# COLLEGE MASTER PLAN

BRIEF DESCRIPTION

Design a complete master plan college campus being self – sustaining in terms of energy resources

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# 1. INTRODUCTION

Ilanthalir as a charitable organization is committed to the cause of the less privileged children, in the region of central Tamil Nadu and works for the social, physical and spiritual welfare of them.

This NGO has a children's home (Ilanthalir Illam) located in Vaiyampatti in where 2 sisters take care of 47 girls aged between 8 and 16 years old. Just a few of them are completely orphans but most of them have a family's economic situation that cannot allow them to support the children and therefore they are forced to transfer them to Ilanthalir Illam. In this place, the organization can provide them accommodation, food and also their school fees and the uniforms they need.

The access to a college is limited by the number of places available. In India, many of the universities favour access to students who have completed primary and secondary education in their partner schools. For the remaining places, the access criterion is based on the note taken in the government exam.

That means that the students of the humblest or less favoured schools have greater difficulty in continuing their higher education. In order to provide opportunities for this type of student, Ilanthalir proposes to build a university in which they have preference.

The project consists of helping the NGO Ilanthalir making a master plan of the further university. A master plan that includes the investigation of the adequate self-sustainable resources to be implemented in the university. That study has the purpose of saving money to the NGO and minimizing environmental pollution in the world.

# 2. OBJECTIVES

- Study the terrain and the environment to determine the best constructive solution
- Adequately dimension the different constructions required in order to optimize the spaces
- Propose a location of the buildings that suits the needs of the university
- Study the possibility of using renewable energies as an energy resource to meet the needs of the university
- Analyse the viability of the different alternatives.
- Based on the legislation in the area, make a feasible proposal correctly sized, with the possibility of growth in the future.

# 3. STATE OF THE ART

## 3.1. NGO's description

Ilanthalir is a charitable trust for the education and welfare of the disadvantaged children irrespective of creed-caste-gender or any other discrimination. The objectives of the trust are to educate poor and orphan children by providing school fees, books and uniforms.

In their main activities, are included: to provide shelter and food to the orphans, to organize tuition centres in the evening for poor children, to render medical help to children and public, to provide adult education and technical training, to promote social, environmental and economic welfare of all.

Vision:

Their vision is social and economic empowerment of the poor, abandoned and the oppressed Dalits, making equal educational opportunities viable to them. They earnestly hope that zero illiteracy will alleviate the existing social and inequality and bring uniform growth in the Society.

Mission:

Their mission is to give education to children from resource poor and socially discarded families, making available to them, equal educational opportunities and required resources and skills.

### 3.1.1. Historical landmarks

1997 - It was formally started by Rev.Fr.A.Susai Alangaram with 2 other Priests of the Diocese of Tiruchirappalli for helping disadvantaged children in education and other empowerments for their integrated developments. Ilanthalir has long been supported by Famiglie Nuove of the Focolare Movement.

1999 - Ilanthalir was registered under the Indian Trust Act of the Government as an NGO (Non-Governmental Organization)

2000 - Ilanthalir is approved by Government of India under FCRA (Foreign Contribution Regulation Act) and it is also tax exempted under 12AA Act of the Income Tax Department for helping all disadvantaged children without any discrimination.

2001 - Ilanthalir Illam at Karungulam was started to serve the children of poor families and the Orphans and semi orphans in and around Manapparai town at Tiruchirappalli district.

2017 – The Government renewed the FCRA distinction.

### 3.1.2. Beneficiaries

Directly and indirectly, Ilanthalir has helped nearly 8000 children in the past 20 years. Presently, there are 700 children getting educational and other supports. Beneficiaries include:

1. Orphans/semi-orphans: they help primarily the children with single parents or no parents.
2. Poor: Ilanthalir vows to help the children from less privileged families and families below the poverty line struggling for single meal a day
3. Dalits: They have a specific focus to children from these families because of their social situation.
4. Children rendered homeless after the Tsunami in December 2004: when the natural disaster took place, Ilanthalir was an important support for the families.

### 3.1.3. Activities

At Ilanthalir, many activities are developed in order to assist the beneficiaries:

- They identify children, primarily dalits and tribal children and create centres to educate them in their respective locality.
- They supply educational materials like books, notebooks, uniform to children besides paying their school and college fees.
- They provide food and accommodation to the children in their Care Home and provide nourishment to school going children at the different study centres.
- They conduct periodical medical camps in different regions and supply medical aids to needy.
- They arrange Educational Tours to places of historical importance, workship and tourist spots to give the children proper exposure to people and places.
- They organize monthly meetings for children and their parents to review the progress of the children in education and formation.
- They organize Annual gatherings and regional meetings, feasts and festivals etc to socialize and mainstream them in addition to providing them space for harnessing their talents.
- They conduct computer training and awareness programmes for the adults.
- They cultivate in the children and their parents the habit of small savings for higher education
- They create and manage self-help groups for parents for their spiritual and material welfare.

### 3.1.4. Formation programmes

#### Evening Study for Children

The Ilanthalir students in each centre gather in the evening after school for further study and coaching. This programme has three parts:

1. Time for games.
2. Nutritional support
3. Intensive study

This is a routine activity in the centres that goes up to 2 to 3 hours after which they disperse to their respective homes if their centres are not residential ones. There are 58 such centres supported by Ilanthalir.

## English Coaching

Since the children are mostly from rural villages, they lack fluency in English. As a result, they find it difficult to compete with the children from the urban areas who have wide exposure to these extra skills. Regular coaching in the study centres and periodical camps help them to acquire the required knowledge.

## Computer Training

Summer camps organized in the town centres of Manapparai, Dindigul and Trichy reach out to the needy children to have access to computer training and knowledge. Nearly 100 children benefit out of it every year.

## Career Guidance

Career guidance programme for the welfare of the students who complete 10th and 12th is organized every year by Ilanthalir. The two days event focuses on career guidance, leadership training and personality development. A real motivation for life is the purpose of the programme and the results are quite tangible.

## Talent Show

Ilanthalir gives opportunity to children to bring out and develop their hidden talents. The respective caretaker has the responsibility to identify the talents in children and help them to develop. A day in a year is set aside for the children to express their talents in a common platform.

## Exposure Visit

The tour programme organized once in two years to different places of historical and cultural importance gives the children necessary exposure to nature, culture and people giving them abroad vision and learning.

## Seminar for Science

Due commitment to the society at large, Ilanthalir conducts educative programmes for adults. One such programme is a seminar on science, religion and people which used to be conducted occasionally so that people have right understanding of each other and a proper perspective of life. The seminar also provides the platform for an inter-religious experience.

## Medical Camps

Good health is a basic need of people. Since there are no facilities available for basic health needs in rural areas, Ilanthalir as part of its activities organizes medical camps in the respective villages of children to benefit them, their parents and the people of the surroundings. It not only helps their health, but it also brings awareness about certain hygienic practices.

## Conservation of Nature

Ilanthalir is very much conscious about the preservation of nature and the natural resources and has the impetus to pass the same to the children. Work camps are organized at the different centres of Ilanthalir to inculcate in the young minds how important is the preservation of nature and its resources like trees, clean water and clean air. They are made aware of their duty to maintain a clean environment and plant more trees so that the gift of nature that we enjoy today is passed with no blemish on to the next generation.

## Youth Groups

Youth groups are formed in order to provide right motivation and orientation to the youth. They are taught social responsibility and are instilled with a sense of social concern and commitment. Their engagement in social work and related activities trains them in social responsibility.

## Mother Groups

The parents Association of Ilanthalir is in existence for the last many years for the purpose of the social, economic and spiritual welfare of the parents, specially the mothers of children supported by Ilanthalir. They are encouraged to do some savings every month. Educational and other loans are disbursed to them in times of need. The parent's groups used to meet once a month to express their solidarity and support to one another in their path towards progress.

## Celebration & Festival Days

Celebrations are part of their life. Deepavali, Pongal and Christmas are some of the festivals where children are encouraged to involve and participate so that they learn social amity and amicability.

## Annual Get - Together for Children

Coming together is always a pleasant experience. All children and parents in Ilanthalir have their family get-together once in a year. Mutual interaction, sharing, fun games and cultural events would make the day memorable to all.

### 3.1.5. Financial aid provided

- Payment of school fees/colleges fees: Ilanthalir takes care the complete education of the sponsored children by paying them their school/ college fees and all related expenses.
- Uniform and dresses: Uniform and Dress materials are provided to children in the beginning of their academic year and also during the festivals like Christmas and Pongal.
- Tuition and coaching: Tutors are appointed in the respective villages where the children are from to give them the necessary coaching and training in their academic activities.
- Food and nourishment: Nutritious food and nourishment are given to the children in their respective centres and homes that they may maintain good physic.

## 3.2. Requirements

The further college is planned to be constructed between Manikandam and Nagamangalam's towns, in Tiruchirappalli district, Tamil Nadu as shown in the image below.

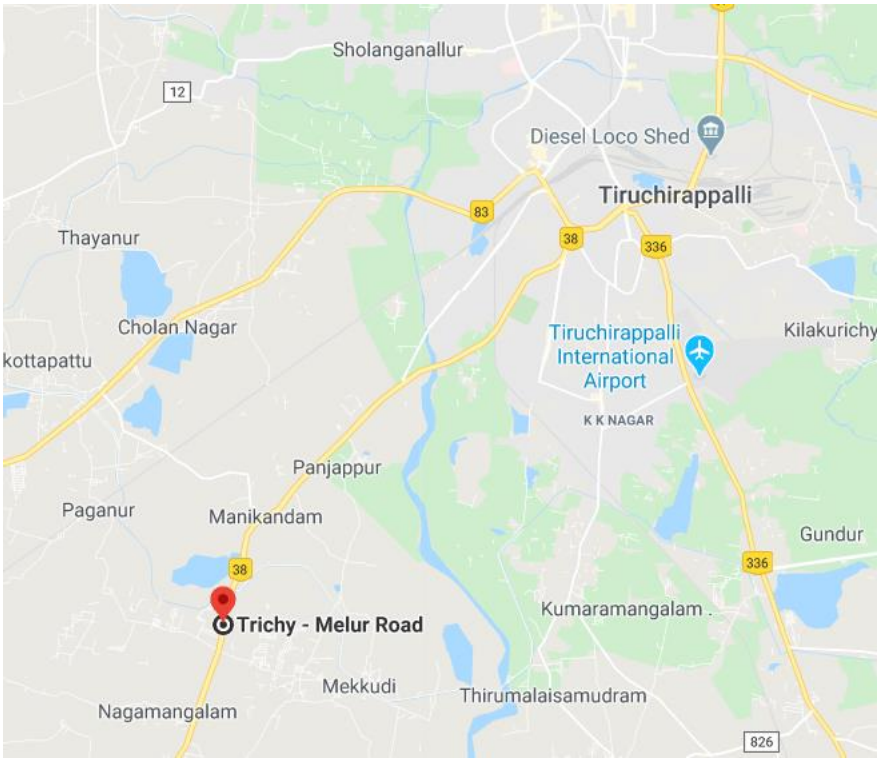



*Figure 1. Project's district*

This land is 10 acres in size, and these are its dimensions:

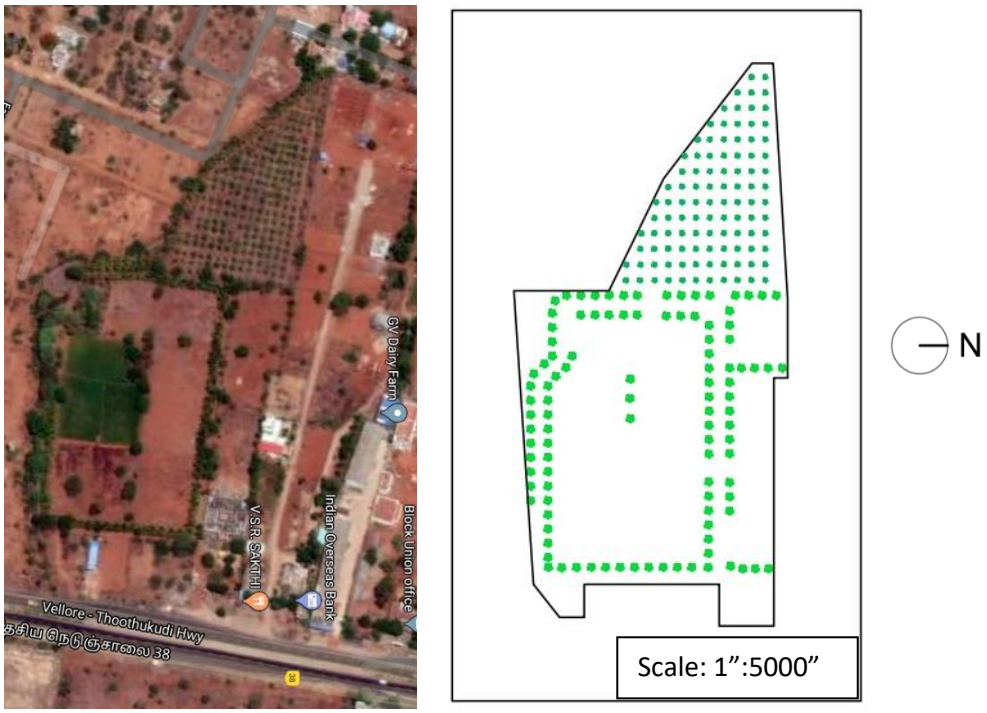



*Figure 2. Terrain and shape*

This university is expected to manage 1500 students. They are going to offer 6 months of preparation prior to university studies, 3 years of degree and another 6 months of skills development before giving way to the working world.

To achieve this objective, the elements detailed below are needed:

Academic buildings:

- Considering 40 people per classroom, the campus will have 30 classrooms
- 2 laboratories are considered enough for research purpose. They would be equipped with all the necessary material so that students can take practical classes.
- Staff rooms in where the teachers can have a coworking space. Given the number of teachers planned, it is considered that 2 rooms are enough to perform their tasks.
- Library in which they can have a place to study and to find the information they need to complete their knowledge.

Sports

- The students will have a large **playground area** where they can do different sports and activities. Besides, a **basketball court** will be provided.

Feeding

- **Canteen** to offer meals to students. For that purpose, it might be necessary a kitchen and a storeroom to keep the food in good condition.
- Due to there are people who bring food from home, there will be enough **space to accommodate** as many students as possible.

Residence

- It will be offered a **two hundred students' residence** for those who can afford it. Boys and girls will have separately buildings (100 people in each).
- A kitchen, dining room and siting room will be provided in this residence.

Church

- Since the NGO is Catholic, a **church** will be found in the poplars of the university.

It should be commented that in all the spaces mentioned above, **toilets** will be found.

# 4. SITE ANALYSIS

The following is an analysis of the site that allows us to specify the geographical, climatic, architectural and structural characteristics of the project being presented.

The aim of the Figure 3 is to situate the project in the world. As mentioned above, Ilanthalir as a charitable organization is committed to the cause of the less privileged children, in the region of central Tamil Nadu and works for the social, physical and spiritual welfare of them.

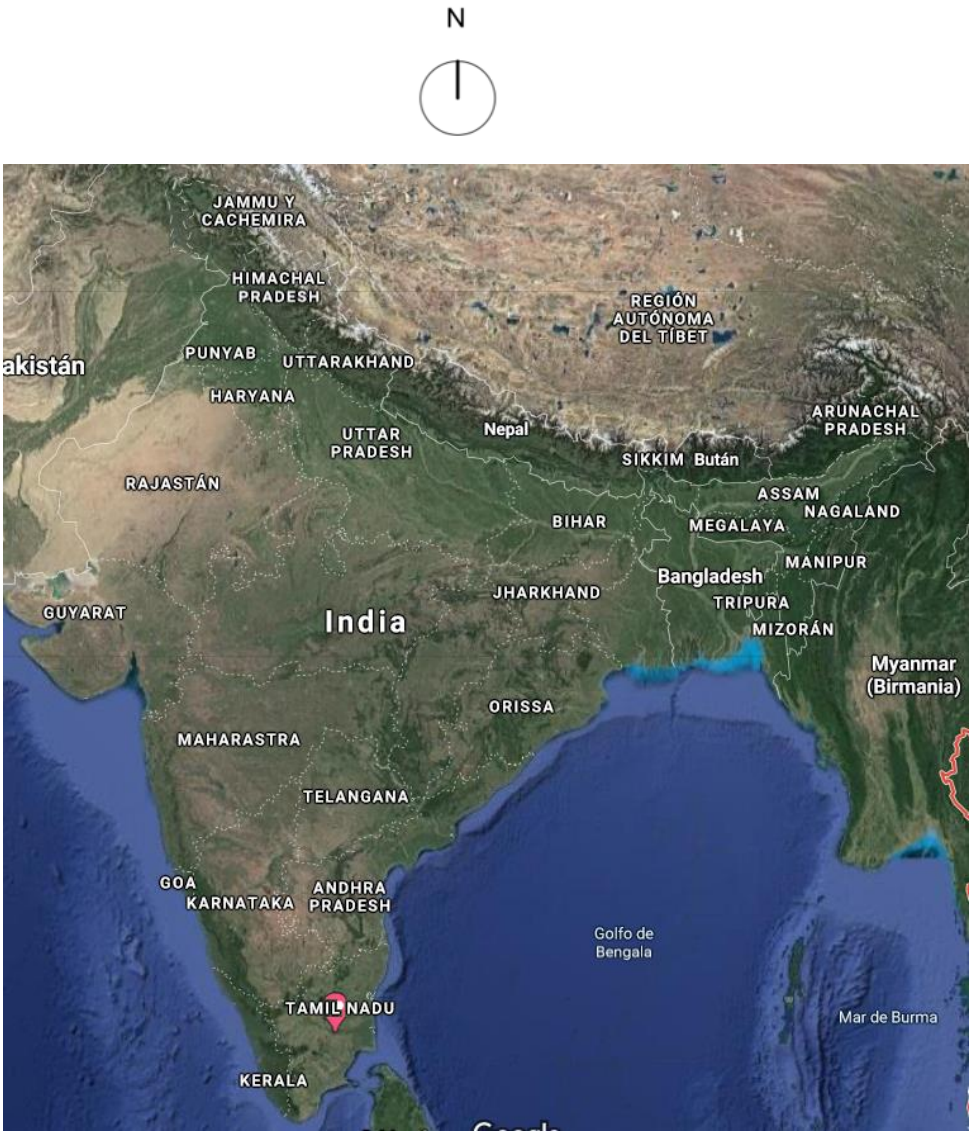



*Figure 3. Project location in India*

If we approach the specific geographical area, it is possible to see in Figure 4 that the project (point red in colour) is located south of Tiruchirappalli. The nearest hospital is “Velan Speciality Hospitals” (point green in colour), it is 12km far from the project. The nearest airport is the Tiruchirappalli Airport (point blue in colour), 15km far from the project. In the same figure it is possible to see in different colours the roads surrounding the university grounds:

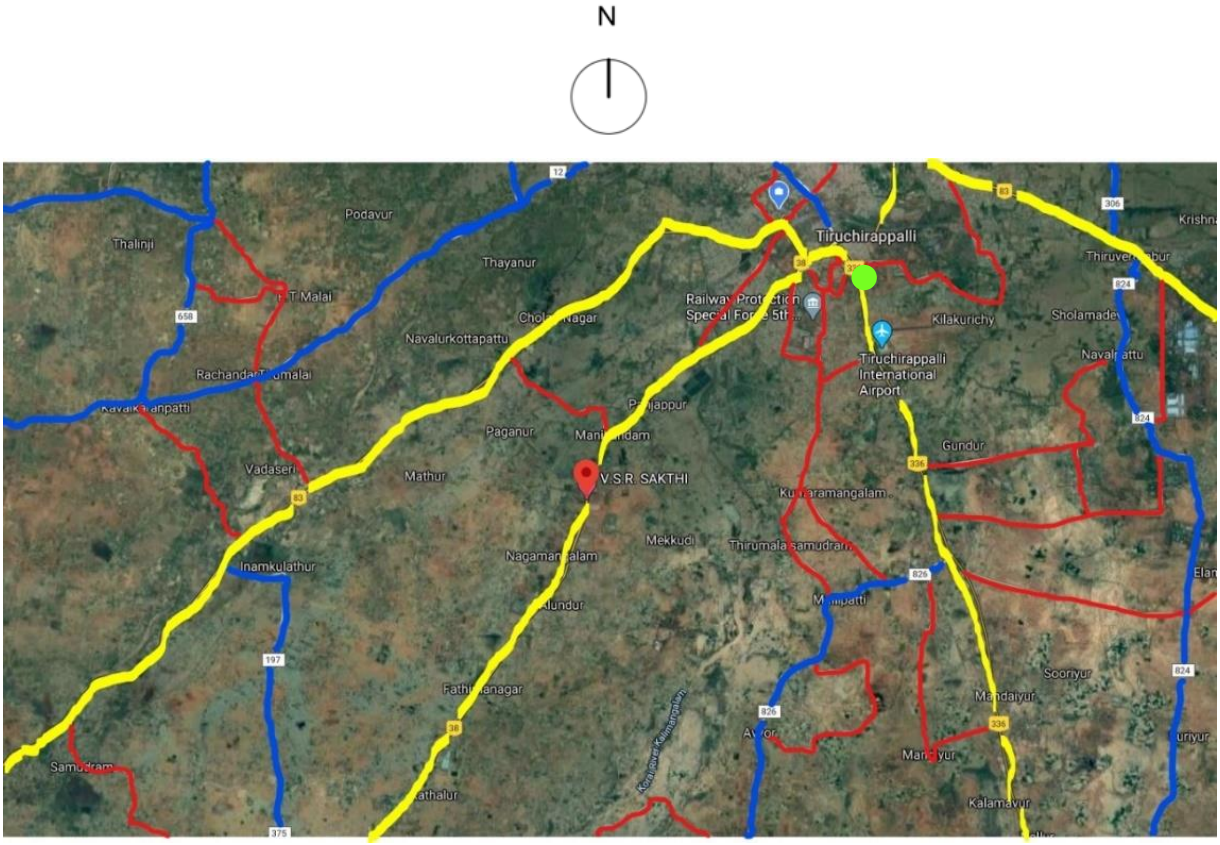



*Figure 4. Detail of the roads surrounding the university grounds*

The tertiary roads are red in colour, this type of road is not usually asphalted and is usually about 5 metres wide. Secondary roads are blue, but these are usually paved and have one lane in each direction. Finally, yellow roads represent the largest urban roads where there are at least two lanes per direction, and high speeds are allowed. As can be seen in the photograph, very close to the university is the 38th highway. This highway is the one that connects the city of Tiruchirappalli with Madurai city. The yellow 83rd motorway at the top right of the image is the one that leads to Thanjavur.

As for the topography of the area, it is important to know what is built and what is not. In the image below (Figure 5), the different topographical characteristics of the area surrounding the project site are marked with colours, whether they are buildings, forests (green in colour) or fields.

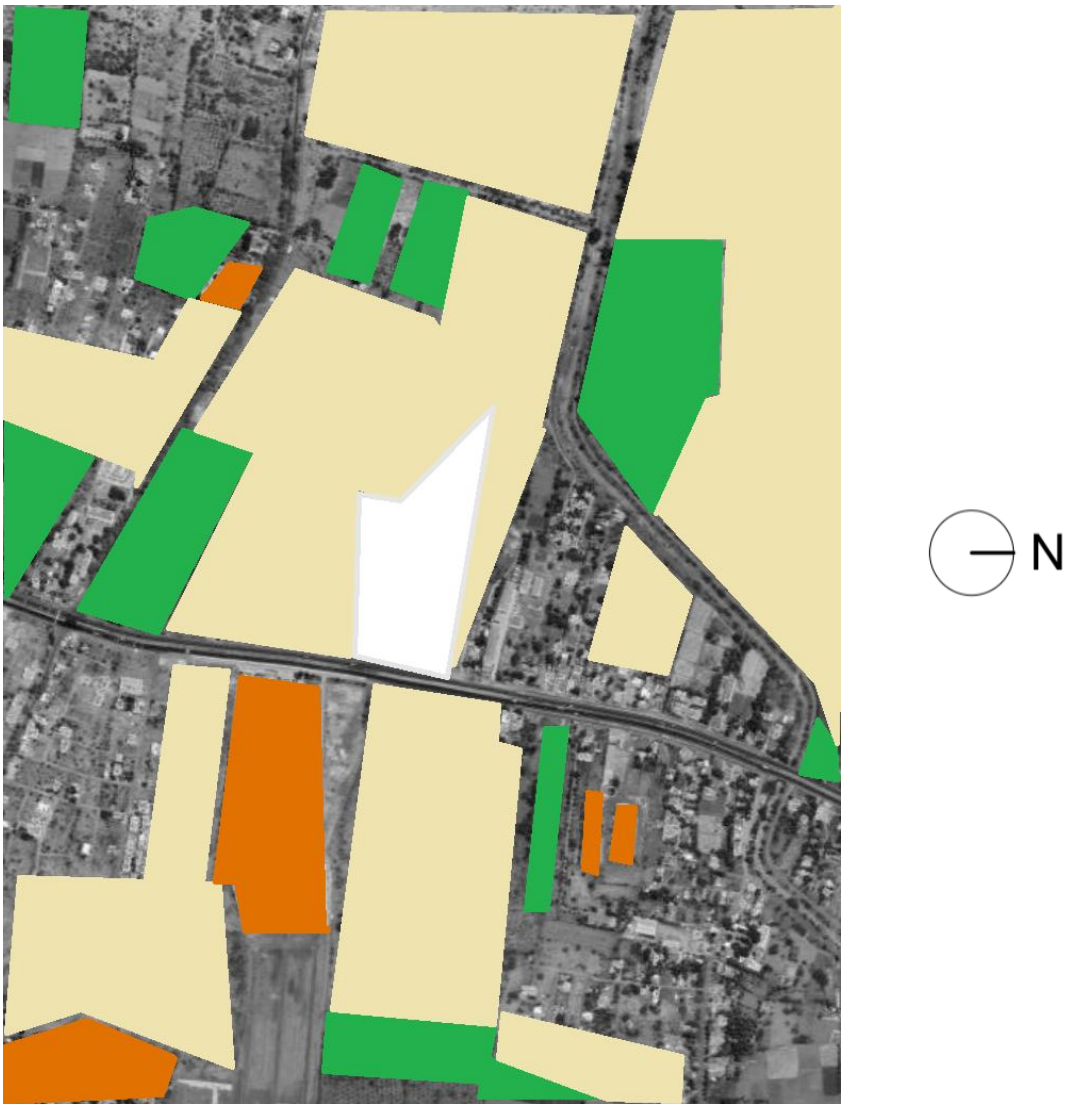



*Figure 5. Detail of the topographic characteristics of the area*

As it can be seen, the field (yellow in colour) predominates in the surroundings since it is a rural area. On the other hand, (orange in colour) there are some buildings in the surroundings. This indicates that the construction project to be carried out fits in with the surroundings. In addition, within the land of the project not only constructions will be made but mainly it will denominate the green of the gardens, palms and trees. In this case, a harmony of the project site with the environment will be appreciated.

