be as mentioned before the Oasia Hotel in Singapore which failed to take into consideration the climate in which it was establishing itself. Even though it fails it still tries to produce a building which favors the growth of plants on its facade which unlike the first degree is a better effort.

Some notable examples of second degree architecture would be the houses of Frank Lloyd Wright especially falling waters. Renzo piano's architecture in the islands of new caledonia is also an interesting way of using biophilic architecture. Toyo ito sendai mediatheque is one of the few buildings that uses biomimicry and actually combines it with a subtle touch of modern architecture to form a brilliant piece of work. This masterpiece can be considered a second degree biophilic architecture as it makes full use of several attributes. It even uses 5 principle pillars which are in the form of algae. The second degree is not that hard to accomplish considering that we can just renovate a first degree to arrive at the wanted results which is already unbelievable. The case study of the bosco verticale

is exactly an example of such an architecture. It might not have been the first intention when drawing the project but it works just fine when we watch it now.

So the difference between the first and the second will depend on the introduction of nature onto and/or into the architecture. The distinction is quite obvious when comparing the two degrees as for the first degree the biophilic experience is mostly the use of the surrounding elements. The second degree goes a bit further with the introduction of nature into the building either with material components like flora or with bio-characteristics, example: design making use of thermals and airflows. The fact that the second degree tries to incorporate bits and pieces of its surroundings to form part of it is also a big feature to notice. However, when it comes to the third degree the distinction is a bit more difficult to make. Biophilic architecture being vast as it is, the perception of these last two degrees will greatly depend on the ability of the architecture to force an unusual experience onto its visitors.

05 A NEW WAY FOR CLASSIFYING BIOPHILIC ARCHITECTURE

Fig. 35



The Therme Vals - Therm, Switzerland, 1996

Fig. 36



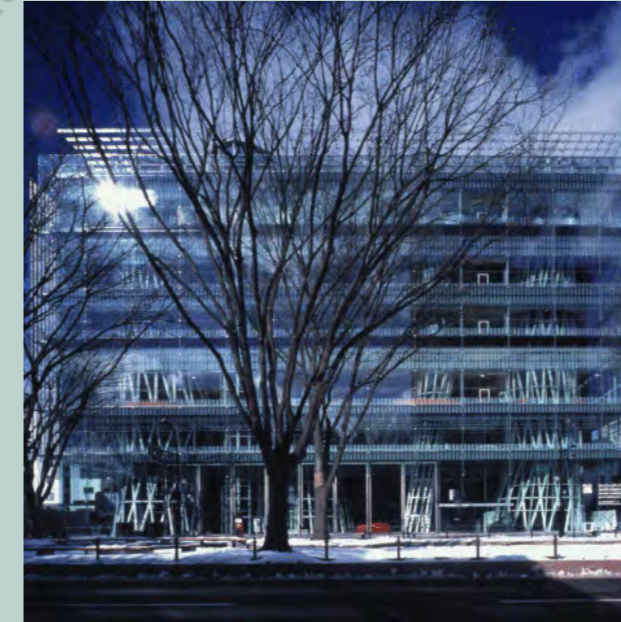
Oasia hotel - Singapore, 2016

Fig. 37



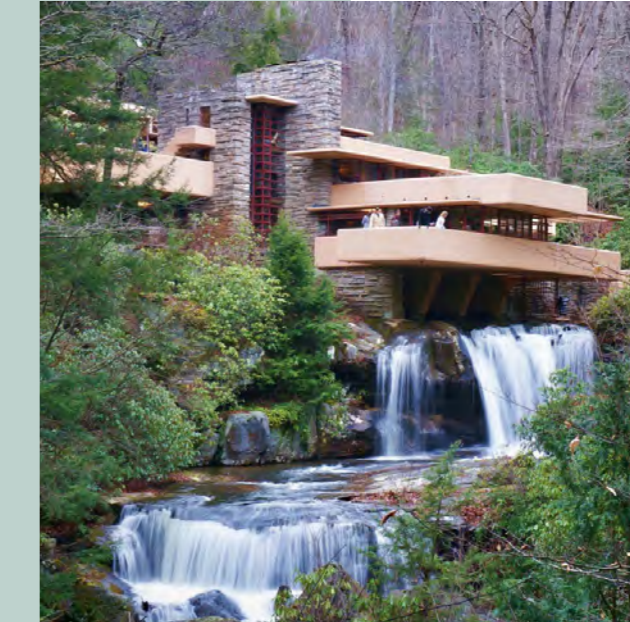
Jean-Marie Tjibaou Cultural Centre - Tinu Peninsula, New Caledonia, 1998

Fig. 38



Sendai Mediatheque - Sendai-shi, Japan, 2001

Fig. 39



Falling waters - Pennsylvania, USA, 1939

Fig. 40



Selgascano office - Madrid, Spain, 2007

5.4 THIRD DEGREE OF BIOPHILIA

The third degree is a collection of experiences that is felt almost immediately when entering the building or just from the sight of it. To further explain this, I will take the four last patterns found in the 14 patterns of biophilic design. It will not be restricted to these four and will involve other experiences such as a calming effect but to have a better understanding, I will use these 4 as a guide.

The experience of prospect, refuge, mystery and risk can be found in the 3rd degree architecture. Feeling these effects just by entering the building is without a doubt, the pinnacle of biophilic architecture but shouldn't be used only in the lobby. Letting ourselves be led by the curiosity to experience new feelings in each section of the building is also one of the reasons to use biophilia. Guiding us by using fear or even refuges where we would be able to stop for a breath of fresh air also seems like a good initiative an architect would take.

Taking the effect of mystery as the main example, we can have a building which invites people to look into its secrets. The Amazon sphere as mentioned before is a great way of showing how mystery can change the aspect of a space. The spheres use interior gardens to direct people's attention, creating refuge or peril depending on the installation. These experiences are subjective to a degree as all people are not the same. We would need strong stimulations that are either common to everyone or that would force a feeling on someone. In the Amazon sphere, the experience is so powerful that even someone who's never ventured in a forest would feel the need to explore.

The third degree is as it should be an increment from the second degree meaning that the third degree of biophilic architecture should also introduce nature by some form into itself. Some buildings may produce the experience mentioned before but might not have any connection to nature. La grande arche de la défense, in Paris,

provides the experience of risk and peril through its design and we feel it whenever we see it. However, it does not introduce any natural attributes which makes it only a first degree biophilic architecture.

Summary

The three degrees explained, we now have an understanding of different biophilic architecture which helps us reduce the confusion that existed in the topic since its introduction. The first degree, the use of surrounding elements, the second degree, the introduction of natural attributes into and onto the building and the third degree, a combination of experiences and the urge to explore or understand how it works. These last two degrees can be further explored now to help architects in the construction of a new biophilic landscape which comprises modern technology and nature.

