

# **Multi criteria site selection for new hospitals in greater Melbourne**

Project design report

## ***Table of Contents***

### ***EXECUTIVE SUMMARY:***

.....	2
.....	1
.....	2

#### **1.1 Topic**

.....	2
-------	---

#### **1.2 Motivation**

.....	3
.....	2

### ***Research questions***

.....	4
-------	---

#### **2.1 Population density**

.....	4
-------	---

2.2 Accessibility	4
2.3 Distance to other hospitals	4
2.4 Ambulance call frequency	5
2.5 Land usage	5
2.6 Water and electricity supply	5
2.7 Terrain	5
2.8 Road vehicle accidents	6
3 Data required	6
4 Analysis Design	7
5 Analysis outcomes	10
5.1 Expected outcome	10
5.2 Outcome File	10
5.3 Limitations	10
5.4 Future Outlook	10
5 Time plans	11
References	12
Appendix - Individual Reflection	13

## ***EXECUTIVE SUMMARY:***

This report presents the project design for identification of suitable sites for building the

hospital in greater Melbourne region. The client in this report is Victorian Health and Human

Services Building Authority, the Department of Health and Human Services region. The

report outlines some set of specifications for the construction of the hospital in potential

suitable locations. In addition, it gives a description of the rules and provides a justification

why each criterion has been chosen. Then it lists the detailed information regarding the

required data and sources. This report also comprises the design of analysis procedure and the

expected outcomes. A Gantt chart has also been included in the report, which clearly illustrate

the arrangement of individual tasks as well as the deadlines for completion of different

project  
components.

## ***1 INTRODUCTION***

The main aim of this project is to build a hospital at three different suitable locations in greater

Melbourne. Here the client is Victorian Health and Human Services Building Authority, the

Department of Health and Human Services region and the client has given some set of criteria for

constructing the hospital from the Health planning and development guidelines – Master planning and

other sources has been cited below the key considerations while building the hospital site selection

includes the availability of public transport routes to the people, The other important factors are

distance from the other hospitals and the expected impact on the existing hospitals and the rate of

population in the location (Soltani, A., & Marandi, E. Z. (2011)).

### **1.1 Topic**

For constructing the hospitals, the client Victorian Health and Human Services Building Authority,

the Department of Health and Human Services region has given some site selection position

requirements such as (Victorian Health and Human Services Building Authority (2018))

#### **1.1.1 Area:**

Does the site allow the best functional relationship to be achieved vertically and

horizontally?

Does the site is large enough for expanding in the future if there are unplanned future growth demand

in services?

#### **1.1.2 Topography:**

2

Does the site relatively flat or there need any changes in level and is able to be readily incorporated

with an efficient site layout.

Does the site subject to inundation, watercourses or overland flood ways which would limit the usable

area?

#### **1.1.3 Site Accessible:**

Does the site have frontage to roads or two streets to enable separation of Visitor or patient vehicle

entry from heavy vehicle entry and emergency?

#### **1.1.4 Public Transport**

##### **Accessible:**

Does the site well serviced by public transport for ensuring access to staff, visitors and users (for

example bus, Train stations, and tram routes are nearby)?

#### **1.1.5 Regional Public Transport**

##### **Accessible:**

For regional centres, are the facilities near to regional transport hubs for facilitating access to staff,

visitors and users travelling from one or more remote locations?

#### **1.1.6 Safe access:**

Site entries consider bicycle, local pedestrian, traffic movement patterns; logistic vehicles separated

from cars; movement of pedestrians separated from vehicles; separate entry and unhindered access

provided for emergency vehicles; appropriate drop-offs and pickup points provided.

#### **1.1.7 Travel distances:**

Travel distances minimised for staff, visitors and patients.