The accessibility to the area is quite good. On the one hand, whether you want to enter the grounds by car from Tiruchirappalli (north) or Madurai (south), the entrance is the same for both. Even if you are coming from the north, you will have to drive one kilometre south to cross over to the other side of the highway and enter the field in the opposite direction from where you originally came. The Figure below (Figure 6) shows the route the vehicle must take to enter the university (regardless of the side of the road it comes from).

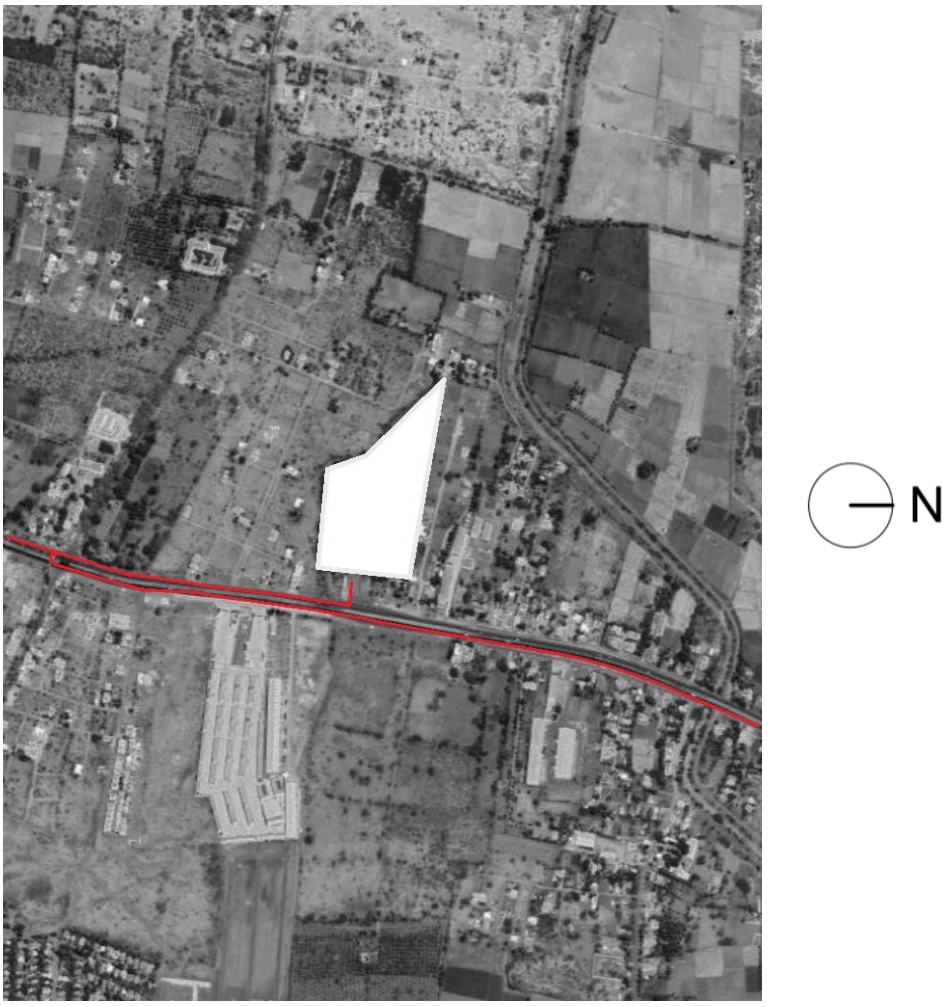



*Figure 6. Tour to enter the university*

On the other hand, you can also get there by public service (bus). In this case, the bus will not turn around if it comes from the north. The bus will stop where it is told to, but always in its own lane, and everyone is responsible for crossing the highway to their destination. If you are arriving from the south (Madurai), the bus will stop on the correct side of the highway, ergo when you get off the bus you will be at your destination. It is important to mention that you should take a bus that is not "one to one" i.e. one that allows you to stop halfway.

To conclude the topographic study, the hydrology that characterizes the area is shown (Figure 7). In this case, the Mayanur Barrage River passes close to the land. Currently, depending on the season, it is barely flowing and is therefore considered a channel.

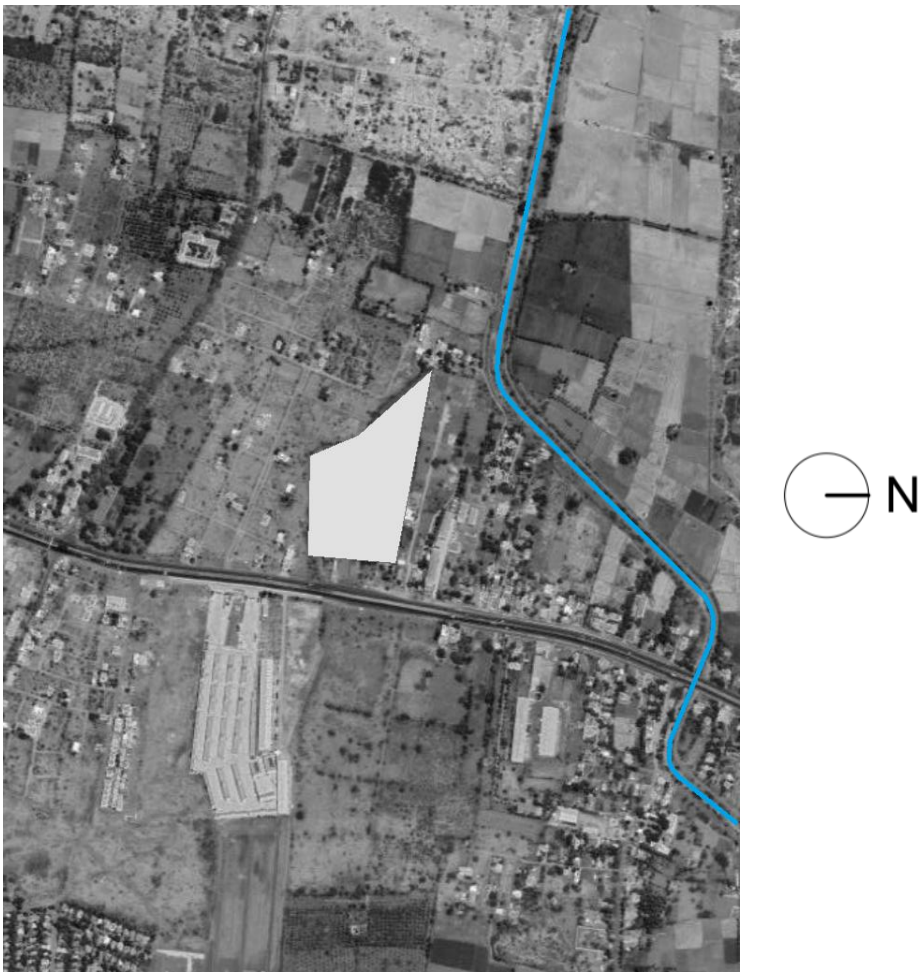
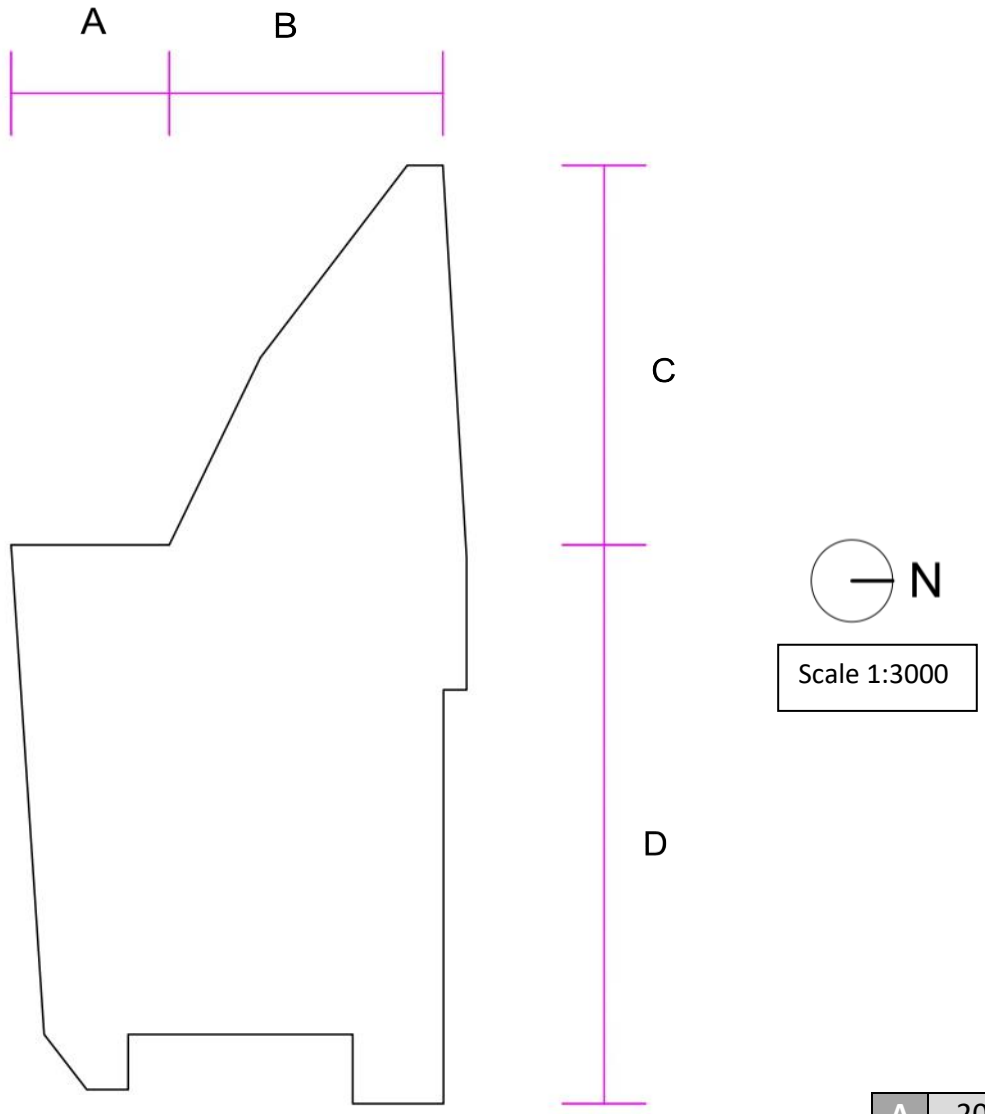



*Figure 7. Hydrology of the area*

## 4.1. Characteristics of the land to be built on

The shape of the terrain, as seen in previous images, has the form shown in the Figure 2. Shape in which later it will be explained how to make the most of this surface. The surface of the land is 10 acres, which is equivalent to 480914,8 square feet. On the other hand, the perimeter is 4407.6 feet.

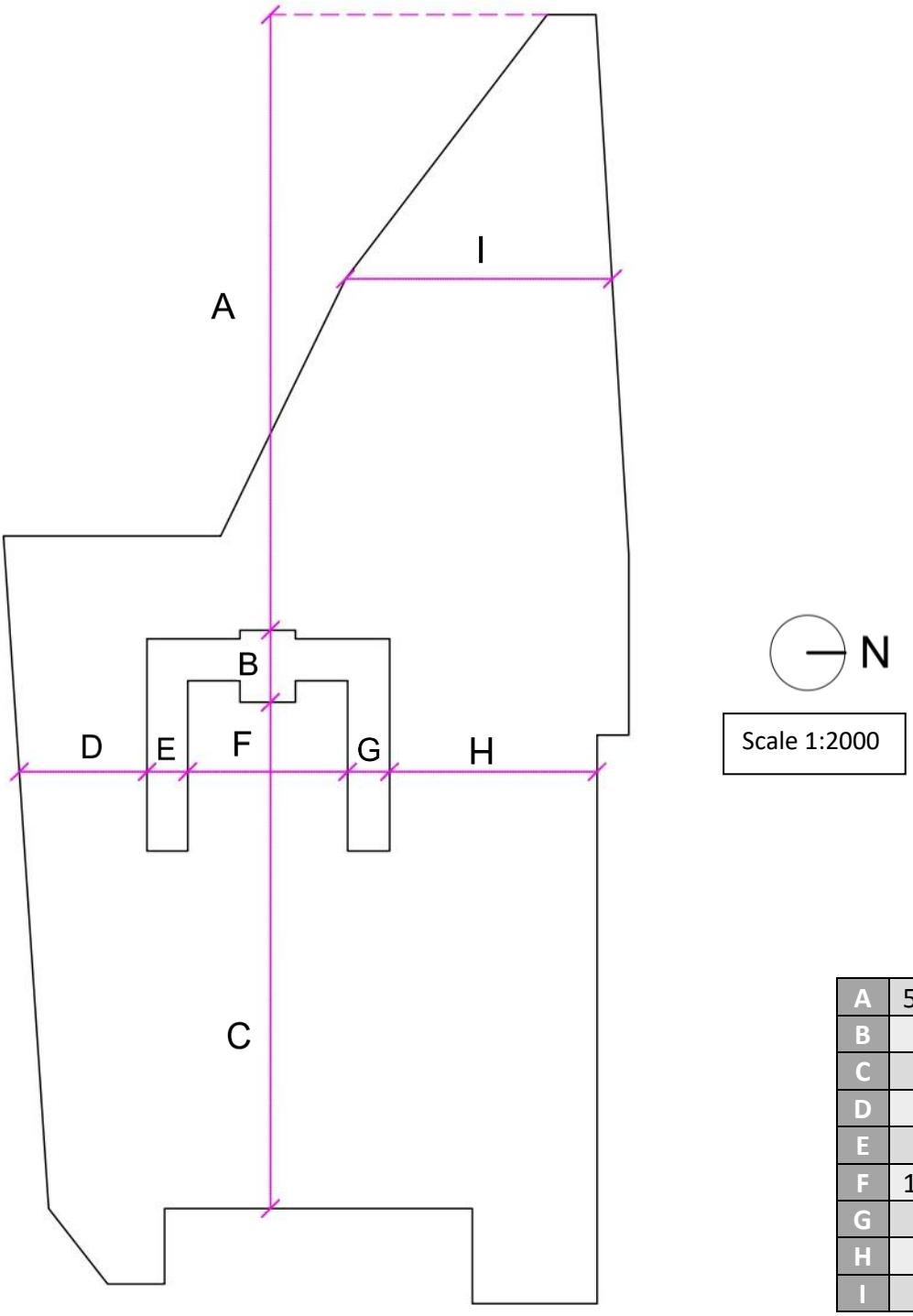
Once the surface and shape of the terrain are known, the measurements are shown in the same Figure 8.




| | |
|---|---|
| A | 206 ft |
| B | 355 ft |
| C | 493 ft |
| D | 726 ft |

*Figure 8. Terrain shape.*

The image below (Figure 9) is intended to give an idea of the relationship of the main building of the university with the rest of the land. The measurements are shown in the same Figure 9.




| | |
|---|---|
| A | 582.5 ft |
| B | 68 ft |
| C | 479 ft |
| D | 121 ft |
| E | 39 ft |
| F | 151.5 ft |
| G | 39 ft |
| H | 196 ft |
| I | 253 ft |

*Figure 9. Measurements of the terrain in reference to the main building*

In order to justify the location of the main building, the following image (Figure 10) shows the acoustic impact that exists on all the land boundaries.

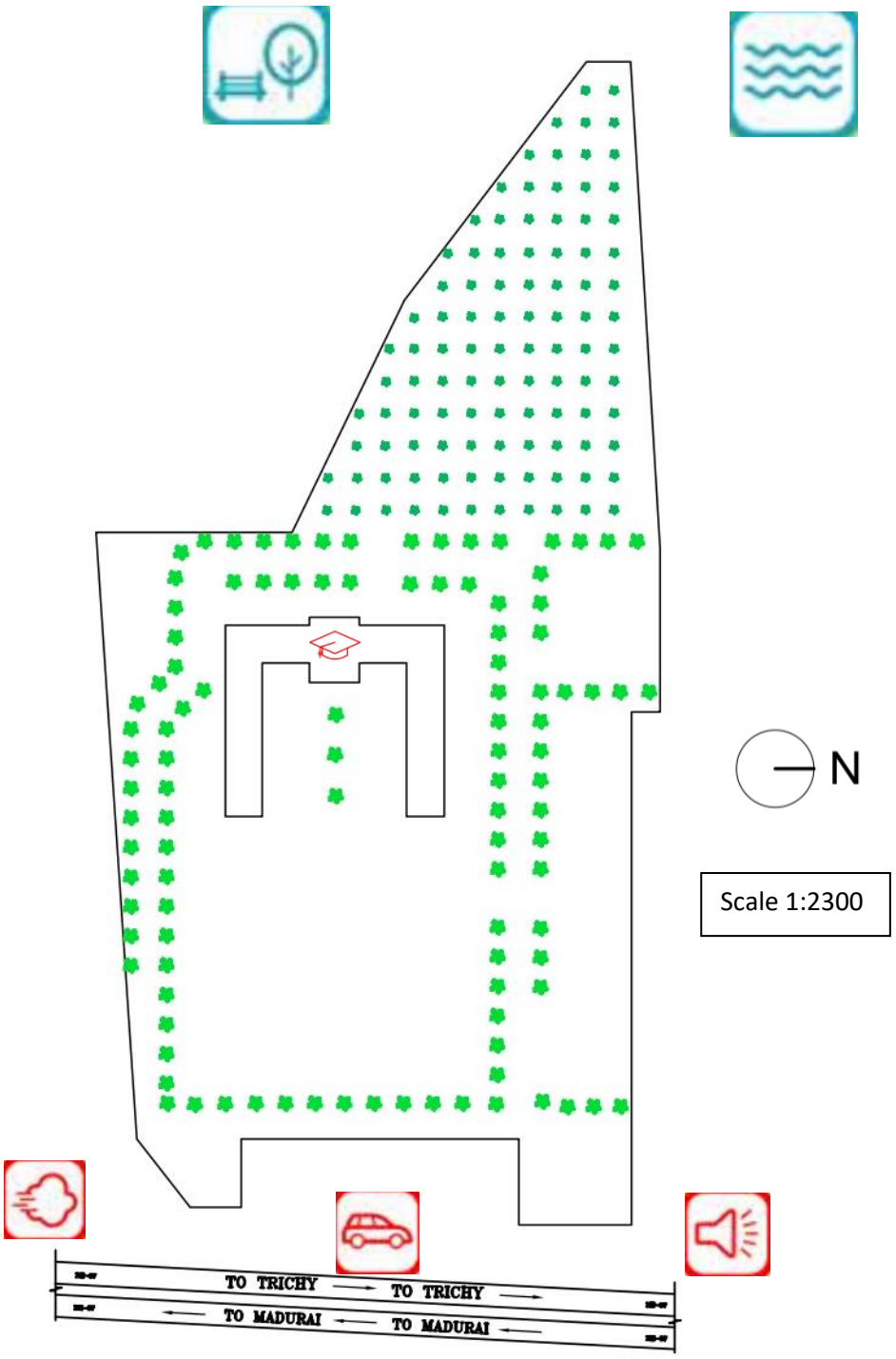



*Figure 10. Acoustic impact received by the terrain*

The main building is where the classrooms, laboratories and professors' rooms are located. In which, the acoustic well-being is of great importance. In order to avoid distracting students from the acoustic discomfort caused by the sound of cars and horns on the motorway, it has been decided to locate the main building as far away from the motorway as possible (as it can be shown in the Figure 10). Consequently, the sound perceived on the opposite side of the motorway is of field, fauna, wind, and river water. This type of sound does not interfere with the well-being of the students, teachers, and other workers in the complex.

For all the rest of the buildings that require the campus, the Figure 11 shows where they are located.

As shown in the image, the different colours indicate the purpose of each building. As mentioned above, the main building (in red) is the most important as it is where the classes are. For that reason, everything revolves around this building. Toilets are available nearby. The canteens (the vegetarian and non-vegetarian) are on the left side of the building. Besides an open table area.

It is possible to see that there is a large playground area next to a basketball court, with some toilet nearby. Apart from this, on the right side it can be seen that it is situated in this order, the administration building, the library in which there is also a computer room, some toilets and a hall for different types of purposes.

On the other hand, the residences are separated from each other, the right one being for girls, the left one for boys, and the one near the entrance for staff. Finally, the church is a bit apart from the playground area so that if someone wants to go and pray, they can do so without sound distractions.

It needs to be said that the Administration office building is already built. In this building, besides the offices, it is possible to find an ATM, an infirmary, a xerox shop and stationery stores.

The parking is located next to the entrance.

It can be seen a borehole that it is also already built.

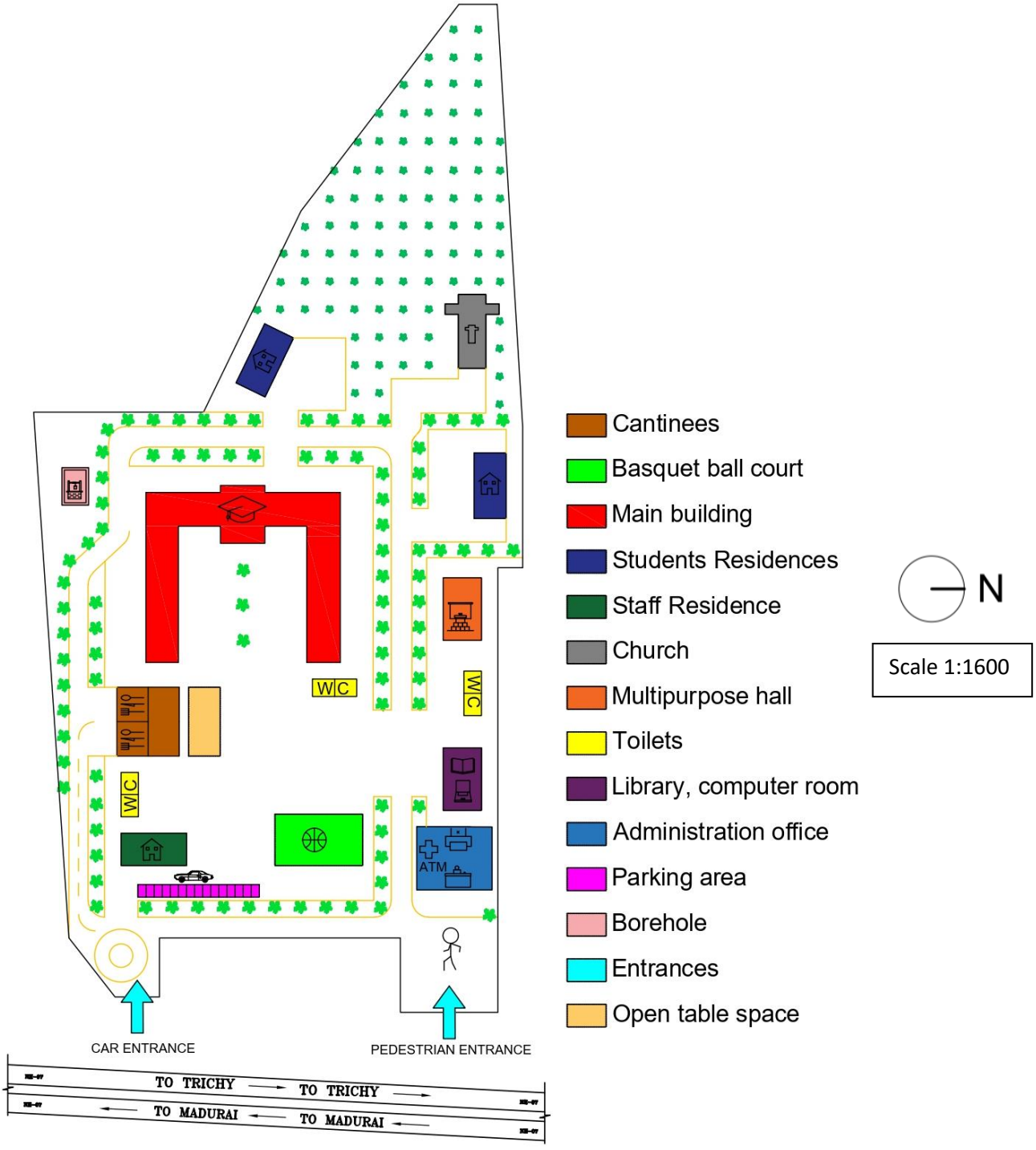



*Figure 11. Layout of campus buildings*

In the Figure 12, the blue lines are 20 feet long (6m). Just to demonstrate that all the buildings (unless administration one because it is already built, pink lines) have a proper movement and setbacks with minimum of 20 feet (6m) all around.