Fig. 41



Amazon Sphere - Seattle, USA, 2018

Fig. 42



Xiangshan Campus of China Academy of Art - Xiangshan, China, 2007

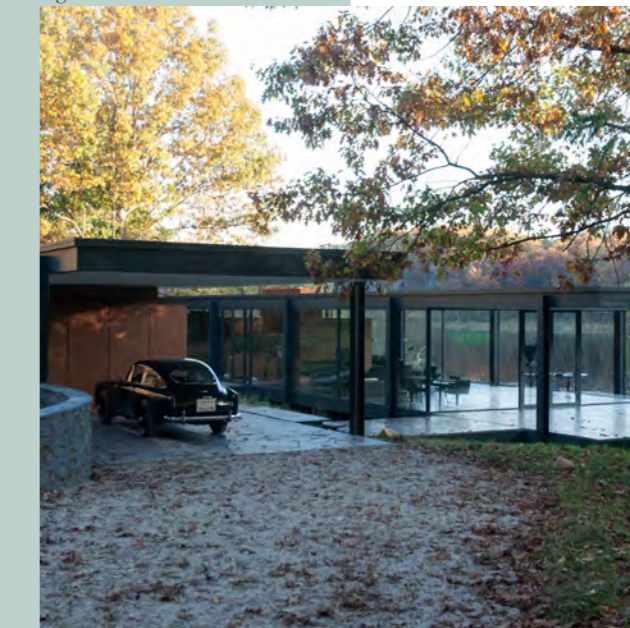
Fig. 43



Khoo Teck Puat Hospital - Singapore, 2009



Kandalama Hotel - Sigiriya, Sri Lanka, 1995



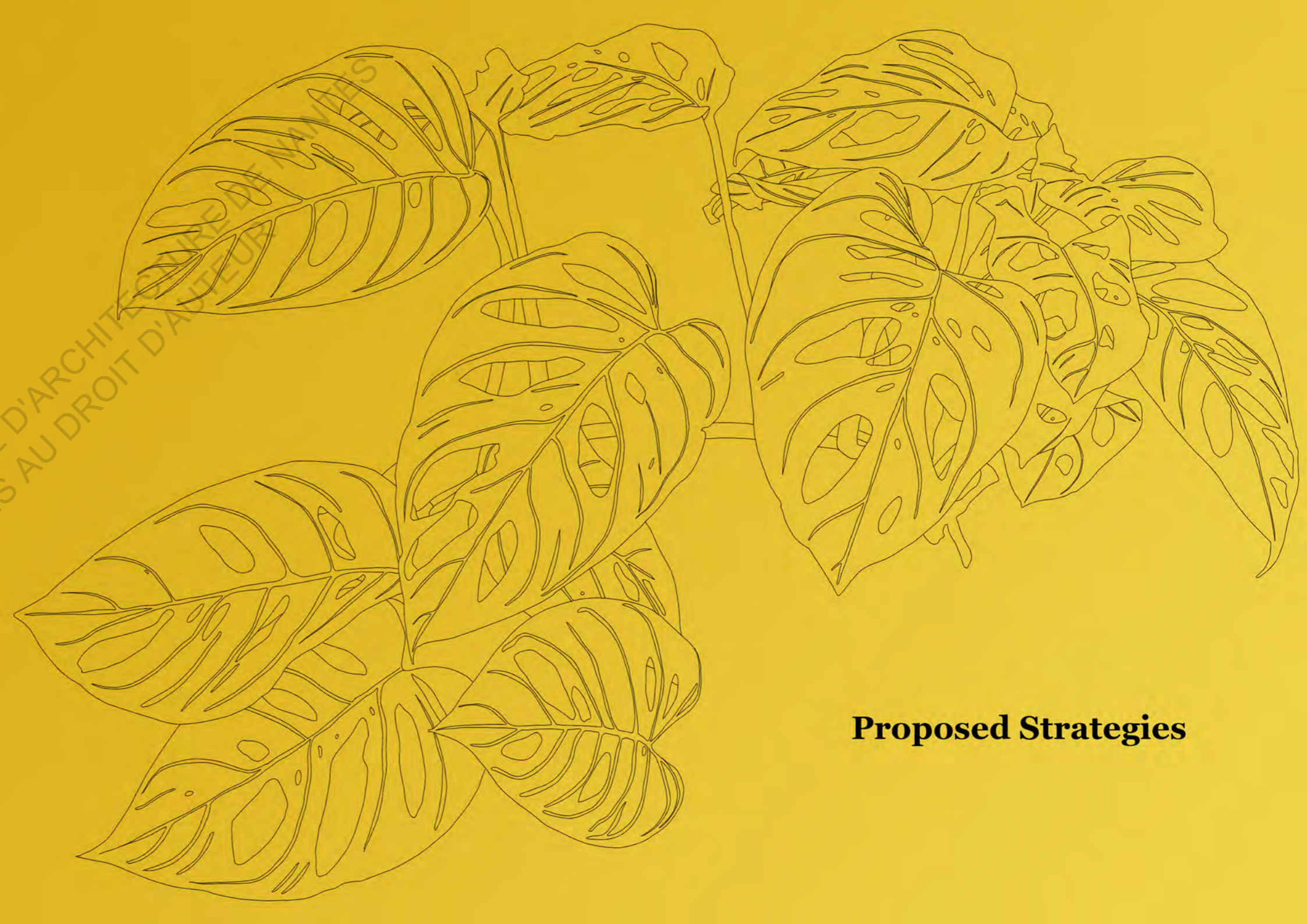
Batman's house inspired from Farnsworth house - Plano, Illinois, 1951