## **1.2 Motivation**

This project predicts that the Melbourne population increases from 4.5 million to almost 8 million—

with Victoria's total population is going to reach 10 million by the year of 2051 (Victorian Health and

Human Services Building Authority (2018)). Therefore, the client Victorian Health and Human

Services Building Authority plans to wisely invest for catering the needs of an ageing population and

the congestion growth. Additionally, the project aims at ensuring economic and social opportunities

and most public value in terms of social, environmental and economic outcomes which is created for

building government hospital. The hospital sites are of civic importance and they are

capable of

contributing positive contribution for the town region or city in which areas that are situated.

3

## ***2 Research questions***

There are many factors to be considered when setting a new hospital, in this section we will talk about

them and find support from related works.

### **2.1 Population density**

People, all over tend to get be health and get the excellent health care that keeps them healthy.

Hospitals will be constructed to be able to make the health of many lives to be healthy. When citing a

hospital, the density of population will be looked and weighed. When the community of an area is

densely populated, it affects the number of hospitals to be constructed. The ratio of hospitals to the

population will be required to be equal. This will be able to make the hospitals to be built as many as

they will be ready to serve the population number. When a domain is sparsely populated, then the

hospital will be built, but the number will not be many because it only has small customers who will

be served by the hospital, making it be regulated. The population will also be determined in

employment that will be building the hospital to run. Among the community, the support staff will



be

selected to make sure that they are running the day in day out activities as compared to the sparsely

populated area the support staff will be limited (Bourbonnais, Vézina, Abdous & Gaudet, 2006).

## **2.2 Accessibility**

The hospitals should be located where the convenience is that easy. Well-developed road networks

and public transportation around the hospital will make the hospital to be accessible by the patients

and staff. Road network is essential to be considered as it makes sure that the raw materials needed to

construct the hospital are well transported. Well-developed road network will also be making the

ambulances of the hospital to be well passing with the patients. If the location of the hospital in not

easily accessed, then the people who are fighting to get into the facility will be facing the challenges

that might be making them get problems or the difficulties to arrive. This will also make the suppliers

of the hospital to be discouraged from supply the hospital with the raw materials or drugs (Lundberg,

Nettleman & Wenzel, 1998).

## **2.3 Distance to other hospitals**

When setting up a hospital, it must be considered that nearby hospitals depend on each other. This

will make referrals of patients to be simple as the distance will not be to far. If in any case, the range

tends to be far, then it will be hazardous on the patients who will be transferred to other

hospitals to

be at risk. If the hospitals are too close to each other, then another hospital should not be set. This will

#### 4

be causing congestion of the hospital, making it serve only a few people. This will be the wasting of

the resources that will be used (Apostoli & Caula, 2008).

## **2.4 Ambulance call frequency**

When in a single area, the rate at which the ambulance is being called is so high, it means the area has

many patients but few hospitals. If in an area the ambulance call rate is low, then it can be concluded

that the people in that area are not exposed to the risk of being sick or the area has enough hospitals.

On these two different examples, the areas that has a high number of calls for the ambulance has high

chances for the hospital to be set as compared to the areas that the rate of the ambulance being called

is low. This makes the hospital to be having minimal chances to be set in low ambulance call

frequency areas (Bourbonnais, Brisson & Vézina, 2011). On the other hand, if a hospital receives too

many ambulance requests, it is a signal to set a new hospital nearby to share the burden.

## **2.5 Land usage**

To set up a new hospital, you must check the land usage and find an available idle land for the new

hospital. You also need to make a reasonable prediction on the growth of the hospital. This will be

done according to the area that the hospital is located. If the hospital is located in rural areas, then

there is a possibility that the hospital will take a large land parcel and can grow horizontally since

there are enough room and space for expansion. When the location of the hospital is in the urban

areas, then the development of the hospital will be vertical. This will make the hospital to start with

strong foundations that will be able to support more floors upwards since the horizontal growth will

not be that easy due to space limitation. (Heiny, 1986).

## **2.6 Water and electricity supply**

A new hospital should be set in a land with stable water and electricity supply. If the area has no

enough water, then it will be difficult for the hospital to be set. The essentials of the hospital to run is

the availability of water that will be used in the cleaning and making sure that the equipment's that are

set in the hospitals are clean. The electricity supply is also essential. Power makes most of the

machines to run in the hospital. Delicate machines like life-supporting machines need to be having an

ability every time so as for them to be relevant (Hassan, 2007).