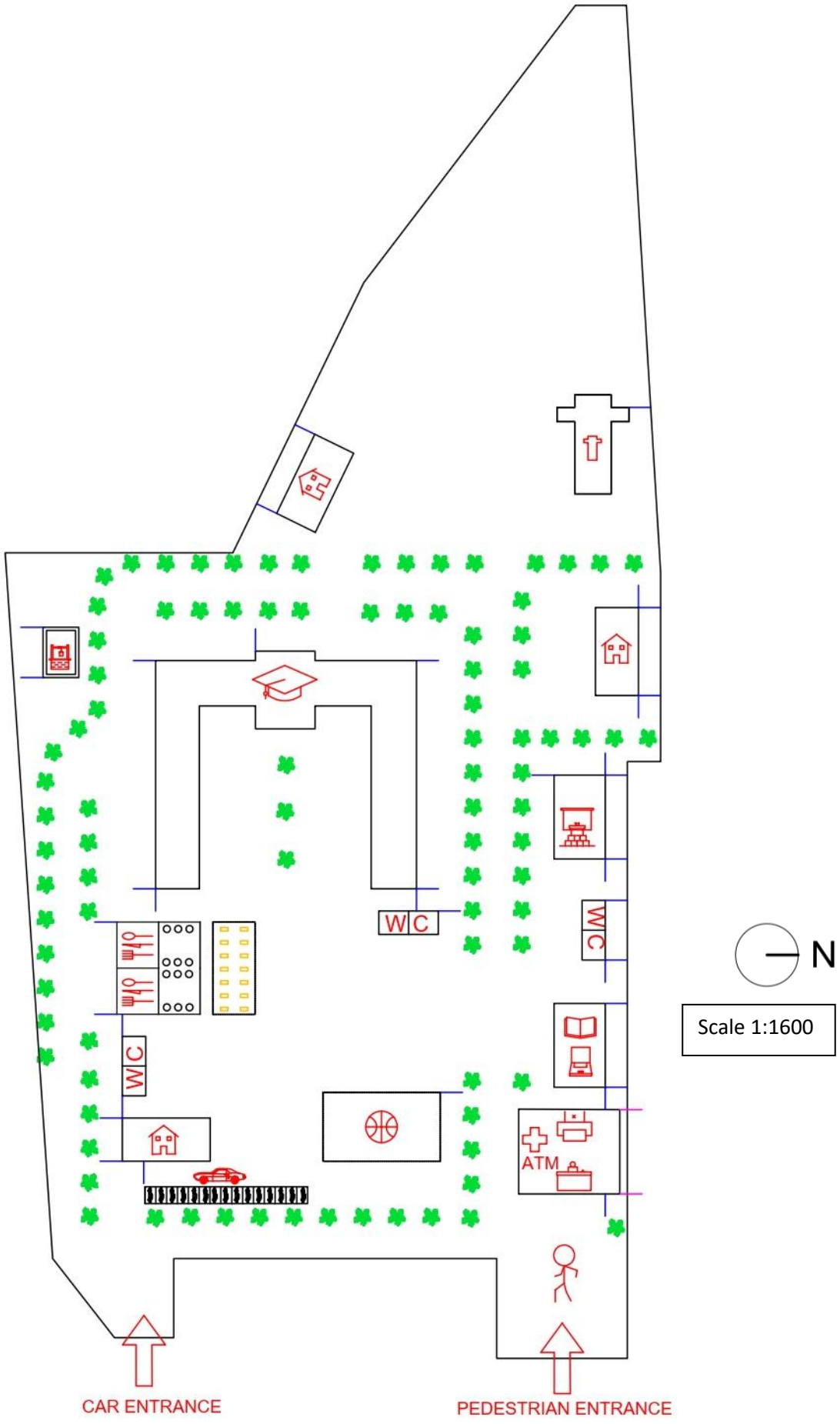



*Figure 12. Proper 20 feet (6m) movement and setbacks of each building*

Figure 13 shows the measurements of each building

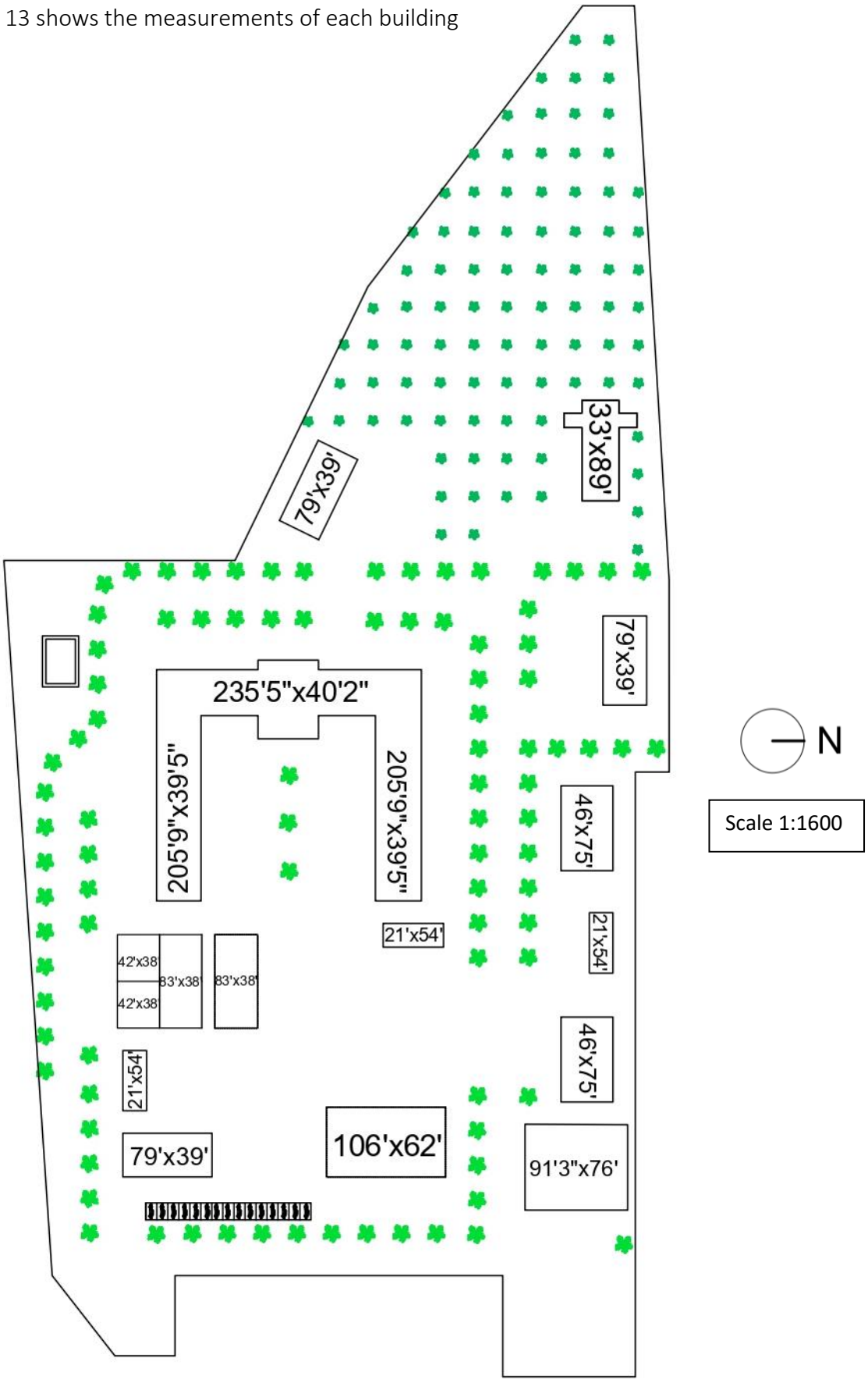



*Figure 13. Building measurements*

Once the campus buildings are known, the Figure 14 shows the different heights of each building. As it can be seen, the buildings in red are the main building (where the classes are) and the student's residential buildings. These are the ones with more height since they have 3 floors each.

Next, the dark orange buildings are those that have 2 floors, such as the staff residence, the multipurpose hall, the library along with the computer room and the administration building. The church is also that same height but, as usual, it only has one very high floor. Also, in light orange, the two restaurants have only one floor, but are considerably high.

Finally, the yellow buildings are the single-story toilets that do not require much height. It should also be noted that the blue boxes are areas that are not covered, that is, they are outdoor table area near the restaurants, basketball court that is also outdoor, parking area near the entrance and the borehole on the left. Each building is explained in more detail below.

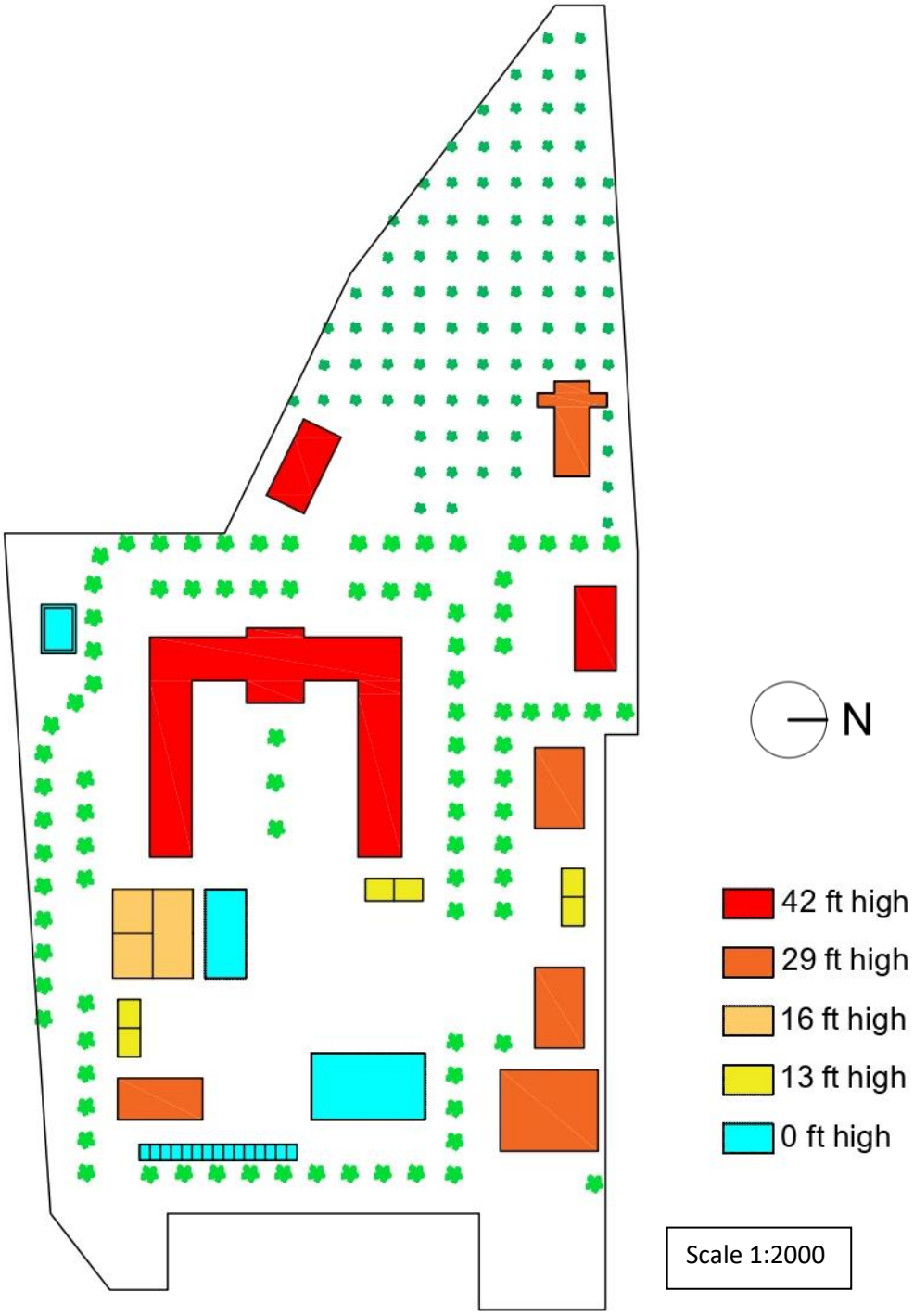



*Figure 14. Heights of the buildings at the campus*

The following Figure 15 shows the pedestrian paths that should be used within the campus. These paths are not compulsory, that is, everyone can walk anywhere, but there must always be a path to walk on. All those areas that are neither buildings nor paths will be areas of beautiful green gardens (Figure 17), which can be walked on, but preferably the paths will be used for travel. In addition, these paths should be made as they facilitate the movement of disabled people.

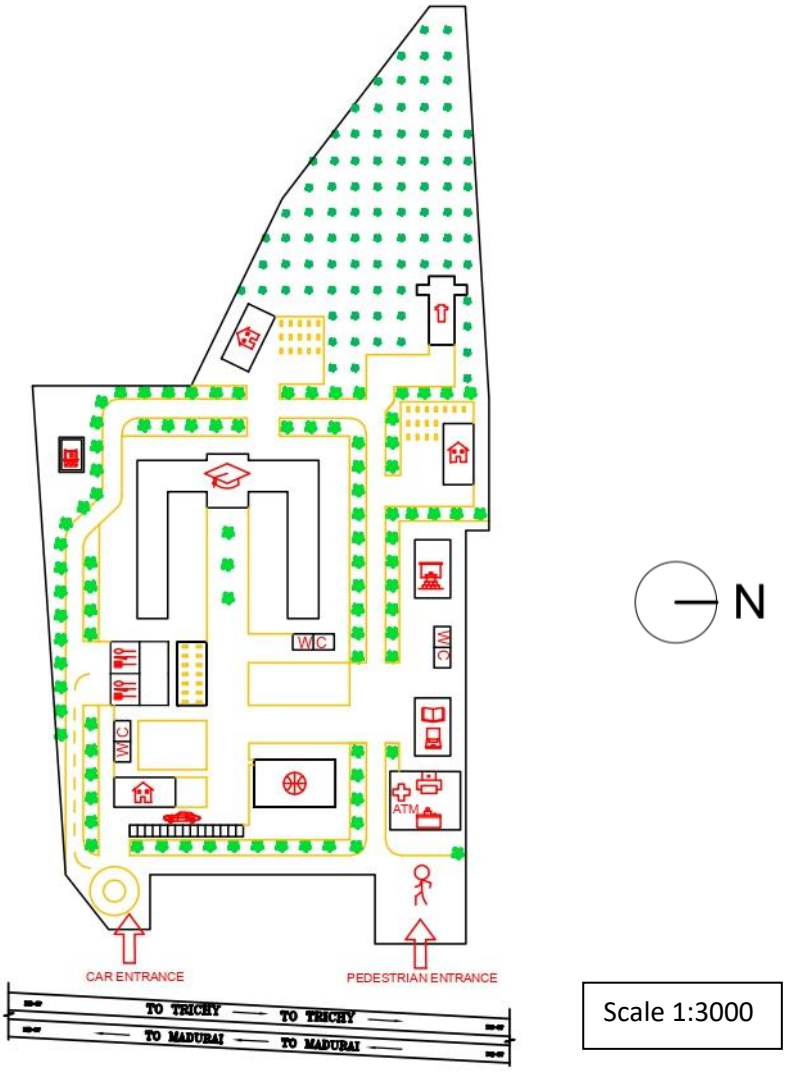



*Figure 15. Pedestrian paths within the campus*

As an example, the Figure 16 contains different types of paths that may be presented in the future campus. They are just different ideas, but it is not up to me to decide which type of path would be ideal. I would choose paths with a gravel surface surrounded by green gardens. In my opinion, these types of roads and surroundings create a natural and pleasant landscape.

*Figure 16. Types of paths*

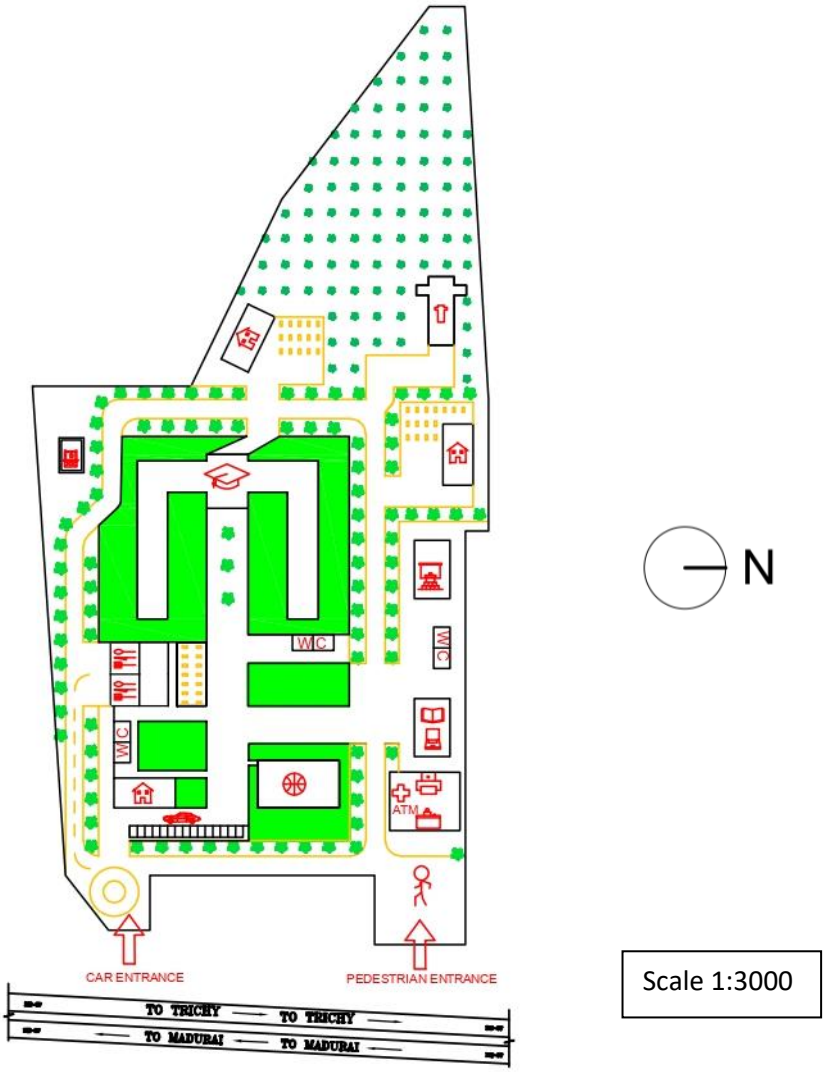



*Figure 17. Gardens*

Below (Figure 18) is represented the movement of the sun with respect to the campus, which goes from east to west. Previously it has been commented that the decision of where to locate the main building (the one with the classes) was very thoughtful. It has been commented that one of the reasons was the annoying sound of the cars and trucks on the nearby highway (especially because of the amount of horns). But in addition to that reason, the sun was another reason why it has been decided to put the main building on that side of the land.

The climate of Tamil Nadu, India is generally tropical and features fairly hot temperatures over the year except during the monsoon seasons. The hot temperatures are especially in the months of April, May and June. Studies have shown that the sun in the afternoon is more damaging to the skin than the sun in the morning. For this reason, the main

building is situated in such a way that it can shade the outdoor playground area in the afternoon.

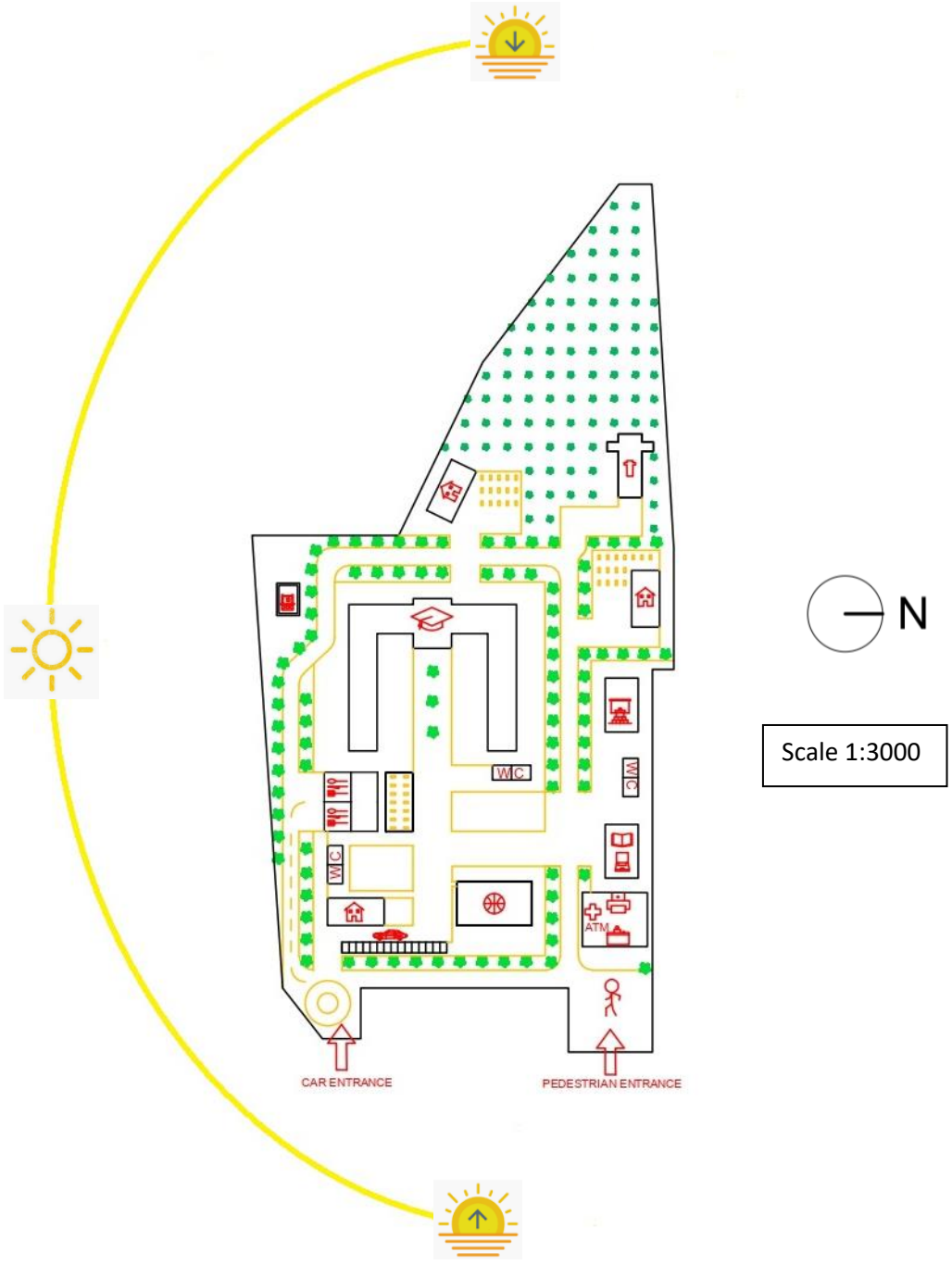



*Figure 18. Path of the sun*

The entrance to the enclosure can be done on foot or by private vehicle. The following image (Figure 19) shows the two main entrances and the access that can be made by each of them.

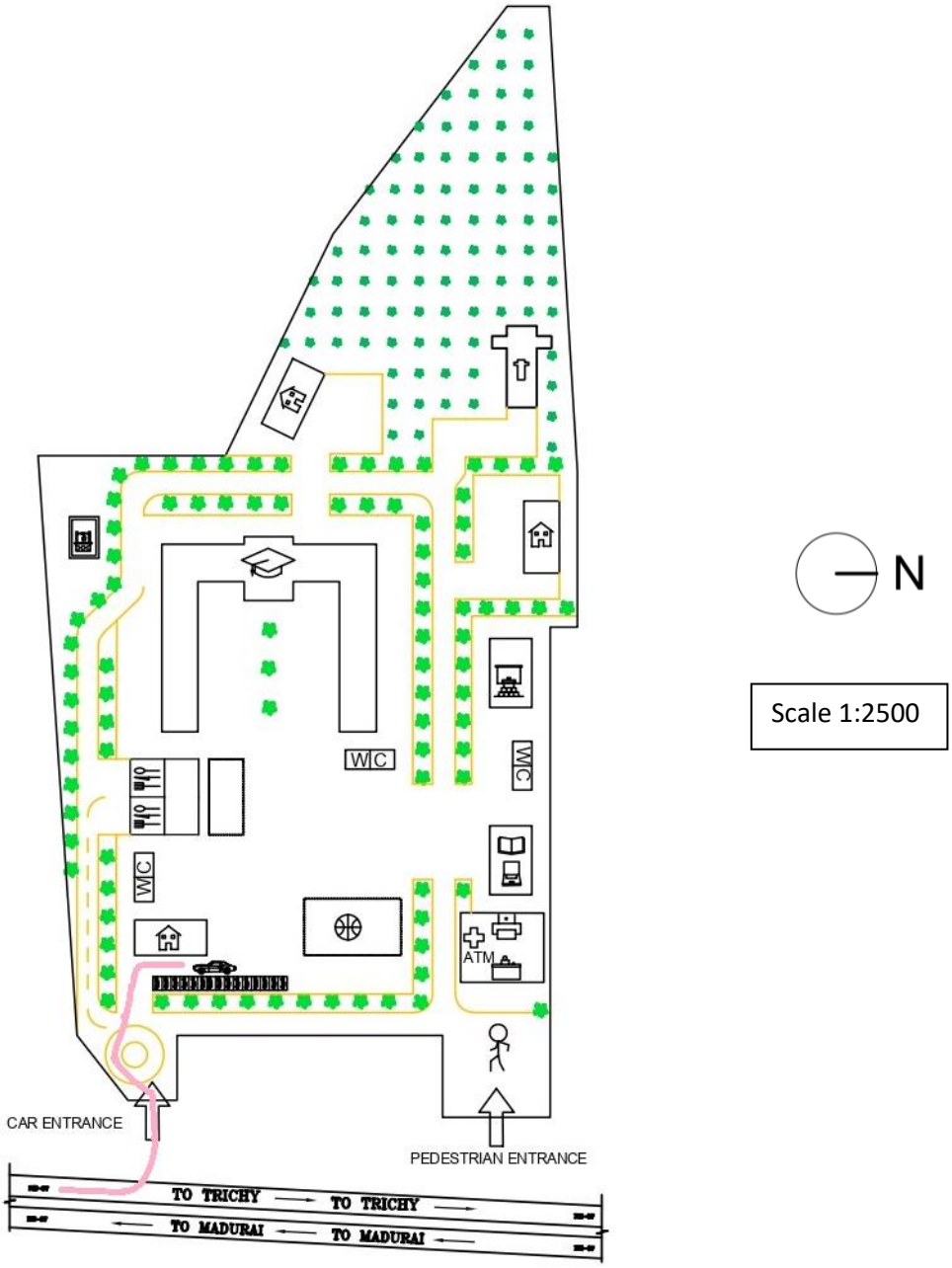



*Figure 19. Accessibility to the venue*

On the left side, the pink line shows the path that must be taken by anyone who has permission to enter the premises with their private vehicle. Generally, they will be teachers and as it is possible to observe, the indicated route is the only space where someone can drive. This route begins at the entrance to the campus and ends at the parking lot located just next to the residence's staff.

On the right side, the entrance is reserved exclusively for pedestrians and, in general, all the campus is a pedestrian area (except the areas indicated for vehicles). This is imposed in order to avoid accidents on campus. No pedestrian route has been indicated because it is possible to reach any point on the campus on foot.

Below is shown the route to be followed by the providers that serve the campus. In the same way that the cars could reach the parking lot, the food supply trucks will also be able to enter the building and reach their final destination, which is the area of the store room of both restaurants before the main building on the left (Figure 20).