Fig. 46



Campus for the University of Ruhuna - Matara, Sri Lanka, 1978

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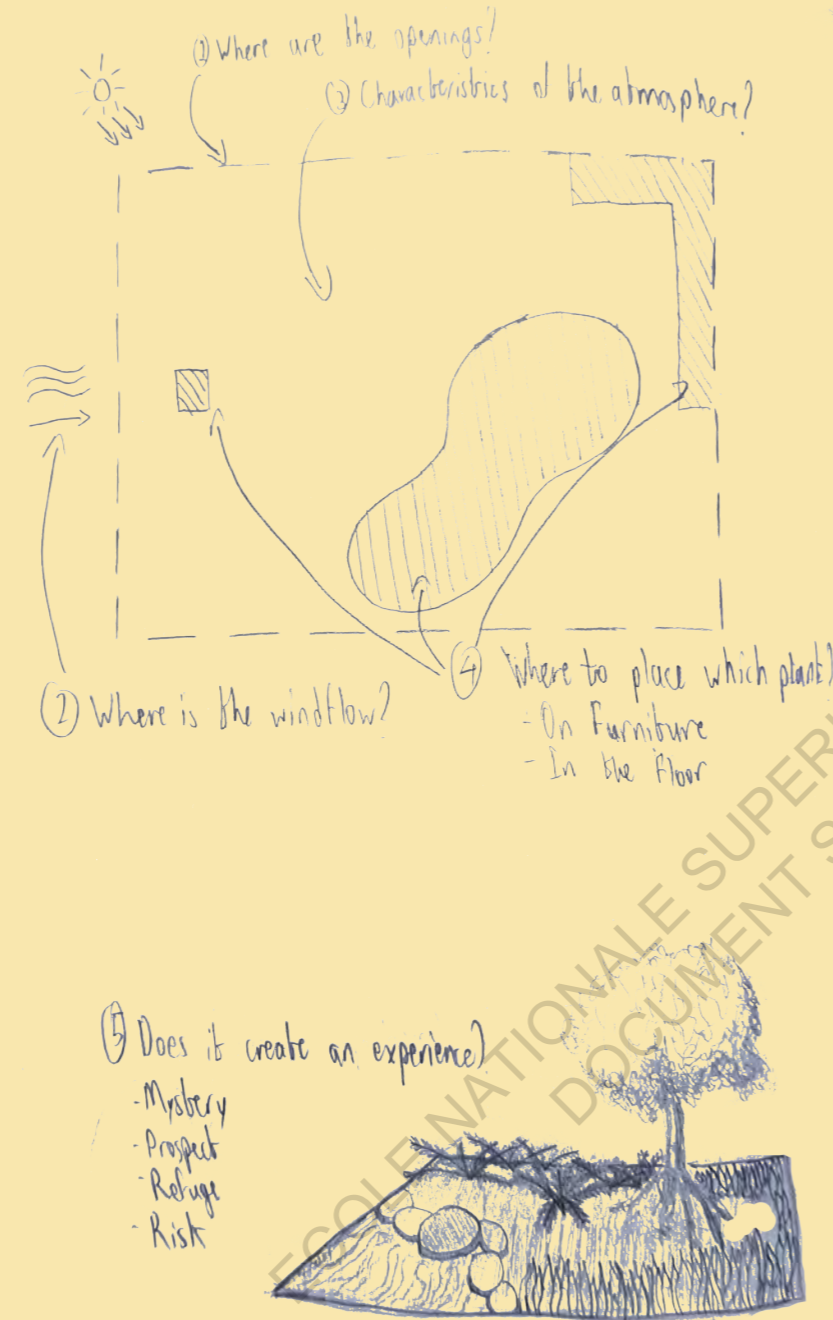


Proposed Strategies

6.1 INCORPORATING THIRD DEGREE BIOPHILIA

Understanding now the different categories, I tried to project myself into an architect that would be aiming for a third degree biophilic architecture. What is the information required to be able to conceptualise such an architecture? Do we just go as usual and then find space for the plants or do we need to take more into consideration? This experiment of mine will help to create guides to conceptualise an architecture for a full biophilic experience.

The experiment will consist of creating a biophilic concept for a room or around it that will be able to reproduce the experience of mystery. We will be conducting it into a familiar environment, in Mauritius, as the latter has a climate that doesn't have much variation between the extremes of summer and winter. The climate is extremely important as it will dictate which plants to introduce as well as the possibilities of using other features as dynamic lighting or thermal airflow. The concept that I will be presenting will focus on the visual connection with nature and the complexity and order placed into the room. This means that it will mainly consist of the introduction of plants into the conceptual drawings.



6.2 ANALYSIS OF THE SPACE

Having already studied the climate, to understand which strategies or guides to use, we first need to analyse the space which we are going to use. The characteristics that are the most important are the luminosity (the openings), the ventilation and the humidity of the room which will determine the hotness and comfort of the room. These are enough to find out which spot is better to introduce plants but if you want to go further and use a new design that makes use of thermal airflows or dynamic lighting, you would need to be careful as to what ambiance you are trying to produce into the space.

Let's start by constructing the room. The specification of the rooms will be as follows: 3.5m x 3.0m with a window and a door. The window and door can be adjusted, as well as the height, to provide the best condition for the room or if the room is connected to another one, the luminosity will be different but can still be calculated. Moreover, with the advances in unreal engine 5 and the introduction of lumen, creating and visualising it into a realistic image, at an early stage, has never been so easy.

Depending on the size of the opening or the orientation of it we can already find out what type of atmosphere will be present in the room. As explained by the diagram, living spaces will have their openings facing north or north west to have the most lighting throughout the year. This will lead to a path of direct illumination in the room and spaces that will receive only reflected light. This will help us divide the room into two zones which will either be for plants requiring direct sunlight or plants living in a bit more obscure setup like orchids. The surface on which the light is reflected will also affect the ambiance of the less exposed zones. Take for example tiles which have a rather high reflective index will heighten the luminosity of the room as well as reduce the need of secondary lights. This will apply to the furniture as well as the color and texture used on the walls. That is why lumen can be helpful here as it gives us an early appearance of the room which can be modified in real-time.