## 2.7 Terrain

Obviously, a flat land parcel is preferred to contribute buildings for a new hospital. Flat and even

areas normally have more well-developed road networks and can be more easily accessed. On the

5

other hand, the cost and construction difficulties will be low for contributing a hospital on a flat land

parcel.

## 2.8 Road vehicle accidents

Areas that are exposed to the road accidents will not be that suitable to fit the location of the hospitals.

Accidents will highly affect the operations of the hospital as staffs and patients of the hospital will be

exposed to the accidents affecting the operations of the hospital. The ambulances will also be highly

affected. When the location has lower threat from the accidents, the location will be fit to be able to

build the hospital. The staffs and the patients will not be exposed to the accidents making the safety of

staffs to be high. The ambulances will not be affected as the safety will be good.

## ***3 Data required***

To achieve the goal of this project, multiple data are required. For example, data of public

transport

system and population should be used to analyze the ideal location for hospitals. Since we are still in

the project planning stage, it is considerably difficult to foresee all the data required in future project

implementation and development. Therefore, the data collected in the current stage is not guaranteed

to be fully used in the next stage, and more data may be collected if needed. In this project, all the

data are collected from reliable sources, such as the open data site of Victoria Department of

Transport, Australian Government Open Data, and Victoria Government Open Data.

Specifically, we have collected following dataset which might be useful for analysis:

### **Transportation:**

- Road Use Hierarchy; contains information about road usage of Victoria.

Source:

<https://vicroadsopendata-vicroadsmaps.opendata.arcgis.com/datasets/road-use-hierarchy>

### **Population:**

- Population by Age and Sex; contains latest estimation of population in Australia.

Source:

[https://data.gov.au/dataset/ds-sa-112e8caf-f991-4322-afc9-](https://data.gov.au/dataset/ds-sa-112e8caf-f991-4322-afc9-2013750f4996/details?q=population)

[2013750f4996/details?q=population](https://data.gov.au/dataset/ds-sa-112e8caf-f991-4322-afc9-2013750f4996/details?q=population)

- Population Projections; contains projections of future population of Australia based on

fertility, mortality and migration. Source:

[https://data.gov.au/dataset/ds-sa-aaa916c6-](https://data.gov.au/dataset/ds-sa-aaa916c6-2013750f4996/details?q=population)

78fd-4a25-8571-e1069201e3cc/details?q=populati  
on

6

### **Safety:**

- Crashes Last Five Years; contains information about car accident in Victoria in last five

years. Source:

<https://vicroadsopendata->

[vicroadsmaps.opendata.arcgis.com/datasets/crashes-last-five-y  
ears](https://vicroadsopendata-arcgis.com/datasets/crashes-last-five-years)

- Crime Statistics Agency Data Table; contains information about crime location in

Victoria. Source:

<https://data.gov.au/dataset/ds-vic-fef84726-eaf7-4985-ac10->

[ac39c7b84da5/details?q=crime%20rate  
s](https://data.gov.au/dataset/ds-vic-fef84726-eaf7-4985-ac10-ac39c7b84da5/details?q=crime%20rates)

### **Existing Hospitals:**

- Ambulance Victoria Incidents 2011-18; contains information of number of ambulance

incidents in Victoria. Source:

<https://discover.data.vic.gov.au/dataset/ambulance-victoria->

[incidents-2011-18](https://discover.data.vic.gov.au/dataset/ambulance-victoria-incidents-2011-18)

- Ambulance Victoria UCL Response Time Performance: contains information of

ambulance response time in Victoria.