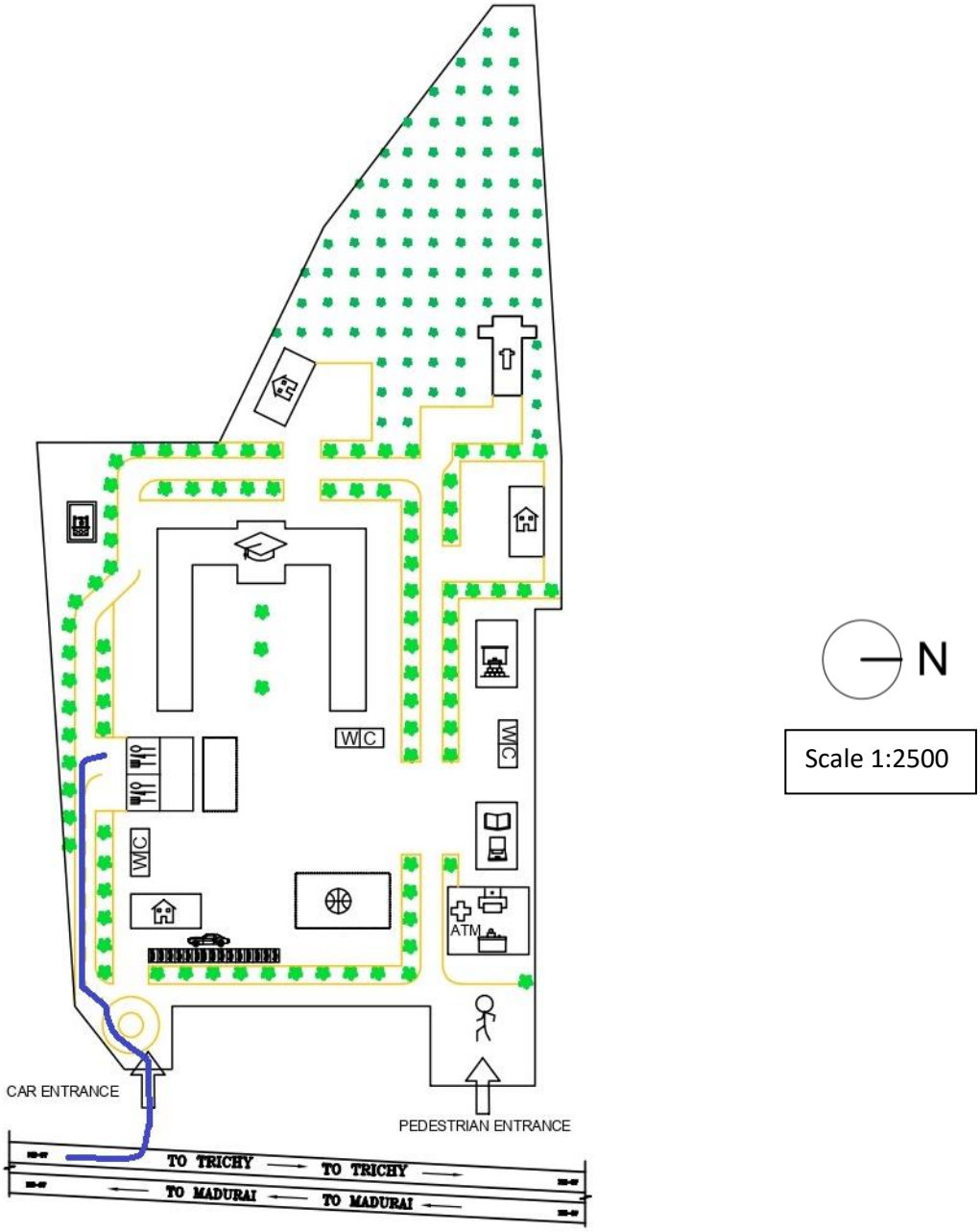



*Figure 20. Tour to be done by trucks*

The route mentioned is the one marked in blue in the Figure 20. The trucks are also prohibited from driving on any other route than the route marked in blue. It is repeated that this is imposed in order to avoid accidents on campus.

In the Figure 21 is shown in red the route that a fire truck or an ambulance could take. As can be seen, the distribution of the campus has been designed so that there is no area that in case of accident, fire or similar, is not possible to reach the danger zone.

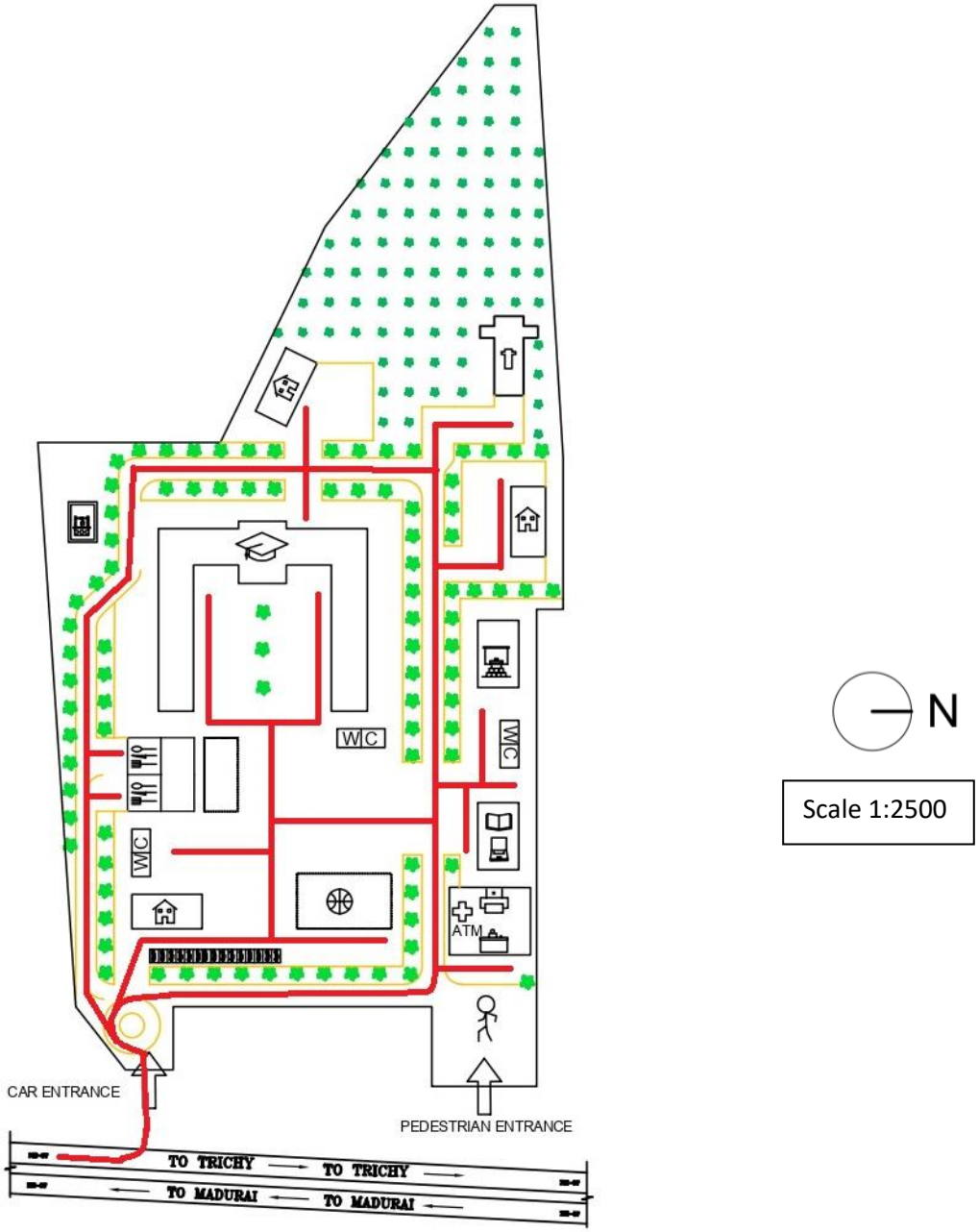



*Figure 21. Access of the emergency services*

Regarding to the security of the enclosure, the Figure 22 shows where the security points within the campus will be located.

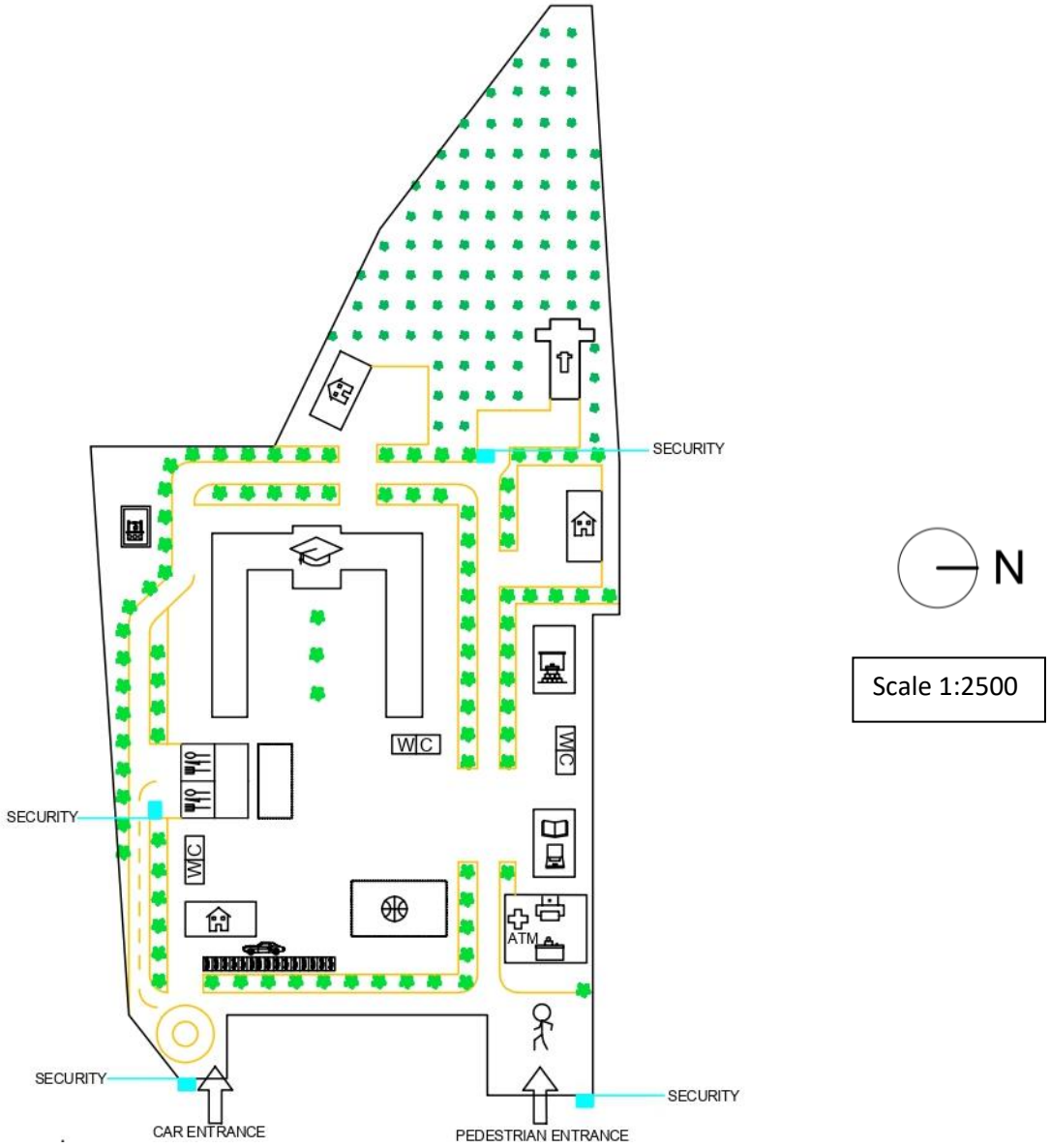



*Figure 22. Security points in the campus*

There are two of them at the entrances to the campus, one at the car entrance and the other at the pedestrian entrance. The objective is to prevent anyone who is not authorized to enter the campus from entering. There is also another security point when trucks turn towards the restaurant storeroom areas. This is to help and monitor the traffic in that area and to prevent them from making a mistake. Finally, there is another security point in the area for attending church or going to the staff residence.

# 5. BUILDING LAYOUT

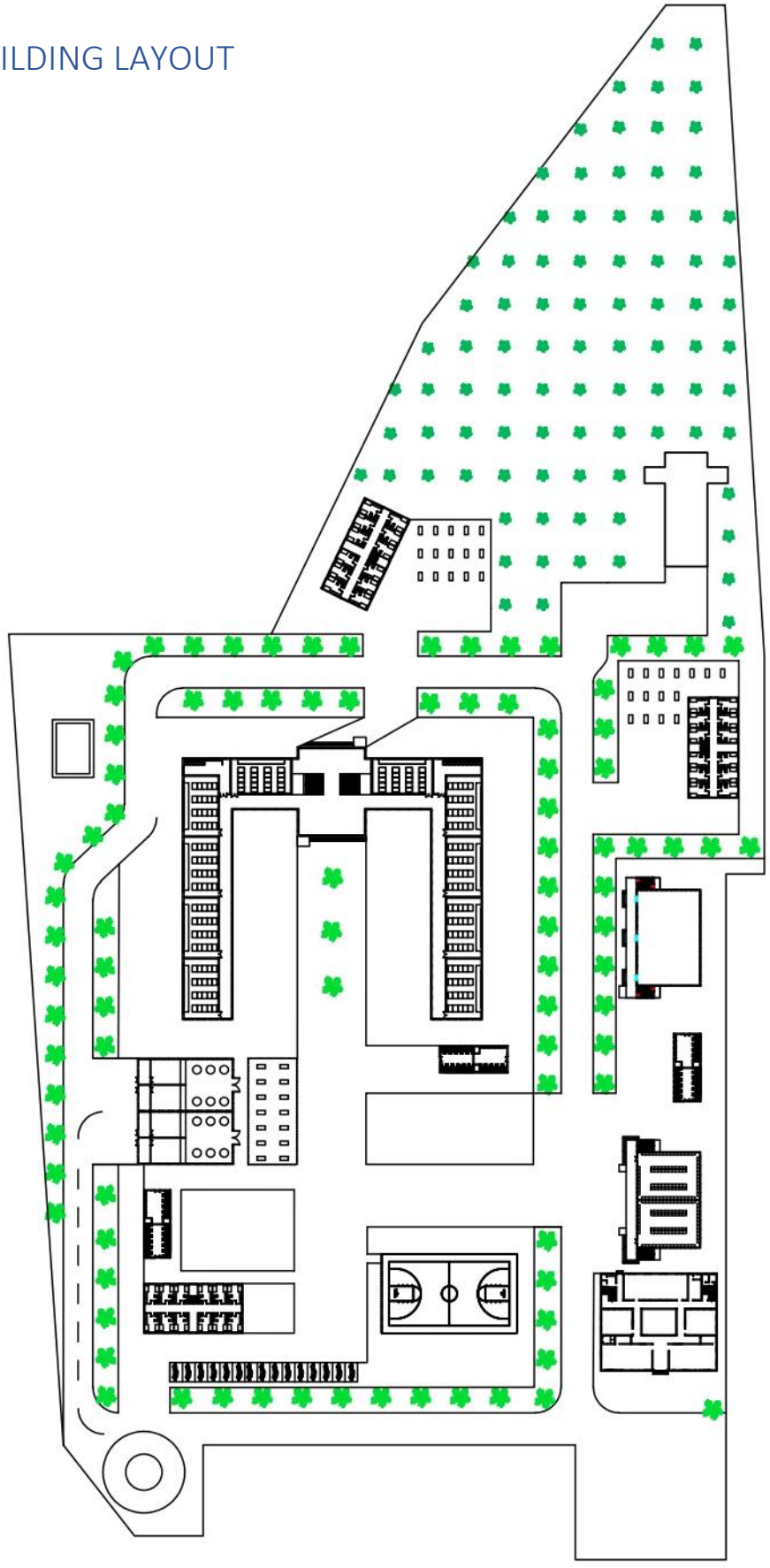
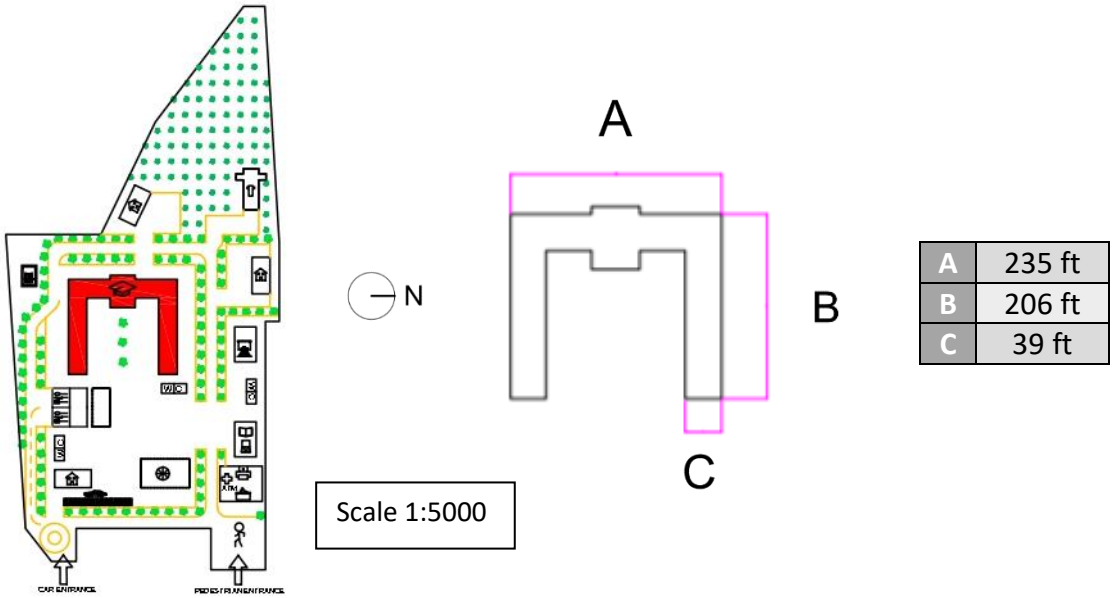



*Figure 23. Campus overview*

The above section shows the campus design and the design of each building separately. In order to be able to appreciate each building on the campus in more detail. The Figure 23 presents what the campus would look like on the ground floor.

## 5.1. Main building

As explained above, the main building is in the middle of the campus, marked in red in Figure 24. Its main dimensions are specified in the table below:




| | |
|---|---|
| A | 235 ft |
| B | 206 ft |
| C | 39 ft |

*Figure 24 Main building*

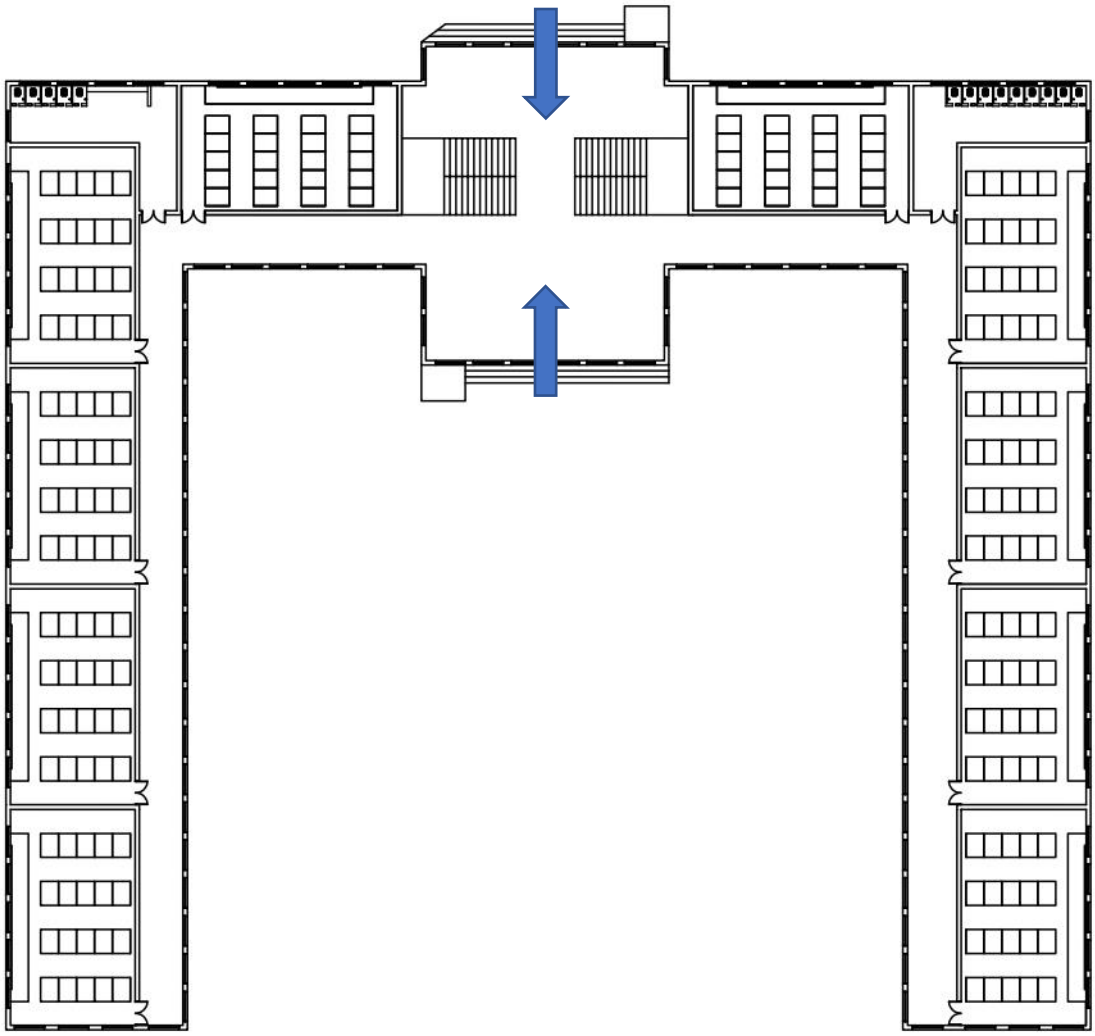
The classrooms building is in this position for three reasons:

1. The acoustic well-being of the faculty and students.
2. Because of the movement of the sun, thus creating a shadow over much of the land at the time when the sun is most damaging to human skin.
3. For the simple fact that it is the most important building and must be centred within the campus.

As the figure 24 shows, the building has a U-shape with the intention of making the most of natural light. The building consists of three floors. Each of them provided of 10 classrooms and separately toilets for men and women.

## Ground floor

The Figure 25 represents the floor plan view of the ground floor of the building.



Scale 1:500

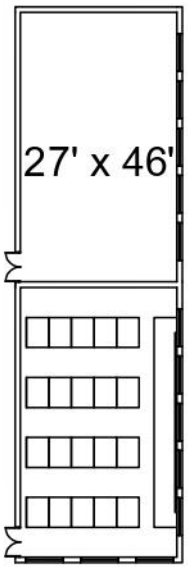
*Figure 25. Main building's ground floor*

As it can be seen, there are two entrances (marked with arrows). The main one, the one through which almost everyone will enter, is the front entrance. The fact that there is a back entrance is for those boys who live in the residence behind and can go straight to class without having to go all the way around the building. As can be seen, both entrances have a small ramp instead of stairs in the case of disabled people.

In the centre, it is possible to see that there are stairs. The reason why there are two stairs is because of space and possible rush hours when there may be many people at the same time.

On this floor there are 10 classrooms, and, like the other floors, all of them have a lot of window area with which they can get natural light from the outside. All classes are designed to have 40 students. These ten classrooms are unified with a very long corridor.

Finally, it should be noted that the men's toilets are in the upper left corner while the women's toilets are in the upper right corner.




27’x46’=1242 square feet > 66 square meter

Scale 1:400

*Figure 26. Classroom size*

### First and second floor

Because they have the same structure, the Figure 27 shows how the classes, the toilets, the staff rooms and laboratories are distributed on the first and second floors of the main building.

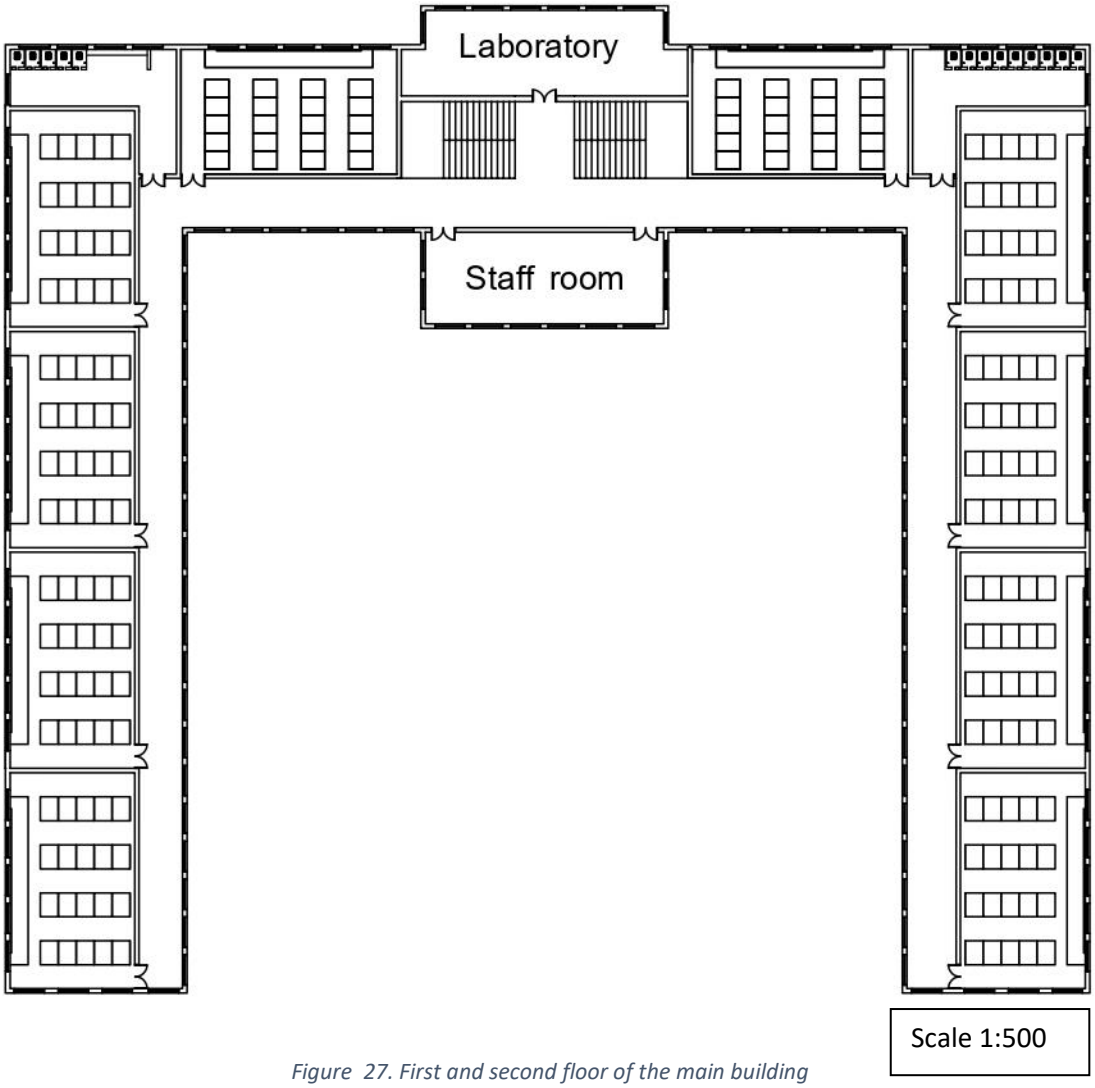



*Figure 27. First and second floor of the main building*

On these floors, it gets the same number of classes (as well as the toilets) with the same location as on the ground floor.

What makes the difference between these two floors above the ground floor is the laboratory and the teacher's room. The laboratory is located to the west of the building overlooking the residence and the river. On the other hand, the faculty lounge is located to the east of the building, where they get views of the outside of the campus, mainly the playground area.

## 5.2. Residences

The residences are essential elements in the construction of the university campus since it is intended to accommodate students. In this case, it is planned to build 3 separate residences for men, women and staff. Their location and their dimensions are indicated in Figure 28.