Table A

Average length of daylight in Port Louis

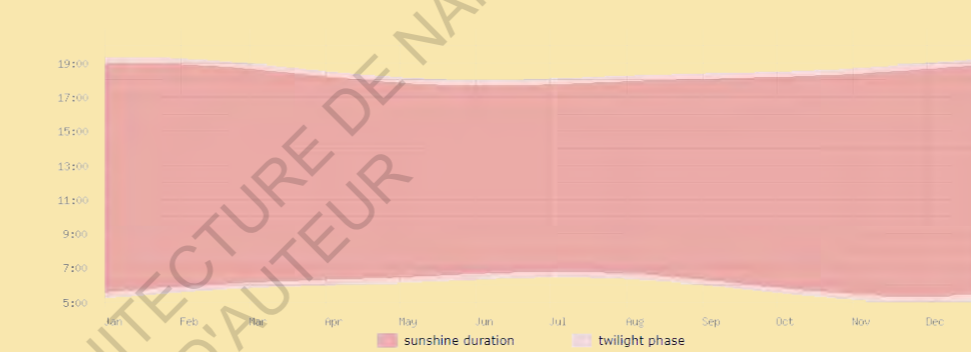


Table B



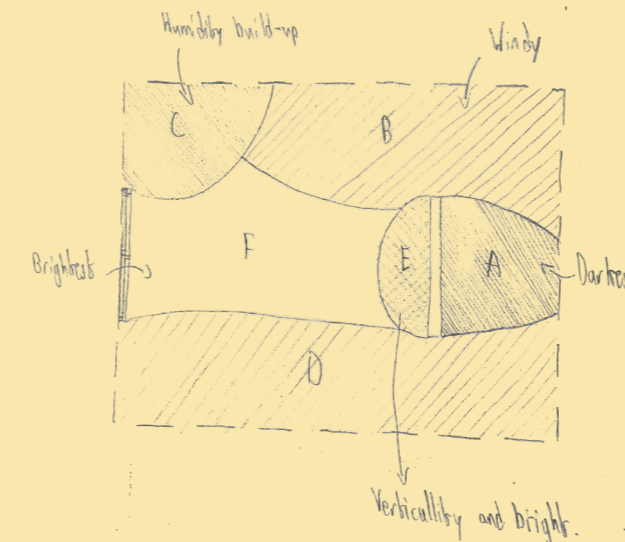
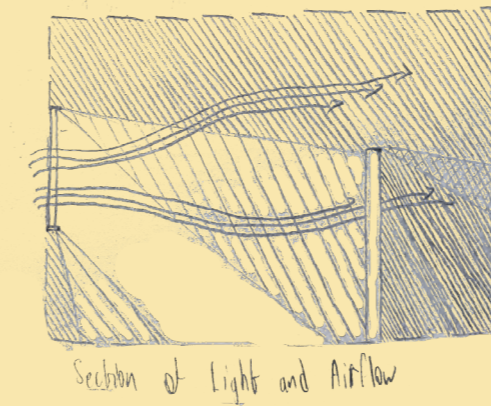
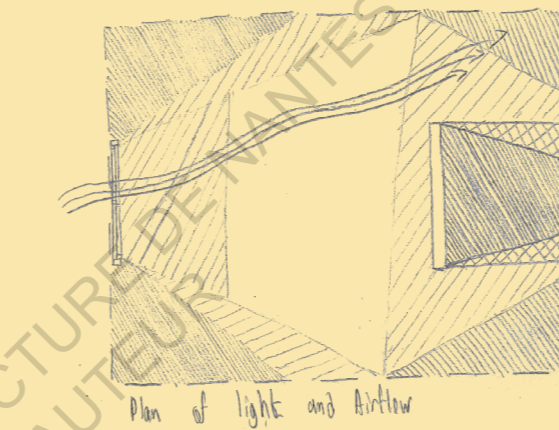
As we are thinking of a biophilic architecture, we would prefer to use natural ventilation as well, but wouldn't be against the use of air conditioning or other home appliances that help in monitoring the temperature of the room. The ventilation will occur naturally through the same opening as the one used for light but will also require another inlet, like the door, into the room. This will confirm the use of cross ventilation which otherwise will lead to a minimal use of natural ventilation. The speed and frequency of wind gust should be well analysed as it will affect some plants which prefer well aerated spaces. It can also be a downside as hanging plants won't be able to resist strong gusts of wind. Mauritius, being an island where microclimate exists, we can have winds in different directions but in a large open area, the dominant wind will always be the south east trade wind.

Another factor is the slope of the roof which may capture hot air or even be used to let a more efficient airflow through the room. This will also affect the plants as a current of hot air will always be passing through the room which can cause severe damage to some plants that prefer cooler spaces. So basically, the number of openings, the direction and frequency/ amplitude of the wind, the design of the room will have an effect on the airflow which needs to be understood as we are going forward.

The introduction of plants will lead to a higher humidity level in some cases as some plants release water vapor to cool their leaves in warmer atmospheres. The humidity of the room should be calculated as it will define whether the person will find it comfortable or not. This factor will be controlled mostly by the presence of water and the number of plants found inside the space.

These are some variables that should be taken into consideration when building a biophilic architecture but we are not limited to. These variables depend vastly on the location of the room which would have been completely different had it been in a European country. The altitude of the room would also have played an important role in this case. The variables are important but can be dealt with depending on what type of architecture/ design you choose to implement. That is why this hypothesis of mine will be in a climate that I am accustomed with and which has minor changes compared to European climate.

06 PROPOSED STRATEGIES



6.3 PROPOSED STRATEGIES

Following the analysis of the environment, we can have several proposals that work well with the design that we are thinking of. The proposals are a collection of ideas which are explained to understand the implementation of each one of them. These are not the only way as mentioned before and can be further explored depending on the different climates and properties of the plants.

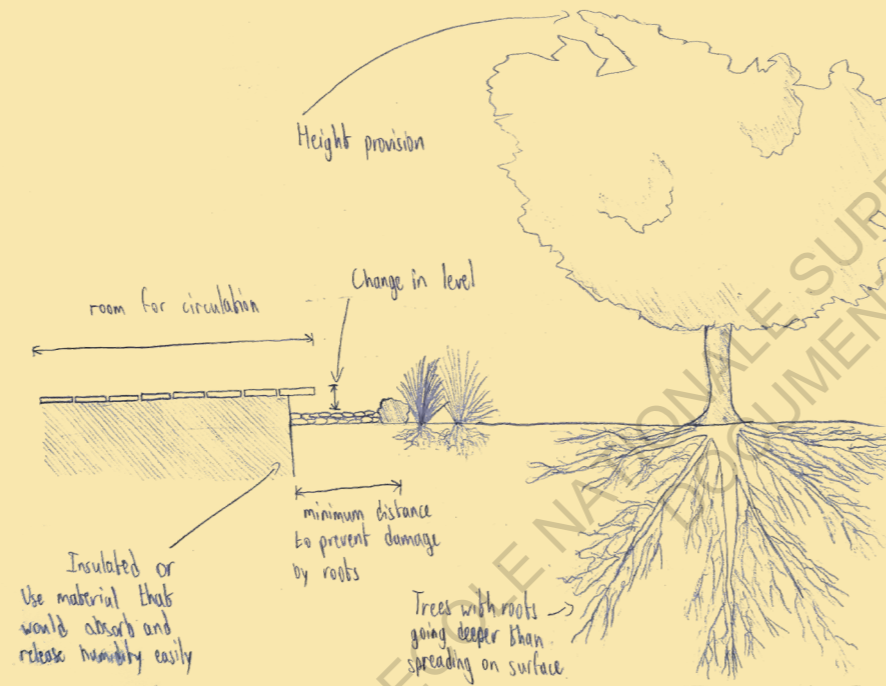
A list of plants has been prepared that includes the different types of plants that can be found in almost all interior conditions in not only Mauritius but also in other countries. Still some endemic plants were added which just can't be ignored as the availability of plants also plays a great role. This list is a hope to help not only architects but also people seeking a new approach to their lifestyle.

6.3.1 INTERIOR GARDEN

One commonly used idea to introduce nature inside is an interior garden. It is one which consumes a bit more space that is required as it is completely separated from the other rooms but still keeps its visual presence and connection with the area around it. In this experiment, we can have a transparent wall that extends into the interior garden or even better, the interior garden can be part of the room.