Source:

[https://discover.data.vic.gov.au/dataset/ambulance-victoria-ucl-response-ti  
me-](https://discover.data.vic.gov.au/dataset/ambulance-victoria-ucl-response-time-)

## performance

- Hospital Locations; contains information about the location of both private and public

hospital in Victoria. Source:

<https://data.gov.au/dataset/ds-vic-d720a1a1-3adb-4a2c-9d75-f08e24889ea1/details?q=hospital>

### **Water and electricity supply:**

- VM Water supply and storage dam polygon 1857-2018; contains information about Melbourne water supply transfer assets for asset management, operational or maintenance purposes. Source:  
<https://data.aurin.org.au/dataset/mw-mw-ws-storage-dam-2018-na>
- Electricity distribution boundaries: contains information about electricity distribution in Victoria. Source:  
<https://data.aurin.org.au/dataset/vic-govt-delwp-datavic-energy-electricity-distributor-na>

## **4 Analysis Design**

The objective of this project is to search three optimal potential locations for a new hospital in Greater

Melbourne. The sites will be determined by multi-criteria evaluation, which is called weighted site

selection using ArcGIS as shown in figure 4.1. The structure of our planned analysis is mainly

organised in the following steps. This project design report focuses on the first 2 steps.

Figure 4.1. the workflow of site selection analysis



Multi-criteria analysis procedures:

***Step 1: Decide the target***

The ultimate goal of the project is to develop a map clearly illustrating three positions that are most

suitable for the new hospital in a specific area in Greater Melbourne. The area will be selected by the

identification of places in the urgent need of hospitals.

8

***Step 2: Identify criteria and data collection***

There are 8 criteria in total which has been summarised in table 1. All the criteria were selected on the

basis of various facets including economic, environment and safety. The data used to derive certain

result layer are listed in the table above.

***Step 3: Reclassify factors in common scale***

After the final decision of criteria, a Weighted Suitability Analysis will be conducted to produce

layers corresponding to each criterion in a common scale. In this project, the suitability analysis of

each layer will be calculated and reclassified as five categories, namely most suitable (5), highly

suitable (4), moderately suitable (3), marginally suitable (2) and unsuitable (1).

#### ***Step 4: Define weights for individual factor***

Weighted site selection requires ranking of cells and the allocation of a relative importance to each

layer in the analysis, the result of the selection will be a suitability surface with values ranked from 1

to 5 as assigned in step 3. Prioritisation of different criteria is essential in the multi-criteria decision-

making (MCDM) process. It will also impose profound effects to the further analysis (Chen et al.,

2010). The level of importance to each specific factor layer will be assigned on the basis of our

personal knowledge and references from literatures and internet at first in this project. In detail, each

group member will accomplish a ratio estimation for the criteria. The score ranging from 0 to 100 will

be allocated depends on the importance of that criteria. Then the final result of ranking is the average

of the four members in our group. According to Şener et al. (2005), the disadvantage of this method is

the shortage of concrete theoretical foundations. Therefore, we will modify the weight allocation with

deliberation until reaching a consensus and ensure the total sum of all weights is always 100.

#### ***Step 5: Aggregate the criteria***

A raster methodology will be applied to create a weighted overlay through aggregating surfaces by

their weight. Then we can identify three locations with highest suitability and produce a map

presenting the three potential sites satisfying the determined

criteria.

### ***Step 6: Validate the result***

The reliability and feasibility of the outcomes should be examined with logical bases. Any issue

occurred along the validation process will resolved immediately by discussion. The weight

distribution is ready for rectification during the design phase. We will repeat the analysis stage to

tackle any issue as presented in the diagram of workflow (figure 1).

## ***5 Analysis outcomes***

### **5.1 Expected outcome**

According to the plan, our client report should be able to provide reasonable answer to our research

question, which is to find the potential locations for building new hospitals in Melbourne. The ideal

places for new hospital should certain requirements and criteria, which should be proved by detailed

analysis. For example, the selected places for new hospitals should be able to relieve the existing

shortage of medical service in their surrounding areas; the future hospitals should be easily accessible

by the public, which means that road network must be taken into consideration; future

population

growth in those regions should be considered, because hospitals are supposed to provide services for

local population in the long run. In addition, safety is also an important factor which should be considered in the analysis. Ideally, the selected locations should have low crime rates and car crash

rates to ensure the safety of hospital staff and patients. Low crash rate is required because ambulances

should be able to safely dispatch.