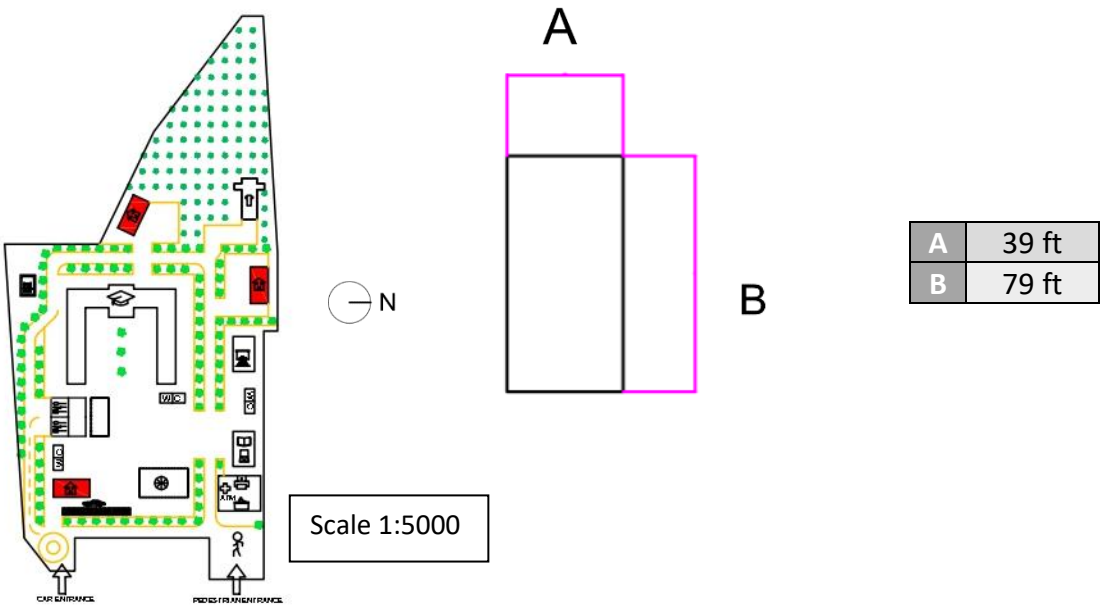



*Figure 28. Residences*

As mentioned above, there will be three types of residences, one for men, located behind the main building, one for women, located north of the main building, and one for campus staff, located near to the entrance. The three residences are the same, with the difference that the staff residence, instead of having 3 floors, has 2 floors only. The two student residences are for 100 people each, and the staff residence is for 52 people.

## Ground floor

The ground floor has 4 rooms, mainly for disabled people. Each room has a bed, wardrobe and wash basin. As it can be seen in the pictures, the spaces inside the room and the toilet are bigger than in the rest of the floors.

On the ground floor there are also, in addition to the 4 rooms mentioned above, the stairs to go up to the other floors, the communal area of the residence, which includes the living room, dining room and kitchen.

Figure 29 shows the plan distribution of the elements just mentioned

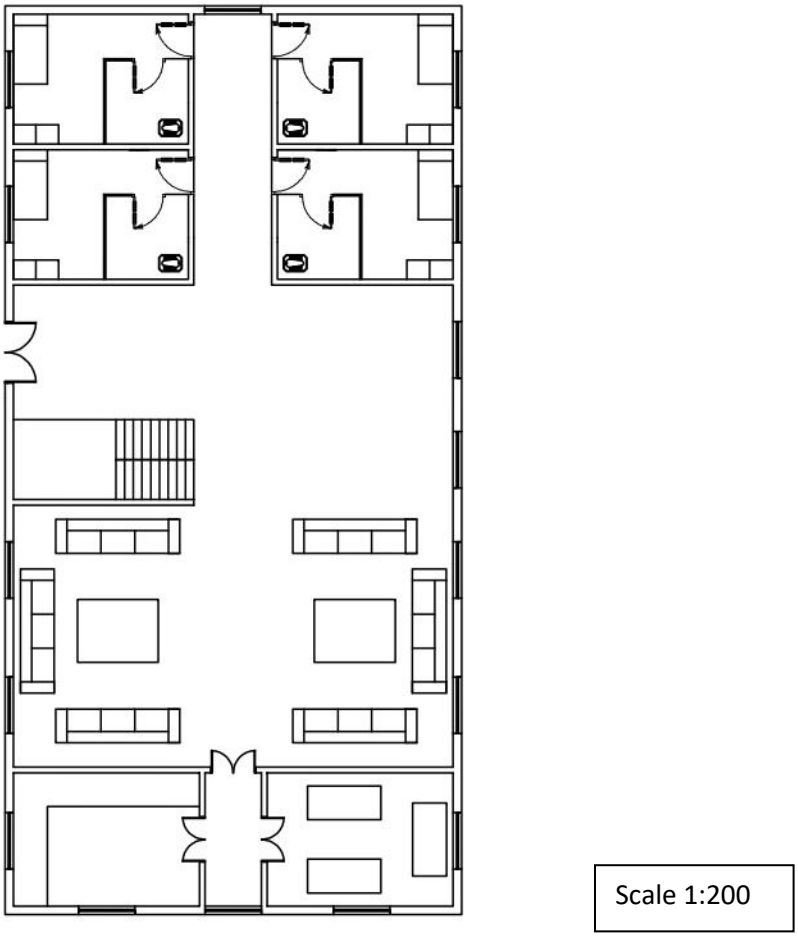
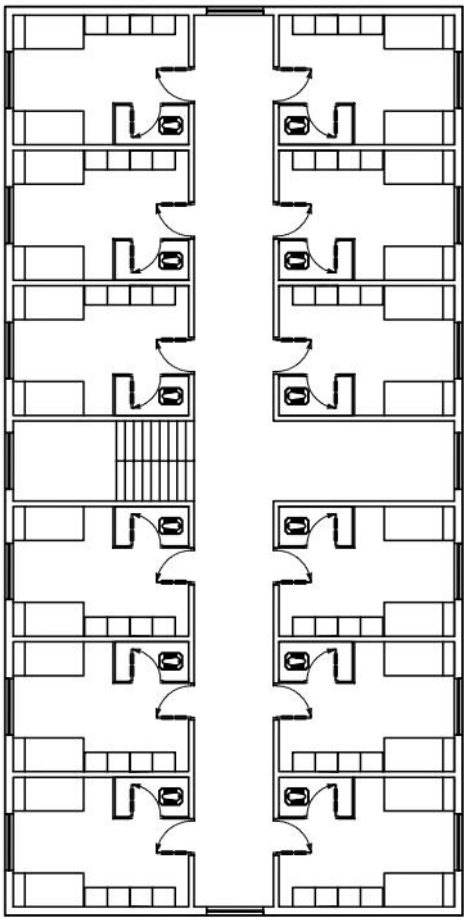



*Figure 29. Residence's ground floor*

## First and second floor

On the other floors, two more in the case of a student residence and one more in the case of a staff residence, there are only rooms. As it can be seen, the rooms are no longer individual, but each room has 2 bunk beds, making a total of 4 students per room.



Scale 1:200

*Figure 30. First and second floor of the residences*

## 5.3. Cantines

In order to provide food service to students and campus staff, it is planned to build four different restaurants located on the left hand of the campus (Figure 31). There are two vegetarian restaurants and two non-vegetarian restaurants.

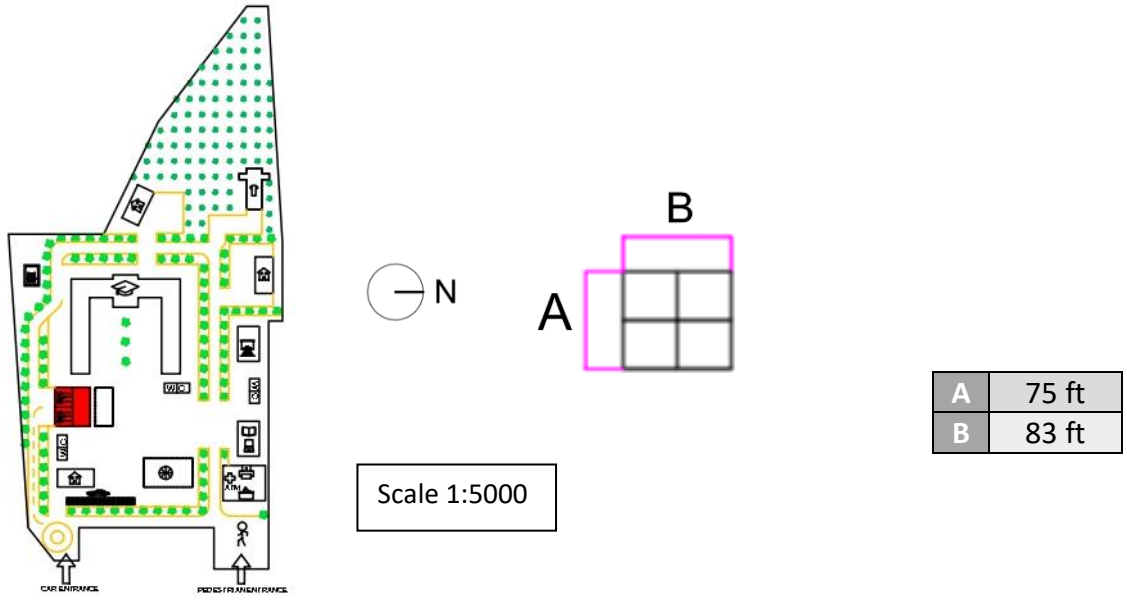



*Figure 31. Cantines*

Each of them is divided into three zones: the private area, where there are kitchens and storerooms, but also a shelf for customers. The interior common area, in which there are some circular tables to be able to eat in a space with a roof. Finally, an outdoor area with tables for those who prefer to eat outside in which there will also be parasols to avoid contact with the sun.

The Figure 32 shows the details of the building. It has a large window area with which it can count on a great deal of natural light from the outside.

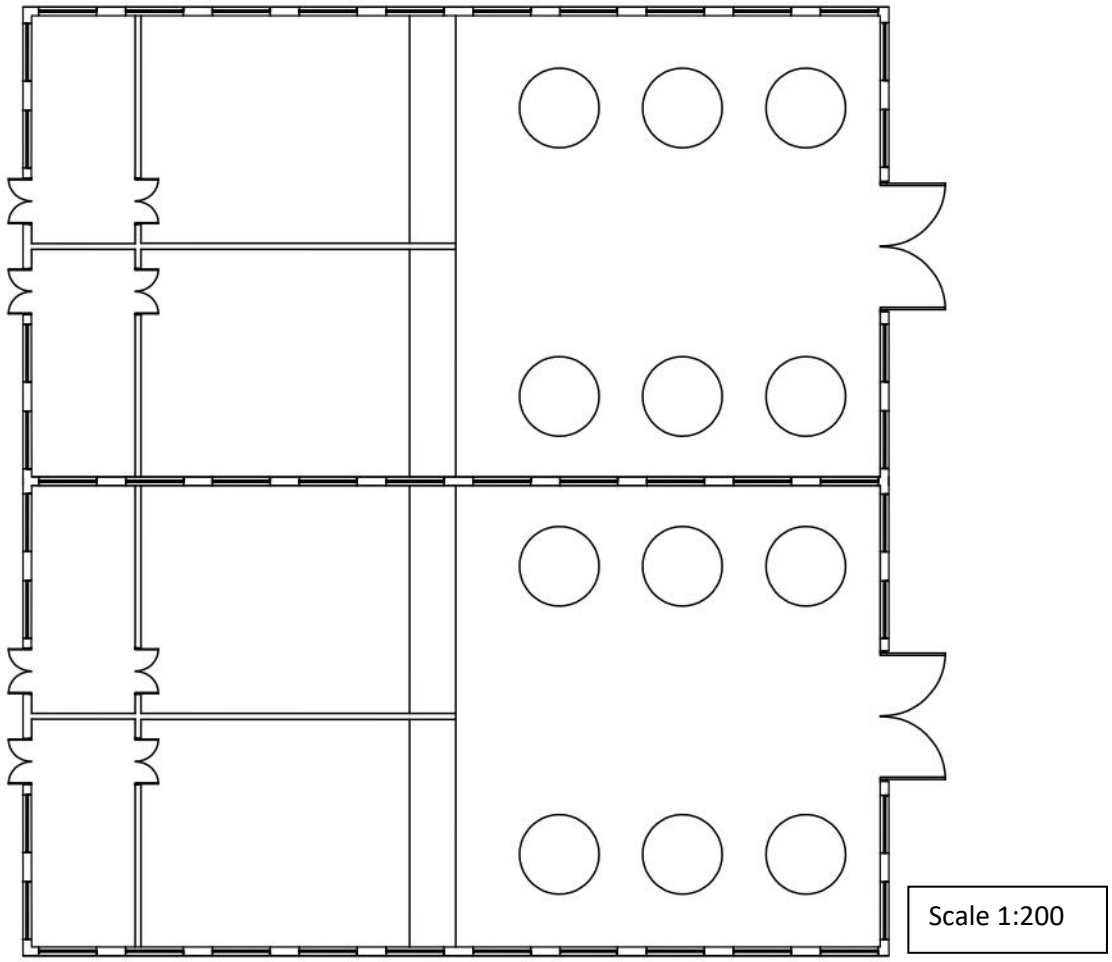



*Figure 32. Details of the cantines (indoor)*

## 5.4. Toilets

Sinks are essential elements in any building. In this case, its location and main dimensions are found in figure 33.

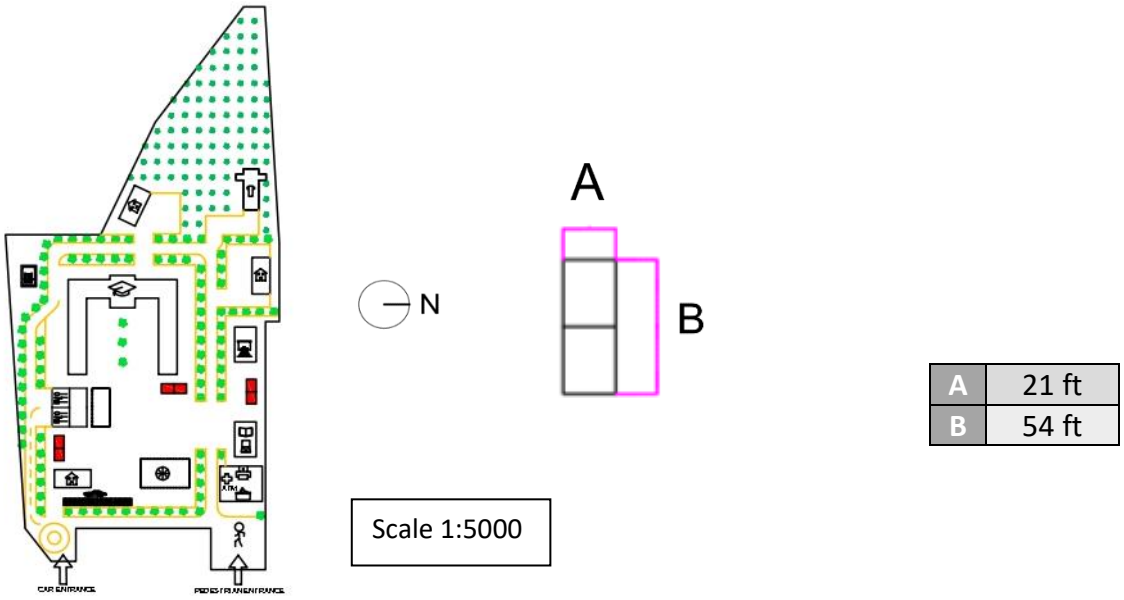



*Figure 33. Toilets*

It should be noted that the toilets are located so that they are easily accessible from anywhere on campus. One near the main building, another one near the restaurants and staff residence, and other one near by the library and multipurpose hall. Each block of toilets is divided according to the gender of the person. The male part consists of 5 toilets and a urination area. The female part consists of 10 toilets. As shown in Figure 34.

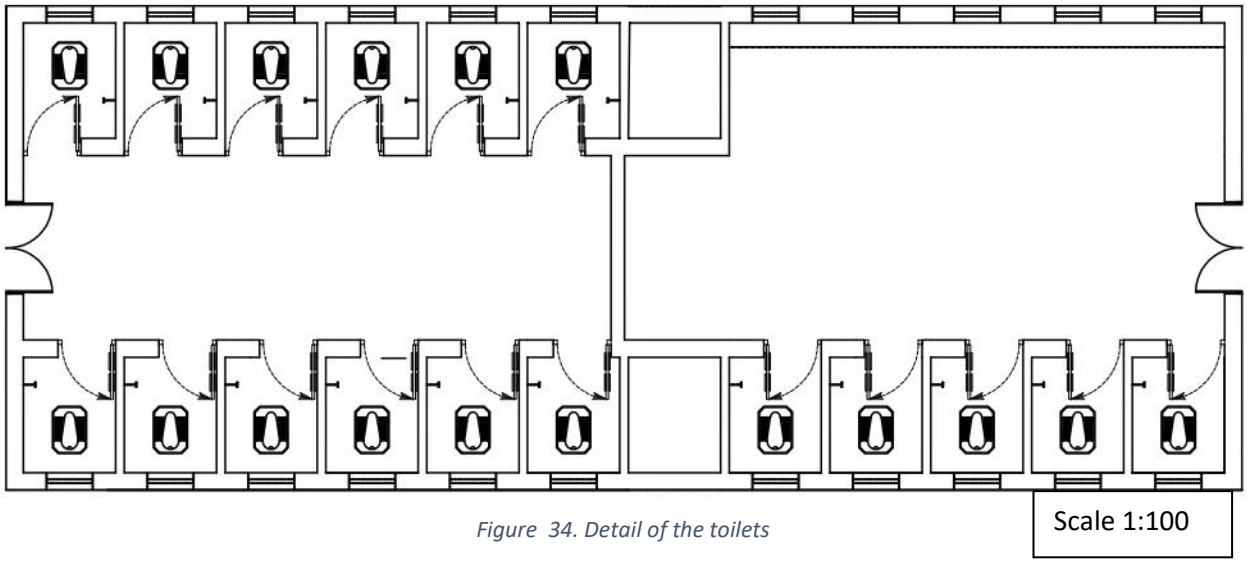
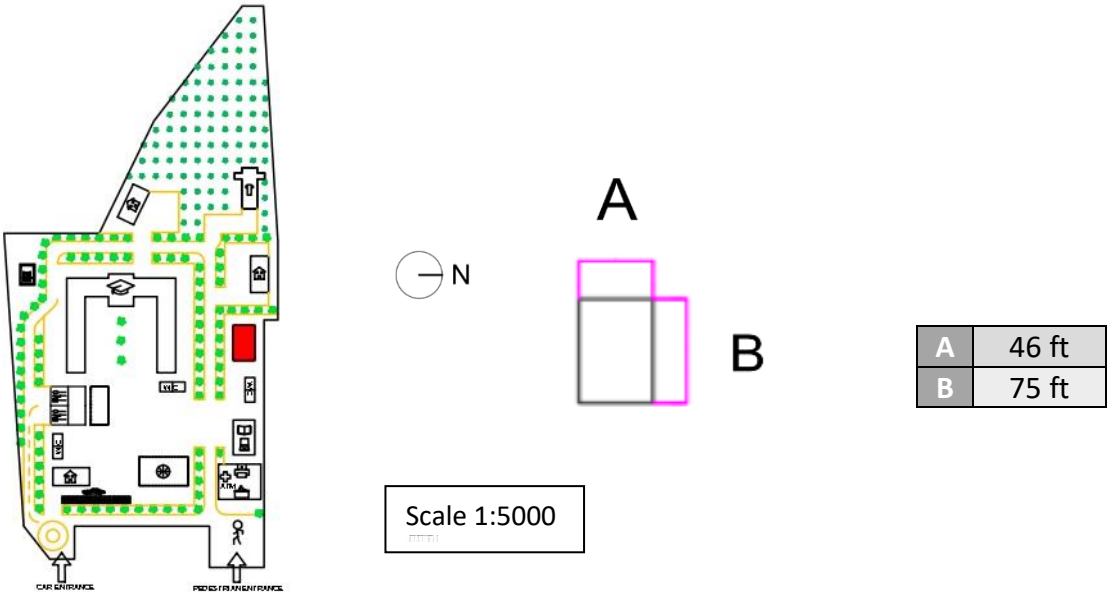



*Figure 34. Detail of the toilets*

## 5.5. Multipurpose hall

In this building there will be activities of collective meetings of many people, auditoriums, theatres, presentations, or even some multitudinous master class.




| | |
|---|---|
| A | 46 ft |
| B | 75 ft |

*Figure 35. Multipurpose Hall*

The multipurpose hall consists of 2 floors. Both floors have 3 possible entrances and a large window area to make the most of the natural light outside. It is also worth mentioning that the first floor is accessible to disabled people. As it can be seen in Figure 36, people can go upstairs to the first floor from both sides of the building.

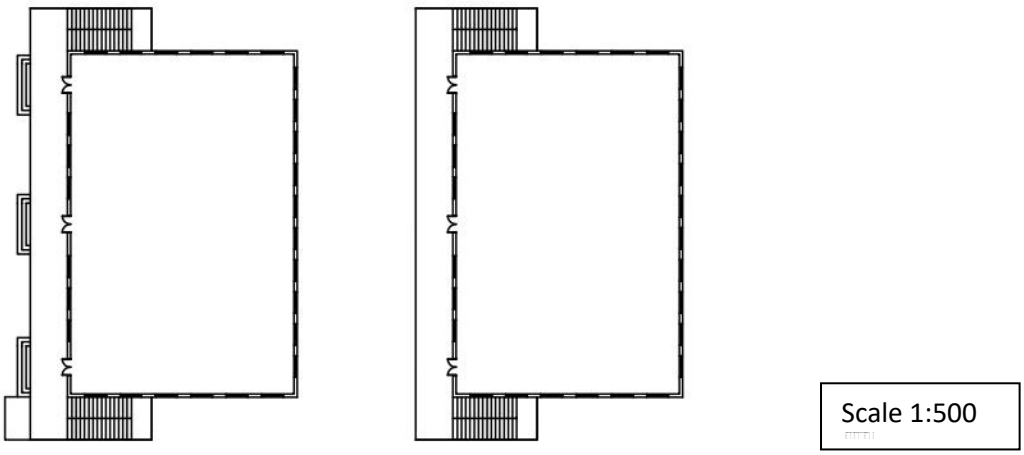
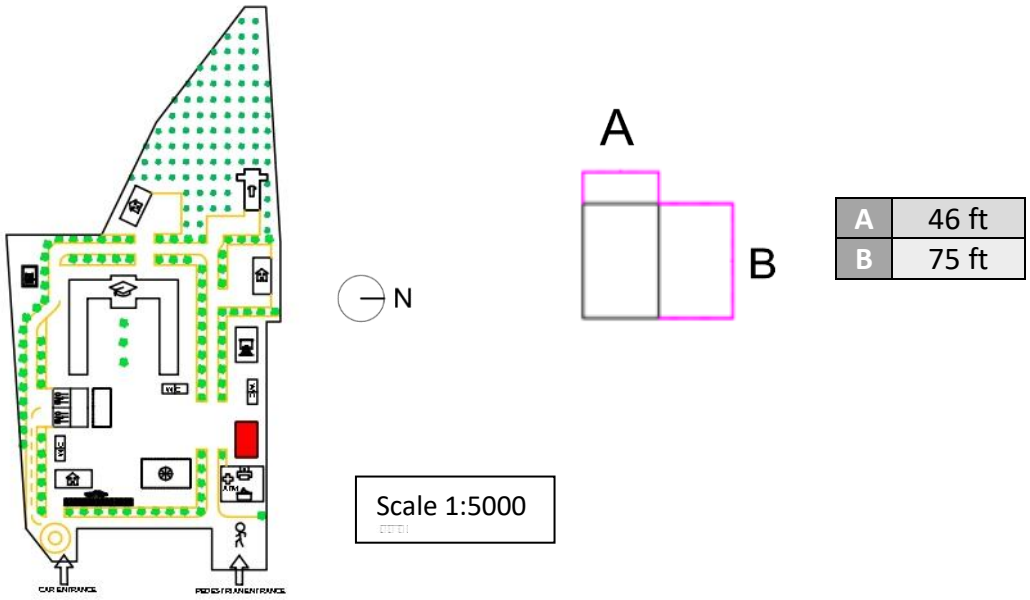



*Figure 36. First and second floor*

## 5.6. Library and computer room

This building is dedicated to the studies and research of the students. For this, it is planned to have a computer area as well as a large library space. Both spaces are in the building marked in red in the Figure 37.




| | |
|---|---|
| A | 46 ft |
| B | 75 ft |

*Figure 37. Library and computer room*

This building has two floors (Figure 38). The first floor, provided of two ramps for disabled access, consists of two equal rooms. One of them have the computers available for student's research while the other one has individual tables for studying.

On the second floor, it will be a study and library area where small study groups can be created.