To convey the effect of mystery, the garden should at least be composed of either a great number of plants or be filled with big trees. To bring mystery it needs to create a change in the setting of the interior like a zen garden or a japanese garden which is different from controversial designs. Several variations of garden are possible in this layout where you create a new landscape for the person inside the rooms. The presence of water can also be introduced like a floating garden which is even better.

The important ideas to keep in mind when creating an interior garden are that it should be visually accessible from every nearby room. It can also play with proportions as this will bring even more mystery like a very small bonsai garden or a very big garden that seems impossible inside the building. Another aspect is that it should be under the roof, even if the roof is transparent it should be protected. This will further emphasize on the fact that we are inside another small world rather than in a garden that can be found anywhere. We can even use a pergola as a roof if we have good drainage and protection around the garden preventing rain and wind from causing damage.

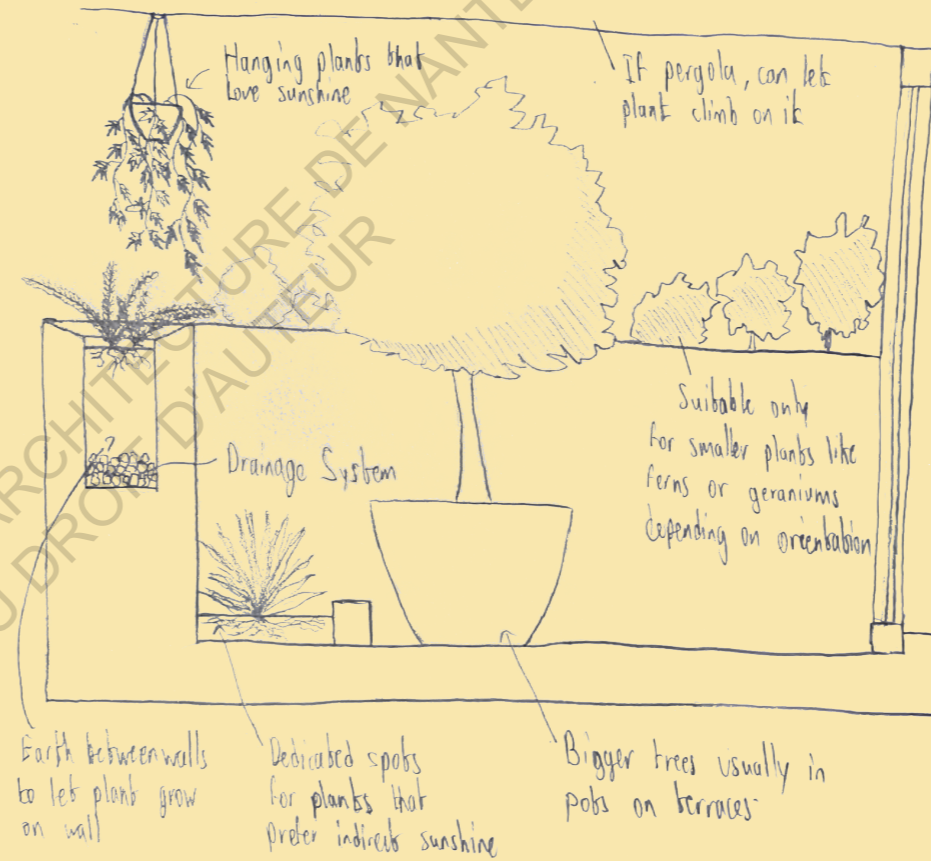


6.3.2 TERRACES

Similar to how Stefano Boeri worked with bosco vertical, we can see that terraces play a huge part in the introduction of biophilia into an apartment building. Contrary to interior garden though, they will have an effect only on the adjacent room but will also have an effect on the exterior of the building. Terraces are exterior spaces which when used correctly bring an even better view than the existing one. The nature that we introduce becomes a painting that we will see through only opening in the room if we are in an apartment/studio configuration.

Openings that make use of exterior spaces to keep the visual connection can be seen in many buildings, especially some of Frank Lloyd Wright houses. However, not all houses are built in the middle of parks. The limited space of a terrace can be embellished to provide the view of nature that you would have from such places. A terrace consists of its balustrade, its floor and finally its ceiling.

The balustrade will play a big part in the introduction depending on its design. We can have double layered balustrades that can accommodate soil in between and then grow on top of it. We can even have simpler metal balustrades that support pots of different sizes. To add to the balustrade, we can add bigger pots on the floor that will allow the growth of small trees which adds to the aspects of mystery. All of this will also depend on the weightload the terrace can handle as well as its area. Finally, as a last addition, we can have plants that descend from the ceiling if you have a pergola roof. It may even be possible for some designs to add ceiling hanging plants, especially in the corners which will protect from strong sunlight in some cases.



6.3.3 CEILING HANGING PLANTS

Mainly used in urban farming for tomatoes and other twisting plants, this method is not commonly used in common houses. It requires a bit of space and proper maintenance which discourages most of its applicants but is truly beautiful when seen. Some examples are the use of it in the middle of spiral staircase with the help of thin metal cables. The cables being resistant and rough enough, the plants can grip onto it to continue their progression either from the bottom to top or more commonly from the top to bottom.

The requirements for this implementation are a strong link to the ceiling with the pots that will contain the plants and space underneath the pot that will ensure that the branches do not tangle with anything. The potential of creating sculptures that would allow the plants to fill it are also unseen and can be used as a way to give a form to the proliferation branches. Ensuring that the plants don't become too big is also necessary as it would require more nutrients, therefore a bigger pot which may lead to its demise.

Spaces that may use this method are nearby walls to create a green wall, or as separation. Between the living room and kitchen might be a good idea or if you have an interior garden, it might be used to produce the borders that are sometimes ambiguous. A combination of several methods is also an option where you choose to use it in the interior garden to accentuate the experience of the prospect.



06 PROPOSED STRATEGIES



6.3.4 DEDICATED SPOTS

Sometimes, arriving on site, an object or part of nature that is present captures our attention which makes us want to conserve it. The trees that were already on site when they built the fuji kindergarten or big rocks that are seen in many villas on the slopes of mountains. Including these elements in the concept is a must for some while being a headache to others as it demands a lot of knowledge on construction to prevent it from being damaged.

Similar to how we would create a space around existing isolated natural objects, we can accommodate isolated natural elements in other dedicated spots. The space is smaller than the interior garden meaning that it can be placed almost anywhere. However, to not push every spot to the corner of the room where we get lost spaces through furniture, we need to already prepare several configurations of the room with the spot in it. It will obviously take several tries before being able to find a right balance as the client needs to be sure that it is satisfactory enough.