## **5.2 Outcome File**

At the end of the project development stage, a detailed report with multiple maps should be produced.

The maps should clearly present information about potential suitable sites for new hospital and demonstrate analyzing process.

## **5.3 Limitations**

It is possible that the outcome could have some limitations in many aspects. For example, the data

collected may be hard to processed or utilized in development stage because of different formats or

references. Moreover, since the dataset contains data from different periods of time, some analysis may

be inaccurate or biased.

## **5.4 Future Outlook**

The scope of the project includes the present conditions of Melbourne. Most of the datasets are based

upon the current and historical monitoring. At present the outcomes shows the areas where the hospitals

need to be located. In the coming years the conditions may not be the same as of now as the potential

expansion of greater Melbourne. As a result, there would be need of remodelling the locations of the

hospitals for fulfilment of the changed needs. For future analysis, the methodology in this project can

10

also be applied for updating the information and enlarge the connection with additional criteria like air

pollution and proximity to the waste disposal plant.

## ***5 Time plans***

Figure 5.1 and 5.2 illustrates the time plan for the realization of designed practice in the GANNT

chart format. The intended commencement and completion time of each task for every team member

has been distributed clearly in the chart.

Figure 5.1 Time plan for project design

Figure 5.2 Time plan for client project

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## ***Appendix - Individual Reflection***

### **Team member: Junyi Shi**

In the project design report, my major contribution is the Research question section. In this section, I

established a set of factors that should be considered when setting a new hospital. For most factors

considered, I find support and prove its reasonability by referencing existing related papers and

articles. Moreover, I make a brief explanation for each factor considered to show why it is considered

and how will it affect the hospital. In the client report, my task is suitability analysis and criteria ratio

estimation.

The set of factors to be considered is the foundation of the project design. I listed the most important

ones, however, due to the time limitation, the research on potential affecting factors is not exhaustive

and there may be more affecting factors ignored or forgotten.



In the second client report, I will take the tasks of checking the land usage, analysing the accessibility

and distances between potential locations of our new hospitals to other existing hospitals.

Overall, I think the project design is appropriate to the client needs that setting a new hospital. Our

plan of analysing is also feasible and reasonable.

**Team member: Zuodong Li**

**Individual contribution**

In this project I was assigned with several tasks including collecting data, processing data, and

some

GIS analysis tasks. Since my major is IT and I'm quite at collecting data and processing data, I will

handle most tasks related to data in this project. Some data we collected may not be directly usable, so

I will try to convert these data into the right format by using some tools such as Python. In addition,

because I have studied subject 'Software project management' before, I'm quite familiar with Gantt

chart, so I build the Gantt chart which presents the allocation of each task of our team. In the

development stage, I will also analyze the suitability of the location. More specifically, I will focus on

terrain data and trying to locate places which are suitable to build buildings. In the last two weeks

before the due date of our client report, I will work with all my teammates to allocate weight for

different criteria, perform aggregate our analysis result, and finally validate our results.

### **Critical review**

I believe our overall design of our project is reasonable and doable. First, we have collected some

core data which are essential for our analysis; second, we have a well-designed analysis plan that

should be able to help us find answers; last, all tasks have been distributed to each team member in a

way that everyone can work effectively and productively in their own paces. However, I do feel that

there are still possible improvements which could be achieved. For example, although all team

members can work collaboratively with each other without problem, it would be even better if we

have a member with a strong leadership. We are all introverts so that sometimes I feel that we need to

take a long time to make a decision for a trivial topic. Besides, I'm not sure about whether our time

plan can be carried out or not. Although we have looked up our schedule in the following weeks,

changes are still very likely to happen because we all have many other subjects which also have group

projects. Therefore, it is possible that the time plan cannot be strictly followed in the end.