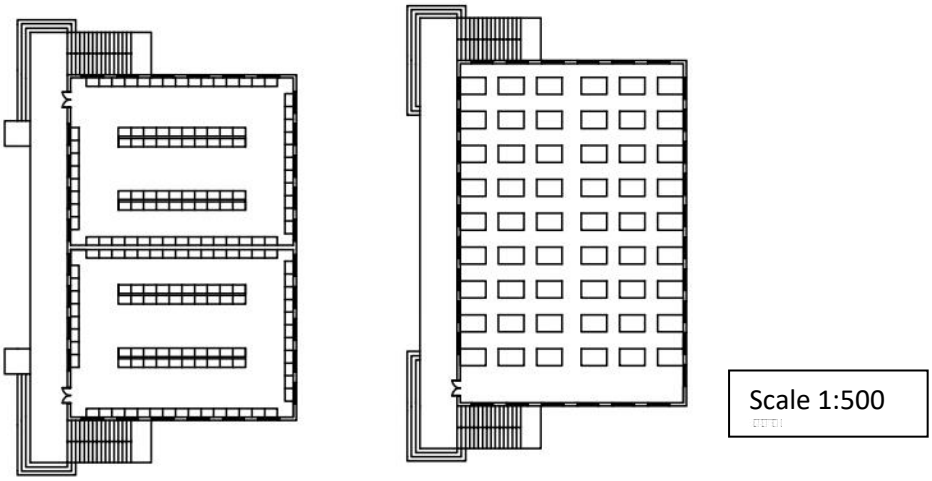
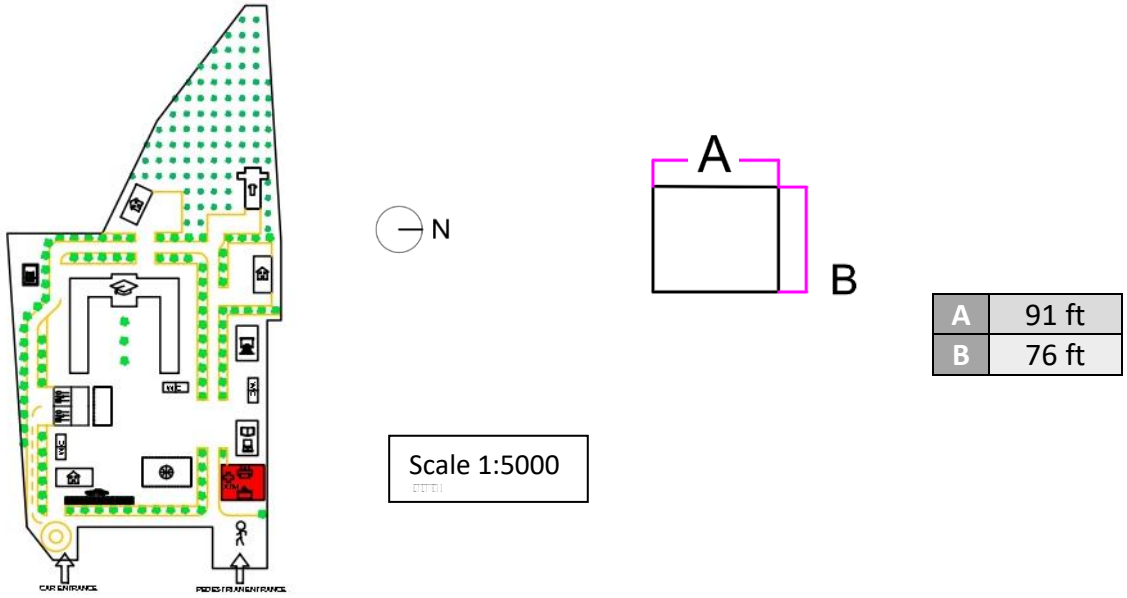



*Figure 38. First and second floor*

## 5.7. Administration Office

As explained before, this building is already built. The administration building is located next to the pedestrian entrance for multiple purposes.




| | |
|---|---|
| A | 91 ft |
| B | 76 ft |

*Figure 39. Administration office building*

As can be seen in Figure 40, it is possible to find administration offices. Also there are a ATM, infirmary, xerox shop and stationery stores for students and teachers. In the next Figure also it is shown the sizes of each space.

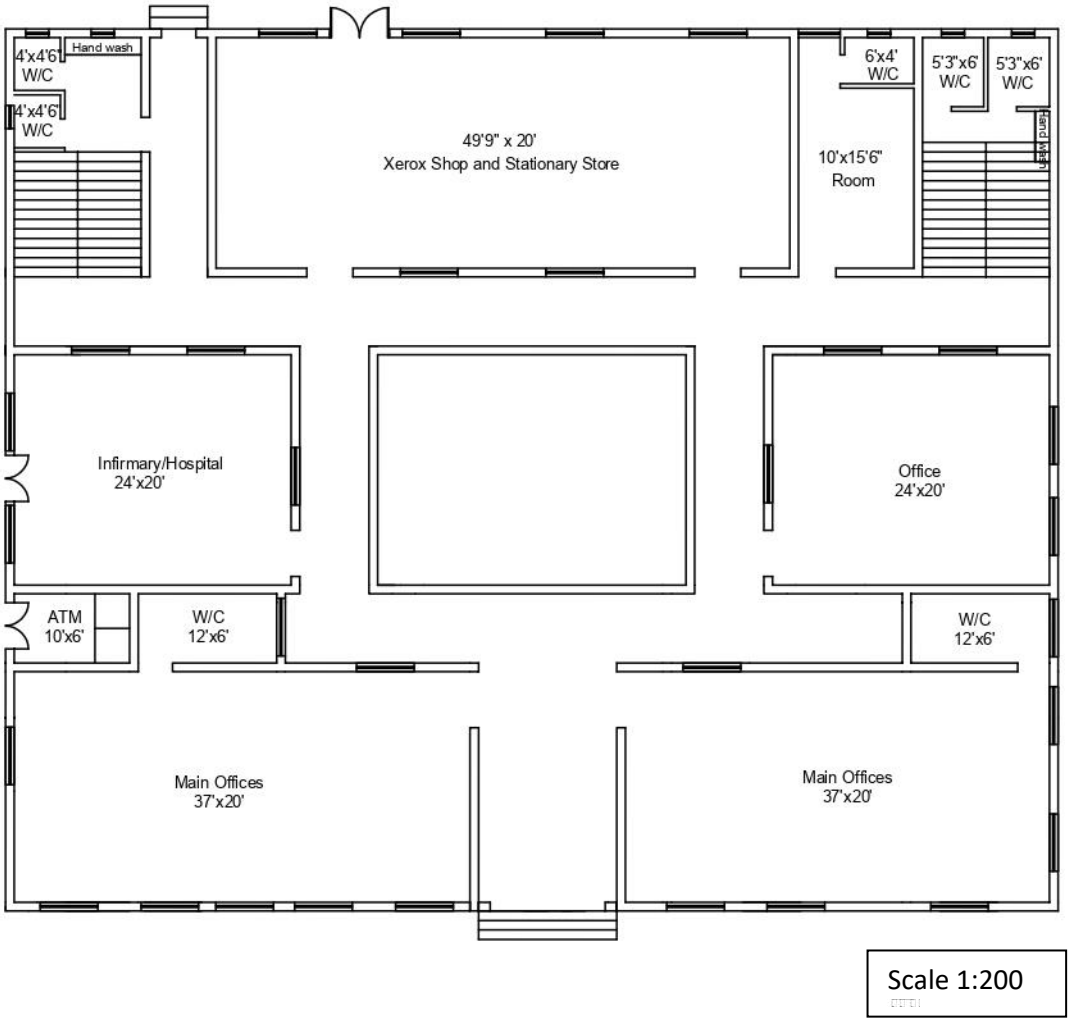



*Figure 40. Administration office building*

# 6. STUDY OF RENEWABLE ENERGY ALTERNATIVES

## 6.1. Current energy consumption in India

This section will describe energy and electricity production, consumption and import in India.

### 6.1.1. Non Renewables

**PRODUCTION**

Currently, the main sources of energy used in India are:

#### Coal and Lignite

Coal is the major source of energy in the country. It provides employment to over 7 lakh workers. Coal has a favour over other fuels as it can be converted into other forms of energy. Presently, it is the principal source of electricity in India.

In future, they are also expected to play more important role in the power generation. Besides this, coal is also an essential input in the steel and carbo-chemical industries.

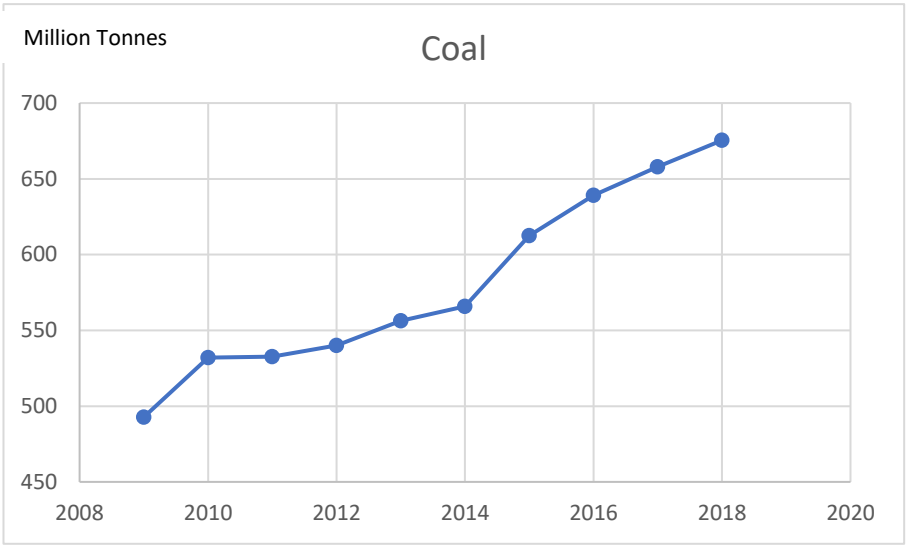
As shown in the table and graphics below, the production of this source of energy has been growing gradually since 2009, with an 37,4% of growth.

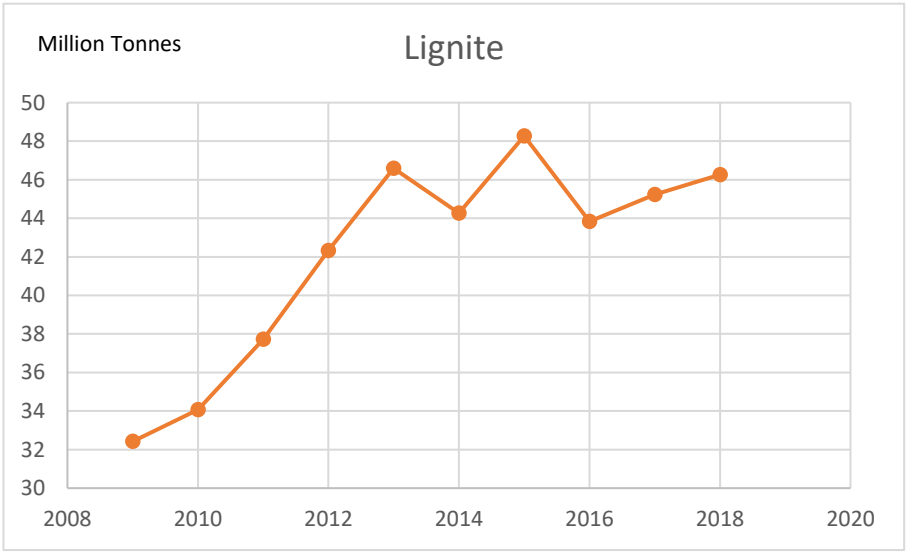
| Year | Coal | Lignite | TOTAL |
|---|---|---|---|
| 2009 | 492,76 | 32,42 | 525,18 |
| 2010 | 532,04 | 34,07 | 566,11 |
| 2011 | 532,69 | 37,73 | 570,42 |
| 2012 | 539,95 | 42,33 | 582,28 |
| 2013 | 556,4 | 46,6 | 603 |
| 2014 | 565,77 | 44,27 | 610,04 |
| 2015 | 612,43 | 48,27 | 660,7 |
| 2016 | 639,23 | 43,84 | 683,07 |

| | | | |
|---|---|---|---|
| 2017 | 657,87 | 45,23 | 703,1 |
| 2018 | 675,4 | 46,26 | 721,66 |

*Units: milion tonnes*

Source: Office of Coal Controller of India



Reserves

Coal's reserves are mainly clustered around a belt extending over the western part of West-Bengal, South Bihar, Orissa, North-Eastern and Central Madhya Pradesh, Eastern figure of Maharashtra and the northern extremity of Andhra Pradesh.

The current estimate of lignite reserves in India is about 629 crore tones, 80 percent occurring in Tamil Nadu. Smaller deposits exist in Gujarat, Rajasthan and Jammu & Kashmir. Neyveli area of Tamil Nadu contains about 330 crore tones -of which 200 crore tones fall in the proven category.

## Petroleum

The second half of the present century may be called the oil age. Petroleum is a very important source of energy and the basis of many chemical industries.

In the last 10 years, the petroleum production has increased up to 64%.

| Year | TOTAL |
|---|---|
| 2009 | 155,15 |
| 2010 | 184,61 |
| 2011 | 194,82 |
| 2012 | 203,2 |
| 2013 | 217,74 |
| 2014 | 220,76 |
| 2015 | 221,14 |
| 2016 | 231,92 |
| 2017 | 243,55 |
| 2018 | 254,4 |

*Units: milion tonnes*

Source: Ministry of Petroleum & Natural Gas.

Reserves

In Indian context, the resources in mineral oil and natural gas are small and these are confined on Nahar-Katia-Moran area in Upper Assam, Bombay High Off and the Bassein structure, Ankleshwar region of Gujarat.

India's total proved reserves of crude oil are estimated to be 131.3 million tonnes.

### Nuclear Energy

This source of energy has tremendous possibilities. According to an estimate, nuclear power station using uranium as fuel will be cheaper than a conventional station at places located away from deposits of coal by more than 800 km. Fortunately, India is the first country in the world which is developing atomic energy.

India has set up nuclear power stations of Tarapur, Kota (Rajasthan), Kalapakam (Chennai), Naroura (UP). Its supply accounts for only 3 percent of the total installed capacity. India is in favour of using nuclear power for peaceful purposes.

Reserves

Its resources of Thorium are the largest in the world, i.e. 5000 tones. Uranium reserves have also been in Bihar and Rajasthan. It has been estimated that uranium reserves available in the country are about 5000 to 10000 MW of nuclear power plants. Recent Pokhran Nuclear Blast has established India's capability to go nuclear.

### Natural Gas

In conventional natural gas deposits, the natural gas generally flows easily up through wells to the surface. In India, natural gas is produced from shale and other types of sedimentary rock formations by forcing water, chemicals, and sand down a well under high pressure. The domestic gas in the country is being supplied from the oil & gas fields located at western and south eastern areas viz. Hazira basin, Mumbai offshore & KG basin as well as North East Region (Assam & Tripura).

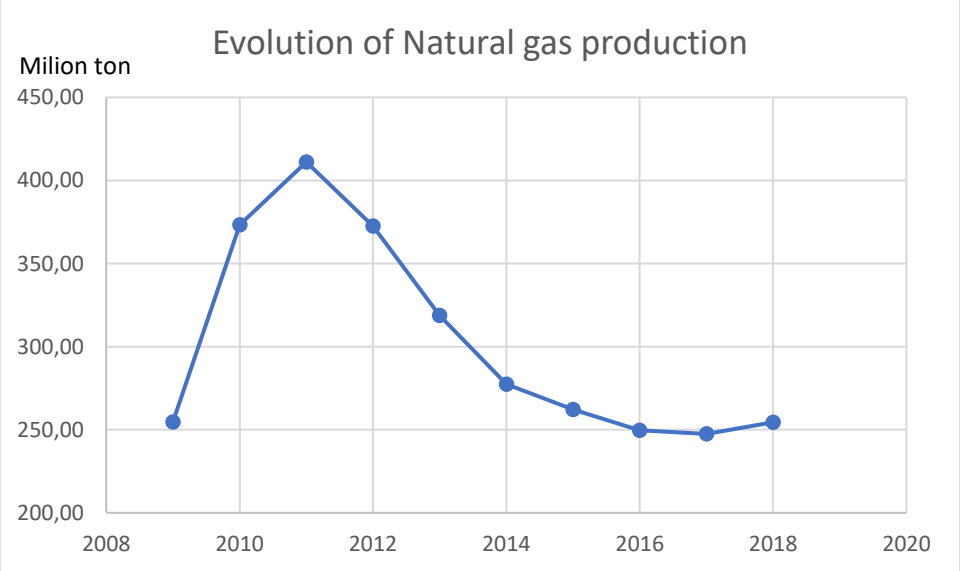
When production is viewed by country, the U.S. is the top producer of natural gas followed by Russia, Iran, Qatar, Canada, and China.

The production's evolution since 2009 is shown in the table below:

| Year | TOTAL |
|---|---|
| 2009 | 254,70 |
| 2010 | 373,26 |
| 2011 | 411,13 |
| 2012 | 372,62 |
| 2013 | 318,87 |
| 2014 | 277,32 |
| 2015 | 262,24 |
| 2016 | 249,64 |
| 2017 | 247,48 |
| 2018 | 254,54 |

*Units: million tones*

*Source: Ministry of Petroleum & Natural Gas.*



## CONSSUMPTION

Since 2013, total primary energy consumption in India has been the third highest in the world after China and the United States.

For coal and lignite, its most important uses are electricity generation, steel production, cement manufacturing and liquid fuel production. As shown in the next table, the consumption of coal and lignite have increased 63% and 44% in the last 10 years.

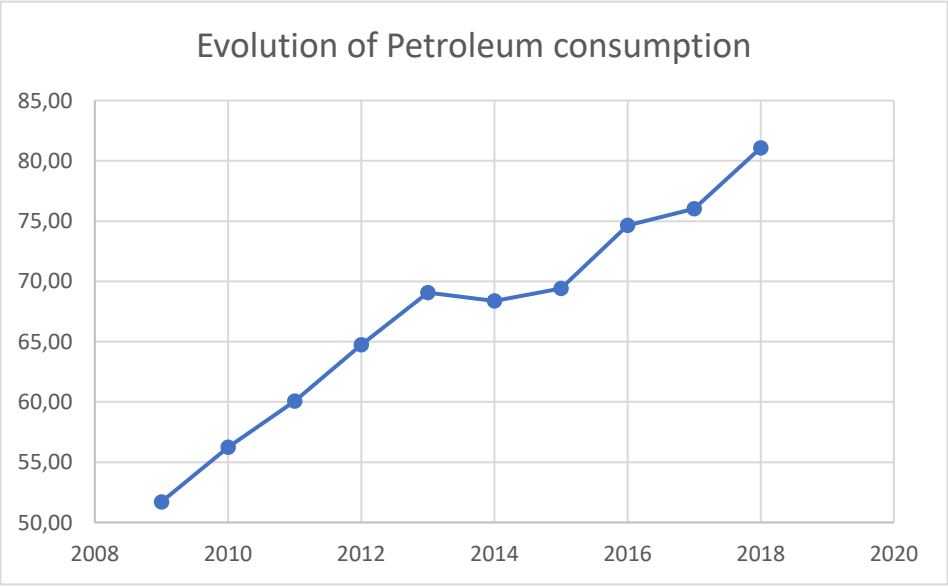
| | 2008 | 2018 | % growth |
|---|---|---|---|
| coal | 549,5 | 896,34 | 63% |
| lignite | 31,85 | 45,82 | 44% |

*Units: million tonnes*

Regarding petroleum, diesel oil accounted for 39.3% of oil total consumption of all types of petroleum products in 2017-18. This was followed by Petrol (12.7%), Pet Coke (12.4%) LPG (11.3%), Naphtha (6.1%).

The main applications of oil are: transportation (land, sea and air), heating, plastics, artificial textile fibres, paints, detergents, explosives, fertilizers, asphalts, etc. In this way, oil derivatives are used practically in all sectors of activity.

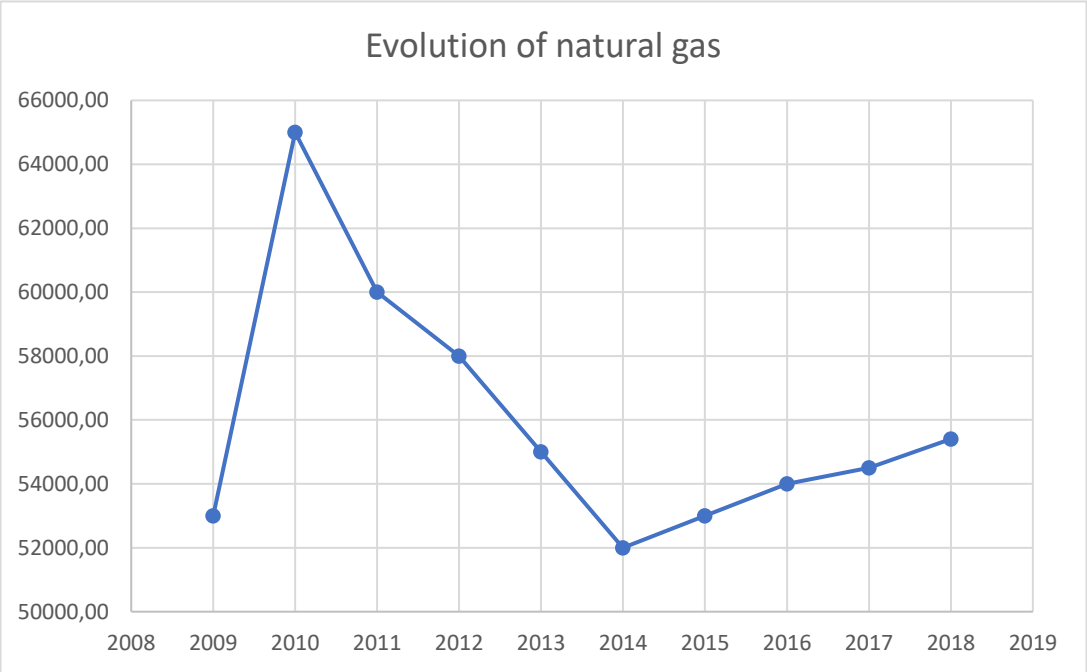
In the lasts 10 years, the petroleum consumption has increased gradually every year as shown in the graphic below:



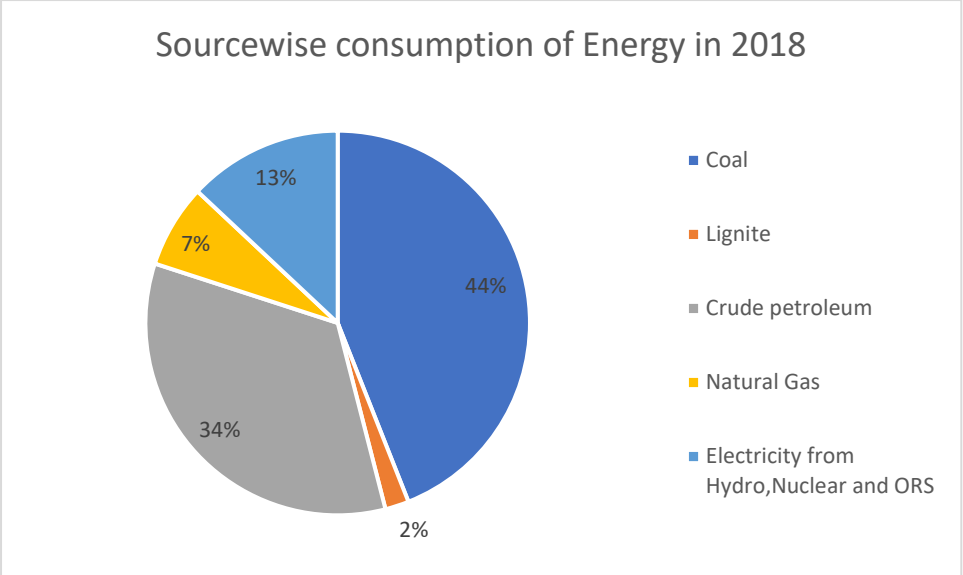
In terms of nuclear technology, the main use of nuclear energy is the production of electrical energy. Nuclear power plants are responsible for generating electricity. Nuclear energy can be used for various industrial applications, such as seawater desalination, hydrogen production, district heating or cooling, the extraction of tertiary oil resources and process heat applications such as cogeneration, coal to liquids conversion and assistance in the synthesis of chemical feedstock.

Finally, for natural gas there are many domestic uses such as: heating, air conditioning, sanitary hot water, etc.

Among its many advantages are its numerous applications. Industry wise off-take of natural gas shows that natural gas has been used both for Energy (60.68%) and Non-energy (39.32%) purposes.



The consumption ratio of the different non-renewable energy sources is shown in the following graphic.




India is the second top coal consumer in the year 2017 after China. India ranks third in oil consumption with 221 million tons in 2017 after the United States and China.

## IMPORTATION

India is net energy importer to meet nearly 45% of its total primary energy.

India is the third highest importer of petroleum all over the world.

India is heavily dependent on oil and natural gas imports with 82.8% import dependence for oil and 45.3% for natural gas. India generated 35.2 million tons of petroleum products from indigenous oil production whereas the consumption of petroleum products is 204.9 million tons.

### 6.1.2. Renewable resources

Top-priority is being accorded by the Government to promote renewable sources of energy so that alternative to the fast exhausting non-conventional sources of energy are found. Use of non-conventional sources of energy can be made in the same manner as conventional sources.

Renewable energy sources and technologies have potential to provide solutions to the long-standing energy problems being faced by the developing countries. The renewable energy sources like wind energy, solar energy, geothermal energy, ocean energy, biomass energy and fuel cell technology can be used to overcome energy shortage in India. To meet the energy requirement for such a fast-growing economy, India will require an assured supply of 3–4 times more energy than the total energy consumed today. The renewable energy is one of the options to meet this requirement.

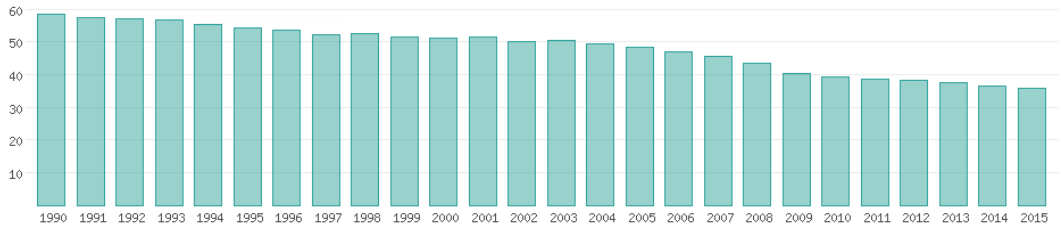
India is one of the countries with the largest production of energy from renewable sources. As of 2019, 35% of India's installed electricity generation capacity is from renewable sources, generating 17% of total electricity in the country.

India is increasingly adopting responsible renewable energy techniques and taking positive steps towards carbon emissions, cleaning the air and ensuring a more sustainable future. In India, from the last two and half decades there has been a vigorous pursuit of activities relating to research, development, demonstration, production and application of a variety of renewable energy technologies for use in different sectors.

Renewable energies include wind, solar, biomass and geothermal energy sources. This means all energy sources that renew themselves within a short time or are permanently available.

In 2015, renewable energies accounted for around 36.0 percent of actual total consumption in India.

The following chart shows the percentage share from 1990 to 2015:



## PRODUCTION

The main renewable sources in India are solar energy and wind energy being the 83% of the all total renewable sources. The following non-conventional sources of energy in the country are:

*Bioenergy:*

This type of energy is obtained from organism or organic matter. It is of two kinds:

### a) Biogas:

Biogas is the mixture of gases produced by the breakdown of organic matter in the absence of oxygen (anaerobically), primarily consisting of methane and carbon dioxide. Biogas can be produced from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste or food waste.

Biogas differs from natural gas in that it is a renewable energy source produced biologically through anaerobic digestion rather than a fossil fuel produced by geological processes. Biogas is primarily composed of methane gas, carbon dioxide, and trace amounts of nitrogen, hydrogen, and carbon monoxide.

Uses of biogas. Biogas is environment friendly and has various applications. They are cooking, drying, cooling, heating etc. It is used in producing electricity, methanol and production of steam.

In biogas plants, gas (biogas) is produced through the controlled fermentation of biomass which, thanks to its high methane content, can be used to produce electrical and/or thermal energy. The biogas plant needs to be fed with raw materials, which are generally known as substrates, and can be some of the following: manure from domestic animals (cows, pigs and poultry), from vegetable waste (straw, grass, dry leaves) and from domestic waste such as food scraps, grass, fruits, vegetables, etc.