The use of lost space in furniture can also be an interesting option to cultivate more plants. Like urban farming, the proposal of growing plants for culinary purposes is also a way to connect to nature. The use of spaces under the table of work in the kitchen or just on the edge of the window ledge so that you get fresh herbs whenever you are cooking is a reliable way of using dedicated spots. A small amount of soil should be enough as these plants require mostly sunlight and water to grow well.

6.3.5 GREEN WALL

Green walls are the most delicate way to introduce flora as they require a lot of attention and care. It is a combination of different plants which are planted in bags of soil fixed on the wall. It usually requires constant running water on the surface of the wall to keep it cool and to supply the moisture that the plants need. This type of installation is actually the opposite of what modern architecture is trying to achieve as it costs a lot of money and the installation uses a lot of energy which increases the cost of the project in the long term.

The use of green walls is good when you can fix a good amount of soil for each plant on the wall. To include a green wall, a special type of insulated wall is necessary which will be able to support the load as well as prevent the roots from perforating it. The soil can be either incorporated in the design of the wall or can be added afterwards. This gives birth to different types of green walls which may even consist of shelves supporting pots of vines.

Another type would be those that are used only for the proliferation of vines leaving the roots on the floor. It can be seen in some of Geoffrey Bawa's work as well as in the Xiangshan campus of china academy of art. To ensure that the plant will grow onto the wall, the direction of lighting is extremely important as well as the finishing used on said wall. In interior conditions, green walls are mainly used for decorative purposes in lobbies and lounges but could be extended to other rooms if the right conditions are present.



06 PROPOSED STRATEGIES



6.4 ADVICES FOR FUTURE CONCEPTS

The incorporation of plants depend greatly on what type of atmosphere and ambiance you want to create for the room. It always starts with that small intention of what you want for the specific room and then you can use one of the proposed scenarios or create a new one with your design. You just need to supply enough room for the soil needed and then predict the expansion of the plants.

The effect of mystery can be achieved through other means than just introducing plants; however, this will require an even more profound understanding of biophilia. The use of natural materials in walls such as rocks or simply the presence of water can create the effect but it will not be as aesthetically pleasing as bringing in living organisms. The creation of a new ecosystem which englobes the room might also be a way to bring in the effect of mystery into a building and should be the starting point of the concept if ever used. The reason why I choose plants is simply because they provide us with much more possibilities than other methods and due to their needs, we will keep the connection with them.

It can be said that there is no simple way to create a third degree biophilic architecture as it requires the cooperation of the architect, a landscaper, if the architect and the client are not knowledgeable enough which leads them to hours of discussion before being able to draw a line. Biophilic architecture is a mixture of other types of architecture but needs proper thinking. It has been used thoroughly in many big structures, however now, during the pandemic and for our future lifestyle, is the time to bring it to the smaller ones, like houses or apartments.

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Maintenance and inconveniences



7.1 THE ATTENTION NEEDED

When it comes to plants, there is always a minimum of maintenance to do unless you want the plant to die in less than a month. Fortunately from my research I found that succulents need a little attention because they stock a lot of water in the leaves. Watering them once every two weeks is enough depending on the conditions of the rooms. Even though succulents are low maintenance plants, they are not sufficient to create a third degree biophilic environment unless you are creating a big zen(mineral) garden. So what kind of maintenance would a third degree biophilic architecture need?

Third degree architecture is the incorporation of plants from the conceptual process to create an environment that will forcibly coin our curiosity. Following the strategies mentioned above, we can have different kinds of setup for the space we want to achieve which is not limited to only those presented. Through those strategies, we identify that most of the plants indoors are in pots or in dedicated slots which leads to many situations. The first step in these situations is always a good discussion with the owner to understand the criteria of the plants he wishes to introduce and then from there, explain the demands that these plants would need.



Fig. 47



Fig. 48

7.2 WATERING AND DRAINAGE

Watering the plants will depend greatly on which type of plants you decide to incorporate. It will also depend on the climate reigning in the space where the plant is found and whether it has good aeration or direct sunlight, conditions that have been explained above. However watering is inevitable and to do so will be difficult if not calculated in advance. Take for example the bosco verticale, the terraces all have drainage systems which prevent accumulation or infiltration in the concrete. But when other strategies are used, we will probably have some more difficulties to adjust the drainage systems.

When the roof hanging strategy is used the drainage is done by hanging another bigger pot to the plant to let any excess water fall in it. The water can then be reused in other plants hanging around or for other purposes. This will demand a stronger fixation as the weight of the plant with soaked soil will be heavier, possibly falling if not done right. For the other strategies it will be straight forward enough as they will mostly be pots except for the green walls which will need more accommodation and thinking.

Drainage systems are important when thinking about the introduction of plants for a constant visual connection with nature as it will determine whether the plant will live or simply die after several weeks. This applies to large plant additions. Adding only one or two pots will not require such effort from the owner or the architect.

7.3 FLOWERS AND INSECT

When it comes to plants, most of them use flowers for reproduction which releases a lot of pollen. This may cause allergies to people who are unaware of the season in which the flowers bloom. One more factor to take into consideration for biophilic architecture. It may seem minor but it can cause great damage if not dealt with. Simple solutions would be to either choose flowerless plants like succulents or control the flow of air to collect the floating pollen particles.

Not being allergic will let you appreciate the beauty of the flowers but it will attract bugs that will come to pollinate them. The floor on which you are may help to reduce the unwanted insects but the best solution remains a repulsor. I personally think that some insects are the most welcome as they would only be flying around the flowers and then go back to their hives. They may also be prey to the plant if you choose to grow a venus fly trap.

Variables like insects and allergies will depend on the owners as the latters are the ones who will be living there. They also need to force pollination if they choose to prevent bugs from entering, especially if they are growing edible plants. It is actually what they do in indoor urban farms to prevent the deterioration of the plants and to increase the yield. Furthermore, in Mauritius, bugs tend to be scarcer when we are in the winter season.



Fig. 49

7.4 ROOTS PROLIFERATION

Flora will obviously involve root management as explained in the fuji kindergarten case study. For already grown up plants, we will be able to identify the exact location of the roots as well as protect them during the construction. However, when building with new flora, the space required for the root expansion needs to be calculated as it may cause cracks in the concrete depending on the direction they proliferate. Most of the time when choosing big trees for courtyards, we choose trees that have roots growing further down than those growing on a horizontal plane.

For potted plants, the management is different as we either let it fill the pot until it has no more places to go or we simply choose a pot that is bigger than it will ever be able to fill. For bonsai trees, it is usual to change the pot every two years as when the roots fill the pot, the plant has less chances of surviving. The process is simple, removing it from the old pot, cutting the excess roots without damaging the main ones, and transplanting it into another pot with fresh nutrients.