In conclusion, I'm fully convinced that our projects will bring us a good result, and it should be a

reasonable answer to our initial research question.

**Team member: PRIYANKA SHIVAMPETHA**

### **Individual contribution**

For this project design report, I was allocated to do topic and motivation part for this area it was mainly

focused on GIS analysis of the social and economic factors for this project (for example hospital location and population in areas). I was assigned the task of identification where the hospital site

location would be more suitable and the factors which influence in finding the appropriate location. As

this data plays an important role for our study area in Greater Melbourne which defines the highest

demands for hospital within that region. For future outlook, it requires me to analyse the non-spatial

data and the conditions may not be similar as of now there might be changes takes place in the future.

In the local government areas and some other areas are expected to have a higher population density

compared to now. For this I required to analyse what are the site locations with already hospitals available in that region and to identify the potential sites which requires the hospitals.

My tasks for this project are:

For analysing the appropriate data I used ARCGIS which included in the usage of network analysis

and spatial data

For this project it requires the searching and extraction of data such as hospital site selection and

population

Being a part of team member, I was assigned to write future outlook.

## **CRITICAL REVIEW**

The beginning of the project design seems to be in achieving the project goal. For initial scope of the

project the client needs to be taken into account where the study area needs to be conducted. But, the

important criteria we have chosen initially for identifying appropriate hospital site location is comprehensive and relevant when sourcing the data difficulties has been arisen since the data was

unavailable and out dated.

The time plan has been developed by our team member as all our teammates belong from different

backgrounds and our schedule was quite different, some of them had tutorials and other group project

meetings so we couldn't follow strictly according to our time plan.

Hence I believe that project design has satisfied the criteria according to the client needs, if necessary

we can adjust the criteria aggregation method for providing better results according to the client needs.

15

## **Team member: Xiao Luo**

**Part 1. Individual contribution** My major effort in the project design phase is designing the multi-criteria analysis procedures and clearly displayed it in a workflow diagram. Additionally, I contributed to the discovery of topical challenge, narrowing down of the research area, selection of analysis criteria and data collection from various websites with the collaboration of other team members.

As for the accomplishment of client project in the future. My individual contribution will focus on two parts: (1) The first one is the reclassification of different factor layers into a common scale. This is the foundation for the suitability analysis so that all the layer can be aggregated smoothly. (2) The second task is the suitability analysis regarding the determined criteria. Each member will be assigned two criteria to ensure that everyone contribute to the overall analysis. In this stage, I will account for the analysis concerning the frequency of road vehicle accidents and the ambulance call. By reranking different values in the raster layer of the given factors, I can produce two surfaces that illustrating the suitability distribution pattern of accidents and ambulance calls.

After completion of suitability analysis to all criteria, we will assign weights to each layer together and reach a consensus of the final score allocation. Then we will aggregate the layers collaboratively to create an overlay that can show the result of our research question. Before sharing the final map of suitable hospital locations to the client, we will validate and revise the outcome carefully to guarantee the rationality and feasibility of the result.

**Part 2. Critical review** The project design is appropriate and practical in general and can achieve the ultimate goal of the project from my perspective. First of all, the problem identification is based on thorough consideration of client needs. The motivation of the project has been clarified to support in- depth research. In addition, the scoping of Victoria state helps narrowing down the study area to a reasonable and viable scale.

However, there are disadvantages with respect to the data sources. Although the criteria initially determined in the design stage are relevant to the goal, the data collected from varied sources may not be updated, complete or compatible enough with other types of data. Therefore, we need to examine the availability of the data throughout the analysis implementation stage. Every member should pay attention to the result of each step and apply modification timely to ensure a desirable outcome.

The detailed time plan is the critical factor in guiding our project towards final success. The GANNT chart presents the task allocation in a succinct manner so that avoid the conflicts during the implementation process. Furthermore, each item has clear start and end point to remind everyone to finish their job in time. Finally, frequent group meeting will safeguard the performance of each member and accomplishment of tasks.