A biogas plant can use different types of substrate or raw material to produce energy. To explain how a plant works, will be used a example of one that works with manure and food waste. The steps for energy generation are as follows:

1. Liquid manure is pumped, through a pipe, into the fermenter (or biodigester).

2. Once the fresh substrate (raw material) is inside the fermenter, the second element is added: the waste from the agro-food industry. In this case, those coming from the University restaurants. This waste has been previously stored in a reserve pit and, in addition, before being poured into the fermenter, the agri-food waste is heated in a tubular heat exchanger for approximately one hour.
3. Once the two types of substrates (manure and agri-food waste) have been added to the fermenter, they are continuously removed by blades to prevent the formation of floating layers. In addition, the fermenters have heaters on their perimeter that keep the mixture at about 40º C, which facilitates the formation of methane. The whole mixture is kept for about 60 days inside the fermenter.
4. Once the mixture has been fully exploited, all the contents are transferred to another fermenter where the mixture is de-gassed for a further 60 days.
5. The final product is a high-quality fertilizer. This liquid can be accumulated for a maximum of 6 months before being used in the agricultural extensions.

The gas is produced in the fermenters, whose operation has been explained above. Once the substrate has been added to the biodigester (or fermenter), the biogas is obtained as follows:

1. When the fermenter of the biogas plants is filled with fresh biomass, heated and stirred, the process of gas formation is initiated. The fats and carbohydrates of the components are digested by bacteria that generate large amounts of methane during digestion.
2. The resulting gas (composed of 60 % methane and 40 % water vapour, carbon dioxide, hydrogen and hydrogen sulphide) is continuously rising in the tank (it is hermetically sealed) which allows its extraction from the tank.
3. Once the gas is extracted from the biodigester, the water vapour and hydrogen sulphide are removed, as they are problematic for the subsequent use of the biogas. The water vapour is extracted by a condensation method and the hydrogen sulphide is removed by passing the gas through a biological desulphurisation plant.
4. To finish the cleaning, the product is subjected to a washing and drying process
5. The resulting gas, already cleaned of impurities, is passed through a compressor that prepares it for subsequent combustion.
6. Finally, the gas is used to feed the electricity generators.

In addition to producing electricity and high-quality fertilizers, the heat resulting from the cooling of the electricity generators is used to heat the mixture in the digesters, so that the energy produced is used to the full.

The energy produced by the generator of the eco-generation biogas plants is converted into a generator at the level of the network voltage. Normally, the most advanced biogas plants are operating 24 hours a day, every day of the year. This is a great advantage over other power plants that depend on atmospheric elements for their production and cannot meet the demand continuously.

Therefore, it is the ideal solution to maximize the profitability of an agricultural or livestock production, as it helps to manage the waste from the operation (it translates into savings) and, in addition, to obtain a great benefit from these wastes, both in the form of electrical energy and high quality fertilizers.

### b) Biomass:

It is also a source of producing energy through plants and trees. The purpose of bio-mass programme is to encourage afforestation for energy, so that fuel for the generation of energy based on gas technique and fodder for the cattle could be obtained. 5.6 MW capacity for the generation of bio-mass energy has been installed.

*Solar Energy:*

Solar energy refers to that which is produced by the light of the sun.

### a) Solar Thermal

Under this programme, solar energy is directly obtained. Light of the sun is converted into thermal power. Thermal energy is produced when the atoms and molecules in a substance vibrate faster due to a rise in temperature.

Solar thermal technologies capture the heat energy from the sun and use it for heating and/or the production of electricity. This is different from photovoltaic solar panels, which directly convert the sun's radiation to electricity.

A solar thermal system works by harnessing, is the sun's energy and converting it into heat which is then transferred into your home or businesses heating system as hot water or space heating. Solar thermal panels are used in conjunction with a boiler, collector or immersion heater.

Solar thermal energy can be used for such applications as, space heating, cooking, air conditioning, hot water, drying of the crops, industrial process heat, drying, distillation and desalination, and electrical power.

### b) Solar Photovoltaics

Under the programme photovoltaic cells are exposed to sun light as a result of which electricity is generated at the meeting place of two substances.

Photovoltaic cells are those cells which convert light of the sun into electricity. It is used for street lighting, community light system, T.V. system, water pumps, domestic lights, etc.

Photovoltaics are best known as a method for generating electric power by using solar cells to convert energy from the sun into a flow of electrons by the photovoltaic effect. Solar cells produce direct current electricity from sunlight which can be used to power equipment or to recharge a battery.

Solar photovoltaic (PV) panels (Figure 41) use cells containing a semi-conductor material to capture the sun's energy and convert solar radiation into electricity. ... When light shines on the semi-conductor the electric field across the junction

between these two layers causes electricity to flow, generating direct current (DC).

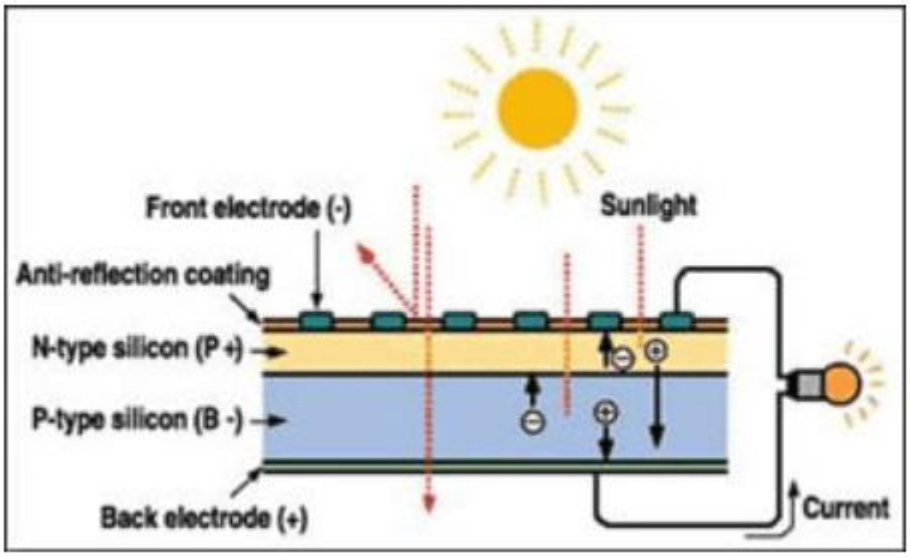



*Figure 41. Photovoltaic panel*

Solar panels do not produce energy at night. Solar panels work hard all-day producing electricity from the sun. They also support sustainable solar energy solutions at night. You can continue benefiting from their energy production after sunset through net metering and solar battery storage.

Solar PV is based on the photovoltaic effect, by which a photon (the basic unit of light) impacting a surface made of a special material generates the release of an electron. Solar thermal, on the other hand, uses sunlight to heat a fluid (depending on the application, it can be water or other fluid).

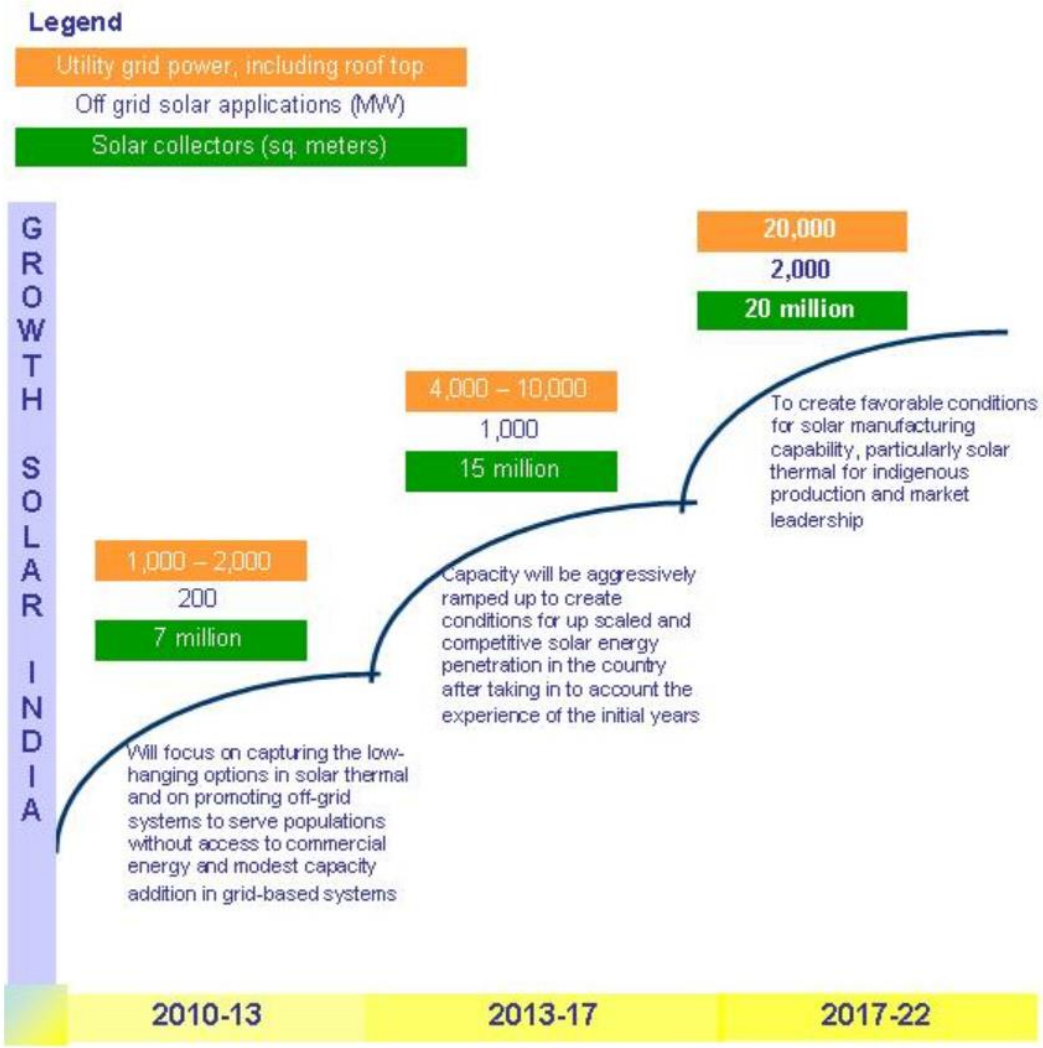
Solar thermal is more space efficient than solar PV. They can be more efficient in collecting heat from sun rays than solar PV. The technology itself is less complex than solar PV.

Solar energy in India has developed increasingly since the early 2010s. India is densely populated and has a large solar irradiation, which makes the country one of the best candidates for the development of photovoltaic solar energy and solar thermal.

The 345 MW Charanka solar park (one of the largest in the world) was put into service in April 2012 and expanded in 2015, together with a total of 605 MW in

the Gujarat region. The construction of other large solar parks has been announced in the state of Rajasthan, and the 40 MW Dhirubhai Ambani solar park was inaugurated in 2012.

At the beginning of 2016, the total installed power in India was above 5 GW.




India's renewable energy capacity increased to 86 GW in 2019, according to the new figures from JMK Research & Analytics, with the addition of 7.5 GW of new solar capacity at public utility scale and 2.4 GW of new capacity of wind power.

The country's renewable energy capacity increased to 86 GW, with wind power providing 44% of the country's renewable energy mix, followed by solar with 39%.

### *Wind Power*

Energy is generated by harnessing wind power.

India has second place in wind power energy generation after U.S.A.

Wind power is a sustainable and renewable energy and has a much smaller impact on the environment compared to burning fossil fuels.

Wind has a lot of potential to generate energy, a study from U.S. estimated wind-energy potential about 10.8 trillion kWh per year -- about equal to the amount of energy in 20 billion barrels of oil (the current global yearly oil supply).

Wind energy (or wind power) describes the process by which wind is used to generate electricity (Figure 42). Wind turbines convert the kinetic energy in the wind into mechanical power.

When the wind blows past a wind turbine, its blades capture the wind's kinetic energy and rotate, turning it into mechanical energy. This rotation turns an internal shaft connected to a gearbox, which increases the speed of rotation by a factor of 100. The wind makes the rotor spin that spins a generator that produces electricity. The motion of the blades turning is kinetic energy. It is this power that we convert into electricity. Mechanical power can also be utilized directly for specific tasks such as pumping water.

Wind turbines take power from the National Grid when not generating electricity, it has emerged. They use electricity to keep their blades rotating slowly in cold weather to prevent them icing up and to power the systems which turn the blades into the wind.

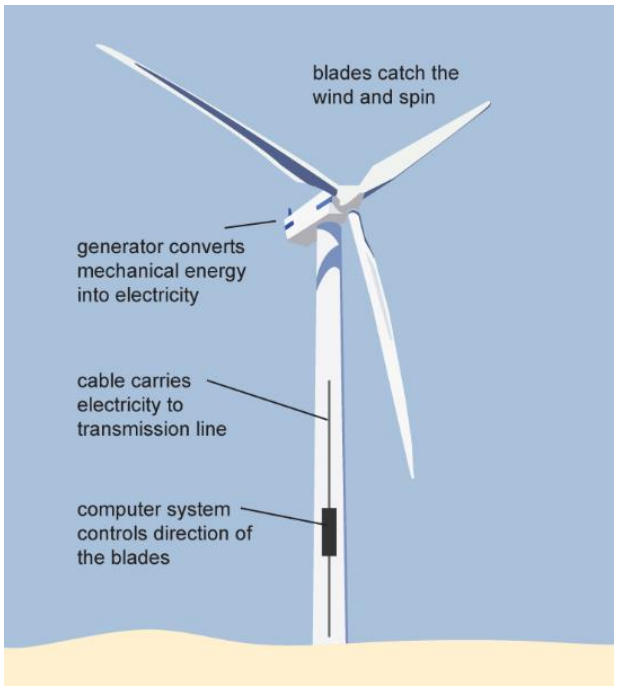
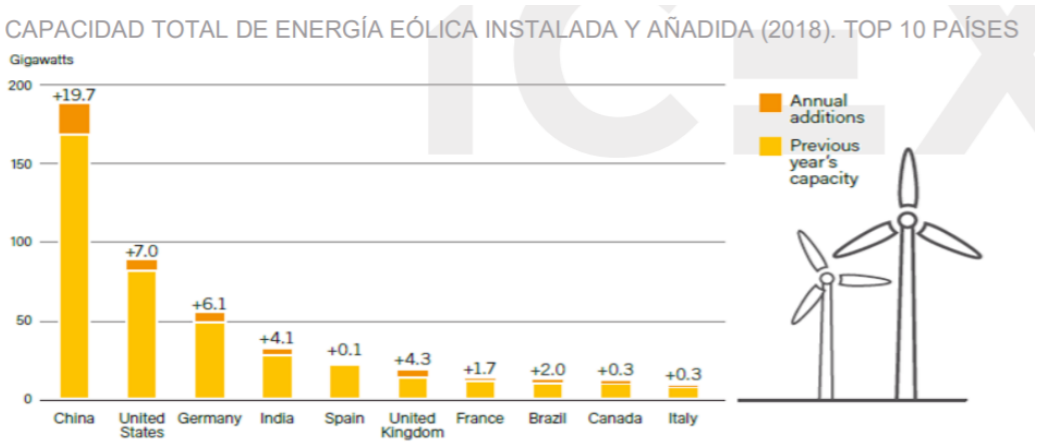



*Figure 42. Aerogenerator*

The Indian wind industry is a mature industry of almost thirty years of age, which currently occupies the fourth position in the world in terms of installed capacity (as can be seen in the graphic, just behind China, the United States and Germany), as well as the fifth position in annual growth of facilities.




In March 2019, the number of GW of wind energy installed in the country exceeded 35 GW, with almost 90% of the investment coming from the private sector.

Wind power represents a greater proportion of India's current share in renewable energy. In March 2019, the number of GW of wind energy installed in the country exceeded 35 GW, with almost 90% of the investment coming from the private sector.

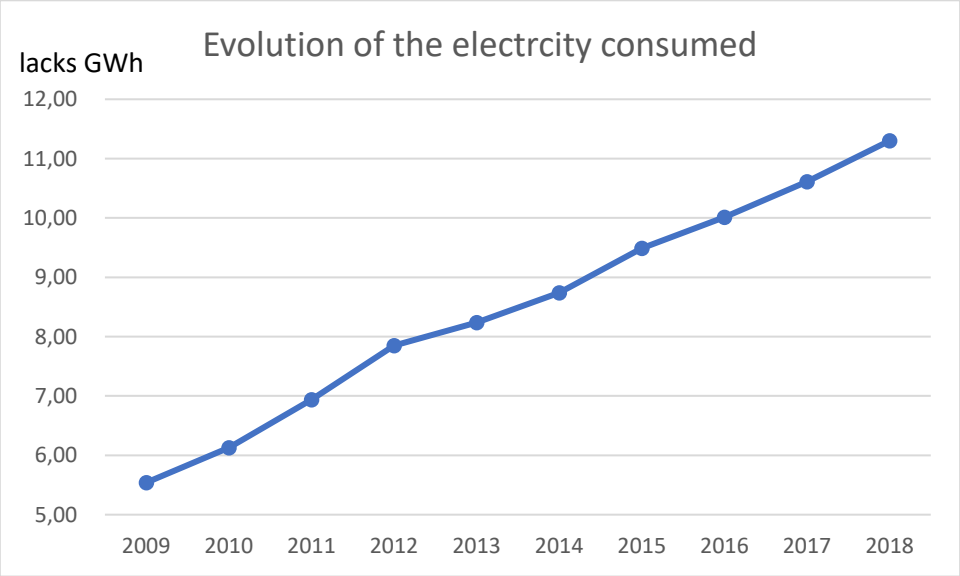
In 2019, the westernmost state of Gujarat installed most of the new wind capacity, installing 1.4 GW, followed by Tamil Nadu with 650 MW and Maharashtra with 212 MW.

As for the wind resources of the country, winds in India are influenced by the strong Southwest summer monsoon that begins in May-June and a weak northeast monsoon, which It starts in October.

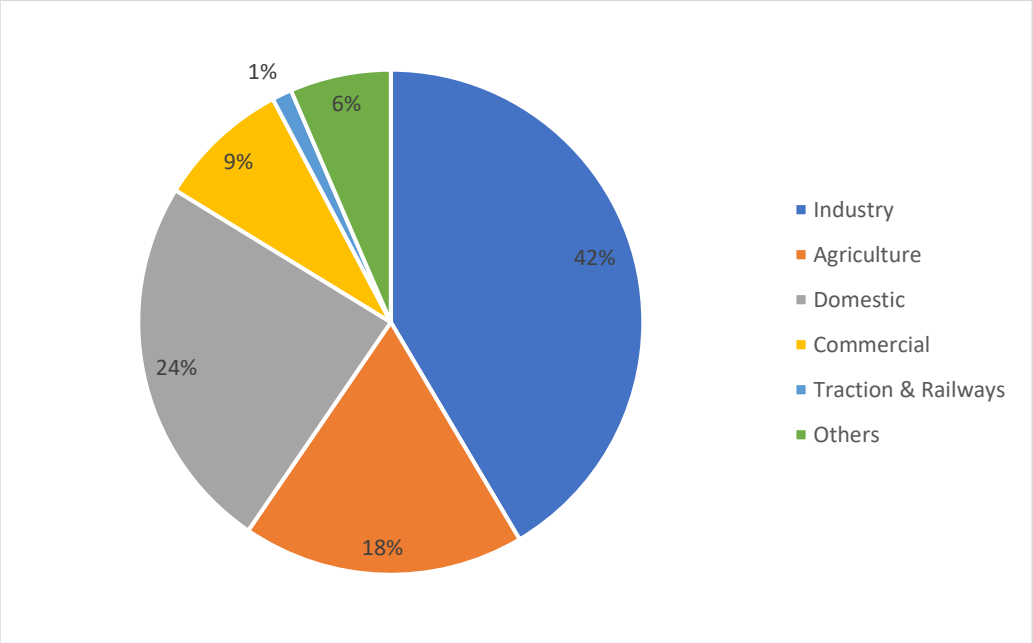
### 6.1.3. Electricity

Secondary energy sources, on the other hand, are the result of transformations of primary energy sources and are not present in nature as resources but are generated from them. Among the secondary sources, electricity and petroleum products are distinguished (naphtha, diesel, fuel oil, etc.). Today's societies are characterized by high consumption of secondary energy sources produced in power generation plants and oil refineries.

The estimated electricity consumption increased from 5,53,995 GWh during 2009 to 11,30,244 GWh during 2018. As shown in the graphic below, this amount of electricity has doubled in the last ten years



Of the total consumption of electricity in 2018, industry sector accounted for the largest share (41.48%), followed by domestic (24.20%), agriculture (18.08%) and commercial sectors (8.51%).




In India, the development of agriculture, industry, urbanisation, electrification of villages and trains would not have been possible without electricity. Demand for electricity also comes from households. Production of electricity was started in 1890 with the establishment of Shivamudram Hydro Electric Power Station in Karnataka.

## 6.2. Description of the area and possible solutions

### Description of the area

India, due to its proximity to the equator, is a warm country that receives a lot of solar radiation. The climate of India is strongly influenced by the Himalayas and the Thar Desert, which favour the development of monsoons. The Himalayas prevent the incoming Central Asian catabolic cold winds, keeping most of the Indian subcontinent warmer than most locations in similar latitudes. The Thar Desert plays a crucial role in attracting the moisture-laden monsoon winds from the southwest, which provide most of the country's rainfall between June and October. As shown in Figure 43 the zone of Tamil Nadu is the warmest.

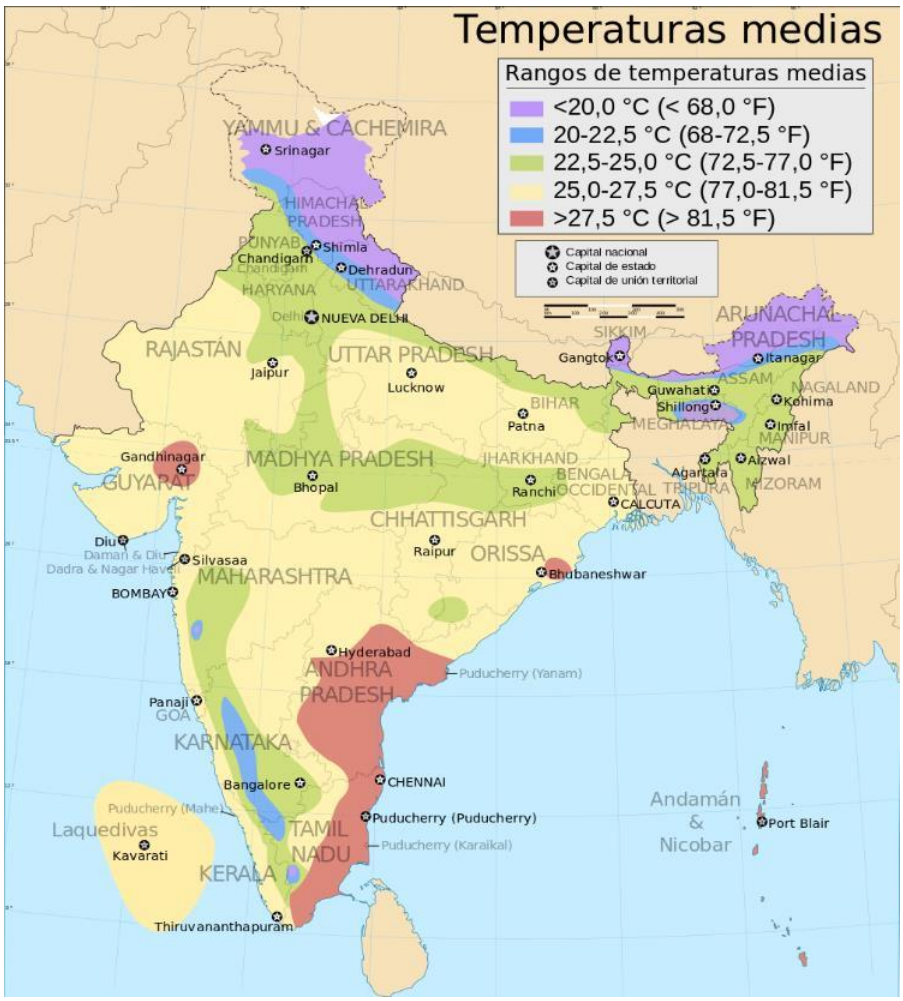



*Figure 43. Map of the average temperature in India*

The four main climatic zones that predominate in India are: humid tropical, dry tropical, humid subtropical and the mountain. Figure 37 shows the average temperature map of India as well as the solar irradiation map that India receives at Figure 44.

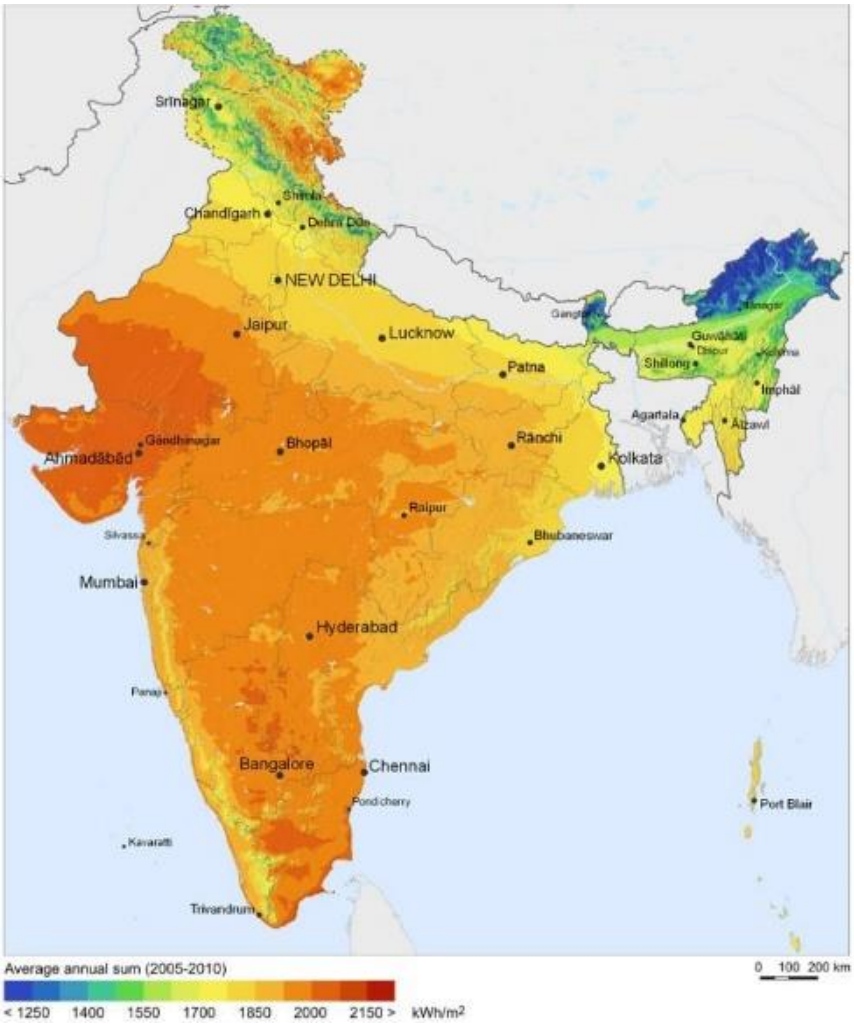



*Figure 44. Map of solar irradiation in India*

That is why India is an interesting country for setting up solar power plants. The irradiation nearby Trichy, where is the further university to be built, is around 2000 kWh/m2.