The roots are even more unpredictable than insects visiting as it happens slowly and without us noticing. Eventually showing the damage that it causes in the form of cracks. For a view on nature, the plants need to be identified and a root study should be made if bigger than average trees are wanted in the design. Usually, in Mauritius, we don't take that much precautions as we like to live on edge but many people having trees near their construction have been affected by it due to their ignorance.



Fig. 50

7.5 GROWTH OF THE PLANT

Like the roots, the type of plants that you opt for will determine the space required for the expansion of its branches and leaves. The choice is very important as if not done right you would have to cut the branches every month to prevent it from destroying the space it was allocated. In a courtyard, we might lose the connection as the vision of the foliage will go beyond the line of sight which will result only in the view of the bark of the tree.

Similar to the roots, the ambiance we want to create will determine the characteristics of the tree we choose. This applies to big trees but is also applicable to vines or hanging plants. All vines don't grow in the same way and some may need some help to direct them in the right direction. As for hanging plants it is simply a matter of equilibrium as most of the time the leaves will fall to only one side which may cause toppling of the pot.

All these variables can be dealt with after the construction but it is better to already have in mind the implications of introducing flora into a house. Biophilic architecture seems simple but actually requires a lot of work from the landscaper or even the architect to find out which plants are the best, especially the aging factor. It will be even more difficult to choose when we adjust it to the budget.



Fig. 51



Fig. 52

7.6 IS BIOPHILIC ARCHITECTURE WORTH IT THEN?

From a material point of view, biophilic architecture may not require more but when it comes to the implementation of the plants, it is a completely different matter. The knowledge required to construct the space is a plus that one architect could bring while another wouldn't even know where to start. The option of taking a landscaper when conceptualizing is also viable as the result might be even more surprising than you would expect. But this option will cost you more as it involves more parties and the coordination from the concept drawings.

Financially, a biophilic architecture will cost more, produce the same amount of carbon dioxide emission or less and will be able to partly replace the land that we took from the plants. The energy required then to maintain the flora will depend on the installation systems as irrigation will be a major factor considering the temperature jumps to 35 degrees celsius in some parts of the island. However, manual maintenance will always be the first proposal for me as it brings an even more elevated connection to nature.

The pros of a biophilic architecture even with all these variables are still undeniable and will have been even more in demand during these harsh times with the covid-19 pandemic. For just a little bit more, about 2-5 percent more in the budget, a more humanise space is provided which will lead to a better well being in the long term. This architecture will also provide an ever changing space that helps in relaxation and productivity. In conclusion, the variables actually help to decide which plants are the best for you and the ambiance that you want to create.

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Plant Library



Fig. 53



Name: Rubber plant
Scientific Name: *Ficus Elastica*
Use: Potted

Fig. 54



Name: Snake Plant
Scientific Name: *Dracaena trifasciata*
Use: Dedicated spots

Fig. 55



Name: Cast-iron-plant
Scientific Name: *Aspidistra elatior*
Use: Dedicated spots

Fig. 56



Name: Boston fern
Scientific Name: *Nephrolepis exaltata*
Use: Potted/ Interior Garden

Fig. 61



Name: ivy arum
Scientific Name: *Epipremnum aureum*
Use: Ceiling Hanging pot

Fig. 62



Name: Betel plant
Scientific Name: *Piper betel*
Use: Green wall

Fig. 63



Name: Creeping fig
Scientific Name: *Ficus pumila*
Use: Green wall

Fig. 64



Name: Jasmine
Scientific Name: *Jasminum officinale*
Use: Green wall

Fig. 57



Name: Western five-fingered fern
Scientific Name: *Adiantum*
Use: Potted/ Interior Garden

Fig. 58



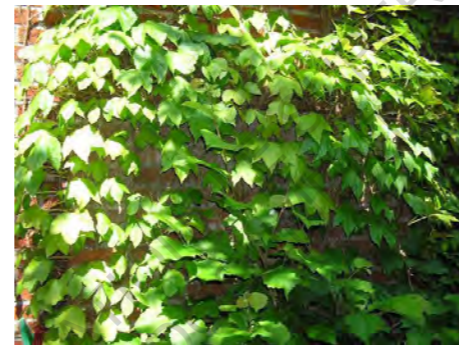
Name: lacy tree
Scientific Name: *Thaumatococcus bipinnatifidum*
Use: Potted/ Interior Garden

Fig. 59



Name: chain of hearts
Scientific Name: *Ceropegia woodii*
Use: Ceiling Hanging pot

Fig. 60



Name: Boston ivy
Scientific Name: *Parthenocissus tricuspidata*
Use: Ceiling Hanging pot

Fig. 65



Name: string-of-pearls
Scientific Name: *Curio rowleyanus*
Use: Ceiling Hanging pot

Fig. 66



Name: String of bananas
Scientific Name: *Curio radicans*
Use: Ceiling Hanging pot

Fig. 67



Name: flaming Katy
Scientific Name: *Kalanchoe blossfeldiana*
Use: Potted/ Interior Garden/ Terraces

Fig. 68



Name: Myersi
Scientific Name: *Asparagus densiflorus*
Use: Terraces/ interior Garden

Fig. 69



Name: African Milk Tree Cactus
Scientific Name: *Euphorbia trigona*
Use: Potted

Fig. 70



Name: Christmas Cactus
Scientific Name: *Dracaena trifasciata*
Use: Potted

Fig. 71



Name: Zebra Cactus
Scientific Name: *Aspidistra elatior*
Use: Potted

Fig. 72



Name: Jade plant
Scientific Name: *Crassula ovata*
Use: Potted

Fig. 77



Name: Pencil Cactus
Scientific Name: *Euphorbia Tirucalli*
Use: Potted

Fig. 78



Name: Burro's tail
Scientific Name: *Sedum morganianum*
Use: Potted

Fig. 79



Name: Mauritian orchid
Scientific Name: *Angraecum baiderae*
Use: Ceiling Hanging pot/ Green wall

Fig. 80



Name: Anthurium
Scientific Name: *Angraecum baiderae*
Use: Dedicated spots

Fig. 73



Name: Crown of thorns
Scientific Name: *Euphorbia milii*
Use: Potted/Terraces

Fig. 74



Name: Aloe vera
Scientific Name: *Aloe chinensis*
Use: Potted

Fig. 75



Name: Panda plant
Scientific Name: *Ceropegia woodii*
Use: Potted

Fig. 76



Name: Hens-and-chicks
Scientific Name: *Sempervivum tectorum*
Use: Potted

Fig. 81



Name: Hibiscus
Scientific Name: *Hibiscus rosa-sinensis*
Use: Terraces

Fig. 82



Name: Peace lily
Scientific Name: *Spathiphyllum cochlearispathum*
Use: Dedicated spots