In terms of wind, due to its location near the Himalayas, India is also an interesting country in terms of installing wind power generating parks. Figure 45 shows a map showing the maximum wind speed. Its appreciable that the zone of the university is the highest of Tamil Nadu, around 50 m/s wind speed.

Of these two facts, the Indian government has realized and is driving both solar and, above all, wind power year after year.

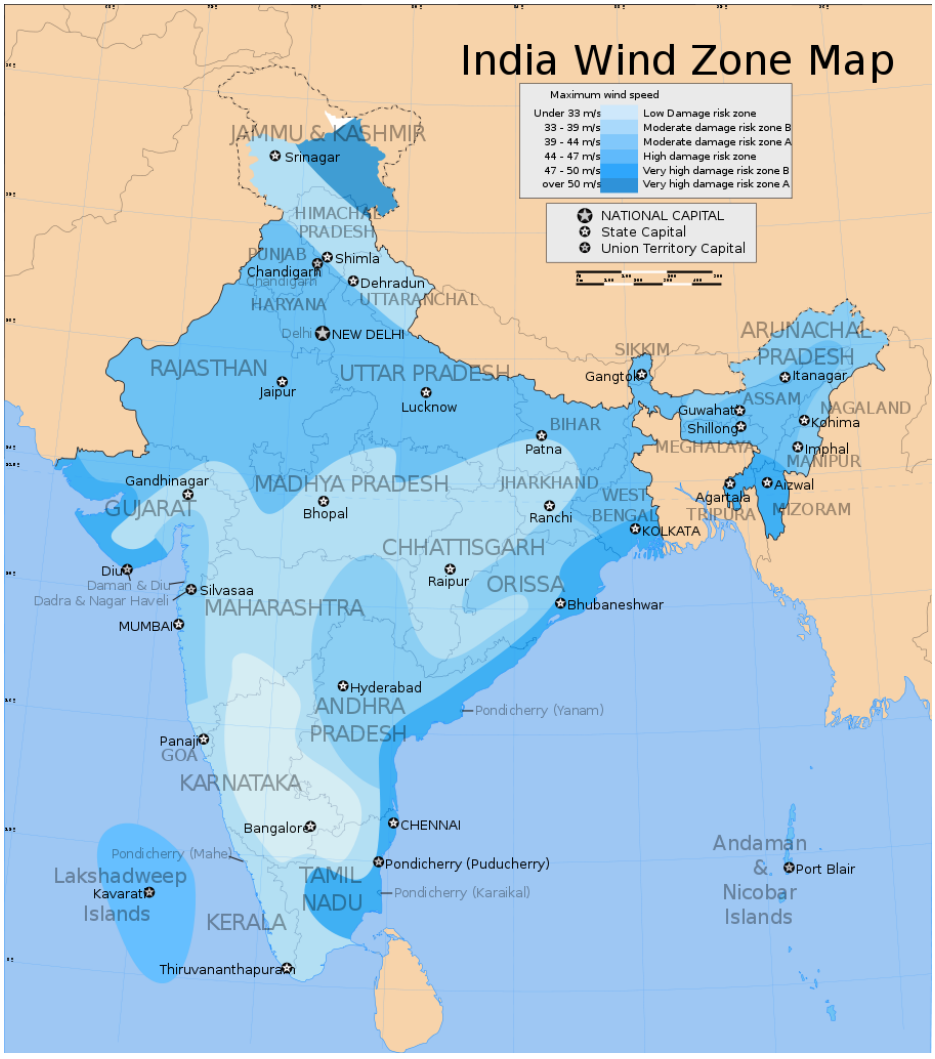



*Figure 45. Highest wind speed in India*

As can be seen in the images, both types of renewable energy can be used at the further university to be built in Tamil Nadu. On the one hand, solar energy because in the land where Tamil Nadu is located there is a large solar radiation that can be used with photovoltaic panels. On the other hand, it can also be seen how wind energy also plays a good role in Tamil Nadu's land. As can be seen in the images, Tamil Nadu gets a lot of wind force that can be used to create secondary energy.

## Possible solutions

As mentioned above, the administration building has already been built. A study has been carried out on how much energy this building consumes having the lights, fans and AC's on 16 hours a day. And it has been obtained that an energy of 600 KWh per month is consumed. The surface area of the administration building counting both floors is 13.927 square feet (1.293,86m2). The surface of all the buildings (adding up all their respective floors) counting the administration building is 111.160 square feet (10.327m2). Extrapolating these figures to the rest of the buildings on campus and relating it to the square footage they have, it sort out an energy for all the campus of 4.788,97 kWh per month.

Applying the safety factor of 1.5 leads to the fact that all the buildings on the campus consume an energy of:

$$4.788{,}97\,\frac{KWh}{month}\cdot 1{,}5\cdot\frac{12\,months}{year} = 86.201{,}46\,\frac{KWh}{year} = 86{,}2\,\frac{MWh}{year}$$

Solar resource

Figure 46 shows the global energy accumulated annually per square meter of horizontal surface of the area that affects the project.

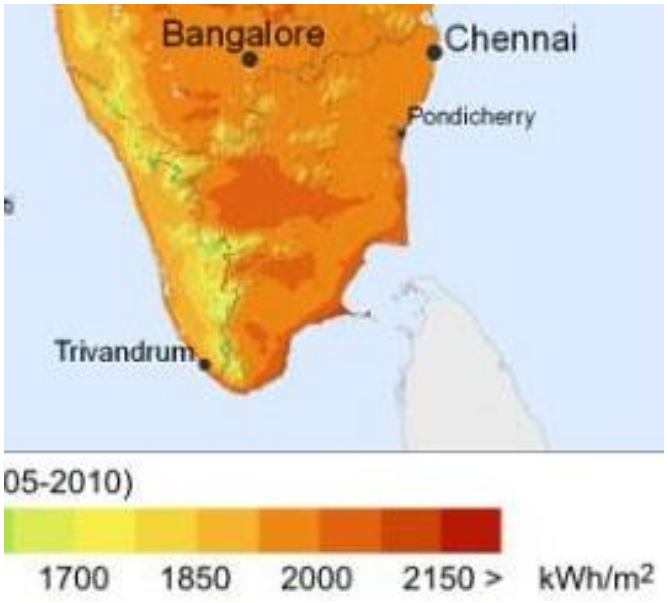
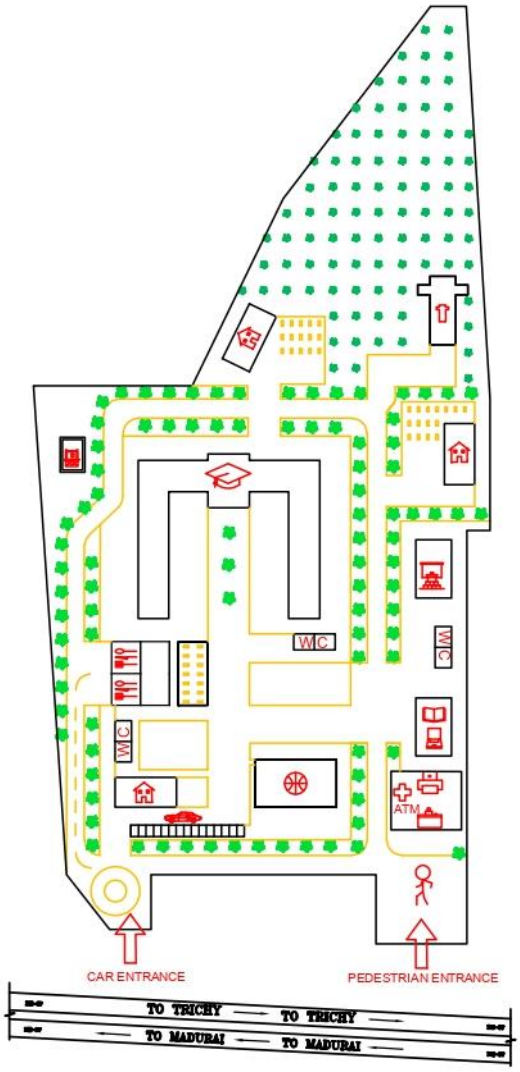



*Figure 46. Accumulated global energy*

It can be estimated that, on average, Tiruchirappalli and surroundings receives 2050 kWh/$m^2$. Considering that solar panels could be installed in 8,5% of the land. Following figure 47 shows the land and the constructed area. The constructed area is 40.908,7 square feet (3800m2) against 480.914,8 square feet (44.678,4m2 or 10 acres) of all the land.




Scale 1:3000

*Figure 47. Land and constructed area*

The following captured radiation could be obtained:

$$44.678{,}4\ m^2 \cdot \frac{2050\ kWh}{m^2 \cdot year} \cdot 0{,}085 = 7.785.211{,}2\frac{kWh}{year} = 7.785{,}211\frac{MWh}{year}$$

Solar panel efficiency is a measurement of a solar panel's ability to convert sunlight into usable electricity. Given the same amount of sunlight shining for the same duration of time on two solar panels with different efficiency ratings, the more efficient panel will produce more electricity than the less efficient panel. Solar panel efficiency is determined by the production of electricity by solar cells, which is in turn influenced by the cells' composition, electrical configuration,

surrounding components, and more. Efficiency is a determining factor if you have limited space on your roof.

Most solar panels are between 15% and 20% efficient, with outliers on either side of the range. High-quality solar panels can exceed 22% efficiency in some cases (and almost reach 23%!), but most photovoltaic panels available are not above 20% efficiency.

Knowing that the efficiency of this type of installation is around 20%, the efficiency of annual energy that can be obtained with safety features is 15%:

$$7.785{,}211\,\frac{MWh}{year} \cdot 0{,}15 = 1.167{,}7\,\frac{MWh}{year}$$

As can be seen, considering the 8,5% of land, the target to be met is far exceeded. Due to the need of the university campus is 86,2 $\frac{MWh}{year}$.

That means, using 3019,9 square feet (280,55m2) of the surface available to install the photovoltaic panels, is enough to supply the 86,2 $\frac{MWh}{year}$ that campus needs. As can be seen, can be perfectly installed on the roof surfaces of the campus buildings, as this area is much larger 40.908,7 square feet (3800m2). This can allow the campus to grow or even provide the poorer rural areas around it with electrical power.

An option is to install all the panels on the main building's rooftop as seen in figure 48 and figure 49:

*Figure 48. Example rooftop solar panel plant*

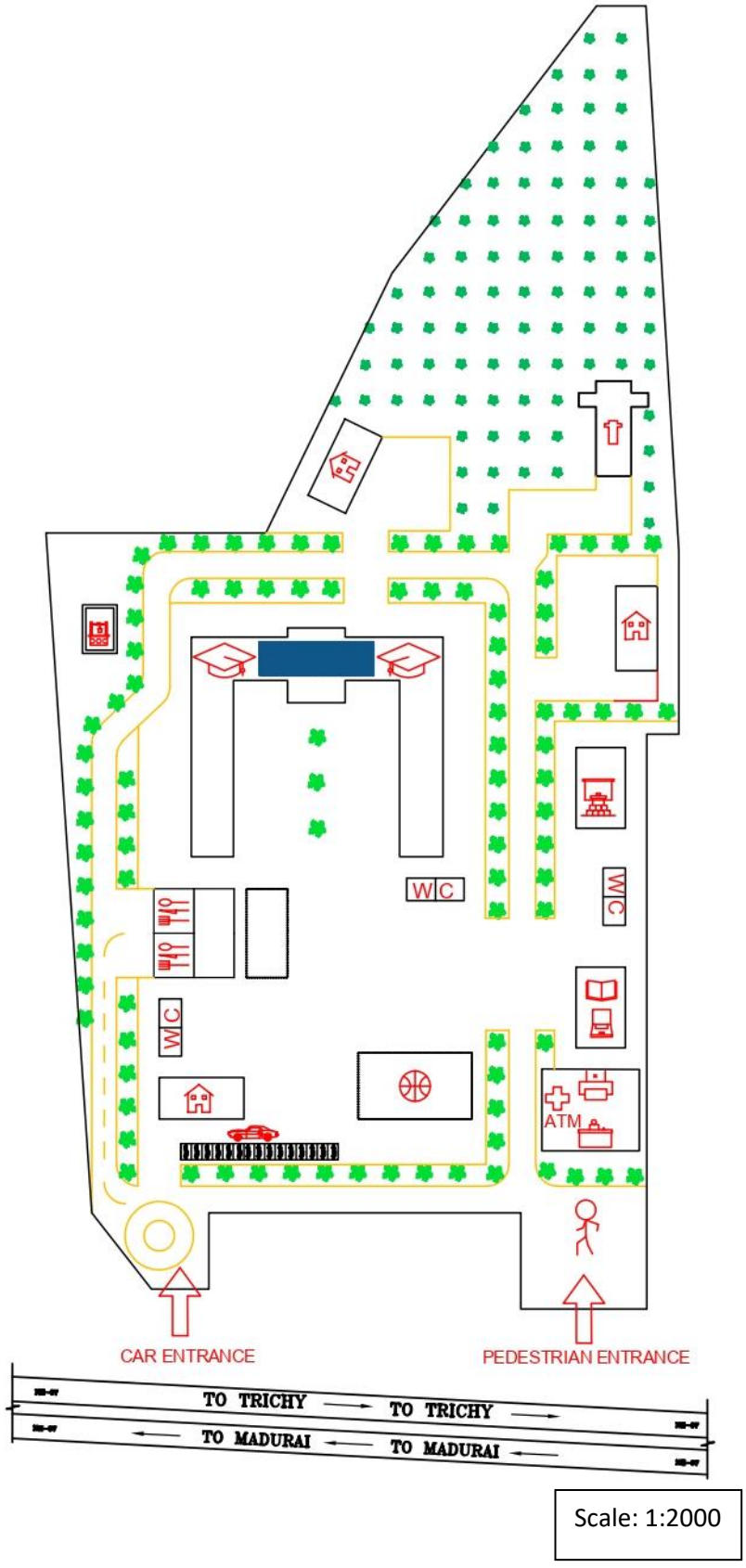



*Figure 49. Location of solar panel plant*

Wind resource

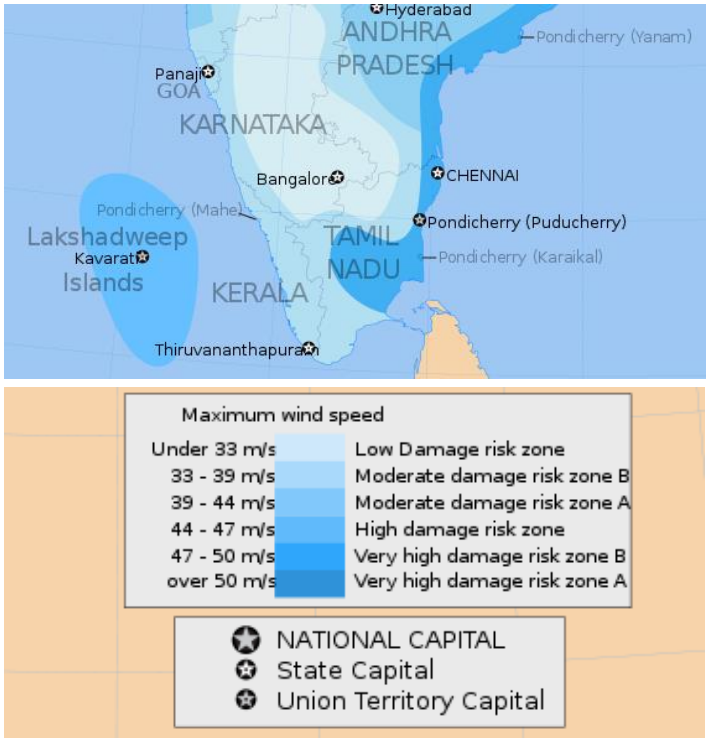
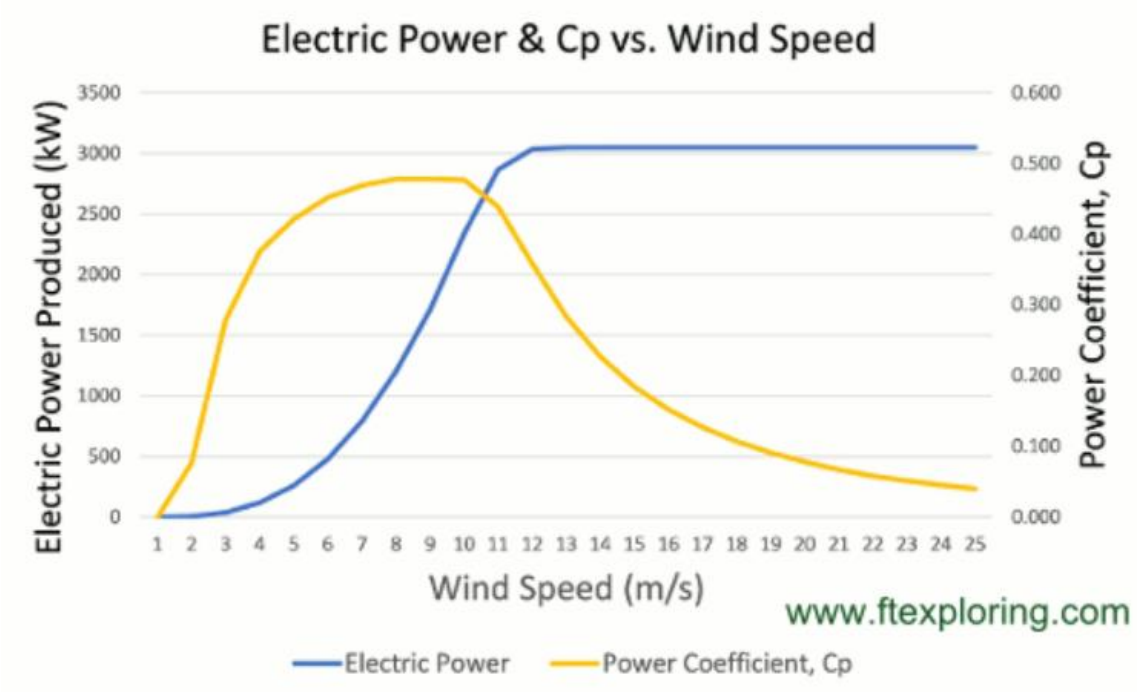



*Figure 50. Wind speed in Tamil Nadu*

As we see on the map, wind speeds are particularly high in this country, which makes it easier to study the feasibility of generating energy from wind. In the state of Tamil Nadu, and specifically in the area of Tiruchirappalli, the average wind speed is 48.5 m/s.

Considering the installation of 1.5 MW wind turbines, which are already widely spread in Europe and Asia, it is possible to estimate the energy that each of them would generate annually. The approximate data used for the calculation are as follows:

- Average wind speed: 48.5 m/s
- Wind turbine rotor diameter: 80m
- Rated power of the wind turbines: 1.5 MW
- Starting speed: 3 m/s
- Average power coefficient: 0.05 (estimated value downwards)
- Annual usage time: 8,000 hours (estimated value downwards)




$$P = \frac{1}{2} C_p \rho A v^3 = \frac{1}{2} \cdot 0{,}05 \cdot 1{,}225 \cdot \frac{\pi}{4} \cdot 80^2 \cdot 48{,}5^3 = 17.561\ KW$$

$$E = P \cdot t_{uso} = 17.561\ KW \cdot 8000h = \ 140.488\ \frac{MWh}{año}$$

As can be seen, the target in terms of power needs to be met is far exceeded

Biogas resource

Assocham's latest 2014 report on collection and treatment shows a 100% collection rate in only seven Indian states in 2014, a remarkable improvement since in 2012 there were only two states, Maharashtra and Bihar, where all waste was collected.

In metropolitan cities, one person produces an average of 0.8 kg of waste per day. The average collection efficiency for municipal solid waste is between 22 and 60 per cent. Municipal solid waste generally contains 51% organic waste, 17% recyclable materials, 11% hazardous waste, and 21% inert waste. However, about 40% is not collected and ends up in drains and water bodies close.

However, the level of waste treatment is very low. In fact, not even a single state treats half its waste. In 2014, Maharashtra and Uttar Pradesh, responsible for 19% and 13% of total waste generation in the country, are only responsible for treating 18% and 27% of the waste, while the rest is transported to landfills.

In India, waste reuse or recycling are the preferred options for municipal waste management, followed by composting. When recovery of materials is not possible, the objective is to recover energy (waste-to-energy) from them.

As it has been explained above, the amount of waste/substrate to be used for the fermenter of the biogas plant of the campus for each person is 0,4 kg of organic waste a day. Knowing that the campus has 1500 students, it works out 600kg/day. Taking into account that methan is 60% of the biogas and the generator sincron stanford HCG534C2 (as an example of biogas generator) has a coefficient of performance of 0,4.

$$600\,\frac{kg}{day}\cdot\frac{1000\ gr}{1\ kg}\cdot\frac{1\ mol}{16{,}04\ gr}\cdot 0{,}6\ = 22.443{,}89\ \frac{mol\ CH4}{day}$$

$$22.443{,}89\ \frac{mol\ CH4}{day}\cdot\frac{890\ KJ}{1\ mol} = 19.975.062\ \frac{KJ}{day}$$

$$19.975.062\,\frac{KJ}{day}\cdot 0{,}4 = 7.990.024\ \frac{KJ}{day} = 2{,}21\ \frac{MWh}{day}$$

$$2{,}21\,\frac{MWh}{day}\cdot\frac{365\ days}{1\ year} = 806{,}65\ \frac{MWh}{year}$$

As can be seen, the target in terms of power needs to be met is far exceeded. Even having 0,1 kg of waste per person a day, I would be enough to reach the target.

## Alternatives solutions

Once we consider the three best possible renewable energy options. The decision will then be made as to which renewable energy is appropriate for the university to be built in Tamil Nadu by Ilanthalir NGO.

Wind, biogas and solar energy are renewable and inexhaustible energies, neither of them contributing to the greenhouse effect or global warming.

SOLAR

| ADVANTAGES | DISADVANTAGES |
|---|---|
| Can be installed very easily on roofs and facades so that space is better used, without occupying useful space and without architectural impact. | They require more square meters for installation. |
| It requires little maintenance and in addition to that, the maintenance costs are low compared to other renewable energy sources. | The amount of energy produced is variable depending on weather conditions |
| It is easy scalable; the system can be easily grown by adding more panels | Generates electricity only during the day |
| In the long term it represents a very low cost | The amount of energy obtained is defined by the space available for the installation of the photovoltaic panels |
| It has a quick return on investment over the life of the installation | |
| It does not generate noise | |
| It does not consume fuel or generate waste | |

EOLIC

| ADVANTAGES | DISADVANTAGES |
|---|---|
| It can be built in a relatively short time | The initial cost of the installation is higher than other systems |
| It has a low maintenance cost | The amount of energy produced is variable depending on weather conditions |
| They produce electricity both day and night. | Previous studies of the wind conditions are needed to decide the exact location of a wind farm. |
| They occupy less land area. | The rotation of the rotor produces noise |
| | It has a great visual impact, as it is a large project and affects the passage of birds in the area where the wind farm is located |

BIOGAS

| ADVANTAGES | DISADVANTAGES |
|---|---|
| Source of income for farmers. | Complex and expensive storage system. |
| Waste production is reversible to clean energy. | Emission of carbon dioxide (CO2) |
| Gives a useful purpose to landfills. | Requires a lot of space and possible annoying sound of the fermenter blades. |
| Fertilizer generation. | |
| Alternative for use in kitchens. | |

## 6.3. Proposed solution

Having studied the advantages and disadvantages of each alternative, the option of using the wind energy source is rejected for the following reasons:

- It is not necessary to take up as much space as this facility requires
- The NGO does not have money enough for the initial cost of the installation
- It would be compulsory to hire a company to study the project and work the exact location out.
- On a college campus, the less noise the better it is. In order to avoid disturbing students.
- It is very important to respect the visual environment; a wind project does not correspond to it.

In addition, the disadvantages of the solar energy source can be easily solved in the way it is proposed:

- Photovoltaic panels only generate electricity during the day → there are batteries that accumulate the energy produced by the photovoltaic panels during the hours of sunshine so that it can be used at night or on cloudy days.
- The amount of energy produced is variable depending on weather conditions → it has been seen before that the atmospheric conditions in Tamil Nadu are optimal for it.
- They require more square meters for installation → Photovoltaic panels require more square meters for installation but are not going to be seen because they are places on rooftops, so they respect nature and the environment.

  Having said this, regarding biogas source there are no options to improve the disadvantages of it. Firstly, because of the emission of carbon dioxide (CO2). Secondly, requires a lot of usable space. On contrary than solar resource that can be implemented on the top the buildings. Finally, despite is not much higher than the solar resource, it has a high initial cost for installation.

So, it is concluded that the solution adopted for the needs of the project has been to consider the SOLAR alternative.

# 7. CONCLUSIONS

The access to a college is limited by the number of places available. In India, many of the universities favour access to students who have completed primary and secondary education in their partner schools. For the remaining places, the access criterion is based on the note taken in the government exam.

That means that the students of the humblest or less favoured schools have greater difficulty in continuing their higher education. In order to provide opportunities for this type of students, the NGO Ilanthalir proposes to build a university in which they have preference.

The project is located India, Tamil Nadu, south of Tiruchirappalli. The project has consisted of helping the NGO Ilanthalir making a master plan of the university campus. A master plan that has included the investigation of the adequate self-sustainable resources to be implemented in the university. That study has had the purpose of saving money to the NGO and minimizing environmental pollution in the world.

This university is expected to manage 1500 students. The project that has been carried out consists of a main building containing 30 classrooms, 2 laboratories and 2 teachers' rooms. On campus there are also three residences (2 for students and 1 for staff), 2 dining rooms for student meals (vegetarian and non-vegetarian), library, computer room, church, a multipurpose hall, an administration building and in addition to a basketball court there is a large playground area.

In order to make the university self-sustainable, different alternatives have been evaluated such as wind power to take advantage of the high wind speeds in this area of Tamil Nadu, solar photovoltaic, to take advantage of the great sunshine in this same area, and biogas plants, to take advantage of the organic waste. The conclusion is that, due to space allowance, technical, topographical, geographical, environmental characteristics, respect for the natural environment and the location of the project, the best solution is to use photovoltaic solar panels that can be used to transform solar energy into electrical energy.

To sum up, a project has been made for the NGO Ilanthalir located in Tamil Nadu, in order to make a master plan for a future university campus to help all those young people who for economic reasons cannot afford a university education. This master plan has included a study to make the project self-sustaining in terms of energy resources. This study has concluded that the best method to implement for various reasons already explained is solar energy with photovoltaic panels.

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