Fig. 83



Name: Geranium
Scientific Name: *Geranium dissectum*
Use: Potted/Green wall/Terraces

Fig. 84



Name: Night Blooming Jasmine
Scientific Name: *Cestrum nocturnum*
Use: Green wall

Fig. 85



Name: Purple Oxalis
Scientific Name: Euphorbia Tirucalli
Use: Potted/ Interior Garden

Fig. 86



Name: Banana tree
Scientific Name: Sedum morganianum
Use: Interior Garden

Fig. 87



Name: Frangipani
Scientific Name: Plumeria rubra
Use: Interior Garden/Dedicated spots

Fig. 88



Name: Ti plant
Scientific Name: Cordyline fruticosa
Use: Interior Garden/Terraces

Fig. 93



Name: Dracaena concinn
Scientific Name: Euphorbia Tirucalli
Use: Potted

Fig. 94



Name: Thyme
Scientific Name: Sedum morganianum
Use: Potted/Dedicated spots

Fig. 95



Name: Lemon grass
Scientific Name: Cymbopogon
Use: Dedicated spots

Fig. 96



Name: Onion
Scientific Name: Allium cepa
Use: Potted/Dedicated spots

Fig. 89



Technique: Bonsai
Use: Interior Garden/ Pots

Fig. 90



Name: money tree
Scientific Name: Pachira aquatica
Use: Interior Garden/ Terraces

Fig. 91



Name: zanzibar gem
Scientific Name: Zamioculcas zamiifolia
Use: Potted

Fig. 92



Name: Lemon Tree
Scientific Name: Corymbia citriodora
Use: Dedicated spots

Fig. 97



Name: Garlic
Scientific Name: Allium sativum
Use: Potted/Dedicated spots

Fig. 98



Name: Radish
Scientific Name: Raphanus sativus
Use: Potted/Dedicated spots

Fig. 99



Name: Mint
Scientific Name: Mentha
Use: Potted/Dedicated spots

Fig. 100



Name: Coriander
Scientific Name: Coriandrum sativum
Use: Potted/Dedicated spots

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Conclusion

9.1 VIABILITY OF THE CLASSIFICATION

Biophilic architecture has always been affiliated with the addition of plants into a building but it doesn't stop there. It consists of so much more as explained through the studies and the definition which is taken for granted or ignored. With the help of this new classification, people will understand what it englobes and therefore help in the promotion of a true biophilic architecture. The classification does not offer a defined image as biophilic architecture is extremely variable considering its vastness but it offers an explanation of the atmosphere that should be present in it to be regarded as such.

The classification that is presented here is still far from being able to identify each and every type of biophilic architecture as it is only divided into three parts. However, these three parts can be further researched with more specification to find out if we can determine an image for each type of biophilic architecture. In the long term, it might be more confusing than now as we will need to know each type's specification to identify a building which goes against this method of identification which simplifies the attributes and experiences. In today's age, to understand and identify biophilic architecture the simplest method is needed and the classification here is presented for this purpose.

9.2 VIABILITY OF THE PROPOSALS

The proposals are actually only examples here and can be transformed into any other variation. They are here as study cases to provide guidelines on the precautions we should take when incorporating biophilic attributes. The concepts of buildings are such now that we can't be allowed to have too much deviation from the original budget but with some reasoning and explanation of the benefits that biophilia can bring, we can actually be allowed to have a little more freedom.

In Mauritius, being islanders, we have an affinity with gardens which is part of our culture as most of the colonial architectures had big gardens as entrances. However, we did not exceed the spatial attribution that we have for the garden. We did not try to incorporate nature further inside our buildings as we saw it as impractical and as we were in the industrial age, we tried to construct functional spaces. Nowadays, it is starting to become more popular to have plants inside our homes as we not only imported a lot of new varieties of plants but also improved our technology and techniques of construction.

The proposals will help the architects or even the person trying to increase the affinity of their houses with nature. In terms of relevance, it will still be applicable in the future as the proposals are more oriented towards the advice for the conception of a biophilic space. Even though the technology will change, the way we integrate nature will depend on the same variables that were mentioned throughout the thesis. The only way that the advice becomes obsolete is through a breakthrough in the way we can grow plants which might not come before several decades.

9.3 PROSPECTIVE STUDY

To further my research on the theme, I would need to study unreal engine 5 and lumen for the analysis as well as the conception as it offers a great view on the start of the project. However, knowing that unreal's library is limited in terms of foliage and specific type of trees, I would need to create a library of plants in the system using nanite or other 3d software. It should correspond to the quality of a realistic 3d world which may result in very large files for only one plant. That is where nanite comes in as it can render an image of millions of triangles in real time which reduce the amount of time spent on renders.

On the other hand, the theoretical part of biophilic architecture and its conception can still be further developed as the conception with other means have not been discussed. It is also a matter of culture as I know for a fact that Mauritians give a great importance to their garden but will it stay the same in future years. Even the government is prioritising the development of new infrastructures rather than improving existing ones which leads to the use of more land and the deforestation of them. If we continue on this path, I am afraid that we would have the same problem as in Port Louis with the increase in temperature.

It is also a pity that I did not focus on the proposal on concepts but instead on the way to include nature in the concepts as it stays a bit vague. Some more concrete examples of concepts should have been used and in this case some examples from architects around the world. Even their point of view on the matter and their personal tips could have been collected to create an even better guidebook. This would of course require the cooperation of many or research on the concepts drawing of a more diverse range of buildings rather than the limited 3 in the case studies.

Another untapped area is the study of already existing biophilic architecture in tropical regions or specifically in Mauritius. It might not be recognised as mentioned before but it is present and is being used in many forms. We can also interview local architects to find their take on the subject as some of them have been promoting it in the last few months. It might also offer us new proposals that we have not seen before but which works well with the traditions and culture there.

To be fair, I don't know what we could see tomorrow and dreaming of a world that is covered in green like vincent callebaut is without a doubt madness. But we are starting to develop the technology required to create a beautiful merge of architecture with nature. Making the image more realistic than they used to be. I would prefer to believe in a utopia with nature than in one where we completely separate it from the place we stay, making it even more functional than it is right now in certain downtowns. The future of developing countries can be shaped in that motion if we are able to advertise about biophilia.

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“Every time, I see what I am creating as more than just a complex of buildings, instead I am building a world. By saying the term ‘world’, I have expanded the scope of activities defined by ‘architecture’. Indeed, the activities are what we should really be building. The activities are about the organization of each site. It’s not just that the house and its surroundings that belong to architecture, we should include the range of activities happening in this space, from the boundary, to the enclosed volume, from inside to outside.”

‘Imagining the House’ (Shu Wang 2012)

